Cooperation & Innovation for Development

-Technical Report of the 30th CR Expo (2019)

I. About CR 2019 and Its Characteristics

(Professor Shi Wenxing, PhD Candidate Xiao Hansong, Tsinghua University)

The 30th International Exhibition for Refrigeration, Air conditioning, Heating and Ventilation, Frozen Food Processing, Packaging and Storage (hereinafter referred to as the 30thCR or CR 2019) was held at the Shanghai New International Expo Centre from April 9 to 11, 2019. The event, co-hosted by the China Council for the Promotion of International Trade Beijing Sub-council, Chinese Association of Refrigeration (CAR), China Refrigeration and Air conditioning Industry Association (CRAA), Shanghai Society of Refrigeration and Shanghai Association of Refrigeration Industry, was organized by the Beijing International Exhibition Center.

The theme of the CR 2019 was "**Cooperation & Innovation for Development**." Featuring product display, theme forum and technical seminar, the event attracted representatives from industry organizations, government institutions, well-known enterprises, industry elites and future industry promoters and builders from around the world. Based on exhibition, supported by high-end forums, the event successfully makes itself a diversified platform, bringing together production, education, research, management, application and media. It celebrates itself with the role it played in disseminating energy conservation and emission reduction, practicing the low-carbon environment friendly policy and advancing cooperation and innovation for development among industries.

(I) About CR 2019

CR 2019 kicked off at the Shanghai New International Expo Centre on April 9, 2019. As one of the largest exhibitions in HVAC&R industries in the world, CR 2019 covered an area of 103,500 square meters with 1,175 exhibitors from 33 countries and regions, including three international group pavilions drawn from Europe, the United States and South Korea. A total of 61,586 visitors from 106 countries and regions attended the exhibition.

Incepted in 1987, CR is positioned as an "International Industrial Exhibition on Refrigeration, Air Conditioning, Heating, Ventilation and Food Refrigeration Processing," aiming at branding, professionalization, internationalization and standardization. After over 30 years of unremitting

efforts of the CR Organizing Committee, along with strong support of relevant government departments and the active participation of industry colleagues, CR has become one of the largest professional exhibitions among its peer industries in the world. With the UFI and the US FCS certification, CR is acclaimed as top-level professional exhibition in the industry.

As one of the largest professional exhibitions of the same kind in the world, CR 2019 attracted 1,175 exhibitors who brought the most advanced technologies and products to the exhibition, building a large-scale communication platform that integrated display, trade and forums.

Figure 1.1-1 CR 2019 Opening Ceremony and Theme Forum

Under the guidance of Xi Jinping Thought on Socialism with Chinese Characteristics for a New Era, CR 2019 held academic and technical seminars around its "**Cooperation & Innovation for Development**" theme, including one theme forum, 27 symposiums and 49 technical seminars. The activities focused on analysis of national policies, hotspots, technological innovation and future trending of the industry.

CR is not only a commercial exhibition, it also carries a social responsibility to lead the industry's healthy and sustainable development. CR Organizing Committee is committed to creating an international, diversified and professional communication platform, and endeavors to serve exhibitors in an all-round fashion, contributing to the innovation and development of the

refrigeration and air-conditioning industry in China and the world.

(II) Characteristics

Under the careful planning and organization of the CR Organizing Committee, CR 2019 features the following:

1. Technical communication activities of all kinds held in conjunction with industry hotspots

During the exhibition, academic conference are were held in various forms around the theme “Cooperation & Innovation for Development”, including, theme forum, symposiums, technical seminars and public welfare activities. The Ozone Climate Technical Roadshow Display Area, Cold Chain Display Area and Heat Pump Display Area were set up to showcase the latest achievements and disseminate new ideas. Representatives from domestic and overseas government departments, experts and scholars, industry organizations and the United Nations were invited to speak and discuss on the industry’s hotspots and issues of great concerns, craftsmanship, industry trending, the latest innovation developments in conjunction with the national "Made in China 2025" strategy and the macro economic status quo.

2. Professional audiences’ in-depth interaction

The CR Organizing Committee exerted enhanced efforts in engaging high-end audiences. Chief Engineers delegation group from national design institutes and refrigeration industry, HVAC high-end users as well as professional buyers group were mobilized to visit the exhibition and conduct in-depth interactions with exhibitors.

In order to enhance the macro-awareness of relevant enterprises about the industry, stimulate the innovative interest and professional level of the industrial personnel (especially young R&D personnel and students), and ensure that relevant technology research and development was carried out on the right track for a long time to come, CR 2019 was keen in organizing a number of welfare events, such as the Refrigeration Industry Observation Group Technical Seminar, HVAC High-end Users Observation Group Environmental Control Technology for Underground Railway Salon, the 13th China Refrigeration and Air-conditioning Industry College Students Science and Technology Contest Launch Ceremony and Press Conference, the "The Fifth Anniversary of 2018 China Refrigeration Industry Development Report Special Edition Press Conference, the Launch of the White Paper on China Refrigeration and Air-Conditioning Industry Development in 2018, the

Technical Seminar of National Chief Engineer Delegation, the Chinese Association of Refrigeration Light Commercial Refrigeration Industry Coordinated Innovation Center Work Conference, the Data Center Cooling Forum - and the 2018 China Data Center Cooling Technology Annual Development Research Report Press Conference, the Global Sustainable Cooling Demand Report Press Conference, the CAR-ASHRARE Student Design Competition Award Ceremony and the 10th Anniversary Celebration Event.

Figure 1.2-1 Launch Ceremony of the 13th Science and Technology Contest for College Students of China R&AC Industry

Figure 1.2-2 Data Center Cooling Forum

3. Practicing green commitments, consolidating brand image of a boutique exhibition

The exhibition invited exhibitors to participate in special report presentation to showcase their business demeanor. The on-site press center cooperated with a host of public and professional media at home and abroad to follow the whole report. WeChat platform and CR official website provided premium service to exhibitors by covering the latest news, promoting exhibitors, their products and corporate culture. In addition, the organizing committee used the database management system for booth arrangement and audience classification and other precise management purposes in view of the fact that viewers now more often than not tend to use online pre-registration system to register for an event. The exhibition management system allowed exhibitors to easily learn about the information about audience, product areas they cared about by

using the mobile APP. In particular, the organizing committee launched an On-line Booth Application System this year, enabling a complete paperless registration process. Besides, the exhibition strengthened on-site noise control, practiced the idea of “green exhibition” with practical actions.

4. Hold dear open cooperation, gather global resources, and seek industry strategy

CR has been keen on the concept of “open cooperation” to attract domestic and overseas industry organizations, exhibitors, media and other advantageous resources to participate in the event built as an international and diversified comprehensive communication platform. The world's leading brands gathered at this year's CR. A total of 1,175 exhibitors from 33 countries and regions, including three international pavilion groups from Europe, the United States and South Korea showed up. The 8th Ozone Climate Technology Roadshow and Roundtable jointly held by UN Environment Programme (UNEP), United Nations Development Programme (UNDP), Foreign Economic Cooperation Office (FECO) of the Ministry of Ecology and Environmentof China and the China Refrigeration and Air-conditioning Industry Association (CRAA), opened a global gala of protecting the ozone layer and mitigating global warming. American Society of Heating and Air-Conditioning Engineers (ASHAE), Europe’s Industry Association for Indoor Climate, Process Cooling, and Food Cold Chain Technologies (EUROVENT), European Partnership for Energy and the Environment (EPEE), Ministry of Environment and Food of Denmark (MEFD) co-organized a host of seminars with the organizing committee respectively.

5. Keeping up with the pace of the times, promoting innovation and development

The 19th CPC National Congress report pointed out: "The main contradiction in our society has turned into a contradiction between the people's growing need for a better life and the uneven development." CR 2019 highlighted integration and innovation of air-conditioning products and served the “Made in China” national strategy. It was an inevitable measure to realize the transformation from a large refrigeration country to a strong country. In the refrigeration and air-conditioning industry, people's demand for indoor environment control is increasing, and the requirements for refrigeration and air-conditioning products’ energy-saving and environmental protection performance are increasing. At this exhibition, many new air-conditioning products and technical reports are rooted in innovation, aiming to improve energy efficiency and comfort, providing users with comfortable and healthy indoor environment with low energy consumption. For example, the "quasi-level two-stage compression cycle" (commonly known as "enhanced vapor

injection" in the industry), "magnetic suspension" technology are widely promoted; the air-source heat pump hot air blower indoor machine, the end products such as indoor units that meet the special needs of bedroom, kitchen, bathroom and other space are emerging; new technologies such as fresh air purification system and air purifiers that focus on indoor health continue to develop.

(III) Highlights

1. Grasp the pulse of the times, highlight the theme of the exhibition

The CR 2019 Organizing Committee entitled the CR 2019 **"Cooperation & Innovation for Development,"** and planned it with theme forum, symposiums and technical seminars.

To fully reflect the theme of **"Cooperation & Innovation for Development**," the theme forum analyzed important issues such as China and the global economic situation, important ways to achieve low-carbon energy --DC building and distributed storage, the "craftsmanship" that needs to be urgently carried on in the refrigeration and air-conditioning industry, digitalization and "Industry 4.0." The seminars, which were meant to provide important reference for the industry, discussed current hot issues such as "coal to electricity" technology, refrigeration and air-conditioning systems' construction, operation, maintenance and management, as well as thermal management of new energy vehicles. The Chief Engineer Forum, the Refrigeration and Air-Conditioning Young Designers Summit Forum held by domestic and foreign industry associations and enterprises respectively provided an important platform for technical communication and personnel training.

The exhibits displayed at this exhibition were closely integrated with the development of social trends. The new systems and new products developed have been integrated with the concept of energy saving, environmental protection and innovative development. The whole exhibition centered on how to achieve a multi-party mutual benefit and win-win development model under the new situation. It fully demonstrated the strong support of the refrigeration and air-conditioning industry for the national development strategy and the long-term vision of promoting development of the industry. The theme of "cooperation" and "development" were fully embodied.

2. Inclusive and open cooperation, global hotspots focused

CR has always held dear the concept of "open cooperation." In 2019, many international organizations, such as EPEE, the Association of European Refrigeration Component Manufacturers

(ASERCOM) and the Indian Society of Heating, Refrigerating and Air Conditioning Engineers (ISHRAE), continued to organize joint seminars with the organizing committee. The Ozone Climate Technology Roadshow and the Industrial Roundtable jointly organized by UNEP, FECO of the Ministry of Ecology and Environmentof China, and the well-known international organizations such as ASHRAE also appeared at the Refrigeration Exhibition. The world's leading brands gathered for this year's refrigeration exhibition. National and regional pavilions of the United States, Europe, Brazil and India continue to make their appearance.

3. Keeping up with the hot spots of the times, leading development with innovation

President Xi Jinping pointed out that science and technology are the primary productive forces, and innovation is the first driving force for development. This refrigeration exhibition is closely linked to the hot spots of the times, fully demonstrating the value of innovation in the refrigeration and air conditioning industry and the development of the times. With the deepening of clean heating in the north, the scope of application of compressors with low ambient temperature has been further expanded. The replacement of refrigerants has been put on the agenda, and the development of new environmentally friendly refrigerants has seen with continued efforts; the arrival of the industrial 4.0 era, the traditional air conditioning heat pump devices have boarded The Internet of Things and the "Internet +" express train; the approaching of the Beijing Winter Olympics, the rapid development of ice chain technology for ice making and snow making. This refrigeration exhibition takes the people's living needs as the background, closely follows the hotspots of the times, and fully combines technological innovation, leading the development of the refrigeration and air-conditioning industry.

II. Technical Progress

(I) Refrigerant Compressor, Working Substances and Lubricant

(Professor Ma Guoyuan, Xu Shuxue with a PhD degree, Beijing University of Technology)

1.1 Technical characteristics

Mainstream refrigeration and heat pump compressors are exhibited in this year's exhibition. In terms of applications, the types of compressors include compressors for household air conditioner and commercial air conditioner, large compressors for water chilling unit, compressors for freezing and refrigeration, etc.; In terms of type, include piston compressor, rotary piston compressor, scroll compressor, screw compressor and centrifugal compressor; In terms of capacity, rotary piston compressors with the refrigerating capacity of dozens of watt and centrifugal compressors with the refrigerating capacity of thousands of kilowatt were exhibited.

The outstanding characteristics of the refrigeration heat pump compressor are:

1) Type diversification of refrigeration heat pump compressor. Compressors for "coal to electricity" heat pump units and heat-pump water heater have many exhibits and models. In addition to traditional enhanced air-supply scroll compressor, rotary piston compressor and screw compressor as well as single two-stage rotary piston compressor and screw compressor, the capability of all models is keeping expanding. For example, the capacity of rotary piston compressor has been expanded to 5 HP - 8 HP, and the capacity of scroll compressor has been expanded to 50HP.

2) Rapid development of low-GWP working substance compressors. Especially lot of compressors using CO_2, R32, NH_3 and other environmentally friendly working substances were exhibited. The application places include household refrigeration air conditioner and commercial air conditioner, also including automotive air conditioner, freezing, refrigeration, etc..

3) Rapid development of maglev centrifugal compressors. The maglev centrifugal compressors and units in this exhibition have many types, and the performance level has been improved than that in previous years and the capacity range has been expanded.

4) The types of compressor for automotive air conditioner are increased. Automotive air conditioner compressors in this exhibition include heating and refrigeration air conditioner compressors for small cars and motor homes, horizontal and vertical compressors for freezing and refrigerator cars. In addition to traditional working substances, such as R410A and R134a, there were many compressors using R407C and CO_2.

1.2 Characteristic technical products

1.2.1 Large, medium and small heat pump compressor

Special heat pump compressor is still the hot product of the exhibition. Compared with previous exhibitions, the products have more types and wider capacity range. For example, Fusheng launched single two-stage low-environment temperature heat pump screw compressor, as shown in Figure 2.1-1 (a), which uses R134a with the evaporating temperature of -20℃-15℃ and condensing temperature of 40℃-85℃ and is suitable for "coal to electricity", with significant energy-saving effect; Hanbell launched the LT-S-A series single two-stage ultra-low environment temperature heat pump compressor which can operate at -30℃, as shown un Figure 2.1-1 (b), with the starting load equivalent to that of single-stage startup. It can directly read the motor temperature, so as to control and protect the motor; At the same time, Hanbell launched the RC2-T series ultra-high temperature heat pump compressor with the 120℃ outlet, as shown in Figure 2.1-1 (c). It is used for high grade waste heat recovery, with the highest waste heat recovery temperature up to 80℃. It has the most suitable high-efficiency motor designed according to the operating condition of high-temperature working substances, and a new bearing designed based on the ultimate operating conditions.

With respect to small heat pump compressor, a large number of new products have been developed for a wider temperature range. For example, GMCC R410A compressor with air supply port and environmentally friendly working substance - R290 compressor solve the problem of low-temperature performance degradation of traditional air conditioners, and expand the application area of air conditioning heating, as shown in Figure 2.1-1 (d); Copeland R290 special compressor for heat pump and hot water YHV0461U-9X9-ABK with rated capacity of 4HP, as shown in Figure 2.1-1 (e), achieves the heating capacity of 3.4-15.7kW by adopting the inverter technology, and is applicable to the heat pump heating or hot water application, especially to working conditions with low environment temperature and high pressure ratio; In addition, without the air supply function, this product of Copeland has simpler and more reliable system and control.

(a)Fusheng large screw heat pump compressor

(b)Hanbell single two-stage ultra-low environment temperature compressor

(c)Hanbell 120℃ ultra-high outlet temperature heat pump compressor

(d)GMCC special heat pump compressor

(e)Copeland R290 special compressor for heat pump and hot water

Figure 2.1-1 Heat Pump Compressor

1.2.2 Variable volume multi-cylinder compressor

GMCC launched inverter and variable volume air supply air-condition compressor with all-purpose coupling, as shown in Figure 2.1-2 (a). Using R32 as the working substance, achieve the refrigerating capacity of 7,967W and COP of 3.58 under the normal condition. GMCC G2 air condition compressor with independent compression also uses R32 as the working substance, with two pairs of independent suction port and exhaust port, with COP of 4.511, as shown in Figure 2.1-2 (b).

(a)GMCC inverter and variable volume air supply compressor

(b)GMCC G2 air condition compressor with independent compression

Figure 2.1- 1 GMCC Multi-cylinder Inverter Compressor

1.2.3 Refrigeration and Freezing Horizontal Compressor

For the field of freezing and refrigeration, a horizontal compressor with intermediate spray structure developed by Gree can reduce the exhaust temperature to the greatest extent. At the same time, differential pressure oil supply is adopted to solve the problems of the lubrication system of oil supply. The compressor can operate at the evaporating temperature of -45℃, as shown in Figure 2.1-3 (a). Copeland launched R407C horizontal scroll inverter compressor for transport, with the overall height lower than 200mm, operating range of 25-100Hz, evaporating temperature of -30℃, condensing temperature of 65℃, as shown in Figure 2.1-3 (b).

(a)Gree refrigeration and freezing horizontal compressor

(b)Copeland R407C horizontal scroll compressor for transport

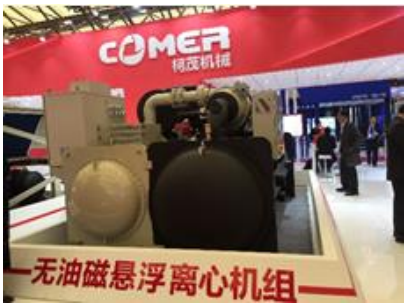
Figure 2.1- 2 Refrigeration and Freezing Horizontal Compressor

1.2.4 Maglev compressor

More maglev compressors were exhibited than previous years, which is another characteristic of the refrigeration exhibition.

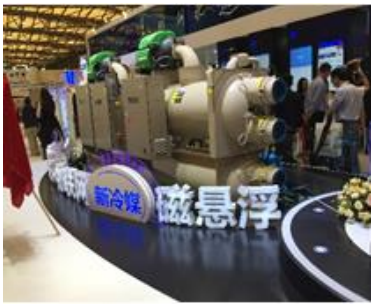
In addition to Gree and other well-known domestic brand enterprises, major manufacturers also include Danfoss, McQuay (Figure 2.1-4(d)), LG (Figure 2.1-4(e)) and other foreign-funded enterprises, and even private enterprises such as Comer also have exhibited maglev products, as

shown in Figure 2.1-4(a). The technology of large maglev compressor is becoming mature, with the product performance more excellent. For example, Gree maglev compressor unit, as shown in Figure 2.1-4(b), with the maximum capacity of 1,300RT, full-load COP of 7.19, IPLV of 12.06, far higher than national Grade I energy efficiency Haier developed maglev water chilling unit with maglev compressor, as shown in 2.1-4(c), which uses new refrigerant R1234ze.



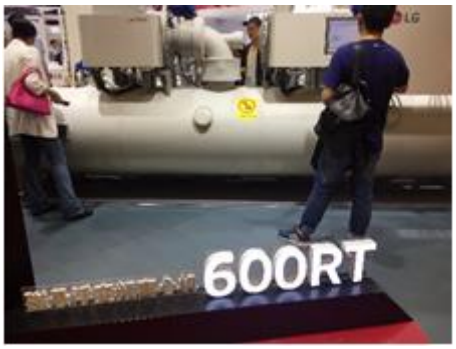
(a)Comer maglev compressor

(b)Gree maglev compressor



(c)Haier R1234ze maglev compressor

(d)McQuay maglev compressor



(e)LG maglev compressor

Figure 2.1- 3 Maglev compressor

1.2.5 Automotive air conditioner compressors

The number of automotive air conditioner compressors in the exhibition was significantly higher than that of last year.

GMCC launched 24V horizontal parking air-conditioning compressor, as shown in Figure 2.1-5 (a), uses R134a as the working substance, with the power of 628W and energy efficiency ratio of 3.25; The horizontal compressor for air conditioning of motor homes of GMCC, as shown in Figure 2.1-5 (b), uses R410A as the working substance, with the refrigerating capacity of 3,900W

and energy efficiency ratio of 3. Zhejiang Boyang Compressor Co., Ltd. lunched double-rotor compressor for electrombiles, as shown in Figure 2.1-5 (c), with the efficiency improved by 30% than similar types; Juneng Group also lunched different types of compressors for electrombiles, as shown in Figure 2.1-5 (d).

(a)GMCC 24V horizontal parking air-conditioning compressor

(b)GMCC horizontal compressor for air conditioning of motor homes

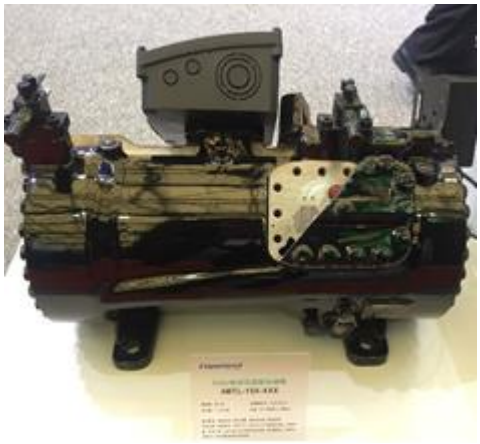
(c)Compressors for electrombiles of Zhejiang Boyang

(d)Compressors for electrombiles of Juneng

Figure 2.1- 4 Electric Automobile Air-Condition Compressor

1.2.6 CO_2 compressor

CO_2 compressors are more diverse. GMCC (Figure 2.1-6 (c)), Copeland and Hanbell have launched CO_2 compressors; Copeland CO_2 compressors are in horizontal and vertical, as shown in Figures 2.1-6 (a) and 2.1-6 (b). CO_2 ZO104KCE fully-closed scroll compressor has the operating condition of subcritical 52bar, refrigerating capacity of 22.7kW and exhaust capacity of 11.7m^3/h. It is mainly used in supermarket display cabinets, frozen food processing equipment, low-temperature refrigerator and other low-temperature conditions; Hanbell launched subcritical semi-closed CO_2 screw compressor, as shown in Figure 2.1-6 (d), with the operating temperature of -55℃-15℃ and displacement of 150m^3/h -850m^3/h, comprehensively covering the large and medium freezing and refrigeration requirements.



(a)Copeland CO_2 horizontal semi-closed piston compressor

(b)Copeland CO_2 vertical fully-closed compressor

(c)GMCC CO_2 compressor

(d)Hanbell subcritical semi-closed CO_2 screw compressor

Figure 2.1- 5 CO_2 Horizontal Compressor

1.2.7 Large-capacity scroll compressor

Danfoss produced a 50HP large-capacity scroll compressor by expanding the refrigerating capacity of 40RT machine, as shown in Figure 2.1-7 (a). It adopts unique intermediate exhaust valve technology to improve energy efficiency of part of the load, and oil and gas separation pipe technology to improve energy efficiency and reliability of the system. Copeland launched 40HP large commercial air conditioning scroll compressor using R32 as the working substance, as shown in Figure 2.1-7 (b). It is designed aim at the application optimization of large chilling (hot) water units, adheres to the Copeland double-flexible scroll technology with the efficiency of 3.36 and noise of 89dB.

(a)Danfoss 50 horsepower scroll compressor (b)Copeland R3240HP scroll compressor

Figure 2.1- 6 Large-capacity Scroll Compressor

1.2.8 Other compressors

Other types of compressors include: GMCC micro compressor for special fields, GEA Bock hydrocarbon compressor, SRM open screw compressor for vessels, Italy Dorin semi-closed CO_2 whole series compressors also attracted widespread attention.

The CO_2 double-rotor compressor for freezing, refrigeration and heat pump of Panasonic Appliances Compressor (Dalian) Co., Ltd., Fusheng two-stage refrigerant compressor, Fujian Snowman propane compressor and Wuhan New World's water vapor compressor were awarded as innovative product in this exhibition.

1.2.9 Refrigerating medium and lubricant

Compared with previous years, the category of refrigerating medium increased significantly this year.

In addition to traditional working substances representing by R22, R410A and R134a, a considerable number of alternatives with environmental protection advantages have emerged, particularly alternatives for R22. The quantity of natural working substances representing by R290, R600a and R600 significantly increased than last year, with their packages and specifications, etc. becoming gradually standard and serial.

Figure 2.1-8 shows the Freon M099 (R438A) working substance of Chemours, the alternative of R22.

Figure 2.1- 7 New series of working substances of Chemours

Figure 2.1-9 shows the XP series products of Opteon, including Opteon XP40, Opteon XP44, Opteon XP10 and Opteon XP30, which can be used for replacing R404A, R134a and R123 respectively. Opteon XL41, Opteon XL55, Opteon XL20 and Opteon XL40 in Opteon XL series can be used for replacing R410A and R404A, respectively.

Figure 2.1- 8 XP Series Products of Opteon

Figure 2.1-10 shows the new refrigerant launched by Shandong Dongyue. Dongyue No. 5 refrigerant, DYR-5, is very similar with R417A, and can be directly filled in the R417A system. For replacing R410A, DYR-3 has ODP=0, and still high GWP, up to 1,980.

Figure 2.1- 9 New Refrigerant Developed by Shandong Dongyue

1.3 Evaluation and prospection

As shown in exhibited products, the future development trend of compressors is as foll ows:

1)The domestication process of compressors is accelerating year by year, so more and more manufacturers will enter into the field, followed by increasing product series and mod els as well as sales volume.

2)The full-condition performance and energy efficiency throughout the year of refrigerat ion compressors will be continuously improved. Therefore, various new compressors have be en developed, such as maglev compressor and multi-cylinder variable capacity compressors.

3)New compressor product series will appear in application fields close to national poli cy and strategy, e.g., compressor for new energy automotive air conditioner and low temper ature heat pump compressor suitable for “coal to electricity”.

In terms of refrigerant, the R&D of new environmentally friendly refrigerants is ongoing, especially for the replacement of R22 and R134a. However, at present, the main schemes are mainly based on mixed working substances, whose practicability and promotion prospect need to be further observed.

(II) Chilling (Hot) Water Unit and Refrigeration Fittings for Industrial and Commercial Central Air Conditioning Application

(Associate professors Xu Rongji and Hu Wenju, Beijing University of Civil Engineering and Architecture)

2.1 Technical characteristics

Chilling (hot) water unit for industrial and commercial central air conditioning application is an important part of all previous exhibitions, and is highly valued by the industry as a representative of the technical level of relevant enterprises. In terms of the exhibition scale, the scale of the exhibition of chilling (hot) water unit for industrial and commercial central air conditioning application was basically the same as that of previous years. More than 30 famous brands in this field, such as McQuay, Gree, Haier, Midea, TICA, GRAD, Dunham-Bush and LG, participated in the exhibition and launched high-performance products. A small number of enterprises shows the "odd-even year" participation characteristics (according to the exhibition rules in recent years). In terms of the technical level of exhibited products and the enterprise development direction, industrial and commercial chilling (hot) water unit is used as the most technically integrated refrigeration equipment. In the exhibition, the exhibited units of all enterprises have represented the highest technical level of each manufacturer, shown the direction and concept of development of each manufacturer and reflected the development trend of refrigeration technology demand and application.

In the exhibition, chilling (hot) water unit for industrial and commercial central air conditioning application mainly has the following characteristics: 5G and environmentally friendly working substances have gradually become the driving force of the new round of technology iteration; Explosive growth of maglev unit, continuous enriching of product lines and further expansion of refrigerating capacity range and applicable scenarios; Further expansion of the application temperature range and continuous development of application scenarios of screw unit; Absorption heat pump has become the main technical solution of "large temperature difference" heating. Absorption refrigeration still has new technology breakthrough.

2.2 Characteristic technical products

2.1.1 Maglev centrifugal unit

With the popularization of maglev compressor and the promotion of replacement with environmentally friendly working substances, the exhibition scale of maglev centrifugal unit is

expanding continuously, showing a trend of rapid growth. In this year, it shows an explosive growth. In this year, more than a dozen core manufacturers represented by McQuay, Gree and Haier have exhibited related products, which are the highlight of the exhibition. The maglev centrifugal units exhibited show the characteristics in technical reserves, routes and development directions of various manufacturers. Some manufacturers even have completed the layout of multiple product lines.

(1) Bidirectional capacity expansion and large refrigerating capacity of maglev unit have gradually become the mainstream

Maglev units have been exhibited in the exhibition for more than 10 years, with continuously expanding single-compressor refrigerating capacity. The unit with the largest refrigerating capacity exhibited in 2018 was the maglev unit independently developed by Gree with a refrigerating capacity of 600RT. In this year, Gree exhibited a maglev unit with single-compressor refrigerating capacity of 1,300RT (Figure 2.2-1). The unit uses R134a refrigerant, with the bearing suspension accuracy of 2 to 5 micron. In addition, LG and McQuay have launched single-compressor large-capacity centrifugal water chilling unit with a single-compressor refrigerating capacity of 1,100RT and 800RT respectively. Different with the single-compressor large-capacity technology of above companies, Danfoss takes the multi-compressor parallel technology as the technical route, and with continuous expansion of chilling compressor capacity. In the exhibition, Danfoss exhibited the chilling compressor with the refrigerating capacity of 2,000RT through multi-compressor parallel by adopting the multi-compressor parallel technology, with the support of the technology of single-compressor refrigerating capacity of 450RT. As a representative manufacturer with independent maglev compressor, McQuay exhibited the double-compressor 1,500RT large refrigerating capacity unit after it exhibited R1233ze new refrigerant maglev unit in last year. The unit uses R134a refrigerant, with COP of 6.9 and IPLV of 11.4.

In addition to the characteristic of large refrigerating capacity, the bi-directional expansion of refrigerating capacity of water chilling unit of maglev centrifugal compressors is also a major characteristic of the products exhibited in this exhibition. In this exhibition, the refrigerating capacity of centrifugal compressor covers a wider range of 50-2,000RT. The refrigerating capacity of LG maglev unit can achieve safe, stable, reliable and efficient operation in the working range of 300-1,100RT.

Figure 2.2- 1 Gree Single-compressor Large Refrigerating Capacity Maglev Inverter Centrifugal Water Chilling Unit

McQuay double-compressor 1,500RT large refrigerating capacity unit adopts the power-supply IPS technology, which can achieve the emergency outage protection of the compressor, with unique technical advantages. In case of the sudden outage of the power system, maglev compressor will continue to rotate at high speed due to inertia. And then the motor will enter into the braking power generation state to convert mechanical kinetic energy into electrical energy and feed it back to the frequency converter. Therefore, the frequency converter supplies IPS, which will continue to supply DC power to the magnetic bearing. Motor decelerates to the normal range. Auxiliary ball bearing ensures that the motor continues to operate safely and gives support, until the unit stops smoothly, to avoid damage of the electromagnetic bearing.

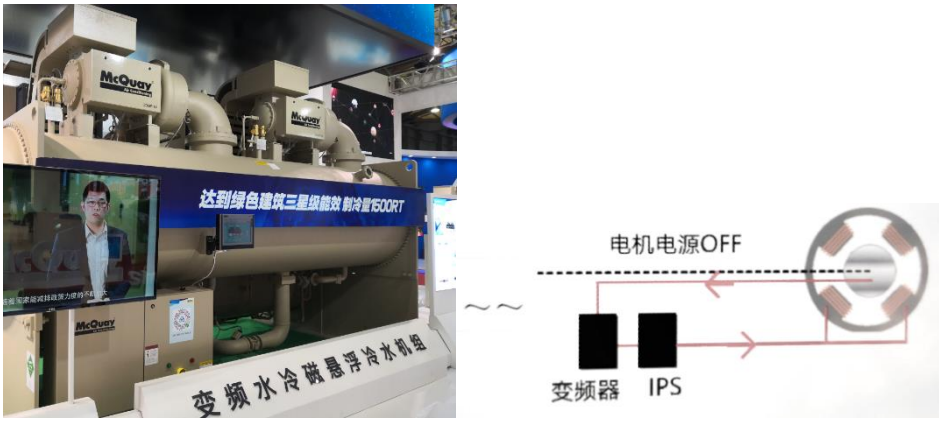


Figure 2.2-2 McQuay water chilling unit of maglev centrifugal compressors and outage IPS protection principle

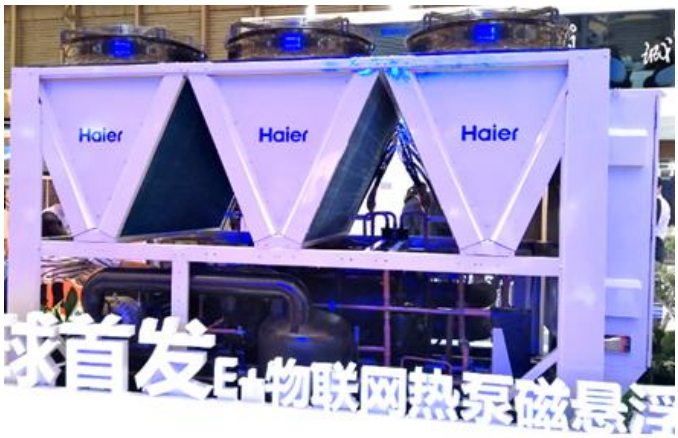
(2) The product line of maglev cooling units is gradually enriched. All enterprise are planning for product layout

In this exhibition, in addition to water chilling unit, each manufacturer exhibited a series of

new products, such as maglev heat pump unit, evaporation cooling unit and direct cooling air handling unit, which further states that the maglev technology is mature and all enterprises have completed the layout of different product lines.

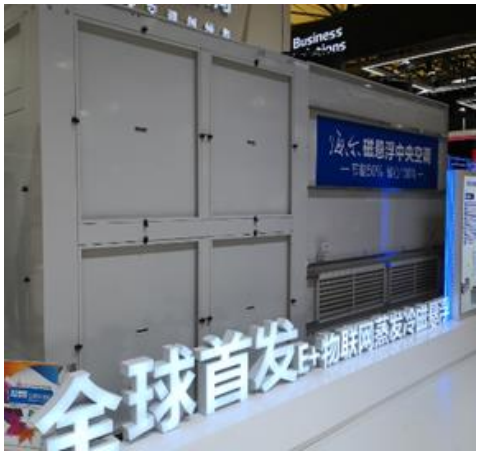
In this exhibition, BSE and Haier exhibited a maglev heat pump unit, which is a new breakthrough and application of the maglev technology in the air conditioning refrigeration field (Figure 2.2-3). TICA (SMARDT) exhibited maglev air-cooled chiller unit. The unit adopts the design of clamshell heat exchanger, which is convenient for cleaning and maintenance of the heat exchanger; Its evaporation cooling unit integrates solar photovoltaic power generation, supported by fan power; It also exhibited the full DC maglev unit which can be powered by photovoltaic cells and can be arranged in full DC building. In addition, Gree and Haier exhibited direct cooling air conditioning unit, which is a new attempt of the centrifugal refrigeration technology.

(a)BSE heat pump unit

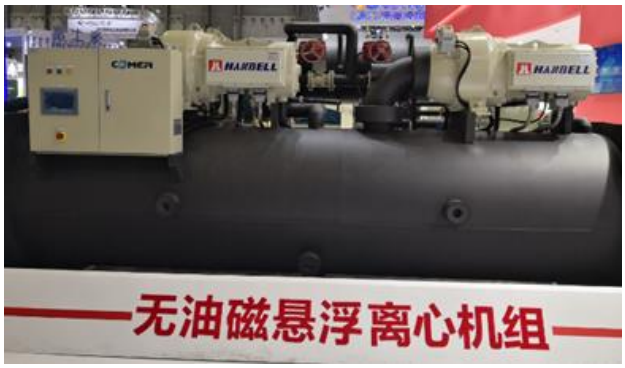


(b)Haier IoT air-cooled heat pump unit

(c)Gree direct cooling air conditioning unit



(d)Haier evaporation cooling unit



(e)TICA air-cooled maglev unit (f)Comer maglev unit

Figure 2.2- 3 Different Maglev Centrifugal Compressor Units

(3) 5G IoT cloud platform service has become the competitive position of all refrigerator enterprises

With the development of 5G technology of IoT, its prospect becomes broader. 5G network has the characteristics of high bandwidth and low delay, etc., and can rapidly transmit the energy consumption data, maintenance reminder and other information of the unit to E+ cloud service platform for high-speed cloud computing, and output the operation report and maintenance plan of the equipment quickly, so as to realize the automatic control of the equipment more accurately and quickly. Based on 5G IoT, the speed and quantity of data transmission have been greatly improved. With the carrier of chilling (hot) water unit, enterprises can provide services for users with more possibilities. In addition to competition in unit performance, refrigerator manufacturers fully utilize 5G IoT technology to strengthen their advantages in service. Therefore, 5G has increasingly become the development target of various manufacturers. Haier, Gree, Midea and other companies have set up their cloud service platforms to serve their water chilling unit and multi-split unit system. Haier, in particular, has been deeply engaging in maglev water chilling unit system and exhibited IoT maglev water chilling unit (Figure 2.2-4) using R1233ze environmentally friendly refrigerant. In addition to the highlight of adopting R1233ze environmentally friendly refrigerant, this unit also strengthens its IoT “cloud control system”. Haier is the typical representative of enterprises with early layout of 5G IoT “cloud control system”.

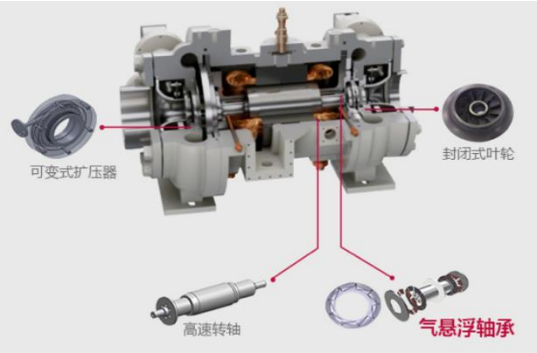
Figure 2.2- 4 IoT New Refrigerant Maglev Centrifugal Water Chilling Unit Exhibited by Haier

2.1.2 Gas bearing centrifugal unit

Gas bearing centrifugal compressor is another technical direction for "oil-free" lubricated bearings. Compared with maglev technology, it does not require complex sensor and control system. It is cheaper and easier to maintain, and is suitable for small refrigerating capacity units. In the previous exhibitions, mainly Midea and LG exhibited gas bearing centrifugal water chilling units. In the exhibition of this year, the exhibition scale of gas bearing centrifugal water chilling unit was increased, and many enterprises launched products, such as Dunham-Bush, LG and Nasen (Figure 2.2-5). Among them, Dunham-Bush exhibited gas bearing centrifugal water chilling unit using R134a refrigerant, with a refrigerating capacity of 300RT, a COP of 6.3 and an IPLV of 12.2. LG exhibited a gas bearing compressor with the refrigerating capacity of 150RT. Its gas bearing uses centrifugal diffusion principle to support axis rotation. Nasen exhibited a gas bearing centrifugal compressor unit with the refrigerating capacity of 175kW, and refrigerating capacity range of 50 to 250RT.

(a)Dunham-Bush gas bearing centrifugal unit

(b)Nasen gas bearing centrifugal unit



(c)Schematic Diagram of LG Gas Bearing

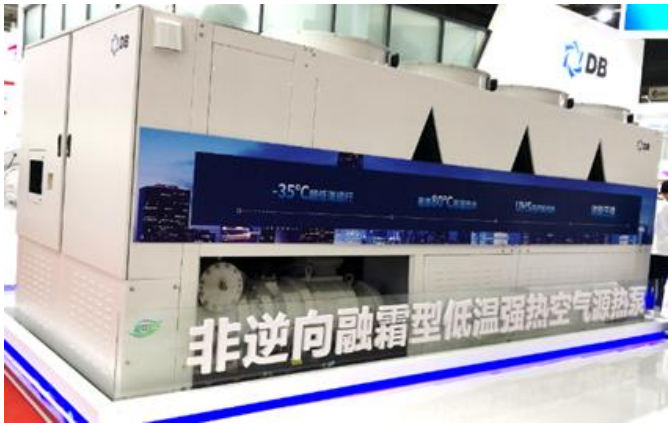
Figure 2.2-5 Different Gas Bearing Centrifugal Compressor Units

2.1.3 Screw chilling (hot) water units

The exhibition scale of screw unit is not much different from last year. Its technical advantage of single-compressor high pressure ratio is further highlighted. The temperature range and scenarios of application are also continuously expanded.

(1)Single two-stage ultra-low temperature air source heat pump meets the requirements of the heat market in Northern China

With the constantly advance of clean heating in Northern China, the heat pump technology adapted to the cold and frigid regions in Northern China has achieved continuous progress. In this field, the technical characteristics and advantages of screw compressor are fully reflected. The corresponding screw air source heat pump unit, especially the ultra-low temperature air source heat pump unit has become an important technical development direction. Dunham-Bush exhibited a single two-stage screw air source heat pump unit which can achieve the ultra-low temperature operation at -35℃, with the maximum outlet temperature of 80℃. It is especially suitable for the cold region in Northern China or places where the traditional air source heat pump unit is restricted by the environment temperature (Figure 2.2-6). In the defrosting condition, the four outdoor air-cooled heat exchangers defrost the condenser in turn, realizing “non-reverse defrosting”. GRAD exhibited a -35℃ single two-stage air-cooled screw unit, with the maximum outlet water temperature of 85℃. The unit adopts a new defrosting mechanism, sets defrosting parameters in different sections, and judges the conditions of entering and exiting defrosting conditions through pressure, so as to achieve “defrosting when there is frost, no defrosting when there is no frost”.



(a)Dunham-Bush low-temperature screw unit

(b)Comer low-temperature screw unit

Figure 2.2-6 Low-temperature Air Source Screw Unit

(2) Continuous broadening of application areas

In addition to meet the refrigeration demand of traditional air conditioners, the development of screw units has begun to be diversified to adapt to the technical requirements in different areas. In this exhibition, Yantai Moon exhibited GHWS-HFO high-temperature water vapor machine (Figure 2.2-7). It recovers condensation waste heat to generate the high-temperature vapor of 128℃. It uses R1336mzz(Z) (ODP=0, GWP=9), a kind of environmentally friendly new working substance; Based on the ORC unit in last year, Wuhai New World exhibited a water vapor screw expansion unit, which directly utilizes water vapor steam exhaust to drive the screw expansion machine to generate power. The unit requires the steam exhaust temperature of 215℃, pressure of 2.03MPa, unit differential pressure of 1.2MPa and generating capacity of 160kW; Dalian Refrigeration Co., Ltd. exhibited a screw ethylene glycol unit especially for petrifaction. It is mainly used in petroleum and chemical engineering fields. Its rotor adopts N-type line, high efficiency oil separator. It uses R134a refrigerant, with the evaporation temperature of -20 - -5℃, and the condensing temperature less than 43℃; TICA exhibited an integrated evaporative cooling screw water chilling unit with integrated main unit, cooling tower and water treatment unit, with continuous falling film of the evaporative condenser, high heat exchange efficiency. It uses R134a refrigerant and adopts flooded evaporator.

(a)Moon high-temperature water vapor unit

(b)Wuhan New World direct water vapor expansion unit

Figure 2.2-7 New Application Scenarios of Screw Unit

2.1.4 Absorption unit

The number of absorption refrigerating unit exhibited in this exhibition was less. Panasonic exhibited absorption water chilling unit (Figure 2.2-8). The unit adopts double-stage evaporation and double-stage absorption technology. The supply and return water temperature at the hot water side can achieve a 40°C temperature difference (95-55°C). The heat recovery rate is twice of traditional unit. The warm water flow is reduced by 38%; the transmission power consumption is reduced; the COP of single-effect unit reaches 0.6-0.7; the refrigerating capacity is 33RT. Shuangliang exhibited its system solution for energy saving of absorption units.

Figure 2.2-8 Panasonic "Large Temperature Difference" Single-effect Absorption Water Chilling Unit

2.1.5 Accessories for central air-conditioning chilling (hot) water system

In recent years, the exhibition scale of accessories for central air conditioning chilling (hot) water system is constantly expanding. And the technology is also constantly accumulated and advanced. In terms of valve parts, Sanhua exhibited the electric water valve for FMF fan coil (Figure 2.2-9). By adopting ultrasonic welding technology, engineering plastic shell is used to install the drive motor, gear, recovery spring and torque transmission parts in the actuator, solving the problem of waterproof and easy corrosion of internal components. The closing and sealing

structure of the valve body adopts self-centering spherical structure, which improves the product consistency.

Figure 2.2- 9 Sanhua Electric Water Valve

In terms of pipe fittings, non-welding joints have developed rapidly. In recent years, Bida and Ningbo Shixin have exhibited clamp hoses and joints in China, which are mainly used to replace the copper pipe of pressure measurement pipe, with more flexible and convenient connection (Figure 2.2-10). According to the needs, the joints can be made of stainless steel, copper, aluminum and other materials. Lokring pipe connection technology is also constantly developed, which uses cold extrusion plastic deformation to achieve a close link between aluminum and aluminum, aluminum and copper, copper and copper, copper and steel, copper and titanium, specifically for connection of non-ferrous metal pipes with small diameter. The designed maximum nominal pressure is 7MPa. It is represented by the German VULKAN LOKRING. It is suitable for different occasions, can completely replace welding, but requires special connection equipment, and the connection parts are expensive. In addition, South Korea ESSEN exhibited fast plug-in copper pipe joints, which are more convenient to plug and connect. However, its products are not sold in China.

(a)High-pressure hose and joints

(b)Lokring pipe connection

(c)Direct plug-in pipe connection

Figure 2.2-10 Welding-free pipe fittings

2.3 Evaluation and prospection

As the representative of the advanced technology level in the industry, the maglev centrifugal water chilling unit is still the key recommending object of all manufacturers as advanced product in this exhibition. It shows a bidirectional capacity expansion. The large refrigerating capacity has gradually become the mainstream. The product shows the diversified development trend. Larger companies have taken the lead in completing initial upgrade and layout of related products. With the help of 5G IoT technology, each enterprise is converting from emphasizing the COP and IPLV of the technology to highlighting service and remote control to improve safety, reliability and high efficiency; The exhibition scale of screw unit is basically equal. However, in order to meet the new application scenarios such as clean heating in the Northern China, the products gradually emphasize the technical characteristics and differentiation, which means that its related refrigeration technology is developing in a deeper and more refined direction; Although the exhibition quantity was small, absorption refrigerating unit highlighted heat recovery and system energy-saving; In terms of pipe fittings, the quick-installed non-welded joint parts have developed rapidly. Products present a diversified development trend.

(III) Medium and small air conditioning equipment and systems

(Zhang Penglei with a PhD degree and Postgraduate Yang Xiaorui, Nanjing University of Aeronautics and Astronautics;

Associate Professor Wang Baolong, PhD Candidate Xiao Hansong and Postgraduate Yang Xufei, Tsinghua University)

3.1 Technical characteristics

With respect to medium and small air conditioning equipment and systems, many famous enterprises at home and abroad attended this exhibition. The exhibition reflects the development trend of comfort, health, market segmentation and intelligence of small and medium-sized air-conditioners.

Driven by the policy of "using electricity when applicable" and "using gas when applicable", the clean heating market in Northern China is continuously to be hot. In this exhibition, among medium and small air conditioning equipment and systems exhibited, the air source heat pump hot-air blower is the focus of all manufacturers. GHP gas heat pump is poised; As the main force of the central air conditioning market, multi-split units show characteristics of intelligence and multi-function. And main manufacturers have exhibited household multi-split unit products; In addition to household multi-split units, the household central air-conditioning with integrated heating and cooling through floor radiation is also the competition object of various manufacturers in the exhibition; Household air conditioners that are used for cooling in summer and heating in winter are continuously to be developed in a comfortable, healthy, and intelligent manner.

3.2 Characteristic technical products

3.2.1 Clean heating equipment

In accordance with *Winter Clean Heating Plan for Northern China (2017-2021)* published by National Development and Reform Commission (NDRC), By 2021, clean heating will be extended to 15 provinces (autonomous regions and municipalities directly under the central government) in Northern China, and the area of electric heating (mainly heat pumps) in Northern China will reach 1.5 billion square meters. Benefiting from the further promotion of "coal to electricity" policy, the clean heating market in Northern China continues to be popular. Various manufacturers have

launched a series of (mainly air source heat pump) heat pump heating equipment and systems.

The main technical obstacles to develop air source heat pump in Northern China are the heating capacity under low temperature and rapid degradation of COP. Therefore, the key technology is how to improve its low-temperature heating performance. From the exhibition, the adoption of “enhanced vapor injection” and “DC frequency-conversion” scheme has become the industry consensus. Air injection can increase the equivalent inspiratory capacity of the compressor and reduce the throttling and overheating loss of the system, to achieve the improvement of the heating capacity and efficiency. It obviously improves the adaptability of wide variable working conditions. In this exhibition, many enterprises launched low-temperature air source heat pump units suitable for heating in winter in Northern China, including: Gree, Midea, TICA, Nasen, AUX, as shown in Figure 2.3-1.

(a)Gree (b)Midea roaring flame (c)AUX (d)Nasen

Figure 2.3- 1 Examples of Low-temperature Air Source Heat Pumps Exhibits

In this exhibition, a large number of low-temperature air source heat pump hot-air blowers were exhibited, becoming one of the hot spots of equipment exhibited. Most of the enterprises involved in small and medium-sized air conditioners exhibited heat pump hot-air blowers, such as Gree, Midea, Haier, TICA, Nasen, Deye and Power World, as shown in Figure 2.3-2. The exhibited hot-air blowers products generally adopt floor-type or low hanging indoor end, with multiple composite mode of “one indoor unit + one outdoor unit” and “multiple indoor units + one outdoor unit”, which can achieve two air supply modes of upper outlet and lower outlet. Lower outlet for heating and upper outlet for cooling can guarantee suitable indoor temperature distribution, and provide better indoor comfort. Compared with the air source heat pump hot water unit, the heat pump hot-air blower has the advantages of compact structure, fast heating, no freezing risk, high reliability and easy maintenance, which has been widely recognized and quickly promoted in the market. However, it is worth noting that, as a new product, the current low-temperature air source heat pump hot-air blowers are still lack of specifications for restraint and the products are spotty. It

is reported that *Low Ambient Temperature Air Source Heat Pump Hot-Air Blower* (JB/T 13573-2018) has been implemented since May 1, 2019. It will promote the standardization and healthy development of air source heat pump hot-air blower market.

(a)Gree (b)Haier (c)Nasen (d)Deye (e)Power World

Figure 2.3-2 Examples of Low-temperature Air Source Heat Pump Hot-Air Blower Exhibits

Considering the snow protection in winter of air source heat pumps in cold areas in Northern China, some enterprises have launched snow-proof centrifugal outdoor unit, as shown in Figure 2.3-3. Different from the ordinary outdoor unit with axial flow fan, this outdoor unit uses centrifugal fan, which can avoid the reduced evaporation temperature of the heat pump due to blocking of outdoor unit by snow in winter.

Figure 2.3-3 Centrifugal Fan Outdoor Unit

3.2.2 Multi-split unit technology

At present, with the declined growth rate of household decoration retail market, the sales volume of multi-split units, as a kind of central air conditioner with the highest proportion, has weakened. However, all major manufacturers are deeply engaging in technology, constantly adjusting their development direction, strengthening product competitiveness, and focusing on the development of intelligence, high efficiency and multi-function, and have launched new products

that meet the development trend of the market.

In the direction of pursuing intelligence, enterprises are committed to introducing big data technology and IoT technology into the multi-split unit system. Based on big data platforms, such as environmental parameters and behavior habits, multi-split unit can achieve self-learning, adjustment and optimization in the working process. The development of the "low power consumption in standby, self-adaptive location and self-diagnosis of the unit" function is the general intelligent development trend of multi-split unit instantly. For example, data communication is achieved between Gree GMV6 AI multi-split unit and the National Meteorological Administration, so that the unit can make automatic adjustment according to the weather forecast parameters. The unit has the fault prediction technology of principal component analysis + Map technology, and can a realize compressor fault diagnosis and early warning through the Map analysis of a large number of operating parameters of air condition compressors; The "E+ IoT" cloud service platform exhibited by Haier can monitor the installation location and operation status of accumulative 500,000 central air conditioners sold through combining big data technology and IoT technology, so as to provide enterprises with more comprehensive service data and provide users with more guaranteed services, as shown in Figure 2.3-4.

(a)Gree GMV6 AI multi-split unit (b)Haier E+ IoT platform

Figure 2.3-4 Examples of Intelligent Multi-Split Unit Exhibits

In the pursuit of efficiency, in order to improve the energy efficiency of air source heat pump at low environment temperature, compressors with enhanced vapor injection technology have been widely used in multi-split unit system in recent years. It adopts (quasi) two-stage compressor, which achieves the secondary suction of compressor through the intermediate pressure air supply port, so as to increase the air displacement of the compressor, increase the effective circulation volume of system refrigerant, increase heating capacity and guarantee that the unit can efficiently operate under -20℃.

(a)AUX enhanced vapor injection multi-split unit

(b)TICA enhanced vapor injection multi-split unit

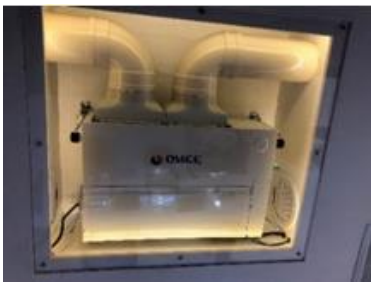
Figure 2.3-5 Example of Quasi Two-Stage Compression Multi-Split Unit

In recent years, multi-split unit has been gradually promoted in residential buildings. The household multi-split unit market, which pursues health, comfort and convenience, is in the ascendant. The market segmentation is getting deeper and deeper. For the humidifying multi-split unit exhibited by TICA, the outlet air temperature in winter of the indoor unit is up to 40℃. It has the humidifying capacity of 800g per hour, with the humidifying ability being 2.5 times of that at 20℃. It can maintain the indoor temperature at 40%-60%.

In addition, the high comfort of the radiant floor heating of water system has been increasingly valued by many multi-split unit manufacturers, and many manufacturers have successively introduced water-fluorine composite floor heating multi-split unit.

Aiming at specific needs of different rooms, household multi-split units with different structures of indoor units can enhance the comfort of users. Therefore, many segmented indoor unit products are developed. Aiming at heavy fume in kitchens, Midea, Gree and other enterprises put forward the dedicated indoor unit for kitchen, which adopts the unique outlet design and increases the efficient filtering structure, providing a clean and comfortable environment for the kitchen; Aiming at the characteristics of high requirements for comfort of bedrooms, Gree put forward an indoor unit with distributed air supply technology to optimize air distribution, reduce the blowing feeling and improve the comfort; Aiming at circumstances with dehumidification requirements, such as locker rooms and bathrooms, indoor unit with constant temperature and dehumidification function can ensure the constant indoor temperature while achieving dehumidification. The bathroom can also be used as drying room, as shown in Figure 2.3-6.

(a)Midea dedicated indoor unit for kitchen



(b)Gree dedicated indoor unit for kitchen

(c)Gree dedicated indoor unit for bedroom

(d)Gree dedicated indoor unit for locker rooms (e)Gree dedicated indoor unit for bathroom

Figure 2.3-6 Example of Multifunctional Terminal of Multi-Split Unit

In addition, LG LGMULTI V WATER IV water-cooling multi-split unit, which uses water or soil as cold and heat sources. It has better performance and more compact product structure, and is conducive to indirect utilization of natural energy, as shown in Figure 2.3-7.

Figure 2.3-7 Schematic Diagram of LG Water Source Multi-Split Unit

3.2.3 GHP gas heat pump air conditioning

The “coal to clean energy” policy in China also promotes the development of gas heat pump air conditioning. GHP gas heat pump adopts natural gas (a kind of clean fuel) as energy source, and adopts gas engine to drive the compressor operation for cooling and heating, and recovers high temperature waste heat of the engine for heating. The technology has many advantages such as no obvious attenuation of heating capacity of low-temperature working condition, no shutdown during defrosting and less electricity consumption.

(a)TICA GHP gas heat pump multi-split unit (b)Panasonic gas water - fluorine complex heat pump system

Figure 2.3-8 Example of GHP Gas Heat Pump

In this exhibition, Panasonic exhibited a gas water - fluorine complex heat pump system, the unit can realize three functions of air conditioning refrigeration, heating and domestic hot water. This product adopts the unique heat recovery technology, to provide domestic hot water by recovering the high temperature waste heat exhausted by refrigerant and engine while cooling, with the highest temperature of hot water up to 75℃. When heating, the heat pump is used to extract heat from the engine heat extraction and the atmosphere to supply heat and produce domestic hot water. The rated heating efficiency is 1.7 times of the gas boiler. The product was granted as the innovative product in this exhibition (Figure 2.3-8a) . TICA and Japan Yanmar launched GHP gas multi-split unit, which doesn't need defrosting and achieves no heating decay at -20℃ in winter by utilizing waste heat of combustion. The technology is expected to become an important supplementary scheme for the multi-split unit market (Figure 2.3-8b).

In general, gas GHP heat pump has problems such as high initial investment, low primary energy efficiency for cooling in summer, and low autonomy level of key components (gas engines). In the past few years, the market promotion was more difficult. However, with the increased demand of clean heating in Northern China (especially in severe cold areas), with the national policy of "using electricity, gas, coal and heating when applicable" on household heating and the improvement of natural gas pipeline network supporting facilities in China, gas GHP heat pump is poised and is expected to achieve wider promotion.

3.2.4 Household central air-conditioning with integrated heating and cooling

In recent years, with the increased requirement on heating comfort of human being, the high comfort of radiant floor heating has been widely concerned. A variety of household central air-conditioning systems with integrated heating and cooling are also developed This kind of system generally adopts radiant floor heating in winter (usually using water; refrigerants are also available), and adopts forced convection terminals such as fan coil or air conditioning indoor unit for refrigeration in summer. With an outdoor unit, the heating and cooling needs of residents can be met, and the comfort in winter and summer can also be guaranteed. There are three types of refrigerant and heating media in such systems: 1) the whole water system: the hot water in winter is produced by radiant floor heating, while the chilling water in summer is produced by fan coil refrigeration, such as the whole-house refrigeration + heating solution exhibited by New Energy (Figure 2.3-9a); 2) the water-fluorine combined system: the hot water in winter is produced by radiant floor heating, while the refrigeration in summer is achieved by the indoor fluorine terminal, such as the floor heating multi-split unit exhibited by TICA (Figure 2.3-9b); 3) the whole fluorine system: high temperature refrigerant enters the floor fluorine coil for heating in winter and enters the indoor fluorine terminal for refrigeration in summer, such as the no-water floor heating exhibited by Phnix (Figure 2.3-9c). This part will be described in detail in Section 5: heating and hot water equipment and system.

(a)New Energy water system floor heating + air conditioning

(b)TICA floor heating multi-split unit

(c)Phnix no-water floor heating

Figure 2.3-9 Example of Floor-Radiation Composite Household Central Air-Conditioning with Integrated Heating and Cooling

In addition, many manufacturers use condensing heat, solar energy and other clean thermal energy to provide users with refrigeration, heating and domestic hot water, and build multi-source complementary composite household energy system. For example, the multi-function air conditioner launched by Clivet not only meets the heating and refrigeration needs of residents, but also successively uses solar energy, condensing heat, heat pump and gas boiler to produce domestic

hot water according to outdoor conditions, as shown in Figure 2.3-10 This kind of multi-source complementary “integrated multi-function” equipment reduces the floor space of the equipment and the operating cost. However, there are also problems such as the difficulty in complementary control between multiple heat sources and the complexity of installation.

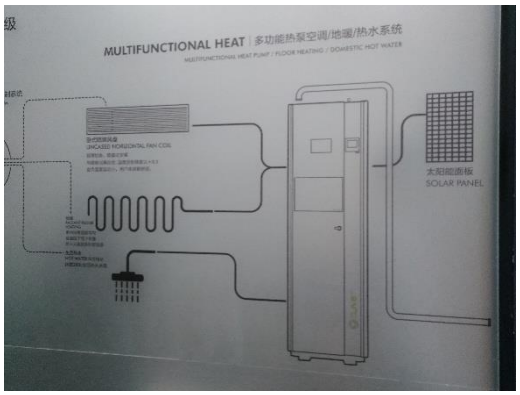


Figure 2.3-10 Clivet Multi-Source Complementary and Multi-Function Air Conditioner

3.2.5 Household air conditioner

With the improvement of people's living standards, comfort level has gradually become the main goal pursued by major air conditioner manufacturers. This comfort level is no longer simply the heat comfort of people in the indoor environment, but is more reflected in the comfort level of the entire home system. In this exhibition, the comfort level is mainly reflected in: Comfortable and healthy indoor environment (including temperature, humidity, cleanliness, air supply body sense), intelligent control mode, as well as visual comfort of air conditioner appearance.

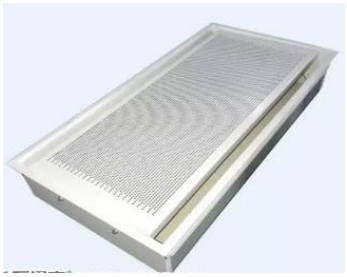
Comfortable and healthy indoor environment requires reasonable air supply mode, accurate temperature and humidity control and healthy indoor air quality.

In terms of air supply mode, major manufacturers exhibited their own comfortable air supply schemes, such as, ecological breeze of Haier, intelligent air supply based on infrared induction of Midea, distributed air supply of Gree and induced radiant air beam of TICA, as shown in Figure 2.3-11. Gree distributed air supply technology is based on the characteristics of intermittent operation of heat pump air conditioner, combined with human body dynamics and steady-state heat comfort requirements, and determines the optimal outlet position, size and air volume ratio according to the outlet air temperature, flow rate and angle adjustment range. The refrigeration and heating modes of the air conditioner are distinguished with the upper and lower outlets, improving the body comfort level. TICA induced radiant air beam can achieve the overall vertical temperature difference less than 1.5℃ in indoor space below 1.7 m, which is far less than 5-10℃ of

conventional air conditioning. At the same time, it can realize no wind feeling in refrigeration and more balanced heating, enhancing the comfortable experience. In general, manufacturers are continuously developing and investing the comfortable and intelligent air supply technology with "wind moving with people" that reduces the blowing feeling and vertical temperature difference. The technology has been widely recognized by the market.

(a)Haier ecological breeze

(b)Gree distributed air supply



(c)TICA induced radiant air beam

Figure 2.3-11 Examples of Comfort Air Supply Technology

In terms of improving comfort level, humidity control is getting more and more attention. Among which the concept of "independent temperature and humidity control" and "separate temperature and humidity control" is gradually gaining popularity. In view of the indoor temperature drop during the dehumidification process in the transitional season, Gree, Midea, Haier and other manufacturers have proposed a "dehumidification without cooling" air conditioner with separate control of temperature and humidity, which mainly uses three-control technology and dual heat exchangers. The condensation heat is recovered during dehumidification to control the outlet air temperature and maintain balance, thus achieving independent control of humidity and temperature (Figure2.3-12(a)).

The SSLC compressor developed by Highly achieves the separate cooling and dehumidification of the air conditioning system through the separate control of two different evaporation temperatures, meeting the evaporating temperature adjustment of different air conditioning areas, and improving the overall energy efficiency and comfort of the system (Figure 2.3-12 (b)). In order to improve the dehumidification efficiency, Panasonic dehumidifier adopts W-HEXS dual dehumidification system with multi-layer dehumidification film. It has a vertical and horizontal design, which diverts hot and cold air and guides air through the dehumidification film for second dehumidification, increasing dehumidification area and improving dehumidification efficiency (Figure 2.3-12 (c)).

(a)Air conditioner with separate control of temperature and humidity

(b)SSLC compressor with separate control of temperature and humidity

(c)Panasonic W-HEXS dual dehumidifier

Figure 2.3-12 Examples of High-Efficiency Humidity Control Technology

In this exhibition, under the continuous outdoor haze and various indoor pollutions, the guarantee of indoor air quality is still the focus of this exhibition. Many manufacturers exhibited air conditioning products with purification and dust removal functions. In general, the structure, purification and heat recovery technology of the exhibited products are basically the same as those of the previous exhibitions. The structure and layout types are wall-mounted, ceiling-mounted, cabinet-type, etc.. High-efficiency filtration methods include HEPA, static electricity, plasma with electret. The heat recovery method of the fresh air machine is mainly based on plate heat recovery.

a.Songjing all-heat capillary fresh air dehumidification and haze removal machine

b.Nather wall-mounted all heat-exchange fresh air machine

Figure 2.3-13 Examples of Partial Purification and Dust Removal Technology

With the development of AI and IoT technology, the control technology of household air conditioner is also continuously developed to improve users' experience. For example, Gree zero-carbon intelligent household system can achieve joint control of lighting, curtain, TV, dehumidifier and other equipment through voice control of air conditioning. The air conditioner with "smart self-cleaning" function exhibited by Haier can independently judge the hygienic

condition of the equipment. When the evaporator needs to be cleaned, a large amount of condensed water is first produced to freeze in the evaporator. After the condensed water is melted and discharged, the heat sterilization is carried out. The whole process takes only half an hour, which greatly saves manpower.

In the past development of air conditioning technology, reducing cost and improving energy efficiency are often the focus of equipment manufacturers. And in recent years, the appearance and aesthetic design of air conditioning has become increasingly important. For example, the wall-type fresh air haze removal machine of Gree, the butterfly wing-type air duct machine of Haier, the wall-type fresh air machine of Panasonic, and the “Hanbaiyu” air conditioner of Gree, all greatly save the installation space while meeting the needs of users, ensuring the indoor layout required by users, and enhancing the visual experience.

a.Gree wall-type fresh air machine

b.Haier butterfly wing-type air duct machine

c.Panasonic wall-type fresh air machine

d.Gree “Hanbaiyu”

Figure 2.3-14 Examples of Industrial Design of Some Products

3.3 Evaluation and prospection

As shown in the above technical progress: Due to the continuous popularity of the cleaning heating market in Northern China, low-temperature air source heat pump hot-air blower has become a new focus in the market; The multi-split unit technology is developing towards the direction of intelligence, high efficiency and multi-function. The household multi-split unit is in the ascendant; GHP gas heat pump multi-split unit air conditioners products (heat pump) are emerging; The radiant floor heating in winter and household central air-conditioning with integrated heating and cooling are in robust development; Household air conditioner is developing towards comfort, health and intelligence.

In addition to the characteristics of the small and medium-sized heat pump air conditioner market, it can be seen that small and medium-sized air-conditioning equipment R&D and manufacturing enterprises have strong market tracking and response capabilities, and also have

strong ability of introduction, digestion and re-innovation, and are able to research and develop refrigeration and air conditioning technology suitable for China's national conditions according to China's national conditions and living habits. At the same time, the research and development of products has been developed from the pursuit of energy efficiency and cost to meeting higher comfort and intelligence of users. And the segmentation of air conditioning market is getting deeper and deeper.

(IV) Air Handling Unit and HVAC Automatic Control System

(Associate Professor Zhou Xiang, Associate Professor Li Zhengwei and Assistant Professor Ye Wei, Tongji University)

4.1 Technical characteristics

In this exhibition, exhibitors in air handling unit and terminal, air conveying components, fresh air purification, heat recovery and automation control of buildings, still maintain a considerable scale, which not only exhibited traditional technical products, but also exhibited new technologies. With the further segmentation of the air-conditioning related market, traditional air-conditioning products are more targeted in applications. Maglev, EC motors, frequency converters and other technologies have promoted further improvement of product performance. The application of radiant heating and cooling, indoor fresh air purification, Internet and IoT keeps up with the trend of the times, fully embodies the people's yearning for a better life after the development of the times and the improvement of material life.

4.2 Characteristic technical products

4.2.1 Air handling unit and terminal

In terms of air handling units, Gree launched the maglev direct cooling air conditioning unit and won the innovative product award in this exhibition. The product uses the “small flow small pressure ratio maglev compressor” independently developed by Gree to solve the working condition offset efficiency decay and improve the efficiency of the whole working conditions and is suitable for the working condition of the subway station. The unit can achieve the performance coefficient of 5.37-5.68, and the integrated part load value of 8.66-8.71, as shown in Figure 2.4-1(a); TICA Jingrun series combined air handling unit is suitable for occasions with clean requirements. It is equipped with digital frequency conversion outdoor unit, can realize the minimum 8℃ air supply without freezing, realize the 10-100% stepless capacity adjustment of the compressor, and precisely control the air supply temperature. It is suitable for temperature and humidity control under various bad working conditions such as large fresh air ratio, large fluctuation of working conditions, variable air volume operation and low load, as shown in Figure 2.4-1(b).

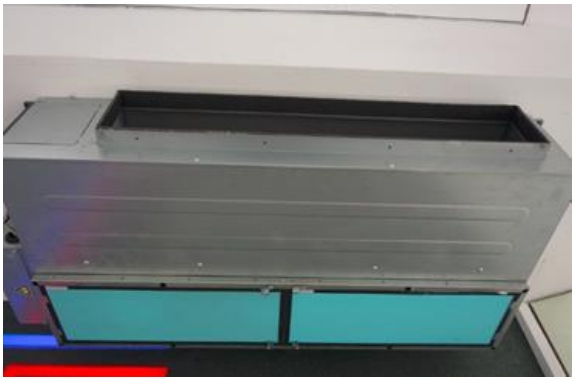
(a)Gree maglev direct cooling air conditioning unit

(b)TICA Jingrun series combined air handling unit

Figure 2.4-1 New Progress in Air Handling Unit

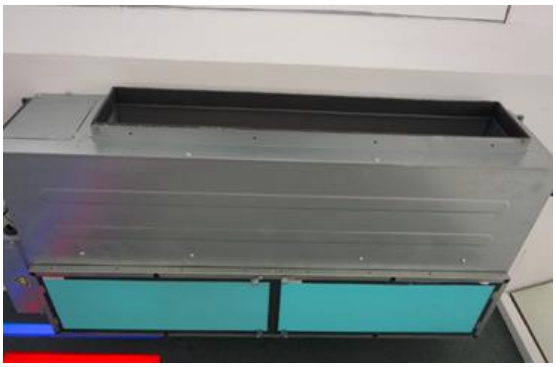
Fan coil is a mature air conditioning terminal product. The brushless DC motor (EC) fan coil, characterized by low energy consumption and low noise, has become popular in the market. In this exhibition, some manufacturers also exhibited fan-coil units with purification function, such as Jiangsu Jiabao “fan coil with electrostatic precipitation air return box”, as shown in Figure 2.4-2(a) and TICA “fan coil with purification filter” as shown in Figure 2.4-2(b); And fan coils combined with air supply outlet which achieve different air supply distributions. For example, Wuxi Hammer “embedded Coanda fan coil” can be directly installed on the ceiling and utilizes attached jet effect for improving air distribution, as shown in Figure 2.4-2(c); And Co Creation “nozzle outlet air supply fan coil”, as shown in Figure 2.4-2(d).

(a)Jiangsu Jiabao fan coil with electrostatic precipitation air return box



(b)TICA fan coil with purification filter

(c)Wuxi Hammer embedded Coanda fan coil

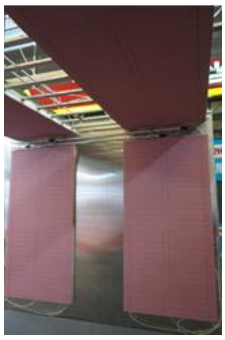


(d)Co Creation nozzle outlet air supply fan coil

Figure 2.4-2 New Technology of Fan Coil

Radiant air conditioning terminal and matching dehumidification system can achieve higher comfort level and uniform indoor environment Gogee exhibited the “indoor climate system” composed of capillary radiation terminal, dehumidification unit and integrated control module, among which dual-cooling source fresh air unit, household fresh air dehumidifier, indoor pre-cooling dehumidifier unit and other equipment can meet the different dehumidification needs of users, as shown in Figure 2.4-3(a); Tillerson exhibited gypsum board, polyethylene tube, aluminum plate and thermal insulation composite gypsum board radiant board, as well as the matching fast connection pipeline and heat recovery dehumidifier, as shown in Figure 2.4-3(b); TICA exhibited an induced radiant air beam combined with the air supply of the indoor unit, which can achieve large radiative transfer area, reduce blowing feeling and improve the uniformity of indoor temperature, as shown in Figure 2.4-3(c). In terms of radiant heating, manufacturers exhibited a heating pipeline with an oxygen barrier layer, which can reduce the oxygen permeation of the system, improve the oxidation and corrosion resistance of the system, and the matching modular insulation board, which can be directly embedded in the pipeline, simplify the construction process, improve the construction efficiency and quality, such as MENRED floor heating pipes and modular insulation board, as shown in Figure 2.4-3(d).

(a)Gogee capillary radiation terminal



(b)Tillerson gypsum radiant board

(c)TICA induced radiant air beam

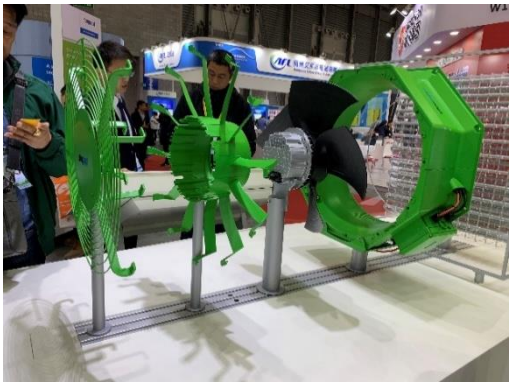
(d)MENRED floor heating pipes and modular insulation board

Figure 2.4-3 New Technology in Radiant Air Conditioning Terminal

4.2.2 Air conveying components

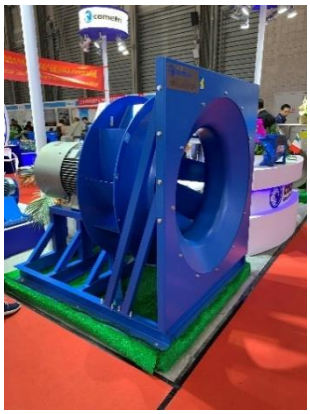
In this exhibition, some new products in the fan manufacturing industry were launched. Among them, the “Condensing and evaporating fans for electric bus with higher EMC grade” exhibited by Ebmpapst is the only fan product among innovative products in this exhibition. The fan optimizes the electrical drive module inside the motor, isolates the signal circuit and the power circuit, and improves the anti-interference ability; It increases capacitor filtering, weakens power induction and optimizes the filter circuit; Conducted interference and radiated interference not only meet the latest national standards, but also meet the abundant margin in the future limit area of national standards, as shown in Figure 2.4-4(a). In addition, Ebmpapst also exhibited a new improved fan for refrigerator. The fan adopts several specially designed structures to form certain attachment effect between the outlet airflow of the fan and the top of the indoor space, so as to achieve the effect of longer transmission distance, as shown in Figure 2.4-4(b). In this exhibition, Blauberg exhibited the updated ZAbluefin series centrifugal fans. Compared with the last exhibition, most of domestic fan enterprises participating in this exhibition launched products using EC motor. It will gradually improve the competitiveness of domestic enterprises in this segmented field, and promote the development of fan industry, while driving and contributing to the energy conservation of buildings and in industry. In addition, Comefri, South Korea WuHyun, SANMU and other enterprises launched new voluteless fans which reduces hydrostatic pressure head and improves the fan efficiency under low air pressure by removing the volute. It is suitable for air supply with medium and small volume and has large advantage than traditional centrifugal fan due to the uniformity and volume, as shown in Figure 2.4-5.

(a)Condensing fan and evaporating fan for electric buses



(b)Fan for refrigerator which can transmit a longer distance

Figure 2.4-4 New Fan Products Exhibited by Ebmpapst



(a)Comefri high-temperature explosion-proof voluteless fan

(b)SANMU new voluteless fan

Figure 2.4-5 Partial New Voluteless Fans Exhibited

For fabric air duct enterprises, Durkee (Wuhan) Insulation Material Co., Ltd. exhibited a new formed flexible adiabatic air duct system (InsuSox^{TM}) which is manufactured according to the industrial standard. The product only needs to be mounted by hanging at site, which can effectively save engineering construction time, as shown in Figure 2.4-6(a). PRIHODA, FabricAir, Jiangsu Yaodi and other companies have exhibited flame retardant flexible air duct and inlet products with various forms, convenient installation and personalized color, as shown in Figure 2.4-6(b). In addition, the SVAD inlet exhibited by Royal Service Air Conditioning integrates variable air volume equipment and air supply terminal, forming an integrated product, as shown in Figure 2.4-6(c). Jinhua Langtong launched the dedicated HDPE plastic pipe for fresh air, as shown in Figure 2.4-6(d).

(a)Durkee air duct manufactured based on new industrial standard

(b)PRIHODA flexible air duct machine and inlet products

(c)Royal Service Air Conditioning integrated variable air volume outlet product

(d)Jinhua Langtong fresh air HDPE plastic pipe

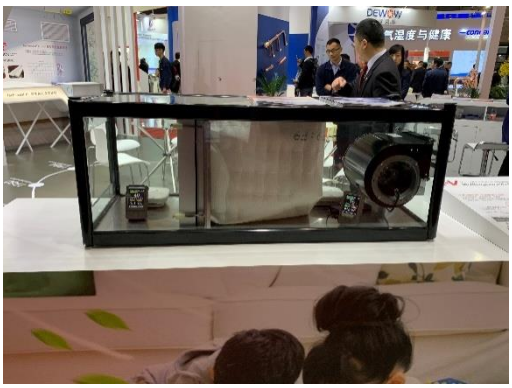
Figure 2.4-6 Partial Air Ducts and Terminal Products Newly Exhibited

4.2.3 Fresh air purification and heat recovery system

According to incomplete statistics, nearly 30 enterprises (more than 40 enterprises exhibited fresh air products in 2018 exhibition) exhibited different forms of fresh air units. Compared with the last exhibition, the exhibitors have changed a lot. The competition in the fresh air industry is relatively large. Many enterprises have made innovations in terms of differentiated demand and complete functions.

The wall-mounted all heat-exchange fresh air machine (FA150-W) of Nather Ventilation System Co., Ltd. is an innovative product in this exhibition. This product belongs to new energy-saving and environment-friendly product in the field of construction equipment. It can automatically adjust the opening ratio of the air valve according to the outdoor temperature, and provides a solution for the continuous operation of the new exhaust heat recovery air purification equipment under the extremely low and high outdoor temperature, as shown in Figure 2.4-7(a). In order to adapt the air quality demand of household environment, AIRQUALITY and other enterprises exhibited products mainly focusing on the purification capacity of particulate matters, volatile organic compound (VOC) and other different kinds of pollutants. Hollingsworth &Vose exhibited a fresh air unit with NanoWave® filter material, as shown in Figure 2.4-7(b).

(a)Nather FA150-W fresh air machine



(b)Hollingsworth &Vose NanoWave® filter materials

Figure 2.4-7 Partial Fresh Air Units and Filter Materials Newly Exhibited

Many enterprises pay attention to the improvement of air quality in the environment such as kitchen and bathroom this year. MayAir, Jinan Grass Green and other companies launched a professional equipment for fume purification for household and commercial kitchens, as shown In Figures 2.4-8(a) and (b). Panasonic launched an air “bath heater” product for improving and ensuring the air quality of bathrooms, as shown in Figure 2.4-8(c).

(a)MayAir fume purification products for kitchen

(b)Jinan Grass Green fume purification product

(c)The new “bath heater” product of Panasonic

Figure 2.4-8 Partial Exhibits Focusing on Improving the Air Quality in Kitchens and Bathrooms

4.2.4 Automation control technology

“Internet +” is still one of the biggest characteristics of the intelligent direction of this exhibition. On the one hand, traditional refrigeration equipment has increased remote data transmission and even optimized control functions. On the other hand, all components of the HVAC system, including sensors, actuators, are increasingly providing interfaces for data acquisition and remote control. The progress on these aspects makes the HVAC system rapidly transfer to the information era.

On the one hand, intelligent actuators provided by IMI and Belimo can be controlled remotely by mobile phone. On the other hand, they also provide fault analysis and diagnosis functions for problems such as power interruption and valve blockage. In this exhibition, the intelligent actuator of Belimo shows two new characteristics: (1) It can be connected with any butterfly valve through universal connector, thus improving the universality; (2) It adds the Near Field Communication

(NFC) function, which can communicate with the actuator on the spot through the mobile phone, enhancing the convenience of field debugging, as shown in Figure 2.4-9.

Figure 2.4-9 Belimo Universal Butterfly Valve Actuator with NFC Function

After the integration of sensors measuring different variables in previous exhibitions, the integration of various sensors through remote communication is a new characteristic of this exhibition. For example, Belimo provides the interface supporting BACnet and Modbus protocols on its uniform housing for sensors, as shown in Figure 2.4-10; Basic comprehensive accounting management platform connects the meters for air conditioning, heating, tap water, electricity and gas through the two-wire system Modbus bus, which can realize functions such as remote meter reading, real-time meter reading, remote control and accounting by different periods, as shown in Figure 2.4-11.

Figure 2.4-10 Belimo Sensor with Communication Interface

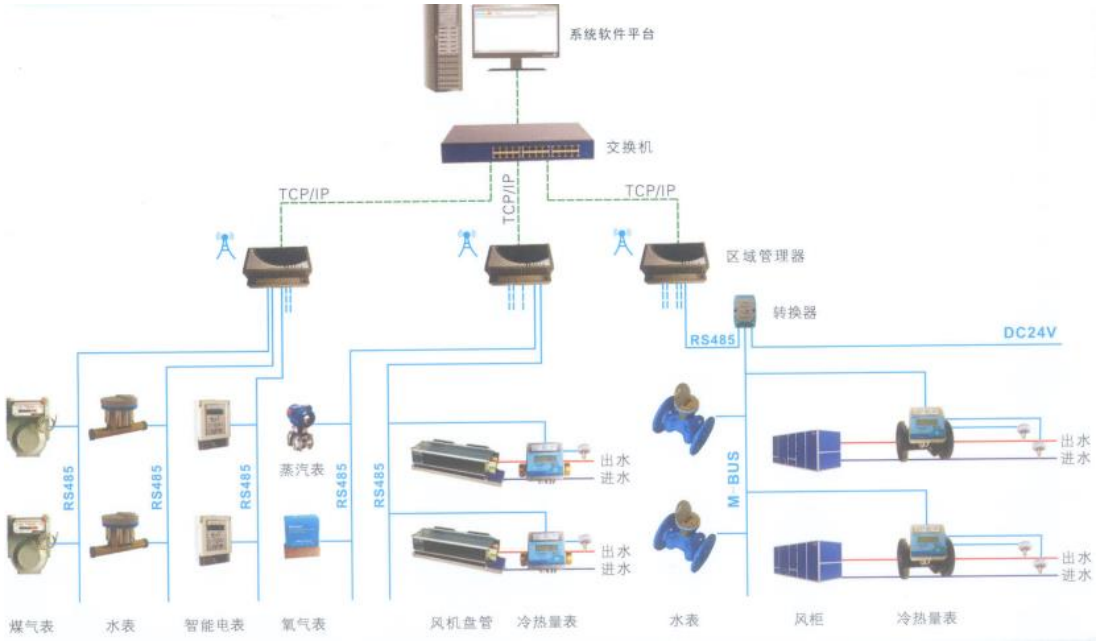


Figure 2.4-11 Basic Multi-Meter Comprehensive Accounting Management Platform

In terms of research and development of frequency converter, different with technical path of replacing large electrolytic capacity with thin-film capacitor with small electric capacity in previous years, Zhuzhou National Engineering Research Center of Converters Co., Ltd. adopts liquid cooling, PMW whole-process rectification, built-in harmonic suppression system and high-precision motor control technology, etc. to improve the efficiency, electromagnetic compatibility and adaptability of frequency converters to various motor types, as shown in Figure 2.4-12.

Figure 2.4-12 tPower-IC Series Central Air Conditioning Frequency Converter

4.3 Evaluation and prospection

Continuing the trend of previous exhibitions, application scenarios segmentation, equipment performance improvement, and intelligent interconnection applications are still the highlights of this exhibition in air handling units and HVAC automatic control systems.

In this exhibition, air conditioning unit, fan and all heat-exchange fresh air machine were granted with the innovative product of the exhibition, which have reflected the exploration and

efforts of traditional manufacturers for industrial innovation. In terms of air handling terminal, there are not only direct cooling air hundling unit for metro application scenarios and clean air conditioning occasions, but also indoor radiant cooling and heating terminal with high comfort level and supporting products; In terms of air conveying components, high-efficiency and energy-saving fans, flexible air ducts are still hot products; In terms of fresh air purification, the number of manufacturers in this exhibition was numerous. In addition to paying attention to efficiency and product performance, products which are applicable to more occasions (such as different climate zones, kitchens and bathrooms) begin to be popular; In terms of automatic control of buildings, the Internet and IoT are the biggest highlights, including remote data transmission, remote control, cloud platform and big data application of refrigeration equipment, actuators, sensors and central controllers, which closely follow the current trend of IT technology development.

(V) Heating and Hot Water Equipment and System

(Professor Jiang Yiqiang and Associate Professor Dong Jiankai, Harbin Institute of Technology)

5.1 Technological development characteristics

In terms of heating and hot water equipment and systems, many well-known enterprises at home and abroad, such as Midea, Gree, Haier, TICA and Phnix, participated in this exhibition. The exhibition provides a platform for enterprises to exhibit new products and technologies, as well as an opportunity for communication between enterprises, enterprises and users. There are many kinds of products for heating and hot water exhibited in the exhibition, including traditional products, and new products combining the current background of heating in Southern China, "coal to electricity" in Northern China, and haze governance. In this exhibition, the heating and hot water equipment and systems are featured with high efficiency, environmental protection, individuality and high comfort. Few traditional fossil fuel heating and heat source equipment was exhibited.

5.2 Characteristic technical products

In this exhibition, a large number of heating and hot water equipment and systems were exhibited. In addition to conventional plate heat exchangers, double-pipe heat exchangers, high-efficiency tubular heat exchangers and other heat exchange equipment, warm air curtains, fan heaters, electrothermal film and other heating terminals, as well as heating system accessories, such as temperature controllers, temperature control valves and water mixing device, numerous heat pump units, drying heat pumps, comfort high-performance heating terminals, two-stage supply units, and overall customized heating equipment for buildings were exhibited.

5.2.1 Heat pump unit for heating

With the promotion of national energy conservation and emission reduction and environmental protection policies, heat pump technology has become a rising star in the field of energy conservation with its clean, pollution-free, energy-saving and efficient advantages among numerous heating and hot water equipment. The value and role of heat pump become more and more prominent. The heat pump area was set up in this exhibition, as shown in Figure 2.5-1. The exhibits included air source heat pump, sewage source heat pump, full heat recovery high temperature heat pump, gas heat pump and absorption heat pump unit, all of which have good heating performance. Jinan Dasen full heat recovery steam generating unit can achieve full heat recovery and produce hot water of 70℃ and 100℃ and 0.4MPa vapor. The heat pump unit for sewage heat recovery of Dalian Bingshan can achieve simultaneous heating and refrigeration in summer, with the hot water

production capacity up to 12.2-44.8L/min. Gas-fired water-fluorine compound air-conditioning heat pump system effectively utilizes the exhaust heat of the gas engine and greatly reduces the power consumption.

(a)Jinan Dasen full heat recovery steam generating unit

(b)Dalian Bingshan dedicated heat pump unit for sewage recovery

(c)Gas-fired water-fluorine compound air-conditioning heat pump system of Panasonic Appliances Air-Conditioning and Refrigeration (Dalian) Co., Ltd.

Figure 2.5- 1 High Efficiency Heat Pump Unit

In many heat pump exhibits, relevant air source heat pump products are the most prominent. With the continuous promotion of “coal to electricity” in Northern China and heating in Southern China, air source heat pump is taken as the first choice for heating in many areas. Therefore, the heat pump air conditioning manufacturers are focusing on the R&D and active improvement of air source heat pump products by closely combining the national situation. In this exhibition, Midea, Gree, Haier, Zhejiang Dun’an Environment, Hisense, Tsinghua Tongfang and other enterprises exhibited relevant products, as shown in Figure 2.5-2.

(a)TICA “Jiajiarun” system all variable-frequency household air source heat pump unit

(b)Haier high temperature outlet air source heat pump unit

(c)Phnix ultra-low temperature heating air source heat pump unit

(d)Midea roaring flame series all-DC variable-frequency low-temperature air source heat pump unit

(e)AMITIME ultra-low temperature variable-frequency air source heat pump

(f)Midea air source heat pump hot water machine

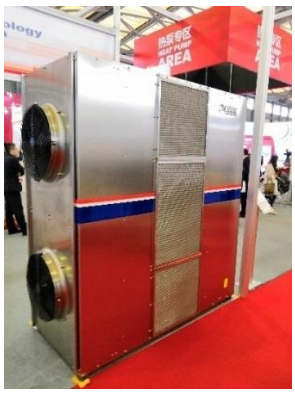
Figure 2.5-2 Air Source Heat Pump Unit

In order to effectively solve the problems of efficiency decrease and frosting at low environment temperature and defrosting in the heating process of air source heat pump, relevant enterprises adopt enhanced vapor injection compressor, full DC frequency conversion technology, intelligent defrosting technology and intelligent control technology of the system, etc., effectively improving the heating performance of air source heat pump. Most exhibits can be forcefully heated at -20℃, while some products can achieve heating at -25℃。 For example, Nanjing TICA “Jiajiarun” series all variable-frequency household air source heat pump unit adopts all-DC variable-frequency scroll compressor + variable-frequency water pump + variable-frequency fan + enhanced vapor injection technology, so that the system heating capacity does not decrease when the outdoor environment is at -20℃, and the integrated part load performance coefficient of the unit is up to 4.3. In addition, it adopts a split structure, and the water system can be installed indoors, thus effectively avoiding the freezing crack of the water circuit. Midea roaring flame series all-DC variable-frequency low-temperature air source heat pump unit adopts enhanced vapor injection technology and intelligent defrosting technology, so that the system can achieve forced heating at outdoor temperature of -26℃.

5.2.2 Rapid development of heat pump units for drying

The wood and crop drying industry has large energy consumption. Its traditional drying methods are unable to meet the current requirements on energy efficiency and environmental protection due to its low efficiency, high cost and environmental pollution. As a new energy saving technology, heat pump drying solves the problems of long time, low efficiency, high energy consumption and great influence on product quality in traditional drying methods to a great extent. Therefore, heat pump drying has brought a significant technical revolution in the drying industry. In the heat pump area of this exhibition, the drying heat pump unit and its corresponding components

were exhibited. Their practical application effect was introduced, which expands the market of heat pump unit and provides reference for the application of heat pump unit in the new industry. As shown in Figure 2.5- 3.



(a)Tsinghua Tongfang wood heat pump dehumidification dryer

(b)Special compressor for high temperature drying heat pump of Panasonic Appliances Compressor (Dalian) Co., Ltd.

(c)Runte heat recovery heat pump dryer

Figure 2.5-3 Heat Pumps for Drying and Their Special Components

Tsinghua Tongfang exhibited a variety of wood heat pump dryers with scroll-heating technology, which has increased the energy efficiency ratio by about 20% compared with conventional products. The compressor with axial flexible pressure balancing device can run under larger working conditions and is suitable for the maximum temperature of 65℃ in the kiln. According to the positive and negative running state of the circulating fan in the kiln, the temperature and humidity sensor signals in the kiln are automatically adjusted to control the drying process more accurately. Finally, it achieves discharge without waste gas, waste water and waste residue. The boards with drying heat pump have less cracks and less deformation.

5.2.3 Environment-friendly refrigerant unit and high-performance components

With the development of clean heating, the types of air source heat pumps used for clean heating have increased. Their performance has become more and more perfect. Related heating and hot water equipment pay more attention to environmental protection, and heating performance of the equipment has improved.

The refrigerant of heat pump unit is more environmentally friendly. In this exhibition, Gree, Midea, Haier, Hisense, Dun'an and Zhejiang KINGAIR exhibited heat pump units using R32 refrigerant; Dun'an Environment, Haier, Heilongjiang ARCO and Kunming Dongqi exhibited heat pump units using CO_2 refrigerant; Midea and AUX exhibited a heat pump unit using R290 refrigerant, as shown in Figure 2.5-4.

Compared with traditional refrigerator environmentally friendly refrigerant has more advantages. R32 refrigerant, for example, has a lower GWP, with an ignition temperature up to 648℃

and a critical temperature of 59.5℃. Under bad working conditions, it has better performance, higher heat exchange performance and no temperature glide. Therefore, smaller size piping can be used to optimize the heat exchanger, thus reducing the production cost. Therefore, based on the consideration of protecting the environment and improving the system performance, high-performance environmentally friendly refrigerant will play an important role in the heating and hot water equipment system in the future.

(a)Haier CO2 air-source heat pump heater

(b)Dun'an Environment CO2 heat pump hot water unit

(c)Environmentally friendly refrigerant heat pump unit in the air conditioning heat pump exhibition area

(d)Danfoss scroll compressor for heat pump

(e)Danfoss FHF water manifold and collector for floor heating

(f)MENRED fan coil temperature controller

Figure 2.5-4 Environment-Friendly Refrigerant Unit and High-Performance Components

In order to improve the performance of the heating and hot water system, high-performance compressor for heating, high-precision water manifold and collector and temperature controller were also exhibited in this exhibition. Danfoss scroll compressor for heat pump adopts environmentally friendly refrigerant, is based on the optimal design of heat pump working condition, improves the energy efficiency ratio of the system, has larger operation range, and can provide 60℃ hot water at -15℃. The FHF water manifold and collector for floor heating realizes the reliable control of each floor heating circuit, effectively solves hydraulic balance between circuits, and realizes the visualization of circuit flow.

Microchannel heat exchange technology is further popularized and applied in heating and hot water equipment. Following the introduction of the air source heat pump water heater based on

cryogen microchannel aluminum flat tube last year, the performance of related products in this exhibition has been further improved. The scheme of the second generation microchannel liner heat exchanger was exhibited, as shown in Figure 2.5-5. The relevant content will be described in detail in Section “(6) Cold Chain Equipment and Refrigeration System Accessories”.

(a)Hangzhou Sanhua water heater microchannel liner heat exchanger

(b)Midea microchannel heat-exchange water heater

Figure 2.5-5 Microchannel Liner Water Heater

5.2.4 Highly-comfort heating terminals

In this exhibition, one of the characteristics of heating products and systems is to pay more attention to comfort of indoor environment. The traditional split-type air conditioning terminal is generally wall-mounted and cabinet type. However, due to the rise of hot air flow under natural buoyancy and the different working conditions in winter and summer, the indoor environment temperature has significant stratification of conventional terminal under heating working condition in winter, resulting in poor comfort for human. This has caused the attention from enterprises engaging in the R&D and production of heat supply products. In this exhibition, Haier, Gree, Midea, Nasen, AUX and other enterprises launched terminals or systems to improve indoor comfort. The comfort of air supply has been introduced in “(III) Medium and Small Air Conditioning Equipment and Systems “, in which, in terms of performance improvement at the heating terminal, the main concern is the air supply distribution at the terminal.

The heating terminals exhibited in the exhibition are mainly divided into floor type or low hanging type. Generally, the return air inlet is set at the middle of the heating terminal equipment. And the air outlets are set at the upper and lower positions. When heating, upper and lower outlets are used to supply air separately, so as to achieve carpet air supply effect and ensure the rapid

heating of indoor environment. Hot air is mixed with indoor air during rising, so as to ensure the comfort of personnel in working area, as shown Figure 2.5-6.

(a)Nasen heat pump air conditioning terminal

(b)Gree heat pump air conditioning terminal

(c)Haier heat pump air conditioning terminal

(d)Midea air source heat pump two-stage supply unit

(e)Haier Yunnuan series-integrated air-conditioning and floor heating machine

(f)AUX low-temperature air source heat pump integrated refrigeration and heating machine

Figure 2.5-6 Highly-Comfort Heating Terminals

5.2.5 Two-stage heat pump unit

In this exhibition, another major technical characteristic of the heating system is the two-stage supply heat pump unit. Under normal circumstances, the outdoor unit is a conventional air source heat pump unit. The indoor part is equipped with two sets of heat dissipation terminals, i.e., floor radiation terminal and convective heat dissipation terminal. Under heating condition in winter, high-temperature hot water generated by the outdoor unit is transmitted to the floor radiation terminal for indoor heating. Compared with the convective heat dissipation terminal, the floor radiation terminal can achieve the heating effect of “feet warm and head cooling “, so as to effectively improve the indoor thermal environment. Under working condition in summer, convective heat dissipation terminal is used for indoor refrigeration. This two-stage supply system

effectively unifies the requirements on the performance of different heat dissipation terminals in indoor environment under heating and refrigeration conditions.

These products have both water and fluorine circulation systems, which increase the complexity of the equipment. At the same time, the existence of water system improves the anti-freezing requirements of the system. In order to realize the operation of a single refrigerant in the two-stage supply system, Phnix has developed the no-water flooring heating air source heat pump unit, as shown in Figure 2.5-7.

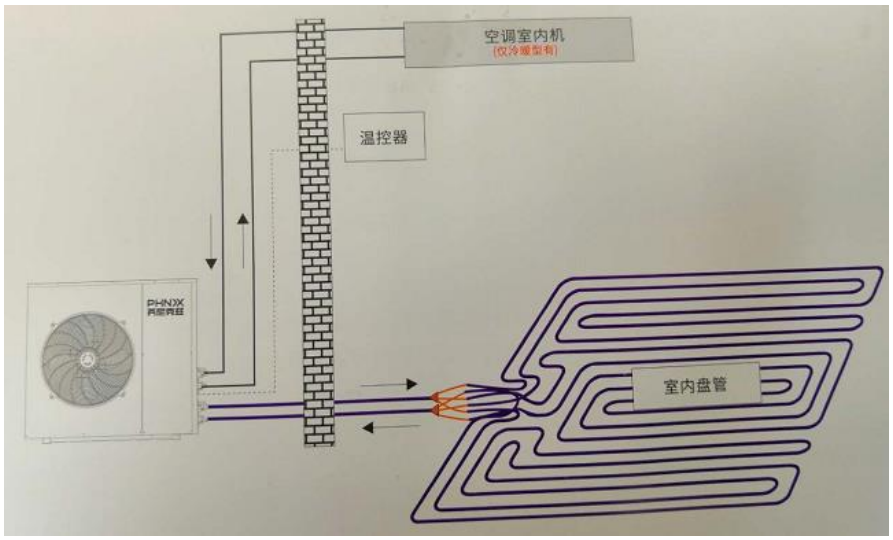


Figure 2.5-7 Schematic Diagram of the No-Water Flooring Heating System (Phnix)

Phnix no-water flooring heating system comprehensively adopts enhanced injection compressor + single electronic expansion valve, and utilizes automatic vacuum pumping design, solves the safety problem caused by uneven distribution of refrigerant during system switching. It uses R410A environmentally friendly refrigerant. Its operation environment temperature can be expanded to -30-43℃. Compared with water floor heating, this system makes full use of the heat storage capacity of the floor, forming a large condensation space and ensuring the stability of the condensation condition. It doesn't need the secondary heat exchange between water and fluorine, which saves a lot of waterway parts, eliminates the frost crack of water pipes at low environment temperature in winter, and avoids a lot of potential safety hazards and complicated waterway maintenance works. Its energy efficiency ratio is greatly improved, with the nominal heating energy efficiency up to 4.2. Under the same conditions, the annual operating cost is at least 30% lower than that of conventional machines.

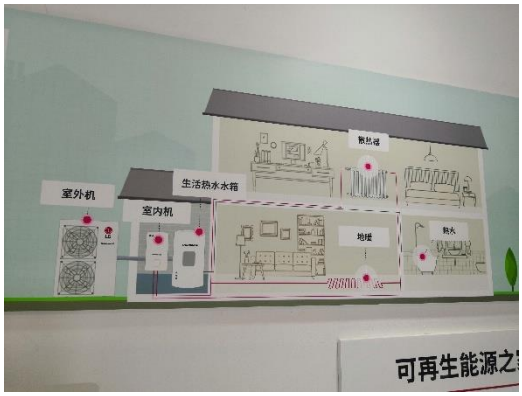
5.2.6 Overall customized heating and hot water equipment and systems for buildings

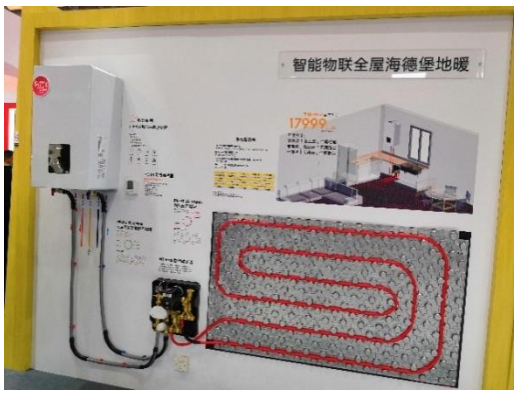
The ultimate goal of heating and hot water equipment is to create a healthy and comfortable indoor environment with low energy consumption. Conventional heating and hot water equipment are usually installed after the construction of the building, which may lead to problems about the matching and unity of the heating equipment and the building, as well as the waste of cold energy

and heat energy. In this exhibition, equipment manufacturers launched the overall customization schemes for heating and hot water equipment and buildings, as shown in Figure 2.5-8. For example, Phnix launched a whole-house heating + refrigeration customized scheme based on the heat pump air conditioning; Dalian Bingshan launched a whole house customization scheme of refrigeration + heating + domestic hot water based on air source host; LG launched a whole house customization scheme of heating + domestic hot water based on air source host; MENRED launched an intelligent IoT whole-house Heidelberg floor heating customization scheme based on the wall-hanging gas stove. According to characteristics, functions and layout of different buildings, the whole house customization scheme has put forward the corresponding supply schemes of heating, refrigeration and domestic hot water, to achieve the organic unity of heating and hot water equipment and building. At the same time, the customized scheme puts forward a reasonable and strict intelligent control scheme, which realizes the improvement of indoor environment and energy saving of buildings. With the continuous development and progress of the society and people's pursuit of diversified life, the design and control of the heating and hot water equipment aiming at whole house customization scheme of different buildings will be an important development direction.

(a)Phnix whole house heating + refrigeration solution

(b)Dalian Bingshan heating and refrigeration + domestic hot water solution





(c)LG whole house heating + domestic hot water solution

(d)MENRED intelligent IoT whole-house Heidelberg floor heating customization scheme

Figure 2.5-8 Whole House Customization Scheme for Heating and Hot Water Equipment and System

With the whole house customization development of heating and hot water system, in order to meet the requirements on environmental comfort of special indoor rooms and the demand for domestic hot water and achieve the coordinated utilization of cold energy and heat energy. Phnix launched a domestic cooling water heater for the kitchen environment, as shown in Figure 2.5-9. While heating domestic hot water, the refrigerating capacity is released into the kitchen space, to reduce the environment temperature in the kitchen and realize the dual use of refrigeration and condensing hot water.

Figure 2.5-9 Domestic Cool Air Water Heater (Phnix)

5.3 Evaluation and prospection

In this exhibition, there are many products about heating and hot water equipment and system exhibited. However, under the background of clean heating, heat pump system, especially air source heat pump system still occupies an important position. In particular, in the process of “coal to electricity” in rural areas of Northern China, air source heat pump is an important heat source for heating.

With the continuous promotion of energy conservation and environmental protection, heat pump technology has been rapidly developed in the drying industry. The environmental protection and high performance of heating and hot water system is still an important direction of product performance improvement, promoting the development of environmentally friendly refrigerant, special compressor for heat pump, high performance solenoid valve and other related products. At the same time, heating and hot water products pay more attention to comfort of indoor environment. The corresponding two outlets, air supply terminal and two-stage supply units have been developed. At the same time, the whole house customization of heating and hot water system is developed based on the characteristics, functions and layout of buildings, achieving its organic combination

with building.

With the development and progress of the society, the individuation and intellectualization of heating and hot water equipment and systems will be further developed.

(VI) Cold Chain Equipment and Accessories of the Refrigeration System

(Researchers Tian Changqing and Shao Shuangquan,
PhD Candidate Zhan Binfei and Postgraduate Huang Qionghai, Technical Institute of Physics and Chemistry, CAS)

6.1 Technical characteristics of cold chain equipment

As shown in this exhibition, under the background of energy conservation and environmental protection, NH_3 refrigeration safety, and welcoming the Olympic Winter Games, many products and technologies related to cold chain equipment have achieved rapid development. From all links of the whole-process cold chain, the focus of the industry has gradually extended from the traditional freezing and refrigeration (processing and storage) to the whole process of food processing industry. The weakest "first kilometer" and "last kilometer" have been well developed. In terms of cold chain equipment and systems, many famous enterprises at home and abroad attended this exhibition. The exhibition not only provides a platform for enterprises to show their technical strength and latest product characteristics to users, but also provides a good opportunity for enterprises for exchange and cooperation.

The cold chain equipment exhibited in this exhibition covers all links in the whole cold chain process. By analyzing the exhibition situation of the cold chain equipment in this exhibition, the overall performance of cold chain equipment is the further development of the natural working substance refrigeration system, safety improvement of ammonia-related refrigeration system, development of high-efficiency cooling and heating integrated unit, development of "first kilometer" and "last kilometer" cold chain equipment and ice and snow equipment development driven by the Olympic Winter Games.

(1) Further development of refrigeration system using natural working substances

In terms of the application of refrigerant, the proportion of the traditional R22 and R404A refrigerating units decreased significantly. The natural working substances represented by CO_2 and NH_3 occupied the main position, especially the refrigerating units represented by CO_2 transcritical system, CO_2 cooling system and CO_2/ NH_3 cascade system. The proportion of their products exhibited increased significantly. From the perspective of refrigerant application in the freezing and refrigeration field, the cold chain equipment industry is developing towards the sustainability of low

carbon and environmental protection. In addition, the exhibition also set up the relevant exhibition area of "ozone climate technology roadshow", to help the cold chain equipment industry to firmly take the road of environmental protection development.

(2) Safety improvement of ammonia-related refrigeration system

In order to improve the safety of ammonia-related refrigeration system, exhibitors in the field of freezing and refrigeration have been making continuous efforts to launch new equipment and solutions. Based on the NH_3/CO_2 cascade system technology mainly promoted previously, the NH_3/CO_2 cascade + micro-filling technology system, pure NH_3 microfilling system and equipment and technical solutions were exhibited in this exhibition. They reduce the filling quantity through the integration technology and significantly reduce hidden danger of ammonia - related refrigeration system in practice; In addition, special seminars such as "Sino-Danish NH_3 Refrigeration Safety International Forum" were arranged in this exhibition to promote the communication and development of ammonia-related refrigeration safety technology in the field, and learn from the experiences of technology application and management of international ammonia-related enterprises.

(3) The high-efficiency cooling and heating integrated unit has been developed

A large amount of condensation waste heat will be generated on the condensing side of the cold chain equipment during active refrigeration. However, the traditional refrigerating unit directly releases the heat into the environment without effective utilization. Several high-efficiency cooling and heating integrated units were exhibited in this exhibition, which effectively combine the freezing and refrigeration field and the application field of commercial air conditioning and industrial heat pump, and provide medium and high temperature hot water and vapor by utilizing the exhaust heat of refrigerating unit, saving a lot of energy for the domestic and industrial production. Moreover, the effective combination of refrigerating unit and heat pump unit has great advantages in improving space utilization and optimizing comprehensive system management.

(4) The "first kilometer" and "last kilometer" cold chain equipment has been developed

From the perspective of all links of the whole-process cold chain, attention has also been paid to the weakest link - precooling. A number of vacuum precooling devices, differential-pressure precooling devices and chilling water precooling devices and relevant modular equipment (such as Zhongji multi-functional modular combined refrigerating box) and supporting innovative refrigerating units (such as, Moon NH_3 micro-filling unit and ice slurry unit) were launched, to

provide equipment support for solving “first kilometer” of cold chain. In addition, the “last kilometer” of fresh food distribution has always been the development bottleneck of cold chain logistics. However, on this exhibition, automatic selling cabinet and vending machine (coffee maker, juicer and milk machine) were exhibited to support the distribution of the “last kilometer”.

(5) Ice and snow equipment development driven by the Olympic Winter Games

In order to welcome the 2022 Beijing Olympic Winter Games and respond to the national call of extensive promotion of ice and snow sports, many enterprises took it as an opportunity and launched characteristic refrigeration systems and equipment for winter sports venues and ski resorts in this exhibition. Taking the main refrigerating unit in the snow and ice venue for example, many enterprises have mainly launched NH_3/CO_2 cascade + micro-filling technology system and related integrated structural design and installation schemes, as well as the use of supporting integrated cooling and heating machine to provide hot water in living and recreation areas. Olympic Winter Games will greatly promote the vigorous development of ice and snow equipment and technologies in the next few years.

6.2 Characteristic technical products of cold chain equipment

In this exhibition, some special products were exhibited in every link of cold chain.

6.2.1 Supercooled water ice slurry unit

DISU ice slurry unit of Moon Environment Technology Co., Ltd. has broken through the key problem of crystallization prevention of supercooled water, and realized the technology of producing ice slurry with supercooled water. During ice-making, the refrigerating capacity generated by the direct evaporation of refrigerant cools the water in the ice storage tank to the -2 °C supercooled water through the supercooler in the ice slurry unit, and then releases the supercooling through the ultrasonic crystallizing device to generate ice slurry and then transport ice slurry to the ice storage tank through pipelines. The ice water is stratified due to different densities. The ice floats on the top of the tank and accumulates continuously. The water below is pumped continuously to produce ice slurry (Figure 2.6-1). The ice slurry produced by the supercooled water ice slurry unit can be used in pre-cooling or refrigeration of fruits and vegetables, which can save energy and operating cost by shifting peak load and high-efficiency accumulation of cold, and reduce the installed capacity and operating cost of the system.

Figure 2.6- 1 DISU Ice Slurry Unit of Moon Environment Technology Co., Ltd.

6.2.2 NH_3 micro-filling unit

Reducing the filling amount of NH_3 and improving the safety of the system is the development direction of the ammonia refrigerating unit. The GMCW-NH_3 microfilling chilling unit of Moon Environment Technology Co., Ltd. is a new product developed in this situation. It adopts screw refrigerant compressor, is equipped with condenser, evaporator, throttle valve and cooling water system. The unit is modular, compact and convenient in operation and management, can provide air-conditioning chilling water or low-temperature saline water. The unit uses the environmentally friendly natural working substance NH_3 and reduces the working substance filling quantity to the greatest extent. The unit includes the following characteristics: 1) Using permanent-magnet variable-frequency high-efficiency NH_3 semi-closed screw compressor, patented line; 2) Using U-turn+ board to replace microgravity fluid supply, with high heat exchange efficiency and small liquid amount; 3) Integrated oil separator, oil cooler and condenser, with compact structure and small volume; 4) COP=5.06 (Outlet at 0.5℃). NH_3 micro-filling unit, as shown in Figure 2.6-2, can provide ice water and precooling for dairy industry.

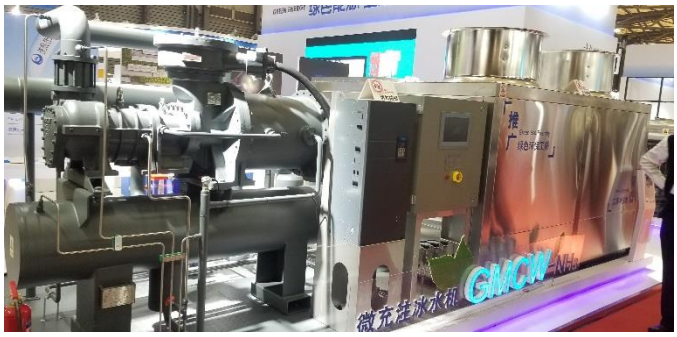


Figure 2.6-2 GMCW-NH3 Microfilling Chilling Unit of Moon Environment Technology Co., Ltd.

6.2.3 High-temperature water vapor machine

In the application field of freezing and refrigeration, such as dairy industry, livestock slaughtering and food processing enterprises, on the one hand, there is a large amount of condensation heat emission from the refrigeration system. On the other hand, a large amount of hot water and vapor is needed during processing. GWHS-HFO high-temperature water vapor machine of Moon Environment Technology Co., Ltd., as shown in Figure 2.6-3, uses new working substance R1336mzz (Z) to replace conventional R245fa. R1336mzz (Z) is a kind of environmentally friendly refrigerant with higher critical temperature than R245fa, GWP of 9 (which is much lower than 858 of R245fa; Adding regenerative cycle and preheating of filling water achieve improved overall energy efficiency ratio of the system; For possible scaling problems, the high temperature steam is generated by throttling, decompression and flashing to ensure the cleanliness of vapor.

Figure 2.6-3 GWHS-HFO high-temperature water vapor machine of Moon Environment Technology Co., Ltd.

6.2.4 High-efficiency phase-change refrigerating technology

GEPT-R290/CO_2 high-efficiency phase-change refrigerating machine of Moon Environment Technology Co., Ltd. shown in Figure 2.6-4 has the main innovation point of applying CO_2 refrigerating medium in the chemical industry field to replace conventional cold saline water refrigerating medium. Liquid CO_2 has weaker metal corrosion and is easy to operate and manage. The saline solution, conventional refrigerating medium for chemical industry, has large heat transfer temperature difference. CO_2 phase-change refrigerating medium has minimum change between the outlet temperature and the back temperature, and the efficiency is higher. By converting it to the same outlet temperature, its COP is increased by 10%.

Figure 2.6-4 GEPT-R290/CO2 High-Efficiency Phase-Change Refrigerating Machine of Moon Environment Technology Co., Ltd.

6.2.5 New refrigerator board

As shown in Figure 2.6-5, various forms of refrigerator boards were launched in the exhibition, with many board structure innovations, such as hook-type refrigerator board. It adopts eccentric hook locking linkage to make the refrigerator board installation convenient and is suitable for small refrigerators; Plug-in laminboard adopts hinge between PVC slot profile and metal panel to make EPS laminboard more firm and smoother after installation. The slot is filled with PU, which can effectively cut off the cold bridge. The fire rating of common polyurethane refrigerator board can be generally divided into A, B_1, B_2 (Grade A has the highest flame retardant rating, followed by the latter). The flame retardant rating of the mainstream refrigerator board exhibited in this exhibition has been upgraded to Grade B_1. In addition, the environmental protection materials and their application have also been improved accordingly.

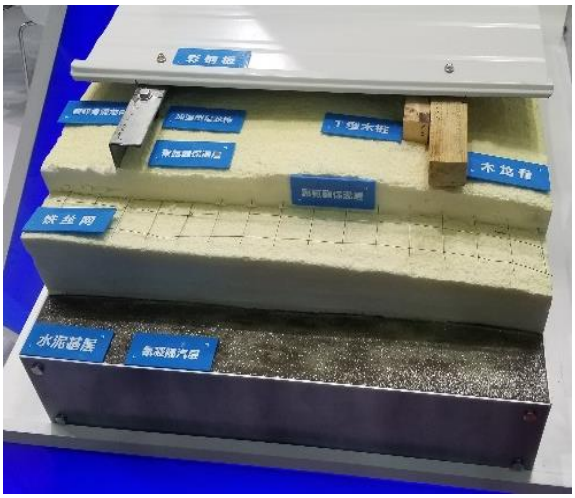


Figure 2.6-5 Layered Structure of Refrigerator Board

6.2.6 Multi-functional modular combined refrigerating box

Once the refrigerators with civil engineering and steel structure are constructed, their scale and functions are difficult to be changed with the market demand. In order to overcome the above

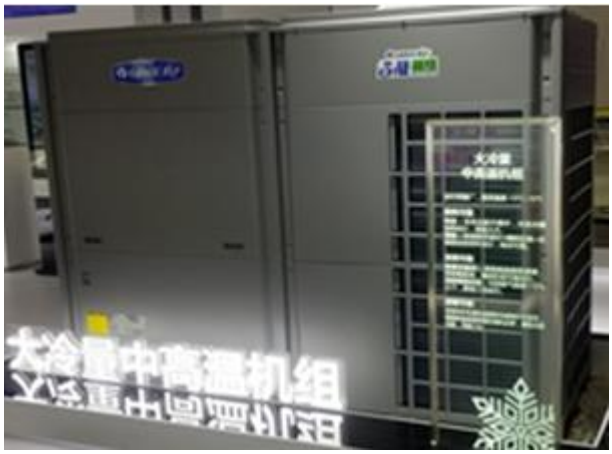
deficiencies, Zhongji Cold Chain Company exhibited a mobile multi-functional modular refrigerating box in this exhibition, as shown in Figure 2.6-6.

Figure 26-6 Multi-Functional Modular Combined Refrigerating Box

The modular refrigerating box is improved based on the original traditional refrigerated containers. The functions of pre-cooling, refrigerating and quick freezing can be separately configured in the refrigerating box as required. Single refrigerating box can also realize the function of refrigerating under multi-temperature zones. In addition, the multi-function modular refrigerating box can be freely configured and combined according to the demand of refrigerating capacity and refrigeration space. If not in use, it can be disassembled and moved at any time.

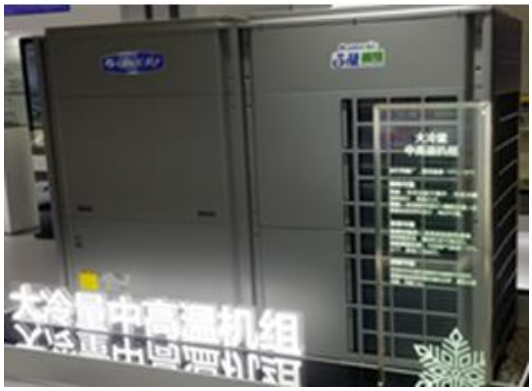
6.2.7 Intelligent condensing unit

When being used in refrigerated cabinet and refrigeration system of small refrigerator, such as display refrigerator, it can achieve multi-split. Gree has launched a medium and high temperature, all-DC variable-frequency and integrated intelligent condensing unit, as shown in Figure 2.6-7 The medium and high temperature unit with large refrigerating capacity shown in Figure 2.6-7(a) has the evaporating temperature of -15℃-10℃ and controllable exhaust temperature below 115℃. It adopts internal and external units communication or receives the opening and closing signal of the solenoid valve, directly controls the startup and shutdown of the compressor according to the storage temperature, to avoid invalid startup and shutdown; The all-DC variable-frequency air-cooled condensing unit shown in Figure 2.6-7(b) adopts an intermediate air-feeding compressor with two-stage compression. It is especially suitable for high pressure ratio operation, can control the storage temperature at -25℃-5℃; The integrated unit of the system shown in Figure 2.6-7(c) doesn’t need additional valve and electric cabinet when installation, and doesn’t need welding and onsite filling of refrigerant. It can operate only with external power supply.



(a)Medium and high temperature unit with large refrigerating capacity

(b)All-DC variable-frequency air-cooled condensing unit



(c)Integrated intelligent low-temperature condensing unit

Figure 2.6-7 Gree Intelligent Condensing Unit

6.2.8 High-efficiency CO_2 condensing unit

High efficiency CO_2 condensing unit of Carel Electronic (Suzhou) Co., Ltd. as shown in Figure 2.6-8 achieves adjustable refrigerating capacity of the system through DC variable frequency

compressor, so as to achieve low energy consumption. In particular, under part load, the optimal pressure control point is calculated to achieve the maximum energy efficiency ratio. The whole-range control algorithm of frequency converter can ensure the operation safety of compressor. Real-time terminal and refrigerator communication can achieve constant temperature control and ensure food quality. The application of CO2 transcritical control system in small condensing unit can achieve the optimal pressure control and achieve optimal COP of the system. The whole-range control of DC inverter compressor and advanced pressure and temperature control algorithm and real-time load feedback are used to optimize the system simultaneously, so as to achieve efficient refrigeration of the natural refrigerant, system reliability and food preservation; At the same time, the remote monitoring system can be combined to monitor the unit status in real-time and optimize and control the system intelligently, so as to further improve the efficiency and reliability of the system.

Figure 2.6-8 High Efficiency CO_2 Condensing Unit of Carel Electronic (Suzhou) Co., Ltd.

6.2.9 Ultra-low temperature freezing conversion cabinet

Ultra-low temperature freezing conversion cabinet of Qingdao Haier Special Freezer Co., Ltd. as shown In Figure 2.6-9 can achieve the -60℃ ultra-low temperature storage through high-efficiency single-stage dual-element regenerative heat refrigeration technology. The selection and proportion of mixing working substance (such as R290 and R170) are determined by the physical property parameters of refrigerant and its saturated vapor pressure curve; Regenerative cycle based on a single-stage compressed vapor refrigeration cycle can reduce the pressure ratio of the system and control the intensity of pressure of the vapor pipeline to reduce the slip temperature of the non-azeotropic mixed refrigerant, thereby increasing the refrigerating capacity of the system and achieving the set temperature. The product can be switched in general cold and low temperature

fields, with the temperature adjustment range of -15℃ to -60℃; At the same time, the stainless steel inner can be adopted to provide professional low-temperature storage for deep-sea high-end food materials such as tuna. In addition, the product has great freezing capacity and can freeze 60kg of food materials to under -18℃ within 24h.

Figure 2.6-9 Ultra-Low Temperature Freezing Conversion Cabinet of Qingdao Haier Special Freezer Co., Ltd.

6.3 Refrigeration system heat exchanger

In terms of heat exchanger, exhibits on this exhibition involves many structural forms of heat exchanger, including shell and tube heat exchanger, brazing plate heat exchanger, shell and coil (plate and shell) heat exchanger, high-efficiency tank heat exchanger, coaxial double-pipe heat exchanger, finned tube heat exchanger, microchannel heat exchanger. Brazing plate heat exchanger was very popular among them. Many manufacturers exhibited brazed plate heat exchanger series products. In this exhibition, manufacturers from all over the world not only exhibited a variety of heat exchangers, but also exhibited many surface treatment technologies of heat exchangers, such as surface coating technology.

6.3.1 Shell and tube heat exchanger

Jiangsu Wuxi Tongli Air Conditioning Equipment Co., Ltd. exhibited high-efficiency new shell-and-tube heat exchanger (as shown in Figure 2.6-10), to ensure that the refrigerant in each heat exchange tube conducts heat transfer at a uniform flow rate, to solve low heat transfer efficiency caused by gas-liquid stratification.

Figure 2.6-10 High-Efficiency New Shell-and-Tube Heat Exchanger

6.3.2 Plate heat exchanger

Brazed plate heat exchanger is one of the most popular heat exchangers in China Refrigeration Exhibition. The brazed plate heat exchanger is an upgraded version of sealed gasket-plate heat exchanger. It is composed of the front and rear baffles and the herringbone corrugated plates. The corners of adjacent corrugated plates are opposite. The peaks between the plate components cross with each other forming a large number of contact points. Through vacuum brazing, the brazing material is melted to generate alloy with the base material, so that every contact point between the plates becomes a welding point, which enhances the strength of the heat exchanger and improves the heat transfer efficiency. Jiangmen East-Alliance Thermal Equipment Co., Ltd. launched a large diagonal-flow brazed plate heat exchanger (as shown in Figure 2.6-11). The design of double-channel makes the heat exchanger provide better performance under full load and half load. It is suitable for refrigeration, refrigeration cooling and waste heat recovery.

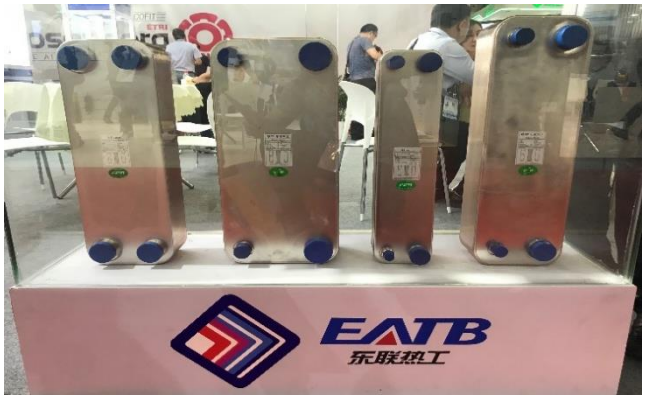


Figure 2.6- 11 Brazed Plate Heat Exchanger

Jiangyin Yalong Heat Exchanger Co., Ltd. exhibited B3 series removable plate heat exchanger and sheets for plate heat exchanger (as shown in Figure 2.6-12).

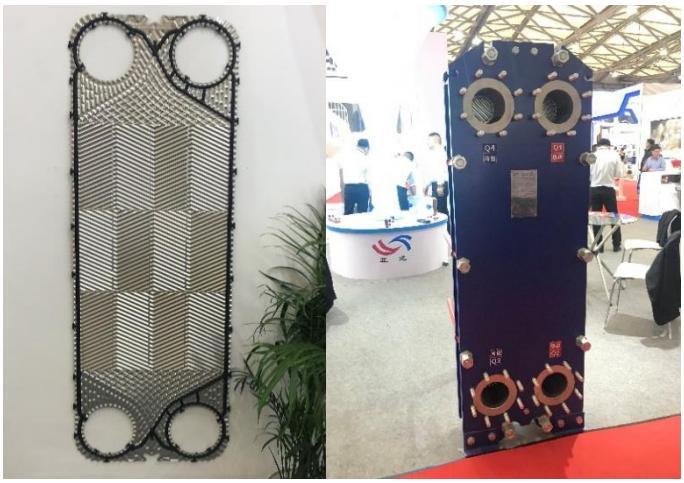


Figure 2.6-12 Removable Plate Heat Exchanger and Its Plate

South Korea DS developed the first "copper interface" plate heat exchanger (as shown in Figure 2.6-13) in the world.

Figure 2.6-13 Copper-Interface Plate Heat Exchanger

A plate heat exchanger exhibited by German Thermowave Company uses gasket plates with the design pressure up to 30ba, laser semi-welding plates with the design pressure up to 63bar (as shown in Figure 2.6-14).

Figure 2.6-14 Plate heat exchangers of Thermowave Company

A removable plate heat exchanger (as shown in Figure 2.6-15) exhibited by Shanghai Hengaoda Heat Exchanger Co., Ltd. is easy to maintain and clean. It adopts the unique herringbone corrugation, with high heat transfer efficiency, minimum logarithmic temperature difference of 0.5 °C. The plates are made of stainless steel 304, 316, titanium plate, etc., with strong corrosion resistance. The plates cover different specifications, such as shallow groove, deep groove and ultra-deep groove, and forming plate heat exchanger with narrow channel or ultra-wide channel after assembly. It is designed by combining the principles of plate heat exchanger and shell and tube exchanger. It composes of laser-welded sheet heat exchanger and the outer shell designed with the pressure bearing, to make two different medium flow through the plate stroke and shell stroke, respectively. It has compact structure, large heat transfer coefficient, high temperature and high pressure resistance, low pressure drop, and can combine in series to extend heat exchange length, or combine multichannel design in parallel.

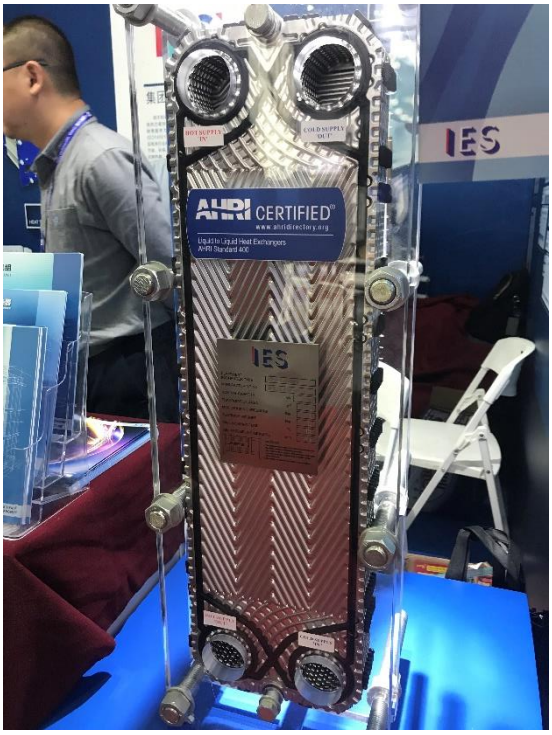


Figure 2.6-15 Removable Plate Heat Exchanger

6.3.3 High-efficiency tank heat exchanger

High-efficiency tank heat exchanger is suitable for various refrigeration (heat pump) systems, with water flowing in the inner tube, and refrigerant flowing in the interlayer between the inner tube and the outer shell, with even water flow speed and not easy for local freezing and scaling than plate heat exchangers. Zhejiang Forwon Plate Heat Exchanger Co., Ltd. exhibited high-efficiency heat exchange tank. The internal structure of the high-efficiency heat exchange tank is shown in Figure 2.6-16.

Figure 2.6-16 High-Efficiency Heat Exchange Tank

6.3.4 Coaxial double-pipe heat exchanger

SF150 series coaxial double-pipe heat exchanger exhibited by Jiangsu Weyee Heat Exchanger

Co., Ltd. has characteristics of spiral flow of medium, difficult scaling, less retained fluid and strong loading capacity. It is suitable for heat pump water heater, coal to electricity in Nothern China, constant temperature of swimming pool, etc.. Jiangyin Yalong Heat Exchanger Co., Ltd. exhibited SF200 series coaxial double-pipe heat exchanger (as shown in Figure 2.6-17)

Figure 2.6-17 Coaxial Double-Pipe Heat Exchanger

6.3.5 Finned tube heat exchanger

Figure 2.6-18 is the finned tube heat exchanger with coating exhibited by Hangzhou Wosi Enetgy-saving Technology Co., Ltd. and Shanghai Zhongjie Thermal Technology Center. The coating is P413 HereSite phenolic plastic coating, which is processed on the surface of the heat exchanger without exposure, hanging and flowing, and can strengthen the corrosion resistance of the heat exchanger.

Figure 2.6-18 Finned Tube Heat Exchanger and Anticorrosive Coating

6.3.6 Microchannel heat exchanger

Microchannel heat exchanger (as shown in Figure 2.6-19) exhibited by Changzhou Changfa Refrigeration Technology Co., Ltd. is mainly used for household and commercial air conditioners, air conditioner in machine room, vehicle air conditioner and supporting of heavy industry

machinery.

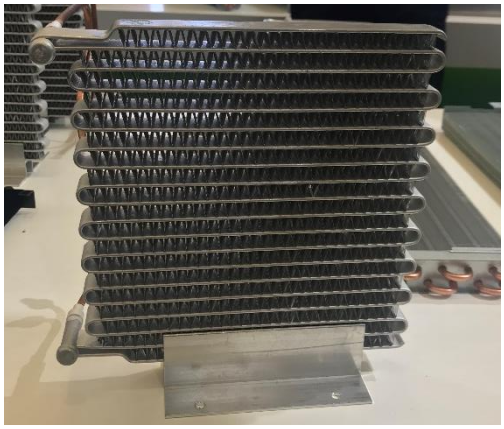


Figure 2.6-19 Microchannel heat exchanger of Changzhou Changfa Refrigeration Technology Co., Ltd.

A microchannel heat exchanger exhibited by Zhejiang SunCo Heat Exchange System Co., Ltd. adopts integrated NOCOLOK brazing and combines fin with aluminum alloy flat tube, to achieve small thermal contact resistance, significant improvement of thermal conductivity, no galvanic corrosion between high-alumina flat tube and aluminum fin and strong resistance to corrosion. It adopts louver fins to effectively break the air thermal boundary layer, reduce the heat transfer resistance, and long contact time between the air wave path flows and fin and enhance heat transfer.

Hangzhou Shenshi Energy Conservation Technology Co., Ltd. exhibited integrated microchannel heat exchanger and its internal section structure (as shown in Figure 2.6-20).

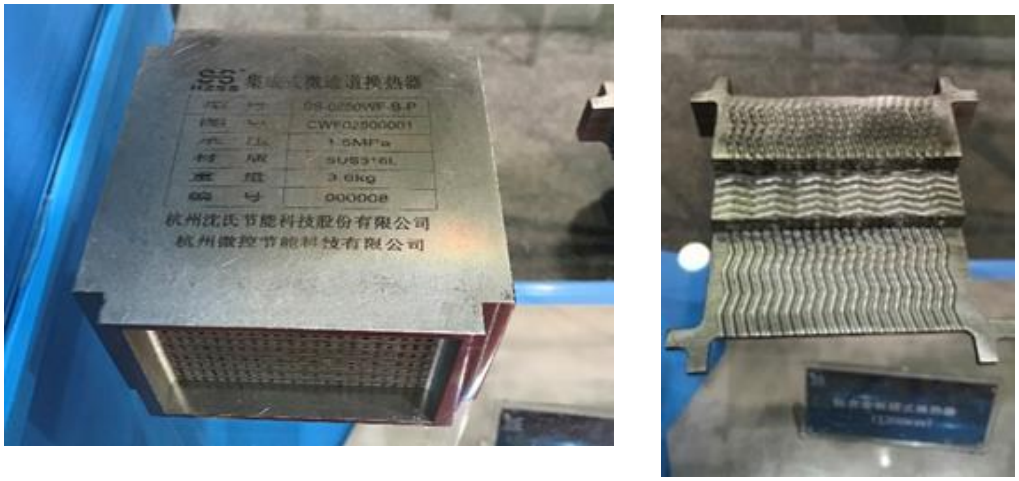


Figure 2.6-20 Integrated Microchannel Heat Exchanger and Its Internal Section Structure

Modular heat pump microchannel heat exchanger (as shown in Figure 2.6-21) exhibited by Sanhua (Hangzhou) Micro Channel Heat Exchanger Co., Ltd. is a 100% all-aluminium heat exchanger and is easy to recycle. The special fin design is convenient to drain water, reduces 30% filling amount of refrigerant, and is more environmentally friendly. The microchannel coating

solution launched by Sanhua (Hangzhou) Micro Channel Heat Exchanger Co., Ltd. includes standard 3102 aluminium alloy, long-life 3103mod aluminium alloy, TCP coating, electrophoretic AA coating and other schemes, which can extend the service life of the heat exchanged in corrosive environment.

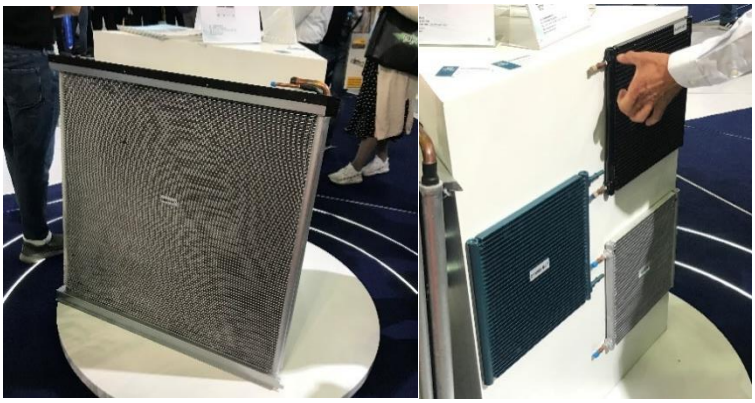


Figure 2.6- 21 Modular heat pump microchannel heat exchanger and coating

6.3.7 Tube-in-sheet evaporator

Changzhou Yunhai Refrigeration Equipment Co., Ltd. exhibited the tube-in-sheet evaporator (as shown in Figure 2.6-22). The tube-in-sheet evaporator is attached to the liner surface of the box of refrigerating chamber, and is used for single-door, multi-door direct-cooling refrigerators and direct-cooling of refrigerating chamber.

Figure 2.6-22 Tube-in-sheet evaporator

6.3.8 Roll-bond evaporator

Roll-bond evaporator (as shown in Figure 2.6-23) exhibited by Changzhou Changfa Refrigeration Technology Co., ltd. is suitable for freezing, refrigeration and other fields.

Figure 2.6-23 Roll-bond evaporator

6.3.9 Wire-tube condenser

Changzhou Changfa Refrigeration Technology Co., ltd. exhibited wire-tube condenser (as shown in Figure 2.6-24). Its system form has general cold type, strong cold type, compound type, back cold type, bottom cold type, etc..

Figure 2.6-24 Wire-tube condenser

6.3.10 High-efficiency heat exchange tube

Shanghai Weilian Heat Transfer Company launched a series of high-efficiency heat transfer finned tube products (as shown in Figure 2.6-25). High-efficiency heat transfer evaporator tube is suitable for flooded evaporator and falling-film evaporator, which can effectively reduce the filling amount of refrigerant in the system. The high-efficiency heat exchange evaporation tube has fish scale-like grooves on the outer surface, forming an interconnected circular passage under the surface layer of the tube. The micro-holes formed provide a large number of gasification core points required for evaporation and heat transfer, and promote the formation of liquid film evaporation with high efficiency in the process of liquid gasification, which reduce the liquid film and reduce

the thermal resistance, and utilize the capillary action of holes to make the liquid and bubbles to circulate in the circular passage and the holes. Utilizing the special structure of heat exchanger, the refrigerant can produce continuous bubbles under the condition of small degree of superheat, the evaporation heat transfer coefficient can reach up to more than 30 times of the light pipe. The fin structure of the high-efficiency heat exchange condensing tube is staggered and serrated, which can make the condensate flow in disturbed state, promote the convective heat transfer of the condensate film, reduce the liquid film, and increase the secondary action of the internal surface area and turbulence, and strengthen the total heat transfer capacity.

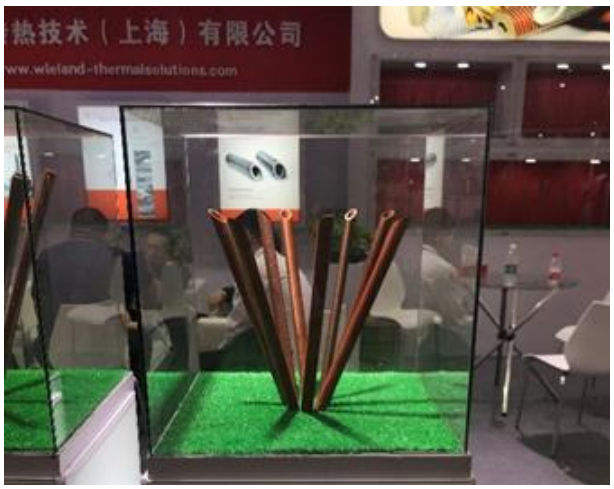


Figure 2.6-25 High-Efficiency Heat Transfer Finned Tube

6.4 Refrigeration system valves

The electronic expansion valve with low internal leakage (as shown in Figure 2.6-26) for freezing and refrigeration exhibited by Sanhua reduces the wear of valve port due to rotation and extends the service life of soft seal by setting a micro bearing in the valve needle, making the internal leakage level constant with that of solenoid valve. It can replace the solution of solenoid valve + thermal expansion valve. Ultra-quiet high-durable electronic expansion valve for multi-split unit (as shown in Figure 2.6-27) exhibited by Dun'an matches the quiet flow characteristic curve at valve port design and valve chamber runner structure, so as to reduce the refrigerant throttling sound; It improves the technical level in terms of bearing structure and working accuracy, increasing the service reliability and life of the valve.

Figure 2.6-26 Sanhua electronic expansion valve with low internal leakage

Figure 2.6-27 Dun'an quiet electronic expansion valve

Foshan Hualu Automatic Controls Ltd. exhibited several expansion valves for refrigeration system. For example, UKV-H electronic expansion valve (as shown in Figure 2.6-28) has large caliber and is suitable for commercial air conditioning and heat pump water heater. With significantly increased maximum operating pressure differential (MOPD), it can be used in cold regions and high-temperature regions. It also significantly increases the outlet temperature of heat pump water heater; For example, AEX-Z ultra-low temperature thermal expansion valve is suitable for the evaporating temperatures of -70℃ - -100℃ (R23) and 10~-70℃(R404A), and can be used in ultra-low temperature region below -100℃ and is suitable for preservation of tuna; For example, EPV high-durability solenoid valve (as shown in Figure 2.6-29) has the high-durable use times of 35 million, and doesn't need additional solenoid valve for liquid supply, and is suitable for display cabinet, freezing and refrigeration devices; For example, NSK high-precision pressure sensor can achieve the accuracy of ±%FS, and achieve high precision control in any climatic conditions in the world, and is suitable for commercial air conditioning, condensing units, water chilling units, heat pump water heater, etc.; For example, LKV quiet electronic expansion valve has the characteristics of quiet design, low valve leakage and available for coping with high reverse pressure.

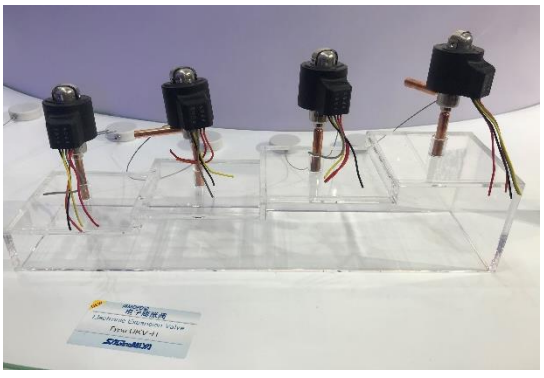


Figure 2.6-28 UKV-H Electronic Expansion Valve

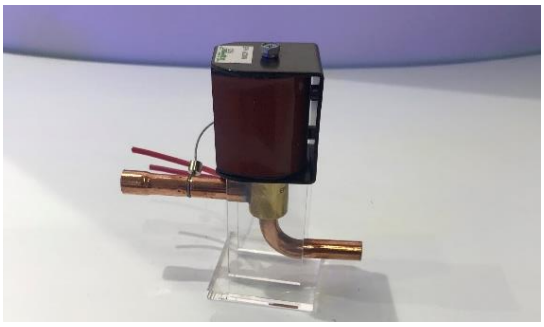


Figure 2.6-29 EPV High-Durability Solenoid Valve

For CO_2 refrigerant, many manufacturers exhibited expansion valves suitable for CO_2 refrigerant, such as, UKV-J controller for CO_2 refrigerant (as shown in Figure 2.6-30). It can be controlled and used under ultra-high pressure, with the maximum operation pressure of 15mpa. It can be used under supercritical condition, and is suitable for heat pump water heater, display cabinet, etc.; CV(B) series CO_2 one-way valve (as shown in Figure 2.6-31) exhibited by Dun'an Environment has the maximum operation pressure of 14MPa, applicable refrigerant temperature of -30℃-120℃, applicable environment temperature of -30℃-120℃ and minimum differential pressure for opening valve of 0.04 MPa.

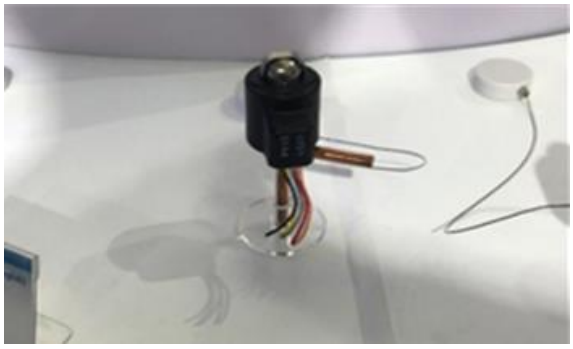


Figure 2.6-30 UKV-J controller for CO_2 refrigerant

Figure 2.6-31 CO_2 one-way valve

Dun'an Environment also exhibited ELF08 series dynamic balance electric regulating valve with iron flange (as shown in Figure 2.6-32). DSF series four-way valve (as shown in figure 2.6-33), has the characteristics of excellent commutating performance, improved system energy efficiency, low starting voltage and low power consumption.

Figure 2.6-32 Dynamic Balance Electric Regulating Valve with Iron Flange

Figure 2.6-33 DSP Four-Way Valve

6.5 Insulation material for refrigeration system

The modified graphite polyurethane compounds for B1 refrigerator (as shown in Figure 2.6-34) exhibited by Weihai Yunshan Technology Co., Ltd. achieves high-efficiency flame retardance by adding graphite flame retardant. It can be stably stored in polyurethane rigid foam for a long time, can effectively solve the problem of failure of traditional liquid flame retardant. The polyurethane rigid foam has the thermal conductivity of≤0.022W/(m·K) (25℃)/0.020 W/(m·K) (0℃), water absorption ≤ 2%, dimensional stability ≤ 1.0%, and compressive strength ≥ 200kPa.

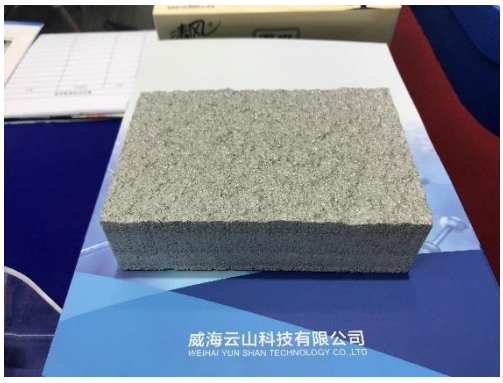


Figure 2.6-34 Modified Graphite Polyurethane Compounds for B1 Refrigerator

Wuhu Dajin New Material Technology Co., Ltd. launched a wide range of insulation pipes and coating copper pipes (as shown in Figure 2.6-35). They have high temperature flame retardant, multi-layer flame retardant and other different characteristics, and is suitable for single pipe and double pipes and extra-thick single pipe. The product is made of cross-linked polyethylene closed-cell foaming, realizes no interface crack in the inner pipe wall, no false welding and empty package of pipe, high temperature resistance, impact resistance, friction resistance, ageing resistance, small hygroscopic property, good insulation performance and no corrosion to copper and aluminum pipes. The whole series of coating copper pipes adopts 120 degree

high-temperature-resistant and insulated pipes for both cooling and heating. The copper pipes support the soft annealing copper materials for soft construction. The surface of the bell mouth is treated with smooth glazing to avoid the risk of air leakage. The nuts are subject to anti-cracking forging, which is convenient for accessories management and also saves construction preparation time. Refrigerant piping and installation accessories include Y-type splitter, insulation box of splitter and U-type splitter (as shown in Figure 2.6-36).

Figure 2.6-35 Insulation Pipes and Coating Copper Pipes

Figure 2.6-36 Refrigerant piping and insulation materials

Huamei company launched the alkadiene cryogenic insulation material (as shown in Figure 2.6 - 37). After the GB/T10294-2008 test, under cryogenic environment, the heat conductivity coefficient is 0.0127 W/(m·K) (-196 ℃), and 0.0242 W/(m·K) (-100 ℃), with no crack, good heat preservation effect and good flame retardant performance. It is widely used in the adiabatic process of production of liquefied natural gas, pipeline transportation, petrochemical ebgineering and other pipelines and equipment and insulation under other cryogenic environments.

Figure 2.6-37 Alkadiene Cryogenic Insulation Material

Wincell exhibited a variety of insulation material accessories, such as soundproof sponge, wave sponge, laminated rubber tape, duct tape, pre-cut pipe, film-coated sponge, filter screen, WFD composite rubber and plastic, WFC composite rubber and plastic, WFA composite rubber and plastic, Grade 0 rubber and plastic insulation material and special A insulation pipe (as shown in Figure 2.6-38).

Figure 2.6-38 Insulation Materials Accessories

6.6 Evaluation and prospection

Cold chain equipment as an important part of the China Refrigeration Exhibition, on the one hand, exhibited rapid development of technologies and products in all links of cold chain, such as the further development of precooling equipment for “the first kilometer” of cold chain and “the last kilometer” of fresh food distribution equipment. And the cold chain equipment technology is steadily developed to safety, environmental protection, high efficiency, energy-saving, multi-functionalization and intelligence. On the other hand, on account of that cold chain logistics and cold chain equipment are still in the initial development stage in China, it faces the challenges of weak research foundation, high energy consumption, low degree of automation, low level of

proprietary technology, and lack of competitiveness. Technical breakthrough and product R&D are required in the application of safe and environmentally friendly refrigerating medium and renewable energy sources, multi-functionalization of cold chain equipment and informatization of cold chain equipment, to expect that more enterprises can join the cold chain equipment industry to jointly build a cold chain logistics service system featuring “whole-process temperature control, sound standards, environmental protection and wide application”, and provide technical and equipment support for food safety.

Refrigeration system heat exchangers, expansion valves, etc. are important components of refrigeration and air conditioning systems, and are the key to building new refrigeration system forms and improving the performance of refrigeration systems. Various forms of heat exchangers have been exhibited in this exhibition, reflecting a high level of design and manufacturing. The development direction of heat exchanger is high efficiency, compactness and low filling capacity. The optimization of heat transfer performance can effectively improve the energy efficiency and performance of refrigeration system; The technology of heat exchanger with small pipe diameter and microchannel heat exchanger is an effective way to reduce the filling quantity of refrigerant, which is very important for the application of combustible refrigerant. In addition, in order to improve the dehumidification and defrosting performance of the refrigeration system, conducting various treatments on the surface of heat exchangers will also be an important development direction in the future. High-precision control and quiet design of throttling components, such as expansion valves, are a trend in the past few years and for a long time to come.

Insulation materials provide guarantee for the performance of refrigeration systems and related equipment. Improving thermal insulation performance is always its development trend. In the past few years, there were many safety accidents caused by the ignition of insulation materials. Therefore, another development trend of insulation material is the improvement of flammability. Insulation materials with high flame retardance, low heat conductivity coefficient, high stability and long service life will be an important development direction in the future.

III. Academic Exchange

(Professor Yan Chengchu, Postgraduates Zeng Ruixuan and Peng Songyang, Nanjing Tech University; PhD Candidates Xiao Hansong and Yang Zixu, Tsinghua University)

The academic exchange is the important content of CR 2019. During the exhibition, the organizing committee held 1 theme forum, 27 symposiums and 49 technical seminars. The scales and quantities of various academic exchange activities were unprecedentedly large. Centering on the exhibition theme **Cooperation & Innovation for Development**, the academic exchange activities analyzed the national policy guidance, paid close attention to the hot topics of the industry, focused on the industrial technology innovation and discussed the future development direction.

(I) Theme Forum

The year 2019 is a year in which the spirit of the 19th National Congress of the Communist Party of China is deeply and comprehensively implemented. To promote green development and establish a clean, low-carbon, safe and efficient energy system is a part of the important contents of the report delivered by President Xi to the 19th National Congress of the Communist Party of China. At the opening ceremony of the exhibition, Professor of Tsinghua University Li Xianting presided over the theme forum themed Cooperation & Innovation for Development. Four famous experts from home and abroad respectively conducted their deep analyses on the four topics: Analysis of China's Economic Development Situation, DC Building and Distributed Energy Storage, Advance Craftsmanship of Great Powers, and Connectivity, Digitisation and Industry 4.0.

1. Analysis of China's Economic Development

Director of the Regional Economy Research Center of Shanghai University of Finance and Economics Professor Liu Naiquan delivered a keynote speech entitled Analysis of China's Economic Development Situation at the invitation of the organizing committee. Starting from the four aspects — Analysis of the Current International Problems, Some Existing Problems in China, Basic Judgment on the Development Trend and Several Advices on Stable Development, Professor Liu Naiquan deeply analyzed the current economic development situation and pointed out that to strengthen the domestic market construction and promote international and regional cooperation and exchange would be an important measure to ensure China's stable economic development when the international economic development environment was severe and China's economic growth speed slowed down.

First, Professor Liu pointed out that China's economic development was facing a complex international environment: Since the 2008 financial crisis, the global economy had not get rid of the shadow of the 2008 financial crisis and it was facing a downward pressure; when the economic

growth speed slowed down, deglobalization and trade protection behaviors such as the U.S. withdrawal from TPP and Brexit occurred frequently, the benchmarking effects of the trade protection behaviors and the related effects adversely affected the global economy; besides, the economic position of the United States had been challenged, the United States had regarded China as its rival; though the Sino-U.S relations would not fall into "the Thucydides's Trap, the competition would not be avoidable and the frictions and conflicts would be normal.

In the context of a poor international economic development environment, Professor Liu pointed out that there existed five prominent problems in China's economic development: (1) Affected by the global decelerated economic growth, the Chinese economy is shifting from a high-speed growth to a medium-to-high-speed growth and the economic growth speed is obviously slowing down. (2) Affected by the decelerated economic growth of China, the employment and poverty problems are becoming increasingly prominent and the college graduate employment problem has become the focus. (3) The Chinese demographic dividend problem and population aging problem have begun to appear. In China, the traditional demographic dividend is gradually diminishing while the population aging problem is becoming more and more prominent. A "getting old before getting rich" situation is approaching. (4) There is a great gap in innovation ability between China and developed countries and the dependence on foreign technology is obvious. (5) In China, the two leading industries — the real estate industry and the automobile industry — are cooling down, which puts pressure on the economic growth to slow down. We need to carefully consider the internal problems that affect the economic development of China.

Professor Liu offered his basic judgments on the current Chinese economic development situation based on the analysis of the current international and domestic environments. At present, the Chinese economic growth is at the bottom of the long economic cycle — an adjustment stage. According to the economic cycle theory, the Chinese economy will maintain a medium-to-high-speed growth of 6% in the near future and its growth speed will gradually get close to the global average growth speed. Whether China can promote its independent innovation level and become a country with high-level scientific and technological innovation capability is the key to the continuous stable growth of the future Chinese economy and the successful economic progress out of the adjustment stage at the bottom of the cycle. In addition, the effects of consumption on economic growth will be prominent. China will be a consumption power as well as a large consumption country in the world economy. Furthermore, the market potential enhancement and the business environment improvement will attract foreign investments.

"Only to clearly understand the current international economic situation and formulate policies and strategies suitable for the markets and the actual national conditions enables us to remain invincible in the future economic competition." To ensure the sustained and stable economic

development of China, China should promote the technical progress and innovation ability upgrade by opening wider the door to the outside world, comprehensively carry out international and interregional cooperation, strive to expand the domestic market and turn China into a consumption power, and formulate the urbanization strategies and the greater city cluster development strategies.

2. DC Building and Distributed Energy Storage

Academician of the Chinese Academy of Engineering and Professor of Tsinghua University Jiang Yi delivered a keynote speech entitled "DC Building and Distributed Energy Storage". He pointed out in his report that China should adjust the electric power system architecture and develop and promote the energy consumption mode of "DC Building + Distributed Energy Storage" to solve China's unbalanced distribution problem of renewable energy sources and mismatch problem of the source side and load side of the grid.

First, the report reviewed the AC and DC development history: 100 years ago, AC defeated DC fore AC had some very good advantages. For example, AC could be transported for a long distance, it could be easily transformed into mechanical work, it could be easily controlled and the electric spark caused by AC could be easily extinguished. However, in the 21st century, great technical changes have taken place, the breakthrough of electric power technology and electronics has made various highly efficient conversions and voltage transformations, and inverter control has become the main regulation and control means of motors and it needs DC, which has caused people to pay great attention to the application of DC again. Now, to relieve the climate change, all the countries of the world need to greatly reduce their carbon emission while they need to meet the enormous energy demands to promote social and economic growth and improve people's standards of living. Therefore, to carry out the energy supply side reform, take low carbon measures and ensure safe and clean energy is the only approach to achieving the above-mentioned targets. The core of energy adjustment is to develop renewable energy and provide enough flexible electric power sources so as to facilitate the multi-energy mutual complement and the supply and demand matching among the random energy sources based on renewable energy sources.

However, at present, the renewable energy development of China mainly faces two dilemmas —unbalanced distribution of renewable energy sources and mismatch of the source side and load side of the grid. To get rid of the renewable energy development dilemma of China and promote the structure revolution of the Chinese energy industry, Academician Jiang described the "DC building + distributed energy storage" system from the problem start to the reform method in simple words.

At present, many people have given up wind power generation and solar power generation because there exists a great difference between the peak power demand and the valley power demand and there is not enough flexible power sources so that wind power and solar power cannot be effectively connected with the grid, which has become the bottleneck of wind and solar power

development. In the future electric power system of China, the western part will be the production base of renewable electric power, the eastern part will receive electric power from the western part and use the received power and nuclear power generated along the coast as the basic electric power source to meet the demand of the basic power load. Meanwhile, the thermal power will the peak adjustment power source and it is used to satisfy the requirement of the load change between the peak load and the valley load of the load side. To deal with the changes in the power demand of the load side, the peak load regulation plan for finding peak load regulation power sources and developing large-capacity power storage has become the key to the future renewable energy development of China. In recent years, new power storage methods such as pumped-storage hydroelectricity, compressed air energy storage, flywheel energy storage and battery energy storage have constantly emerged. Among them, the technology of battery energy storage is relatively mature, its efficiency is relatively high and it has taken an important position in the energy storage and peak load regulation. The closer to the load end the battery position is, the higher the generated efficiency is. Considering from the angle of removing the difference between the load peak and the load valley in a building, it is better to place the battery inside the building.

Though developing the "DC building + distributed energy storage" mode has many advantages, it also faces a lot of problems. Viewing from the power distribution aspect of the external power grid, after a distributed energy storage mode is adopted, a building can receive electric power from the power grid according to a constant power, which greatly reduces the distribution power of the external power grid and enhances the power supply reliability. Viewing from the AC to DC conversion of the electrical appliances used in a building, every end device needs DC supply and the electric power output by photovoltaic power generation equipment is DC. Therefore, DC buildings can maximize the output of photovoltaic power generation equipment and the "DC building +distributed energy storage" mode brings a huge advantage to the electric power system of the building. However, the system is still facing a series of problems. For example, the relevant standards and design methods are not mature yet, the system architecture and the node mode need to be further researched, etc.

Academician Jiang cited a part of the contents of the 6th Session of the Central Leading Group on Financial and Economic Affairs of the CPC presided over by General Secretary Xi — 4 "revolutions" and 1 "cooperation" and pointed out that we should have a sense of urgency and a sense of crisis on developing the DC building + distributed energy storage mode. Academician Jiang believed that to promote the DC building + distributed energy storage mode has very important significance and it will be an important part of the Chinese energy revolution. The air conditioning and refrigeration industry should take active measures to adapt to the change and deal with the challenge. In addition, developing flexible power consumption end devices and operation

modes is also imperative. Finally, with strong expectation, Academician Jiang hoped that the "DC building + distributed energy storage" mode would be developed and promoted first in China.

3. Advance Craftsmanship of Great Powers

Director of China Refrigeration Expo Expert Committee and Consultant Chief Engineer of Beijing Institute of Architectural Design Professor Wu Desheng delivered a keynote speech entitled Advance Craftsmanship of Great Powers. Started from his personal experiences, Professor Wu emphasized that the design, manufacturing, operation and debugging of architecture, construction equipment, air conditioning and refrigeration systems, etc. belong to the work of craftsmen and the people who do such a kind of work need to have craftsmanship. With his feelings, sentiment and innovative profound understanding of craftsmanship, Professor Wu explained the content of the craftsmanship of great powers, the characteristics of craftsmanship and how to cultivate craftsmen of great powers.

In October 2012, Professor Wu delivered a keynote speech entitled "Feelings of Craftsmen" at an important forum, the speech had advance innovative significance and it fully reflected the feelings of the ordinary craftsmen. During the two sessions, on March 5, 2016, Premier Li Keqiang pointed out in the Report on the Work of the Government that we should cultivate the craftsmanship with a constant improvement desire. Based on the expectation of the grass-root workers, the Report on the Work of the Government greatly inspired Professor Wu and enabled him to more concentrate on studying and discussing craftsmanship, craftsman characteristics, craftsman cultivation, etc.

First, Professor Wu disclosed the content of the craftsmanship of great powers. He pointed out that craftsmen of great powers meant national-level great craftsmen. Analyzing the content at the national level, the Chinese nation boasts thousands of years of cultural history, it used to base itself on agriculture and agriculture was just a work form of craftsmen. Therefore, China is a nation with the characteristics of culture + craftsmen. Historically, the Chinese nation made important contributions to the world, which reflected these characteristics. The philosophy, dialectics, epistemology and pedagogy of the Chinese national culture at present still have great influences in the world. For example, Lao Tzu, Mo Tzu, Taoism, the Book of Changes, etc. belong to the Chinese philosophy and Sun Zi Warcraft, Confucianism, traditional Chinese medicine, etc. belong to the Chinese application sciences. The Chinese national craftsmanship with a long history shows that the Chinese national laborers have hard-working and ingenious laborers with precious craftsmanship. The craftsmanship has brought the world one great invention after another, such as compass, gunpowder, papermaking technology and printing technique. All the great inventions are the results of the labor and wisdom of the Chinese national craftsmen. At present, the whole world still approves these great contributions.

In the later several hundred years, sciences, technology, academic learning, scientific

experiment tools, etc. greatly developed and achieved good results in the world. For example, mathematics, physics, electricity, logics, statistics, experimental studies, inductive method, etc. all reached the application level and promoted the progresses of mankind. However, China, as a country with an ancient civilization, did not catch up with the progresses. On the contrary, some countries with only several hundred years of history got the opportunity, their start and development processes were in the progress period, they achieved the late-move advantages and many leading scientific and technological results.

Combining the dream of revitalizing the Chinese nation proposed by President Xi, Professor Wu said that the dream of revitalizing the Chinese nation instructed us to admit, learn from, catch up with and surpass the leading countries with the late-move advantages. We should make use of the modern scientific and technological means to distinguish and examine the contents of the ancient culture and we should judge, develop, correct and supplement the contents. Nobel Prize Winner Tu Youyou did very successfully in this aspect. Combining the craftsmanship, Professor Wu pointed out that we should have a macroscopic understanding of industrialization besides that we should learn from the countries with an excellent craftsmanship tradition to keep, develop and enhance our craftsmanship. Because our country is in the stage of the transformation from Industry 3.0 to Industry 4.0, We are lagging behind the countries with the late-move advantages in many aspects such as solution selection, debugging after construction completion, operation management, maintenance, data accumulation, service life and.

Finally after Professor Wu analyzed the dream of revitalizing the Chinese nation, combining the instructions of the central government, he gave the following suggestions to our professional entrepreneurs, scholars, students and craftsmen to deal with the uncertainty of the world situation in recent years: (1) Hold on and failure is not an option. (2) Find time to learn, read and enrich yourself. (3) Correctly treat the disadvantages caused by the examination-oriented education system in your growth process. (4) Often do the actual work personally at the first line and learn the application of new technological means. The suggestions of Professor Wu are based on the industry, but not limited to the industry. They have indicated the national talent cultivation direction.

4. Connectivity, Digitisation and Industry 4.0

As an EUROVENT member, Doctor Thomas Schräder from VDMA Germany delivered a keynote speech entitled Connectivity, Digitisation and Industry 4.0. In the trend of Industry 4.0, connectivity and digitalization have become the trend of industrial production. Facing the new challenges of Industry 4.0 to the production, application and management of refrigeration and air conditioning products, the industry should actively adapt to the new situation and actively transform so as to “survive as one of the fittest”.

The rise of Industry 4.0 will trigger a brand-new innovation in the industrial circle. To give full

play to digitalization, cloud concepts, interconnection, intersection and AI ideas can tremendously change the traditional industrial ideas. This is an important industrial revolution in the history of mankind. Taking the global close connection in many aspects such as trade, flights, information and networks for example, Doctor Thomas first pointed out that the world was interconnected. At present, the scale of the global interconnected equipment is much larger than the scale of the global interconnected people. Besides, in the actual world, various technology, quality, security, environment protection standards, laws and regulations have provided a good foundation for the interconnection of cargos, manpower, information and capitals. Therefore, connectivity has huge commercial values and it can be applied in many aspects such as government management, industrial production, energy, materials, traffic, transport and e-commerce.

Then, Doctor Thomas pointed out that Industry 4.0 could be regarded as a typical application of connectivity in the industrial production aspect. Doctor Thomas briefly reviewed the histories of the four industrial revolutions. He pointed out that the industrial interconnection was the demand of the digital transformation. Its specific performance was that the highly specialized data management supported the highly specialized mechanical production. To achieve Industry 4.0, the previous relatively fixed industrial chain mode needs to gradually transform into more flexible and modularized production mode. The "digital twins" formed by mapping the offline actual product chain and the cloud virtual data will completely change the current commercial mode. As for digital transformation, Germany has adopted three typical approaches, including Industry 4.0, intelligent services and system autonomy. It has reconsidered and defined the influences of digitalized transformation on production processes, work places, commercial modes, ecological systems, societies, laws and moral.

Industry 4.0 will be the connectivity applied in the industrial production while the high-speed information interaction network will be the foundation of the Internet of Everything. Therefore, the importance of the 5G network for Industry 4.0 is self-evident. At present, all the major economic entities of the world such as the United States, the European Union, Japan and China have done some researches on the 5G network frequency spectrum. The establishment of the Open Platform Communications – Unified Architecture (OPC UA) of VDMA Germany for Industry 4.0 facilitates the development of the high-speed interactive communication.

Finally, Doctor Thomas talked about the effects of digital transformation on the whole refrigeration and air conditioning industry. On the one hand, to adapt to the new changes, the production, application and management of refrigeration and air conditioning products will face various new challenges. On the other hand, abundant ventilation and cooling demands of the computer rooms for data processing and storage will bring the industry many development opportunities and benefits. Therefore, we need to actively adjust our attitudes, actively embrace the

changes and become a victor of digital transformation, as Charles Darwin pointed out in the Origin of Species: “It is not the strongest of the species that survive, nor the most intelligent, but the one most responsive to change.”

(II) Symposium

The organizing committee planned and held 27 symposiums on 25 topics at the Expo. The symposiums were divided into three major categories: international exchange, innovation inspiration and hot topics. The following is about the general situation of some symposiums.

2.1 International exchange

China Refrigeration Expo is an important international academic exchange platform and the exchange on the industrial development trend that attracts the worldwide attention is a part of the important contents of every year's refrigeration expo. This expo held many international exchange meetings and discussed the international cooperation, the industrial development direction guidance, etc.

(1)Sino-Danish Ammonia Refrigeration Safety International Forum

On the morning of April 9, 2019, a highlighted forum — Sino-Danish Ammonia Refrigeration Safety International Forum — of CR 2019 Symposiums was grandly held at Shanghai International Convention and Exhibition Center. The international forum was jointly hosted by the Embassy of the Kingdom of Denmark in China and the Chinese Association of Refrigeration and co-organized by the Organization Committee of China Refrigeration Expo and Danfoss China. Over 200 people from Chinese and Danish governments, scientific research institutions, industries, universities, and the relevant design, manufacturing, installation and use organizations attended the forum and they carried out a brainstorming session on green refrigeration. This international forum was presided over by Deputy Secretary General of Chinese Association of Refrigeration and expert of the domestic ammonia refrigeration technology and application Mr. Yang Yifan.

In recent years, China has paid high attention to the cold chain infrastructure construction in China and issued some relevant policies to support it, and the Chinese cold chain infrastructure construction has developed very rapidly, especially the refrigeration house construction. Meanwhile, the Chinese refrigeration industry also faces multiple challenges such as safety, environment protection and efficiency. In this background, the successfully held Sino-Danish Ammonia Refrigeration Safety International Forum is of benchmarking significance to the food processing and refrigeration house industries.

The keynote speech part of the forum was really brilliant. Authoritative experts and scholars from government departments, industrial organizations, design institutes, production and installation enterprises shared their interesting, profound and high-level speeches with the guests who were present at the forum and they deeply explored the refrigeration storage and ammonia refrigeration application fields from different angles.

Director General of the Ministry of Environment and Food of the Kingdom of Denmark Annelise Fenger delivered an opening report entitled "Refrigeration-related Operation of the Danish

Food Industry and Introduction to the Policies of the Ammonia Refrigeration Industry". Deputy Secretary General of Chinese Association of Refrigeration Yang Yifan, Chief Engineer of Huashang International Engineering Co., Ltd. Ma Jin, Director of the Industrial Refrigeration Department of Danfoss Karsten and Deputy Chief Engineer of Yantai Moon Group Co., Ltd. Jiang Shaoming respectively delivered their keynote speeches entitled "Analyses and Countermeasures of the Current Work Safety Conditions of Chinese Ammonia Refrigeration Enterprises", "National Standards and Ammonia Refrigeration Safety for New Refrigeration Engineering", "Future Road of Ammonia Refrigeration Safety" and "Brief Discussion on the Technological Progress of Ammonia Filling Volume Reduction".

At the forum, Senior Engineer of the Industrial Refrigeration Department of Danfoss China Huang Zhihua deeply explained a standard entitled "Ammonia Refrigeration System Safety Evaluation Methods". The standard is the first industrial standard for social organizations officially issued by the Chinese Association of Refrigeration. The formulation and implementation of the standard is of positive significance to the safety management of the Chinese ammonia refrigeration industry. Therefore, the organizing committee and co-organizers of the forum sincerely hope that more industrial organizations, more enterprises and more government departments will adopt or refer to the industrial standard to guide and promote the safety evaluation work of the ammonia refrigeration system and raise the safety management level of the industry to a new level.

(2) 2019 Ozone Climate Industry Roundtable

The 2019 Ozone Climate Industry Roundtable Conference was held in E2M19 Conference Room of China Refrigeration Expo on April 10. Taking "ozone depletion" and "global warming" as the background, the conference invited officials and technical experts of competent government departments and business people from multiple countries and regions to discuss feasible industry solutions around themes such as refrigerant substitution and global warming reduction. The Conference has four main topics: (1) the policy trend on ozone climate substitution technologies; (2) the international trend of refrigerant substitution; (3) discussions about ozone climate technology problems; (4) the industry's efforts to facilitate the development of ozone climate technologies. Vice President and Secretary-General of China Refrigeration and Air conditioning Industry Association Zhang Zhaohui presided over the roundtable conference, at which the representatives of China's Ministry of Ecology and Environment, relevant UN organizations, industry associations and industries from America, Europe, Japan and other countries and regions delivered extraordinary reports.

In the context of Vienna Convention for Protection of the Ozone Layer and Montreal Protocol on Substances at Deplete the Ozone Layer, centering on the theme "refrigerant substitution policies and progresses in China's refrigeration and air-conditioning industry", Jin Zhao, an official of the

Foreign Economic Cooperation Office, Ministry of Ecology and Environment, PRC, gave a detailed introduction to the relevant situation of the refrigerant substitution policies and progresses in China's refrigeration and air conditioning industry, responding to the Kigali Amendment, the refrigeration industry's agreement fulfillment, and the routes of refrigerant substitution technologies.

Ozone Operation Consultant of the United Nations Environment Programme (UNEP) Alvin Jose delivered a report entitled "The Policy Trend of Ozone Climate Friendly Technologies". Based on the discussions about the Montreal Protocol's influence on refrigerant technology development, the Kigali Amendment's facilitation of ozone climate friendly technologies and the challenges to ozone climate friendly technologies, Alvin Jose explained the situation, influence and development problems of ozone climate friendly technologies.

President of Indian Society of Heating, Refrigerating and Air Conditioning Engineers (ISHRAE) Mr. Vikram Murthy delivered a special report entitled "India Cooling Action Plan — Overall Policy Framework for the Refrigeration Industry". He pointed out India Cooling Action Plan (ICAP) was formulated together by multiple groups and the Ministry of Environment, Forest and Climate Change (MoEFCC). The plan involves multiple aspects and aims to connect energy efficiency with the transition policy for lowering the global warming potential (GWP), so as to acquire relevant data in the country and win the support of more refrigeration experts.

Expert of United Nations Development Programme Mr. Anderson Alves delivered a speech entitled "Global Alternative Refrigeration Technologies: Issues and Progresses". The speech suggested the global alternative refrigerant technologies still faced many obstacles and challenges, and the manufacturing sector, service sector, installation sector and more sectors must work together to realize the low GWP faster.

President of American Air Conditioning, Heating and Refrigeration Institute Mr. Stephen Yurek and Secretary-General of European Partnership for Energy and Environment Ms. Andrea Voigt respectively delivered speeches entitled "HFC Reduction and Alternative Development" and "Experiences of European F-Gas Regulation Implementation", which showed us the efforts of the Western countries to develop refrigerants and protect the ozone layer.

After that, Deputy Chief Engineer of Moon Environment Technology Co., Ltd. Ms. Jiang Shaoming, Chairman of Heilongjiang Arco Technology Mr. Han Xingwang, Deputy Director of Zhuhai Gree Electric Mr. Wang Xianlin, and Director of Emerson Climate Technologies (Suzhou) Mr. Guo Weihua respectively delivered extraordinary speeches entitled "Studies on Reducing NH3 System Refrigerant Charge", "Application of Carbon Dioxide in the Domestic Cooling and Heating Industry", "The Key Technology, Application and Promotion of R32 Commercial Air Conditioner Devices", and "Researches and Development on R290 Refrigerant Technologies and Application",

and gave a detailed introduction to refrigeration optimization studies and the application and development of new-generation refrigerants in the country.

In the end, Vice President and Secretary-General of China Refrigeration and Air-Conditioning Industry Association Mr. Zhang Zhaohui and Secretary-General of Japan Refrigeration and Air Conditioning Industry Association Mr. Tetsuharu Okada respectively delivered special reports entitled “Chinese Industry Development Trend: Efforts and Challenges” and “Ozone Climate-Friendly Technology Transformation: Progresses and Expectations of the Refrigeration and Air-Conditioning Industry”. The detailed and in-depth reports respectively described the issues and challenges in Chinese and Japanese industries on multiple levels, and looked into the future development trend of the refrigeration industry.

(3) Sino-Indian Cold Chain Forum

In the past 10 years, the Chinese Association of Refrigeration and ISHRAE have established a close partnership. The two sides cooperated in a wide range of areas, including academic research, information exchange and technological innovation. At the expo, the Chinese Association of Refrigeration facilitated and contributed to the close cooperation between China Refrigeration Expo and ACREX India on behalf of the Organization Committee of China Refrigeration Expo. Therefore, the success of the first Sino-Indian Cold Chain Forum marked the integration and combination of bilateral technological exchange and exhibition cooperation. It is the new milestone for the cooperation between the Chinese Association of Refrigeration and ISHRAE, and China Refrigeration Expo and ACREX India.

Researcher Tian Changqing from the Technical Institute of Physics and Chemistry, Chinese Academy of Sciences, presided over the forum. President of the Chinese Association of Refrigeration Professor Jin Jiawei, President of ISHRAE Mr. Vikram Murthy, the former President of ISHRAE Mr. Vishal Kapur and other leaders attended the forum.

At Sino-Indian Cold Chain Forum, on the Indian side, Mr. Vishal Kapur described the development of Indian cold chain market and the situation of REFCOLD India, stated that the Indian cold chain market was in the development process from productivity promotion to the industry chain optimization and it had enormous potential and many opportunities. The convener of REFCOLD India 2019 Jeson Sebastian explained to us the business opportunities brought by REFCOLD India. The former President of ISHRAE Mr. Vishal Kapur gave a detailed introduction of Indian government’s supervision policy, guidance policy and other relevant policies to overseas companies to invest and build factories in India. On the Chinese side, Vice General Manager of Beijing Zhixindao Sci-Tech Ms. Yang Ping made a comprehensive and detailed analysis of the development of China’s cold chain equipment industry. Indian General Manager of Moon Environment Technology Co., Ltd. Mr. Gao Rongjian gave a detailed introduction of the R&D and

application of the cold chain technologies of Moon Environment Technology Co., Ltd.

In the end, to help China and India strengthen their cooperation in the commercial cold chain industry and carry out more in-depth exchanges, Manager of the Indian Marketing Department of Fujian Snowman Mr. Shiv Kumar, Vice General-Manager of Dalian Bingshan International Trade Mr. Wan Guohua, and Indian Country Manager of Indian Sanhua Holding Group Mr. Saurabh Bhanot respectively delivered special speeches about Sino-Indian cold chain industry cooperation and overseas strategic investments.

2.2 Innovation Stimulation

China Refrigeration Expo 2019 attaches great importance to the stimulation of innovative products R&D and the promotion of innovative talents cultivation. This year, the "China Refrigeration Expo's Innovative Products Forum" was held as scheduled. In order to commend talents who have made outstanding contributions to the refrigeration and air conditioning industry, the "Senior Engineer Forum" was held for the first time on the Exhibition. The organizing committee also organized the "Summit Forum for Young and Middle-aged Designers in Refrigeration and Air Conditioning Industry" so as to motivate the industry to cultivate more outstanding talents.

(1) 2019 China Refrigeration Expo's Innovative Products Forum

The "2019 China Refrigeration Expos's Innovative Products Forum" was held during this Expo, where representatives from universities and enterprises made detailed analysis about innovative products in refrigeration industry, such as GWHS-HFO High Temperature Water/Steam Integrated Machine, Steam Expander and Danfoss CO2 Adaptive Liquid Management Solution, etc. This forum was presided over by Professor Li Xianting from Tsinghua University, with five other professors, including Professor Ma Guoyuan from Beijing University of Technology, making special reports, which attracted numerous attendees and received overwhelming response.

Professor Ma Guoyuan of Beijing University of Technology gave an opening report entitled "Analysis of Innovative Products Application in China Refrigeration Expo". Professor Ma emphatically introduced the application and evaluation process for innovative products, elaborated the purpose, standards and scope of the application, and explained its process as well as required materials in detail. In the end, Professor Ma declared the winners of all kinds of innovations in 2019.

Engineer Pei Yonghua, marketing manager of electronic control and service department of Danfoss business division, made a report entitled "Danfoss CO2 Adaptive Liquid Management Solution". Manager Pei emphatically explained the operational principle and important components of the transcritical adaptive liquid management system, and summarized its advantages and application scope.

During the report "Promotion and Application of GWHS-HFO High Temperature Water/Steam Integrated Machine", Engineer Wen Chenyang of Yantai Moon Co., Ltd. comprehensively and introduced the company's R&D and application of the machine in detail.

Deputy General Manager Li Jun of Wuhan New World Refrigeration Industrial Co., Ltd. made a report entitled "Steam Expander and Its Application", who pointed out that current situation of energy consumption in China is not optimistic, and introduced the working principle and application of steam expander in detail from three aspects, namely steam expander, steam expander set and the application of steam expander by associating with various engineering cases.

He Yaping, Deputy Director of the Technology Center of Zhuzhou CRRC Times Electric Co., Ltd., made his report on "Current Situation and Development Prospect of Large Central Air Conditioning Variable Frequency Drive System". The report introduced current industry background and technical background of HVAC in China, showing that the improvement of electric drive efficiency of central air conditioning has become the focus of the industry. In the end, He made his prospect on central air-conditioning drive system and forecasted that frequency conversion, permanent magnetism, high speed and integration will become the development direction for the next generation of central air-conditioning electric drive system.

(2) Senior Engineer Forum

The first "Senior Engineers Forum of China Association of Refrigeration" seminar was held during the Expo, of which the main content is to have conversation with senior engineers in HVAC industry, and to discuss current situation of HVAC industry, the direction of technology development and the relationship between technology and market. This forum is presided over by Shi Wenxing, professor of Tsinghua University and the deputy director of Professional Standard Evaluation Committee for Professionals and Technicians of Chinese Association of Refrigeration.

Four engineers, Yu Zhiqiang, Ding Jie, Liu Hua and Yu guoxin, were given honorary titles of "Senior Engineer" in the seminar. The host gave a brief explanation on the selection conditions of senior engineers and stressed that: The title of "Senior Engineer" is the highest level for professional standard evaluation of Chinese Association of Refrigeration, and a lifelong honorary title awarded by the association to outstanding professionals and technical personnel in fields of refrigeration and air conditioning equipment (design and manufacture), refrigeration system and air conditioning system.

Four "Senior Engineers" who won the award were invited to give their academic reports of about 20 minutes on their own fields, research contents and technological progress in the industry, mainly outlining their technological contributions to the industry.

Mr. Yu Zhiqiang, president and chief engineer of Yantai Moon Co., Ltd, gave his report of "A Brief Talk about the Road of Industrial Technology Innovation". He explained in detail the

experience and development direction of the company's technological innovation, and how to lead the company to achieve the goal of "becoming a world leading system solution service provider in artificial environment control and comprehensive utilization of energy resources" and the realization of system solution in 2K~200℃ full temperature zone.

Mr. Ding Jie, CTO of Dalian Bingshan Group and general manager of Dalian Refrigerator Co., Ltd., made a report entitled "Combination of Technology and Market in the Context of Sustainable Development". Starting from the current energy situation in China, he gave a comprehensive explanation of current energy consumption situation in China through abundant data comparison, and then pointed out the future development direction. He proposed to develop energy strategy and industrial layout in the next few years according to market demand, policy guidance and a full integration of technology and market.

Mr. Liu Hua, deputy chief engineer of Gree Electric Appliance Inc. of Zhuhai and deputy director of the national key laboratory, issued the report entitled "Research on Energy Saving of Air Conditioning Equipment and System Operation", which focused on the eternal pursuit of energy saving and environmental protection in the refrigeration industry. Facing to problems like large energy consumption, low energy consumption per capita and fast growth in HVAC, Director Liu elaborated the future development direction of the industry as per the implementation of the 13th Five-Year Plan. Taking projects under his leading, which are variable frequency direct-drive maglev centrifuge and household compressor-switching multi-split air conditioner, as examples, he figured out that making full use of big data is an important method to realize energy saving in future system operation.

Dr. Yu Guoxin, chief engineer of Haier Home Appliance Group's Advanced Innovation Center, made a report entitled "Current Situation and Prospect of Refrigeration Technology in Home Appliances". Dr. Yu first gave a detailed introduction to the past, present and future of home appliance development, and also made clear that intelligent home appliance is the upgrading trend for home appliance industry in the future. Taking refrigerators as an example, he analyzed the application of magnetic, semiconductor and gas refrigeration in future refrigerator, and shared his ideas and experiences of Haier's talent cultivation.

After the report, half-hour interaction was arranged in way of asking by the host and audience, and answering by the senior engineers. Here, the four senior engineers shared their ideas and methods in personal growth, enterprise management and personnel training from different angles, and answered technical questions that everyone cared about.

This year's Senior Engineer Forum is held for the first time. Attendees include: Professor Meng Qingguo, secretary-general of the Chinese Association of Refrigeration and chairman of the Professional Standard Evaluation Committee for Professionals and Technicians; Mr. Wang Congfei,

deputy secretary-general of Chinese Association of Refrigeration; Professional Standard Evaluation Committee leaders; leaders of provincial and municipal societies , representatives of engineering technicians who were qualified as Senior Engineer by Chinese Association of Refrigeration in 2018, and many professional audiences. Adhering to its principle of sincerity and amity, this grand forum receives enthusiastic welcome from all sides, and will definitely be better in the future.

(3) Summit Forum for Young and Middle-aged Designers in Refrigeration and Air Conditioning Industry

This Expo also set up a special seminar of "Summit Forum for Young and Middle-aged Designers in Refrigeration and Air Conditioning Industry", which mainly aims at in-depth exchange with young and middle-aged designers in the industry about their gains from and experiences about project design, as well as their opinions towards key technologies. Professor Shou Weiwei, senior engineer of Shanghai Architecture Research Institute Co., Ltd. under Shanghai Xiandai Architectural Design (Group) Co., Ltd, and Professor Zhang Xu, director of HVAC Research Institute of Tongji University's Machinery and Energy Engineering School, co-chaired the seminar.

Seven young and middle-aged designers, including professor-level senior engineer Wang Wei from Beijing Institute of Architectural Design, senior engineer Wang Yan from Tianjin Institute of Architectural Design, and product technology and service director Wang Li from Asian Technology Research and Development Center of Johnson Controls, all made splendid reports on the spot.

Among them, senior engineer Wang Wei made a report entitled "Discussion about Design of Cold and Heat Sources in Zhangjiakou Olympic Sports Center". He gave a detailed introduction to the design principles, project overview and the optimization of its cold and heat sources. Senior engineer Wang Yan gave his report of "Research on Key Technologies of Seawater Source Heat Pump". Taking the design of a sea water source heat pump energy supply station in Qingdao as an example, he introduced the technical characteristics and key issues of the project, and gave a series of equipment operation schemes to associate with project implementation. Director Wang Li made a report named "Technology and Application of High-efficiency Water Chiller". He summarized the technological progress of new high-efficiency water chiller from three aspects: the impact of unit efficiency on operating cost and environment, the efficiency improving technology and application of water-cooling screw units, and of water-cooling centrifuge units. Engineer He Chuan made the report of "Technical Exchange of Cold Chain Logistics Refrigeration and HVAC System". With practical projects, relevant issues concerning cold chain refrigeration system, ground anti-freezing and smoke extraction from cold storage were introduced. Director Zhang Haibo made a special report entitled "Application of Variable Frequency Ice Storage Chillers with Double Working Conditions in District Cooling System", and introduced equipment matching and energy-saving operation of large-scale district cooling system. In the end, experts from system design field, senior

engineer Zhu Xuejin and Shen Liecheng, gave special reports entitled "Environmental Control Design of Large-scale Scientific Facility" and "Design Focuses of Terminal Buildings' Air Conditioning Systems" respectively.

Young and middle-aged designers are backbones for the industries' development, and also represent future vitality and development prospects as a whole. Young and middle-aged designers invited to this seminar shared their design ideas and experiences with everyone through excellent cases, which is of great significance for promoting the development of young and middle-aged designers. Therefore, the opening of this forum has won the welcome and attention of many designers.

2.3 Hot Topics

The Organizing Committee has organized a number of symposiums on important technological development directions in the industry. The contents of these symposiums covered professional directions, technical fields and individual technologies.

(1) Heat Pump Technology and Application Development Forum

The "Heat Pump Technology and Application Development Forum I" of the Expo was successfully held at the Shanghai New International Expo Center, China. This forum was attended by leaders from the exhibition organizers, i.e. the China Refrigeration and Air-conditioning Industry Association (CRAA), the Chinese Association of Refrigeration (CAR), and the China Council for the Promotion of International Trade Beijing Sub-council. At the same time, Prof. Jiang Yi from the Building Energy Research Center of Tsinghua University, Mr. Li Xiangdong, Chief Engineer of Shandong Provincial Architectural Design and Research Institute and other industry experts and industry media were invited. This forum was presided over by Mr. Wu Min, Secretary General of the Heat Pump Branch of CRAA.

In this forum, the application of heat pumps in clean energy fields, in green buildings and in extreme environments was discussed.

In the first session of the forum, Prof. Jiang Yi from the Building Energy Research Center of Tsinghua University explained in detail the special report on "Heat pump, an important way of clean heating". Prof. Jiang Yi pointed out that heat pumps should play a major role in winter heating sources in northern China in the future, and heat pump heating should account for around 25% in the overall heating capacity according to the current heat-to-electric ratios at the demand side and the supply side. Therefore, the domestic market should focus on the development of heat pump units dedicated for winter heating. Furthermore, heat pump can not only help peak-load shifting of power supply, but also improve the instability of clean energy. Therefore, how to realize the operation of heat pumps based on the demand-side response mode is an important research direction in the field of heat pump application.

Mr. Li Xiangdong, Chief Engineer of Shandong Provincial Architectural Design and Research Institute then made a presentation on "Application of Multi-energy Complementary Heat Pump Composite System in a Three Star Green Building Case". In his presentation, he noted that with the improvement of living standards, air source heat pumps are becoming popular with consumers due to such advantages of easy availability and ease of use, the integration of heating and refrigeration functions, the energy-saving and so on, and heat pump research has broad prospects. After that, a representative of Heilongjiang ARCO Technology Co., Ltd. made a report on "Application of CO2 Air Source Heat Pump in Cold (Freezing) Areas". According to this report, although the traditional air source heat pump, with its excellent performance, has successfully dominated the Coal-to-Electricity Project in North China, it is not suitable for freezing areas. The ARCO CO2 heat pump technology for heating and refrigeration has the characteristics of maintaining high heating efficiency and high outlet water temperature at ultra-low temperature, providing a new energy-saving choice for consumers. At the end of the forum, a representative of Tongfang Artificial Environment Co., Ltd. made a wonderful Sharing of Heat Pump Dehumidification Technology for Wood Drying Research and Application Effect.

On the next day, Prof. Li Xianting from Tsinghua University chaired the second session of the forum and gave an opening speech on "Hybrid Heat Pump Features and Applicability". After that, Prof. Zhang Xu from Tongji University and Prof. Zhang Xiaosong from Southeast University gave reports entitled "Analysis on Energy Consumption Features of Intermittent Operation of Air Source Heat Pump in Residential Buildings" and "Heat Pump System Adaptability and Performance Improvement Approaches", respectively. Company participants also shared their experience and achievements: "Regional Heating Clean Energy Solutions" presented by Qingdao Haier Air-conditioning Electronics Co., Ltd. and "Analysis on Single Stage Screw Compressor in Low-temperature Air Source Heat Pump Application" presented by Shanghai Hanbell Precise Machinery Co., Ltd.

(2) North China Clean Heating Technology Forum

On April 10, 2019, the North China Clean Heating Technology Forum of the Expo was successfully held in Shanghai New International Expo Center. This forum was attended by Mr. Lu Bin, Director of the Air-conditioning and Heat Pump Committee of CAR, Mr. Xu Zhaowei, Deputy Director of the Institute of Building Environment and Energy Efficiency, China Academy of Building Research (CABR), Prof. Wang Wei from Beijing University of Technology; Prof. Ni Long from Harbin Institute of Technology, Mr. He Lin, Manager Assistant of Gree Electric Appliances Inc. of Zhuhai and other representatives of major enterprises and industry media. This forum was presided over by Mr. Cao Yang from the National Quality Supervision and Inspection Center of Air-conditioning Equipment.

The latest research results and application of clean heating technologies were introduced in this forum. Experts from universities and enterprises shared their progress in researches, and they believed that currently, clean heating technologies are in a favorable period of rapid development, but at the same time, many problems and challenges still need to be addressed. Therefore, in order ensure the better and faster development of clean heating technologies, it is necessary to collect the opinions of all involved parties, and fully consider the whole cycle from design to construction/assembly to final operation and surveillance.

Mr. Xu Zhaowei, Deputy Director of the Institute of Building Environment and Energy Efficiency, CABR, analyzed and explained the energy efficiency improvement and long-term operation of the clean energy heating system in northern Chinese rural areas. Mr. Xu Zhaowei said that Beijing has now entered the key node of clean heating, and some villages in plain areas of Beijing City have successively carried out the basic finishing work of equipment installation for the "Coal to Clean Energy" Project. In addition, as the installation of clean heating equipment has basically completed, the work emphasis is gradually transferring to the operation service management, and the energy efficiency can be improved by various control strategies such as the optimization of auxiliary electric heating, water pump, return difference, room temperature plus water temperature, etc. Prof. Wang Wei from Beijing University of Technology shared the fruits of "Research on Optimal Control of Variable Water Temperature for Air Source Heat Pump Heating System on the Basis of Supply and Demand Matching". According to Prof. Wang, the water temperature control technology based on low-cost operation for air source heat pump is only applicable to certain heating systems; in order to solve the problem, he has developed a variable water temperature control strategy based on heating demand, which can be used to improve the operation efficiency of air source heat pump heating system and realize energy saving in buildings. Prof. Ni Long from Harbin Institute of Technology made a report on "Feasibility Study of Air Source Heat Pump Heating in Freezing Areas". In his report, he pointed out that the traditional air source heat pump has inherent drawbacks in terms of performance, frost formation and power consumption, which may hinder safe heating in freezing areas. It is found through tests and study that the air source quasi two-stage compression heat pump can operate economically with slight frost formation at very low temperatures, which means that its application in extreme weather has certain feasibility.

Mr. He Lin, a senior engineer from Gree Electric Appliances Inc. of Zhuhai made a special report entitled "Research on Key Technologies to Realize Energy Saving and Comfort by Using Air Source Heat Pumps in Different Climatic Zones". Mr. Zhao Xianqiang, Manager of Emerson Climate Technologies (Suzhou) Co., Ltd. gave a special report entitled "Sharing of Heat Pump System Solutions and Latest Measurements". Manager Wei Xiang from Danfoss (China) Cooling

made a report on "Systematic Understanding of Air Source Heat Pump Heating - from Heat Source to Terminal Units". The vivid and rigorous presentations of company representatives enabled deep exchange between the enterprises and the academic circle, which will jointly contribute to the future of the industry.

(3) Construction, Operation, Maintenance and Management of Refrigeration and Air-conditioning System

Proper construction, operation, maintenance and management of refrigeration and air-conditioning systems are key measures to ensure normal, efficient and energy-saving operation of such systems. In the symposium, five experts on the operation, maintenance, management and research of refrigeration and air-conditioning systems were invited to report and exchange their opinions on the methods and skills of the whole life cycle management and control of refrigeration and air-conditioning systems. The biggest difference from previous years' symposiums is that in this year, more importance was attached to construction of the refrigeration and air-conditioning system. Prof. Shi Wenxing and Associate Prof. Wei Qingpeng from Tsinghua University presided over the symposium.

Associate Prof. Wei Qingpeng from the Department of Architectural Technology and Science of Tsinghua University pointed out that the integration of the "IT+OT" data technology and the operation technology is an important way to improve the energy efficiency of air conditioning systems. He introduced various problems existing in the current refrigeration and air conditioning systems. He pointed out through instance analysis that the coordinated, data driven method can be used for reducing energy consumption of air conditioning systems, and data that are more "detailed" should be used for energy conservation in buildings and for industry progress.

Mao Huaxiong, Senior Engineer, General Manager of YZ MEP Project Consulting (Shanghai) Co., Ltd., analyzed the commissioning method of HVAC systems through a large number of practical cases. He explained the difference between "commissioning" and "testing" with facts, and expounded the importance of calibration of commissioning instruments and the connection between operation management and engineering construction. In the end of his report, he suggested that a consultant team should be set up for the whole process of commissioning to complete such work as diagnosis, evaluation and acceptance according to specific situation of new buildings and old buildings.

Mr. Liu Shouchao, Director of Nanjing Fuca HVAC Automation Technology Co., Ltd., shared his opinions on how important the intelligent control and energy efficiency management can be for the energy efficiency improvement of the cooling station. He used the Guangzhou Metro Cooling Station Project as an example. In his speech, he summarized several important ways to realize high efficiency of a cooling station: accurate load calculation and energy consumption analysis; selection

of efficient and suitable refrigeration host; adoption of large temperature difference and high chilled water temperature technology with intelligent control system; adoption of BIM modeling and construction, etc. In the end of his speech, he noted that accurate installation guidance, intelligent control system and fine on-site commissioning were the key to the success of the Project.

Mr. Xiao Hansong, a PhD student at the School of Architecture, Tsinghua University, made a speech on "Actual Operation Performance and Usage Behavior of Multi-split Air-conditioning System". He first elaborated the necessity and technical difficulties of developing technologies for measuring actual operation performance of multi-split air-conditioning systems. And then, he introduced the energy balance method developed by his team on the basis of "generalized compressor". With this method, the actual operation performance of a multi-split air-conditioning system can be measured accurately.

Mr. Li Ning, Deputy Director of Architecture Design Institute of Shaanxi Construction Engineering Group Co., Ltd. made a speech on how to ensure efficient and energy-saving operation in the future from the perspective of construction. He first analyzed the problems existing in the design, construction, operation and maintenance of actual projects, such as excessive design selection, pipeline blockage, lack of regulation, etc. And then, he proposed that BIM technology can be used to solve the technical handover problems before and after design and construction, guide the site construction, and solve the problems in construction control, engineering commissioning and acceptance. In the end of his speech, taking "funnel effect" as an example, he demonstrated the great contribution of construction control to the overall quality improvement of project, which is worth learning and promoting by the industry.

(4) Evaporative Cooling Air-conditioning Technology

On April 10, 2019, the "2019 Evaporative Cooling Air-conditioning Technology Forum" sponsored by the Evaporative Cooling Air Conditioning Working Committee of CRAA was successfully held in Shanghai New International Expo Center. Over 60 attendees gathered at this forum, including Ma Guangyu, Deputy Secretary-General of CRAA, Huang Hualing, Director of the Evaporative Cooling Air Conditioning Working Committee of CRAA, Huang Xiang, Deputy Director and Secretary-General of the Evaporative Cooling Air Conditioning Working Committee of CRAA, and experts, scholars, engineers, technical personnel, business representatives, professors and students from colleges and universities. They discussed innovations and developments in fields of evaporative cooling, refrigeration and water treatment. This forum was chaired by Prof. Huang Xiang (from Xi'an Polytechnic University), Deputy Director and Secretary General of the Evaporative Cooling Air Conditioning Working Committee of CRAA.

Four technical reports were made in this forum. The first report entitled "Energy-saving Optimization Technology for Evaporative Cooling System" was made by Mr. He Huaming, Chief

Engineer of Aolan (Fujian) Industry Co., Ltd. In this report, Mr. He gave a comprehensive, in-depth explanation of dew point indirect evaporative cooling technology from the research significance to dew point evaporative cooling technology to specific case analysis. The second report was given by Mr. Fan Jiangfeng, Chief Engineer of Xinjiang Huayi New Energy Technology Co., Ltd. He explained the new evaporative cooling air-water system that can be used in data centers. After that, Mr. Zhang Mingyin, General Manager of Yinhai Jie (Beijing) Water Treatment Technology Co., Ltd., made a report on "Water Treatment of Evaporative Cooling Air Conditioning System". His report, which consists of six parts, introduced the water treatment of evaporative cooling systems, and laid a foundation for the application of evaporative cooling technology. At the end of the report part, Prof. Huang Xiang summarized the main points of the first three reports, and introduced his report on "Innovation and Application of Evaporative Cooling Air Conditioning Technology", in which he systematically analyzed the principle, equipment and application of the evaporative cooling technology to let more people understand the development trend of this technology.

After the report was the time for questions, the attendees communicated with the speakers about their questions. The speakers answered these questions and made further explanations. This forum was highlighted by such lively discussions. At the end of this forum, Prof. Huang Xiang made a short speech on the good vision of the future of the evaporative cooling air conditioning system due to its unique advantages in energy saving and comfort. He also called on more experts and scholars to focus on the evaporative cooling air-conditioning system.

(5) Indoor Air Purification and Fresh Air Technology Symposium

Sponsored by the Organization Committee of China Refrigeration Expo, the "2nd Indoor Air Purification and Fresh Air Technology Symposium" jointly organized by the Journal of Refrigeration & Air Conditioning, the Indoor Environment Control and Health Branch of China Association of Environmental Protection Industry (CAEPI) and the Cleanroom Technology Committee of CRAA was successfully held in the afternoon of April 10, 2019 at Shanghai New International Expo Center. Mr. Ma Guangyu, Deputy Secretary-General of CRAA, delivered a speech on behalf of the Organizing Committee. According to the theme of this symposium: the development trend of indoor air purification and fresh air technology, participants made in-depth technical exchanges on the function of the fresh air system, the performance test of wall-mounted ventilation units, the introduction of indoor air quality standards, the investigation of actual operation effect of indoor air purifier and fresh air system, and the application of the electrostatic precipitator coupled with catalyst in fresh air system. This symposium was presided over by Ms. Zhang Jing, Deputy Secretary-General of the Indoor Environment Control and Health Branch of CAEPI. A total of 160 representatives attended this symposium.

Prof. Xu Wenhua from the HVAC Research Institute of the School of Mechanical & Energy

Engineering of Tongji University gave an opening report entitled "Functions and Prospects of Fresh Air Systems in Buildings". Prof. Xu made a detailed and in-depth introduction to the concept, function and development prospect of the fresh air system in buildings. Dr. Li Jingguang, a senior engineer (professor level) from Shanghai Research Institute of Building Sciences (Group) Co., Ltd., made a report entitled "Introduction to Indoor Air Quality Design Standards for Buildings", in which he explained in detail the industrial standard - Standard for Indoor Air Quality of Public Building (JGJ/T461). Prof. Lin Zhongping from the School of Mechanical & Energy Engineering of Tongji University explained in detail the performance test comparison and application analysis of wall-mounted ventilation units. Associate Prof. Pei Jingjing from the School of Environmental Science and Engineering of Tianjin University made a report on "Actual Operation Effect of Air Purifiers and Fresh Air Systems in Chinese Residential Buildings". According to the analysis on factors such as the users' behavior, the ventilation capacity of units, and the effective maintenance, she pointed out that the fresh air system has very limited effect on reducing indoor PM2.5 concentration. Dr. Yao Xin from the Combustion and Environmental Technology Research Center of Shanghai Jiaotong University made a report on "Electrostatic Precipitator Coupled with Catalyst and Its Application in Fresh Air Purification System". In this report, Dr. Yao analyzed the research background of this technology, introduced the development progress of catalytic oxidation technology for VOCs, and pointed out that the catalytic oxidation of VOCs is difficult to realize at room temperature. Associate Prof. Zhou Bin from the Department of HVAC Engineering of Nanjing Tech University made a report on "Research on Using Multi-split Air-conditioning System for Indoor Environment Improvement in Medical Buildings under the Background of Plant VOCs Pollution".

Peng Min, Application Specialist of the Sales & Marketing Department of CAREL Electronic (Suzhou) Co., Ltd., made a report on "Smart home: Intelligent Integrated Control Solution for Constant Temperature, Humidity and Oxygen Concentration". Zhu Lei, Manager and Engineer of MayAir Technology (China) Co., Ltd., explained the efficiency classification, testing procedure, testing system, comparison, advantages and disadvantages, and development of HVAC system improvement schemes according to the new international standard ISO 16890. Chen Renliang, Executive Deputy General Manager of Beijing All View Cloud Data Technology Co., Ltd., made a report entitled "Integrating Fine Decoration with Fresh Air System: Future of the fresh air industry whose market value exceeded 10 billion", in which he pointed out that the current situation of indoor environmental pollution and testing is not optimistic, and there are problems such as the lack of special test method for various complicated pollutants, the imperfect legislation on testing, and the lack of standardized environmental sampling and testing procedure; according to these facts, the market demand for fresh air systems will continue to increase.

(6) Heat Exchangers Development Forum

The Heat Exchangers Development Forum was successfully held on April 10, 2019 at the Expo venue. Experts and scholars from universities and enterprises made several special reports on the development of heat exchangers, such as the development of long-term performance standards and efficient design technology for heat exchangers in air conditioners, the development and application of plate and microchannel heat exchangers, the intelligent manufacturing technology for heat exchangers, and the precision processing and manufacturing technology for copper tubes of heat exchangers. This forum was chaired by Prof. Ding Guoliang from Shanghai Jiaotong University, Chairman of the Technical Alliance of Refrigeration, Air Conditioning and Heat Exchangers.

At the beginning of this forum, Prof. Ding Guoliang gave a special report entitled "Standards for Long-term Performance of Heat Exchangers in Refrigeration and Air Conditioning System and Development of Efficient Design Technology". Prof. Ding first introduced the development process and existing problems of long-term performance standards for air conditioning systems, and then introduced the test methods association standards for long-term performance of heat exchangers in air conditioning systems. At the end of his report, he disclosed the release process and subsequent research of association standards. After that, Dr. Han Weizhe, General Manager of Jiangsu Weyee Heat Exchanger Co., Ltd., made a special report entitled "Development and Application Technology of High Efficiency Plate Heat Exchanger Type Economizer for Multi-split Air-conditioning System". After giving a brief overview of multi-split air-conditioning systems and plate heat exchangers, Dr. Han introduced the advantages of plate heat exchangers, analyzed the optimization of corrugated plate and the model selection of plate heat exchanges, and finally put forward the suggestion of using brazed plate heat exchangers as economizers for system optimization. Dr. Liu Yuzhang from Sanhua (Hangzhou) Micro Channel Heat Exchanger Co., Ltd. made a special report entitled "Research on Application Environment and Long-term Reliability Technology of Micro-channel Heat Exchangers". In this report, he noted some reliability problems in micro-channel heat exchangers, such as easy collision and unsatisfactory overall corrosion resistance; he also pointed out the lack of a rapid performance evaluation method for such heat exchangers. Therefore, he called on the industry to make continuous efforts to solve these problems as soon as possible. After that, Mr. Zhao Bo, Senior Engineer and R&D Director of Hangzhou Shenshi Energy Conservation Technology Co., Ltd., made a special report entitled "Application of Ultra-Compact Heat Exchangers in Aerospace Field", in which he introduced Shenshi's micro-channel technology, and pointed out that the company will focus on the research and development of new materials and cost control in the future. And then, Dr. Cheng Dayong, Director of Golden Dragon Precise Copper Tube Group Inc., gave a special report entitled "Precision Processing and Manufacturing Technology for

Copper Tubes of Heat Exchangers". Using several cases, Dr. Cheng introduced in detail the precision processing technology adopted by his company for heat exchanger tubes. The last report was given by Mr. Long Xiaobin, Senior Engineer, Chairman of OMS Machinery Co., Ltd. In his report entitled "Intelligent Manufacturing Technology and Equipment for Heat Exchangers", he introduced the current technologies and the future development trend of heat exchanger equipment, and pointed out that intelligent technology would be the core of future breakthroughs.

(III) Technical Seminars

Technical Seminars were academic events organized by exhibitors according to their needs. For exhibitors, the seminars were not only a window to showcase their new products, but also an in-depth and effective self-promotion. CR Organizing Committee assisted active efforts to in terms of organization, content preparation and expert invitation.

A total of 49 seminars were staged during the exhibition. Involved exhibitors include Danfoss Automatic Control Management Shanghai Co., Ltd., Matsushita Refrigeration (Dalian) Co., Ltd., Reflex (Shanghai) Heating & Energy Equipment Co., Ltd., Ltd., Gree Electric Appliances Inc. of Zhuhai, Dalian Fuji Bingshan Smart Control Systems Co., Ltd., CAREL Electronic (Suzhou) Co., Ltd and other well-known enterprises at home and abroad.

On the morning of April 9, three technical seminars were held, namely the “Salon of Environmental Control Technology for Underground Railway” held by the Organizing Committee of China Refrigeration Expo/Journal of HV&AC; the "Mayekawa' s CO2 Technology and New Refrigeration Unit『South Polar』" by MAYEKAWA China Industries Co., Ltd.,the Press Conference of the 13th Science and Technology Contests for College Students of China R&AC Industry by the China Refrigeration and Air-Conditioning Industry Association.

On the afternoon of April 9, seventeen technical seminars were held, including the "CO2 refrigeration and heat pump fluid control solution" by the Parker Hannifin Motion & Control (Shanghai) Co., Ltd., Danfoss Automatic Control Management (Shanghai) Co., Ltd., the Danfoss Refrigeration Solutions in IT Cooling Applicationby the Danfoss (Shanghai) Automatic Controls Co., Ltd. and the Industry Energy Comprehensive Utilization of Cold and Hot Solution by the Panasonic Appliances Air-Conditioning and Refrigeration (Dalian) Co., Ltd.

On the morning of April 10, twenty-one technical seminars were held, including the Emerson Integrated Solutions for Air-conditioning and Heat Pumpsby Emerson Climate Technologies (Suzhou) Co., Ltd. and other solution seminars; the Application and Introduction of Fusheng Centrifugal Compressor with Magnetic Levitation and New Launched Two-stage of Screw and Scroll Assembly Refrigeration Compressor and other product introduction by FuSheng Industrial （Shanghai）Co., Ltd. and other product briefings; DORIN CO2 Compressors and Technology for Refrigeration and Heat Pump Application by Officine Mario Dorin S.p.A. and other technical communication and promotion opportunities.

On the afternoon of April 10, eight technical seminars, including the BAC Solutions in Industrial and Refrigeration Industries by BAC China and the BIM, Realize the Architectural Beauty by aquatherm Pipe System (Shanghai) Co., Ltd. concluded the seminar section with a beautiful full stop.

3.1 Industry organization activities

CR 2019 features an array of academic activities planned and organized by the Organizing Committee. There were technical seminars hosted by domestic and foreign industry associations and organizations, communication and awards presentationevents by domestic industry organizations for the purpose to train industrial talents and reserve talents, as well as public welfare activities designed as part of the technical seminar session. These activities not only helped to enhance the overall macro awareness of relevant industries, but also stimulated the innovative interest and professional level of the industry personnel (especially young researchers and students), ensuring that relevant technology research and development could long be conducted on the right track. The main contents include: the Launch Ceremony &Press Conference of the 13thScience and Technology Contests for College Students of China R&AC Industry, the Fifth Anniversary of the 2018 China Refrigeration Market Development Report Special Edition launch event, Launch of the White Paper on China Refrigeration and Air-Conditioning Industry Development in 2018, Data Center Cooling Forum - and the "2018 China Data Center Cooling Technology Annual Development Research Report" press conference, the 10th Anniversary of the CAR-ASHRAE Student Design Competition Awards Ceremony.

(1) Launch Ceremony & Press Conference of the 13thScience and Technology Contest for College Students of China R&AC Industry

The Launch Ceremony & Press Conference of the 13th Science and Technology Contest for College Students of China R&AC Industry kicked off accompanied the opening of CR 2019 at the Shanghai New International Expo Center on the morning of April 9. More than 30 leaders and other people attended the conference. The Science and Technology Contest for College Students of China R&AC Industrywas jointly hosted by the China Refrigeration and Air-conditioning Industry Association and the Teaching Steering Committee of Energy and Power Specialty of Higher Education of the Ministry of Education in association with many well-known domestic universities and related organizations. The theme of this year's contestwas “Independent Innovation, Creating Refrigeration and Air Conditioning Technology for the Future”.

Professor Wang Ruzhu, deputy director of the Teaching Steering Committee of Energy and Power Specialty of Higher Education of the Ministry of Education, said that the contest provided a platform and effort for the cultivation and innovation of innovative talents in the refrigeration industry. The Committee would continue to cooperate with the association to promote the contest. Zhang Zhaohui, Vice President and Secretary-General of China Refrigeration and Air-conditioning Industry Association (CRAA), pointed out that now is the era of innovation leading the development of the industry. The cultivation of high-quality university students is an important

guarantee for the fundamental and sustainable development of industry innovation. Finally, Prof. Ma Guoyuan with the Beijing University of Technology, briefed on the organizational structure and preparationstatus of the contest.

(2) The Fifth Anniversary of 2018 China Refrigeration Market Development Report Special Edition Launch Event

On April 9, 2019, during the 30th China Refrigeration Exhibition, the "2018 China Refrigeration Market Development Report (5th Anniversary Special Edition)" was officially released. Jing Huaqian, Deputy Secretary-General of Chinese Association of Refrigeration (CAR), and Krystyna Dawson, Commercial Director atBSRIA and Asia Pacific General Manager Li Chunlei and other leaders and more than 100 industry colleagues attended the conference.

At the press conference, Deputy Secretary-General Jing said on behalf of CAR that, "CAR, as an academic social group in the refrigeration and air-conditioning industry, has been committed to promoting the development of the industry through scientific and effective methods since its establishment in 1977. The data in the China Refrigeration Industry Development Analysis Report is detailed and reliable. It is an active player in the reform and development of China's refrigeration enterprises and the progress and prosperity of the refrigeration industry."

Krystyna's Executive Director Bai Shiyue delivered a speech. She said: "We are very much honored to have worked hand in hand with our peer Chinese Association of Refrigeration（CAR）- China’s authoritative technical organization, and are pleased that we have contributed our humble share to the development of the industry over the past five years. "To make buildings better" is the mission of the Building Services Research and Information Association. We hope that with the assistance of CAR, we can harvest multiple five years. We wish the Chinese refrigeration industry to prosper."

Figure 3-1 Deputy Secretary General Jing Huaqian delivers a speech on behalf of Chinese Association of Refrigeration (CAR)

(3) Launch of the White Paper on China Refrigeration and Air-Conditioning Industry Development in 2018

On the afternoon of April 9, the press conference of the "White Paper on China Refrigeration and Air-Conditioning Industry Development in 2018" was jointly hosted by China Refrigeration and Air-conditioning Industry Association（CRAA） and ChinaIOL at Shanghai New International Expo Center. It was presided over by Liu Xiaohong, Deputy Secretary-General of CRAA. Representatives from Hefei General Machinery Research Institute Co., Ltd., Dalian Bingshan Group Co., Ltd, Guangdong Midea HVAC Equipment Co., Ltd., Shenzhen McQuay Air Conditioning Co., Ltd. and Emerson Climate Technologies (Suzhou) Co., Ltd. attended the event.

At the beginning of the press conference, Mr. Zhang Zhaohui, Vice President and Secretary General of China Refrigeration and Air-conditioning Industry Association (CRAA), delivered a speech. He pointed out that, as an important component of China's equipment industry and an important part of the national economy, refrigeration and air-conditioning industry has undergone in-depth adjustment. In 2018, China's refrigeration and air-conditioning industry realized a total industrial output value of close to 700 billion yuan, a year-on-year increase of about 6.7%. However, as the national and international market demand grew weakin recent years, a lot of issues aggravated such as declinedlarge-scale engineering projects, increasedchannel inventory, sharply increasedlabor costs. Development of the industry faces tremendous pressure. It is urgent that the industry shift from demand side to the supply side. The “White Paper on China Refrigeration and Air-Conditioning Industry Development in 2018” summarized and analyzed the development of China's refrigeration and air-conditioning industry in the past year. It helps the industry to clarify more clearly policy directions, technical routes and development strategies, serving asa guidance and promotion for industrial transformation and sustainable development.

Yang Jie, Chairman and General Manager of ChinaIOL, delivered a speech on the theme of “Industrial Panorama and Differentiated Industry Development.” He shared the main contents of the White Paper on China Refrigeration and Air-Conditioning Industry Development in 2018. Representatives of the participating units also made speeches. At the end of the conference, the Organizing Committee presented the "White Paper on China Refrigeration and Air-Conditioning Industry Development in 2018" to the guests present as gifts.

Figure 3-2 Secretary General Zhang Zhaohui Speaks at the Press Conference

(4) Data Center Cooling Forum - and the "2018 China Data Center Cooling Technology Annual Development Research Report" Press Conference

On April 10, 2019, the Data Center Cooling Forum and the "2018 China Data Center Cooling Technology Annual Development Research Report" press conference was held at the CR. Guests attending the conference included Academician Jiang Yi of Tsinghua University; Mr. Jin Jiawei, President of CRAA; Professor Chen Huanxin from Huazhong University of Science and Technology; Li Hongxia, Chief Engineer of China Information Technology Designing & Consulting Institute (CITC), and Mr. Zheng Zhuling, Deputy General Manager of Shanghai Jianke Building Energy Services Co., Ltd.

Figure 3-3 Data Center Cooling Forum

The conference was presided over by Academician Jiang Yi of Tsinghua University. He first gave the participants a detailed introduction to the CAR Data Center Cooling Working Group and shared the key points in all the chapters of the China Data Center Cooling Technology Annual Development Research Report 2018. He pointed out that although there are still some shortcomings in the report, the book will be able to continue to be updated with joint efforts of all colleagues in the industry.

Professor Chen Huanxin from Huazhong University of Science and Technology; Shao Shuangquan, researcher at the Technical Institute of Physics and Chemistry of the Chinese Academy of Sciences; Mr. Yu Qin, Technical Manager of the McQuay Central Air Conditioning Major Project Department, and Zheng Zhuling, Deputy General Manager of Shanghai Jianke Building Energy Services Co., Ltd. gave speeches in turn. At the end of the conference, Academician Jiang Yi conducted a signing event.

(5) CAR-ASHRARE Student Design Competition Awards Ceremony and 10th Anniversary Celebration

On April 11, 2019, CAR-ASHRARE Student Design Competition Awards Ceremony and 10th Anniversary Celebration 2018 was held at University of Shanghai for Science and Technology. The

competition was jointly organized by CAR, ASHRAE and the Subcommittee on Teaching Guidance for Building Environment and Energy Application Engineering of the Ministry of Education. Johnson Controls provided sponsored the event which has been held for 10 editions since its inception in 2009.

Guests present at the event included Professor Jin Jiawei, Head of the Competition Organizing Committee and President of CAR; Professor Wu Desheng, Head of the Competition Jury Committee, Consultant and Chief Engineer of the Beijing Institute of Architectural Design; Professor Liu Daoping, Deputy Secretary of the Party Committee of University of Shanghai for Science and Technology, and Ms. Sheila J. Hayter, Head of ASHRAE; Professor Zhu Yingxin of Tsinghua University, Deputy Head of the Competition Organizing Committee, Director of the Building Environment Steering Committee; Professor Pan Yungang, Director of Building Environment Teaching Evaluation Committee, Deputy Chief Engineer of China Architecture Design & Research Group.

Professor Liu Daoping and other experts and leaders were at the site and delivered speeches. Professor Zhang Xu of Tongji University, former Deputy Director of the Building Environment Steering Committee presided over the awards ceremony. The first prize of the CAR-ASHRARE Student Design Competition in 2018 went to Qingdao University of Technology. Winners came to the stage to receive the awards and certificates presented by their seniors in the industry, who congratulated them, hoping that they achieve greater success in their future career development. Yu Huili, Associate Professor Qingdao University of Technology and other teachers won the honor of Outstanding Instructor Award for the 2018 Competition.

On the occasion of the 10th anniversary of the competition, the event commended units and individuals who have participated in the event for consecutive years and have made important contributions. Finally, Prof. Jin Jiawei delivered a thank-you speech and brought the event to a fabulous end.

Figure 3-4 CAR-ASHRAE Student Design Competition Awards Ceremony and 10th Anniversary Celebration Event Group Photo Opportunity

3.2 Corporate Technical Seminar

Corporate Technical Seminars are also rich and colorful. Featuring company's new products and new technical communication, they introduced cutting-edge technologies enterprises face in their development of refrigeration and air conditioning.

The Application and Research of Permanent Magnetic Synchronous Inverter Energy-saving Technology in Railway Transportation Field given by GREE Electric Appliances Inc. of Zhuhai Co., Ltd. introduced the highly anticipated Gree magnetic levitation direct refrigeration air conditioning unit, which is independently developed by Gree. The "small flow and small pressure ratio magnetic levitation compressor" for the working conditions of subway stations solved the efficiency offset of working conditions with a large space, a large population flow, large differences in the demand for air conditioner's cooling/heating in different areas, and large changes in the central air conditioning load. Full working condition and efficiency were improved.

Emerson Climate Technologies (Suzhou) Co., Ltd., introduced, in combination of exhibits, a full range of frequency conversion solutions, low temperature air source heat pumps, integrated solutions for heat pumps drying and cold chain solution proposed by Emerson under the theme of "Emerson Integrated Solutions for Air-conditioning and Heat Pumps" and "Emerson EVI Technologies and Solutions." Its solutions were energy-saving, effort-saving, environment friendly, flexibly reliable and reliably flexible.

BITZER Refrigeration Technology (China)'s "BITZER "YOUR GREEN WORLD" CO2 SEMINAR " introduced a separate CO2 gas cooler solution to replace the traditional parallel installation design of the small heat exchangers with a reduced installation complexity and cost but enhanced resistance to mechanical and thermal fatigue, enabling a more reliable product operation.

CAREL Electronic (Suzhou) Co., Ltd. conducted three technical seminars by centering around "Residential Solution." The seminars mainly proposed Museum Humidification Solution, light commercial refrigeration solutions, Solutions for Commercial Refrigeration (Refrigeration & Retail). In the light commercial refrigeration solution, the application of R290 working fluid frequency conversion system in commercial refrigerators is emphasized. With the increasing demand for energy saving and environmental protection, commercial refrigerators are gradually using natural refrigerant R290 and frequency conversion technology to reduce pollution emissions and improve performance.

Figure 3-5 Technical Seminar

Parker Hannifin Motion & Control (Shanghai) Co., Ltd. held two technical seminars on April 9, demonstrating Parker Hannifin's CO2 refrigeration and heat pump fluid control solutions and the application of NH3/CO2 products in industrial refrigeration. Many professionals visited the exhibition in person and discussed the industry trends with the staff.

Danfoss (Shanghai) Automatic Controls Co., Ltd. delivered six technical seminars on April 9 and April 10, respectively. They featured on cooling solutions for Refrigeration Solutions in IT Cooling Application, Danfoss Case Study-US Steel Tower, Danfoss Industrial Refrigeration New Products, Air-conditioning & Heat Pump Scroll Compressor Products, New Plate Heat Exchangers and DC Variable Frequency Medium Temperature Refrigerated Scroll Compressors.

IV. Technical Characteristics

(Professor Shi Wenxing and PhD Candidate Yang Zixu, Tsinghua University)

1. Exhibit report highlights innovation and development

The CR 2019 Organizing Committee entitled the CR 2019 “Cooperation & Innovation for Development,” and planned it with theme forum, symposium and technical seminar.

To fully reflect the theme of “Cooperation & Innovation for Development,” the theme forum analyzed important issues such as China and the global economic situation, important ways to achieve low-carbon energy -- DC building and distributed storage, the “Craftsmanship” that needs to be urgently carried on in the refrigeration and air-conditioning industry, digitalization and “Industry 4.0.” The seminars, which were meant to provide important reference for the industry, discussed current hot issues such as “coal to electricity” technology, refrigeration and air-conditioning systems’ construction, operation, maintenance and management, as well as thermal management of new energy vehicles. The Senior Engineer Forum, Refrigeration and Air-Conditioning Young Designers Summit Forum held by domestic and foreign industry associations and enterprises respectively provided an important platform for technical communication and personnel training.

The exhibits displayed at this exhibition are closely integrated with the development of social trends. The new systems and new products developed have been integrated with the concept of energy saving, environmental protection and innovative development. The whole exhibition centered on how to achieve a multi-party mutual benefit and win-win development model under the new situation. It fully demonstrated the strong support of the refrigeration and air-conditioning industry for the national development strategy and the long-term vision of promoting the development of the industry. The theme of "cooperation" and "development" was fully embodied.

2. Clean heating stimulates heat pump heater

In recent years, the smog in north China has been serious. Clean heating technology is being eyed on. At the Second Meeting of the 13th National People's Congress held on March 20 this year, Premier Li Keqiang continued to point out in the Government Work Report that, "We must steadily promote the 'coal to gas' and 'coal to electricity' initiative in the north. Do a good job in cleaning and heating and ensure that people spend a warm winter."

Clean heating technology presents a diversified trend, such as air source heat pump, gas heat pump, absorption heat pump and solar composites. Among them, the air source heat pump as one of the main piece of equipment for clean heating solutions, its safety, convenience, energy saving and wide applicability stand out among its peers. As a result, the market share of the air source heat pump blower, air source heat pump hot water unit is increasing.

Air source heat pump heater as a direct expansion device, its simplicity and safety outrun others amidst household heating equipment. At this exhibition, the northern clean and heat supply market continued last year's "explosive" momentum. Majority of small and medium-sized air conditioner exhibitors had hot air blowers on show. Clean heating technology is gaining popularity. The advantage of air source heat pumps has been recognized.

In addition, signs from the exhibition show that the current application of the "enhanced vapor injection" and the "DC frequency conversion" used for the heating air source heat pump compressors in the northern region has become industry consensus. Via the air supply in the compression process to lift compressor's air absorbing capacity, both the heating capacity and efficiency can be achieved and the adaptability of working conditions can be improved in a large range. The hot air blower products on display generally floor-standing or low-hanging indoor end, and there are multiple combination modes, for example the "one for one" and "one for more." They can "ventilate from top" or from "down under." Specifically, it ventilates from the bottom when heating and ventilates from the bottom while cooling, ensuring a suitable and comfortable indoor vertical temperature gradient.

3. Substituting working medium, the continued focus of the industry

Due to the increasing demand for green and environmentally friendly working medium (refrigerants) in the world, the refrigerants currently used in many refrigeration products are being banned. Therefore, many companies have begun to explore new refrigerants.

The Ozone Climate Industry Roundtable and Technology Roadshow series event, which have been going on for years, continued this year. The event was jointly organized by UNEP, UNDP, IECO and CRAA. What was mainly addressed at those events included policy dynamics related to ozone climate friendly alternative technologies, international refrigerant substitution trend, ozone climate technology and efforts to promote ozone climate technologies. Industry associations and representatives from the Ministry of Ecology and Environment, relevant UN agencies, the United States, Europe, Japan and other countries and regions contributed spectacular reports to the roundtable meeting.

In response to this move, the exhibition opened up a special area to showcase the progress of refrigerant replacement technology, such as R1233zd in place of R123; R1233ze, R513a in place of R134a; R448A in place of R404A; R32, R290 in place of R410A. Refrigerant is the "blood" of vapor compression refrigeration heat pump equipment. The revolution of refrigerant will lead to major changes in the whole system. Therefore, it is wise that refrigeration companies be prepared to meet the challenges of the international community.

4. Smart and comfortable are what air-conditioning products are expected with

With the development of artificial intelligence and the Internet of Things, the control

technology of conventional air conditioners is heading towards user experience. "Internet +" is the biggest highlight of the intelligent dimension of this exhibition. On the one hand, traditional refrigeration equipment has increased data remote transmission and even optimized control functions. On the other hand, components of the HVAC system, including sensors, actuators are increasingly providing interfaces for data acquisition and remote control. The progress in these aspects empowers HVAC system to rapidly transform into the information age. For example, Gree exhibited a zero-carbon smart home system. Through the air-conditioning voice control system, it can complete a joint control of lighting, curtain, TV, dehumidifier and other devices. Haier displayed the “E+IoT” cloud service platform. By combining big data technology and the Internet of Things technology, the cloud platform can monitor the installation location and operating status of an accumulated 500,000 central air conditioners sold out, providing enterprises and users with more comprehensive information and more assured services.

Comfort has become the focus of creating artificial environment refrigeration equipment at this year's show. The products and systems on display were more comfort of the indoor environment prone. For example, under the normal end winter heating conditions, indoor environment temperature is stratified obviously but people’s sense of comfort is poor. Haier, Gree, Midea, Nathan, Aux and other enterprises have introduced systems to improve indoor comfort.

Furthermore, in addition to the comfortable indoor thermal environment, the pursuit of the comfort of the entire home system has become the main target of the manufacturers: comfortable and healthy indoor environment (including temperature, humidity, cleanliness), reasonable air supply, healthy indoor air quality, intelligent control and visual comfort of the exterior of the air conditioner. In terms of air supply methods, major manufacturers have exhibited their comfortable air supply end, such as the ecological breeze by Haier, infrared-sensored intelligent air supply by Midea and the distributed air supply by Gree. In terms of humidity control, many companies exhibited air conditioning equipment with humidification and dehumidification functions. In view of indoor temperature drop during the dehumidification process in the transitional season, Gree, Midea, Haier and other manufacturers have introduced air conditioners that “dehumidify without temperature drop.” The HICHLY SSLC compressor can achieve sensible heat load and humidity load of the air conditioning system through independent control of two different evaporation temperatures so that the evaporating temperature adjustment of different air conditioning areas is met, and efficiency and comfort of the system is improved. In terms of indoor air quality, manufacturers have also exhibited products with purification and dust removal functions.

5. Compressors are heading towards refinement in various forms and styles

As a core component of the refrigeration system, compressor is still an important exhibit of this year's refrigeration exhibition. The types of heat pump compressors are diversified. The

compressors for "coal to electricity" heat pump units and heat pump water heaters feature many exhibits and models. In addition to the traditional inflated scroll compressors, rolling piston compressors and screw compressor and the single-stage and two-stage rolling piston compressor and screw compressor, models of all kinds are expanding in capacity. For example, the capacity of rolling piston compressor has been expanded to 5HP~8HP, and the scroll compressor has been expanded to 50HP; magnetic suspension centrifugal compressor is developing rapidly. The magnetic suspension centrifugal compressors and their units exhibited this year were not only exceptional in number, but also seen with improved performance and expanded capacity. As the magnetic suspension compressor technology matures, magnetic suspension centrifugal units with energy saving and low maintenance costs will be securing part of the screw centrifugal units market. The magnetic levitation compressor and its unit are still the most hotly contested area in the refrigeration and air-conditioning industry. In addition, the parking air-conditioning compressors exhibited this year included heating and cooling air-conditioning compressors for small cars, RVs and refrigerating vehicles. They are horizontal and vertical in types. With regards to the working mediums, many compressors use R407C, carbon dioxide in addition to the traditional R410A, R134a.

6. Assist Winter Olympics, accelerate development of cold chain technology

Cold chain technology is an important part of refrigeration technology and an important part of the China Refrigeration Exhibition. In order to embrace Beijing 2022 and respond to the country's call to promote winter sports, many well-known domestic and foreign companies have participated in this exhibition with their cold chain equipment and systems. The exhibition not only provides a platform for enterprises to showcase their technical strength and their latest product features, but also provides a good opportunity for communication and cooperation between enterprises. Many enterprises have taken this opportunity to introduce specialized refrigeration systems and equipment for winter sports venues and ski resorts. The cold chain equipment exhibited at this exhibition contained all the links in the whole cold chain process. The exhibition shows that the overall performance of the cold chain equipment is being further developed built on its natural working medium refrigeration system. What are also developed include safety of the ammonia-related refrigeration system, the heat and cold integrated high-efficiency unit, the "first one kilometer" and "last kilometer" cold chain equipment among others. The Beijing 2022 Winter Olympics is a pivotal driver for the development of winter sports equipment.

For example, for the main refrigeration unit of the winter sports stadium, companies rolled out the NH3/CO2 cascading + micro-filling technology system and related integrated structural design and installation scheme, as well as the use of the matching of the hot and cold integrated machine to provide the living and entertainment area with hot water. The Winter Olympics will significantly

advance development of winter sport equipment and technology in the next few years.

In addition, technical seminars and symposiums involved technical reports and lectures on technologies related to ice (snow) making technology at the Beijing 2022 winter Olympic venues.

7. Value youth, reserve outstanding talents for the industry

Professional talent training has always been one of the key issues in the development of the industry. Talent cultivation is an important guarantee for a vibrant, sustainable development of the industry that can follow the times. Refrigeration and air conditioning fall into the engineering major in the division of discipline. They require students to have a good practical cognitive capability. CR covers most of the research directions in the major, from product display to academic communication. It provides a comprehensive way for university students to get out of the campus and embrace forefront practical experience to improve their professional cognition.

At the exhibition, two events were held as public welfare events, i.e. the 13th Science and Technology Contest for College Students of China R&AC Industry launch ceremony and press conference and the "CAR-ASHRARE Student Design Competition Award Ceremony and the 10th Anniversary Celebration.” One of the events was science and technology contest, the other was a design competition. They were aimed to cultivate students’ professional capability and practical ability, and cultivate the reserve talents for the development of the industry.

The exhibition also witnessed symposiums and technical seminars including "HVAC Designer Forum - Excellent Design Sharing" and "Refrigeration & Air Conditioning Young Designers Forum." Excellent HVAC designers, especially young outstanding engineers, managerial staff and graduate students were invited to share their design, management experience and research results.

In order to motivate young people, the Organizing Committee planned the first “CAR Senior Engineers Forum” and issued certificate to technical staff including engineers and senior engineers. Four outstanding engineers were invited to deliver academic lectures, sharing their growing experience, experience of their R&D research and corporate management. The purpose of this endeavor was to stimulate the Chinese engineering and technical personnel to dedicate themselves to the refrigeration industry.

V. Conclusion

（Professor Shi Wenxing, Tsinghua University）

Under the joint efforts of the organizing committee and various associations, enterprises, universities, after 32 years of hard work, CR has grown into one of the largest professional exhibitions in the global HVAC refrigeration and air-conditioning industry. Every exhibition, every gathering, each "Technical Report" record the grandeur of the event, the hot spots, technological progress and expectations. It is also long-term publicity of exhibitors' technology.

With the theme of “Cooperation & Innovation for Development” and in combination with national policies and strategies, the exhibition showcased the progress of the refrigeration and air-conditioning industry in China and the world over the past years. At the same time, it also built a platform for exhibitors to display technology and products, to communicate and promote their service. These platforms fully reveal the true nature of exhibition – to provide premium service to exhibitors.

Let us look forward to the 31st China Refrigeration Exhibition – See you in 2020 in Wuhan.

Thanks to the expert team of this *Technical Report.* It took their long time to visit the exhibition and write the summary. Thanks for their hard work and dedication.

Thanks to the CR Organizing Committee for its detailed proofreading and information verification, making it a more information accurate and history recording book.

Appendix 1: Summary Table of Enterprises and Products Involved in "Chapter II-Technical Progress".

2.1 Refrigerant Compressor, Working Substances and Lubricant

Serial No.	Name of the enterprise	Product name (Type)
1	Emerson Climate Technologies (Suzhou) Co., Ltd.	CO_2 compressor
2		R290 special compressor for heat pump and hot water YHV0461U-9X9-ABK
3		R407C scroll variable-frequency transport compressor
4		40HP large commercial air conditioning scroll compressor
5	Danfoss Automatic Controls Management (Shanghai) Co., Ltd.	50HP large-capacity scroll compressor
6	Fujian Snowman Co., Ltd.	SRM open screw compressor for vessels
7		Propane compressor
8	Fu Sheng Industrial (Shanghai) Co., Ltd.	Single two-stage low-environment temperature heat pump screw compressor
9		Two-stage refrigerant compressor
10	The Chemours Chemical (Shanghai) Co., Ltd.	FREON M099 (R438A) working substance
11		XP series products
12	LG Electronics (China) Co., Ltd.	Maglev compressor
13	GEA Refrigeration Technology (Suzhou) Co., Ltd.	Hydrocarbon compressor
14	Qingdao Haier Air Conditioning Electronic Co., Ltd.	Maglev compressor
15	Shandong Dongyue Chemical Co., Ltd.	No. 5 refrigerant DYR-5
16		DYR-3 refrigerant
17	Shanghai Dorin Compressor Sales Co., Ltd.	Semi-closed CO_2 whole series compressors
18	Shanghai Hanbell Precise Machinery Co., Ltd.	LT-S-A series single two-stage ultra-low environment temperature heat pump compressor

19		RC2-T series ultra-high temperature heat pump compressor
20		Subcritical semi-closed CO_2 screw compressor
21	Shanghai Comer Machinery Co., Ltd.	Maglev compressor
22	Shenzhen McQuay Air Conditioning Co., Ltd.	Maglev compressor
23	Panasonic Appliances Compressor (Dalian) Co., Ltd.	CO_2 double-rotor compressor for freezing, refrigeration and heat pump
24	Wuhan New World Refrigeration Industrial Co., Ltd.	Water vapor compressor
25	Zhejiang Boyang Compressor Co., Ltd.	Double-rotor compressor for electrombiles
26	Zhejiang Juneng Compressor Co., Ltd.	Compressors for electrombiles
27	Zhejiang GMCC Compressor Co., Ltd.	R410A compressor with air supply port
28		R290 compressor
29		Inverter and variable volume air supply air-condition compressor with all-purpose coupling
30		G2 air condition compressor with independent compression
31		Horizontal parking air-conditioning compressor
32		Horizontal compressor for air conditioning of motor homes
33		CO_2 compressor
34		Micro compressor for special fields
35	Gree Electric Appliances, Inc. of Zhuhai	Maglev compressor
36		Horizontal compressor with intermediate spray structure

2.2 Chilling (Hot) Water Unit and Refrigeration Fittings for Industrial and Commercial Central Air Conditioning Application

Serial No.	Name of the enterprise	Product name (Type)
1	ESSEN Company (South Korea)	Plug-in copper pipe joint

2	Vulkan Lokring Rohrverbindungen GmbH & Co. KG. (German)	Lokring pipe connection technology
3	Moon Environment Technology Co., Ltd.	GWHS-HFO high-temperature water vapor machine
4	Dalian Refrigeration Co., Ltd.	Screw ethylene glycol unit especially for petrifaction
5	Danfoss Automatic Controls Management (Shanghai) Co., Ltd.	Maglev centrifugal unit
6	Dongguan Shenglida Refrigeration Equipment Co., Ltd.	Clamp hose and joint
7	Dunham-Bush (China) Limited	Gas bearing centrifugal water chilling units
8		Single two-stage screw air source heat pump unit
9	Guangdong Midea HVAC Equipment Co., Ltd.	The cloud service platform for water chilling unit and multi-split unit system
10	Hebei Nasen Air Conditioning Co., Ltd.	Gas bearing centrifugal compressor unit
11	LG Electronics (China) Co., Ltd.	Single-compressor large-capacity centrifugal water chilling unit
12		Maglev unit
13		Gas bearing compressor
14	Nanjing TICA Climate Solutions Co., Ltd.	Maglev air-cooled chiller unit
15		Integrated evaporative-cooling screw water chilling unit
16	Ningbo Shixin Refrigeration Equipment Co., Ltd.	Clamp hose and joint
17	Qingdao Haier Air Conditioning Electronic Co., Ltd.	Maglev heat pump unit
18		Direct cooling air conditioning unit
19		IoT maglev water chilling unit using R1233ze
20		The cloud service platform for water chilling unit and multi-split unit system
21	Shandong GRAD Group Co., Ltd.	Single two-stage air-cooled screw unit
22	Shanghai Comer Machinery Co., Ltd.	Maglev unit
23		Low-temperature screw unit
24	Shenzhen McQuay Air Conditioning Co.,	Single-compressor large-capacity centrifugal water

	Ltd.	chilling unit
25		Double-compressor 1,500RT large refrigerating capacity unit
26	Shuangliang Eco-Energy Systems Co., Ltd.	System solution for energy saving of absorption units
27	Panasonic Appliances Air-Conditioning and Refrigeration (Dalian) Co., Ltd.	Absorption water chilling unit
28	Suzhou BSE Air Conditioning Co., Ltd.	Maglev heat pump unit
29	Wuhan New World Refrigeration Industrial Co., Ltd.	Water vapor screw expansion unit
30	Zhejiang Sanhua Intelligent Controls Co., Ltd.	Electric water valve for FMF fan coil
31	Gree Electric Appliances, Inc. of Zhuhai	Maglev unit
32		Direct cooling air conditioning unit
33		The cloud service platform for water chilling unit and multi-split unit system

2.3 Medium and small air conditioning equipment and systems

Serial No.	Name of the enterprise	Product name (Type)
1	Guangdong Midea HVAC Equipment Co., Ltd.	Low temperature air source heat pump unit
2		Heat pump hot-air blower
3		Dedicated indoor unit for kitchen
4		Intelligent air supply based on infrared induction
5		Air conditioner with separate control of temperature and humidity
6	Panasonic Ecology System Guangdong Co., Ltd.	Dehumidifier in the W-HEXS dual- dehumidifier system
7		Wall-type fresh air machine
8	Hebei Nasen Air Conditioning Co., Ltd.	Low temperature air source heat pump unit
9		Heat pump hot-air blower
10	Clivet Aircon Limited	Multi-source complementary and multi-function air

		conditioner
11	LG Electronics (China) Co., Ltd.	Water-cooling multi-split unit
12	Nanjing TICA Climate Solutions Co., Ltd.	Low temperature air source heat pump unit
13		Heat pump hot-air blower
14		Enhanced vapor injection multi-split unit
15		Humidifying multi-split unit
16		GHP gas multi-split unit
17		Induced radiant air beam
18	Ningbo AUX Electric Appliance Co., Ltd.	Low temperature air source heat pump unit
19		Enhanced vapor injection multi-split unit
20	Ningbo Deye Frequency Conversion Technology Co., Ltd.	Heat pump hot-air blower
21	Qingdao Haier Air Conditioning Electronic Co., Ltd.	Heat pump hot-air blower
22		“E+ IoT” cloud service platform
23		Ecological breeze
24		Air conditioner with separate control of temperature and humidity
25		Air conditioner with “smart self-cleaning” function
26		Butterfly wing-type air duct machine
27	Shanghai Highly Electrical Appliances Co., Ltd.	SSLC compressor
28	Shenzhen Power World New Energy Technology Co., Ltd.	Heat pump hot-air blower
29	Panasonic Appliances Air-Conditioning and Refrigeration (Dalian) Co., Ltd.	Gas water - fluorine complex heat pump system
30	Gree Electric Appliances, Inc. of Zhuhai	Low temperature air source heat pump unit
31		Heat pump hot-air blower
32		GMV6 AI multi-split unit
33		Dedicated indoor unit for kitchen
34		Dedicated indoor unit for bedroom

35		Dedicated indoor unit for locker rooms
36		Dedicated indoor unit for bathroom
37		Distributed air supply
38		Air conditioner with separate control of temperature and humidity
39		Zero-carbon intelligent household system
40		Wall-type fresh air haze removal machine
41		“Hanbaiyu” air conditioner

2.4 Air Handling Unit and HVAC Automatic Control System

Serial No.	Name of the enterprise	Product name (Type)
1	Airquality Air Technology (Shanghai) Co., Ltd.	Fresh air purification product
2	Belimo Actuators (Shanghai) Trading Ltd.	Universal butterfly valve actuator with NFC function
3		Sensor with communication interface
4	German Blauberg Group	ZAbluefin series centrifugal fans
5	Tillerson Residential Technology (Jiangsu) Co., Ltd.	Gypsum board radiant board and matching fast connection pipeline and heat recovery dehumidifier
6	Durkee (Wuhan) Insulation Material Co., Ltd.	Formed flexible adiabatic air duct system
7	Panasonic Ecology System Guangdong Co., Ltd.	Air “bath heater” product
8	Guangzhou Basic Intelligent Technology Co., Ltd.	Comprehensive accounting management platform
9	Comefri (China)Co., Ltd.	New voluteless fan
10	Guangzhou Insofan Ventilation Technology Co., Ltd.	New voluteless fan WuHyun Insofan
11	Hollingsworth & Vose (Suzhou) Co., Ltd. (Hollingsworth &Vose)	Fresh air unit with Nano Wave® filter material
12	Royal Service Air-Conditioning	Integrated variable air volume outlet product

	(Guangdong)Corp.	
13	Gogee Technology Co., Ltd.	Indoorclimate system
14	Jinan Grass Green Environmental Technology Co., Ltd.	Professional equipment for fume purification of household and commercial kitchens
15	Jiangsu Jiabao Air Conditioning Co., Ltd.	Fan coil with electrostatic precipitation air return box
16	Jiangsu Yaodi New Material Co., Ltd.	Flame retardant flexible air duct and inlet products
17	Czech PRIHODA Co., Ltd.	Flame retardant flexible air duct and inlet products
18	Jinhua Langtong Plastic Co., Ltd.	Fresh air HDPE plastic pipe
19	Nather Ventilation System Co., Ltd.	Wall-mounted all heat-exchange fresh air machine
20	MayAir Technology (China) Co., Ltd.	Professional equipment for fume purification of household and commercial kitchens
21	MENRED Group Co., Ltd.	Floor heating pipes and modular insulation board
22	Nanjing TICA Climate Solutions Co., Ltd.	Jingrun series combined air handling unit
23		Fan coil with purification filter
24		Induced radiant air beam
25	Shandong Co Creation Composite Material Co., Ltd.	Nozzle outlet air supply fan coil
26	Wuxi Hammer Air-Conditioning And Ventilation Equipment Co., Ltd.	Embedded Coanda fan coil
27	Ebmpapst Fan (Shanghai) Co., Ltd.	Condensing and evaporating fans for electric bus with higher EMC grade
28		Fan for refrigerator
29	Zhejiang Mingzhen Electric & Electronic Co., Ltd.	SANMU new voluteless fan
30	FabricAir (Qingdao) Technology Co., Ltd.	FabricAir flame retardant flexible air duct and inlet products
31	Gree Electric Appliances, Inc. of Zhuhai	Maglev direct cooling air conditioning unit
32	Zhuzhou National Engineering Research Center of Converters Co., Ltd.	*t*Power-IC series central air conditioning frequency converter

2.5 Heating and Hot Water Equipment and System

Serial No.	Name of the enterprise	Product name (Type)
1	Dalian Bingshan Group Co., Ltd.	Heat pump unit for sewage heat recovery
2		A whole house customization scheme of refrigeration + heating + domestic hot water based on air source host
3	Danfoss Automatic Controls Management (Shanghai) Co., Ltd.	Scroll compressor for heat pump
4		FHF water manifold and collector for floor heating
5	Guangdong Phnix Energy Saving Equipment Co., Ltd.	Ultra-low temperature heating air source heat pump unit
6		No-water flooring heating air source heat pump unit
7		Whole-house heating + refrigeration customized scheme based on the heat pump air conditioning
8		Domestic cooling water heater
9	Guangdong Midea HVAC Equipment Co., Ltd.	Roaring flame series all-DC variable-frequency low-temperature air source heat pump unit
10		Air source heat pump hot water machine
11		Heat pump unit using R32 refrigerant
12		Heat pump unit using R290 refrigerant
13		Microchannel heat exchanger
14		Air source heat pump two-stage supply unit
15	Hisense (Shandong) Air Conditioner Co., Ltd.	Air source heat pump unit
16		Heat pump unit using R32 refrigerant
17	Sanhua (Hangzhou) Micro Channel Heat Exchanger Co., Ltd.	Microchannel liner heat exchanger
18	Hebei Nasen Air Conditioning Co., Ltd.	Heat pump air conditioning terminal
19	Heilongjiang ARCO Technology Co., Ltd.	Heat pump unit using CO_2 refrigerant
20	Jinan Dasen Refrigeration Engineering Co., Ltd.	Full heat recovery steam generating unit
21	Henan Runte Refrigeration Equipment Co., Ltd.	Heat recovery heat pump dryer
22	Kunming Dongqi Technology Co., Ltd.	Heat pump unit using CO_2 refrigerant

23	LG Electronics (China) Co., Ltd.	A whole house customization scheme of heating + domestic hot water based on air source host
24	MENRED Group Co., Ltd.	Fan coil temperature controller
25		An intelligent IoT whole-house Heidelberg floor heating customization scheme based on the wall-hanging gas stove
26	Nanjing TICA Climate Solutions Co., Ltd.	“Jiajiarun” system all variable-frequency household air source heat pump unit
27	Ningbo AUX Electric Appliance Co., Ltd.	Heat pump unit using R290 refrigerant
28		Low-temperature air source heat pump integrated refrigeration and heating machine
29	Qingdao Haier Air Conditioning electronic Co., Ltd.	High temperature outlet air source heat pump unit
30		Heat pump unit using R32 refrigerant
31		Heat pump unit using CO_2 refrigerant
32		Heat pump air conditioning terminal
33		Yunnuan series-integrated air-conditioning and floor heating machine
34	Panasonic Appliances Air-Conditioning and Refrigeration (Dalian) Co., Ltd.	Gas-fired water-fluorine compound air-conditioning heat pump system
35	Tsinghua Tongfang Artificial Environment Co., Ltd.	Air source heat pump unit
36		Wood heat pump dehumidification dryer
37	Zhejiang Dun’an Artificial Environment Co., Ltd.	Air source heat pump unit
38		Heat pump unit using CO_2 refrigerant
39	Zhejiang DunAn Electro-Mechanical Technology Co., Ltd.	Heat pump unit using R32 refrigerant
40	Zhejiang KINGAIR Co.,Ltd.	Heat pump unit using R32 refrigerant
41	Zhongshan Amitime Electric Co., Ltd	AMITIME ultra-low temperature variable-frequency air source heat pump
42	Gree Electric Appliances, Inc. of Zhuhai	Air source heat pump unit
43		Heat pump unit using R32 refrigerant

44		Heat pump air conditioning terminal
45	Panasonic Appliances Compressor (Dalian) Co., Ltd.	Special compressor for high temperature drying heat pump

2.6 Cold Chain Equipment and Accessories of the Refrigeration System

Serial No.	Name of the enterprise	Product name (Type)
1	DS Korea (South Korea)	“Copper interface” plate heat exchanger
2	Termowave(Germany)	Plate heat exchanger
3	Moon Environment Technology Co., Ltd.	DISU ice slurry unit
4		GMCW-NH_3 microfilling chilling unit
5		GWHS-HFO high-temperature water vapor machine
6		GEPT-R290/CO_2 high-efficiency phase-change refrigerating machine
7	Changzhou Changfa Refrigeration Technology Co., Ltd.	Microchannel heat exchanger
8		Roll-bond evaporator
9		Wire-tube condenser
10	Changzhou Yunhai Refrigeration Equipment Co., Ltd.	Tube-in-sheet evaporator
11	Foshan Hualu Automatic Controls Ltd.	Several expansion valves for refrigeration system
12	Sanhua (Hangzhou) Micro Channel Heat Exchanger Co., Ltd.	Modular heat pump microchannel heat exchanger
13		Microchannel coating solution
14	Hangzhou Shenshi Energy Conservation Technology Co., Ltd.	Integrated microchannel heat exchanger
15	Hangzhou Wosi Enetgy-saving Technology Co., Ltd.	Finned tube heat exchanger with coating
16	Huamei Energy-saving Technology Group Co., Ltd.	Alkadiene cryogenic insulation material
17	Jiangmen East-Alliance Thermal Equipment Co., Ltd.	Large diagonal-flow brazed plate heat exchanger
18	Jiangsu Weyee Heat Exchanger Co., Ltd.	SF150 series coaxial double-pipe heat exchanger

19	Jiangyin Yalong Heat Exchanger Co., Ltd.	B3 series removable plate heat exchanger
20	Yalong, Jiangyin	SF200 series coaxial double-pipe heat exchanger
21	Carel Electronic (Suzhou) Co., Ltd.	High-efficiency CO_2 condensing unit
22	Qingdao Haier Special Freezer Co., Ltd.	Ultra-low temperature freezing conversion cabinet
23	Shanghai Hengaoda Heat Exchanger Co., Ltd.	Removable plate heat exchanger
24	Shanghai Weilian Heat Transfer Company	A series of high-efficiency heat transfer finned tube products
25	Shanghai Zhongjie Thermal Technology Center	Finned tube heat exchanger with coating
26	Shenzhen Zhongji Cold Chain Technology Co., Ltd.	Mobile multi-functional modular refrigerating box
27	Wuhu Dajin New Material Technology Co., Ltd.	Insulation pipes and coating copper pipes, refrigerant piping and installation accessories
28	Wuxi Tongli Air Conditioning Equipment Co., Ltd.	High-efficiency new shell-and-tube heat exchanger
29	Weihai Yunshan Technology Co., Ltd.	Modified graphite polyurethane compounds for B1 refrigerator
30	Wincell Insulation Co., Ltd.	Insulation materials accessories
31	Zhejiang Dun'An Artificial Environment Co., Ltd.	Ultra-quiet high-durable electronic expansion valve for multi-split unit
32		CV(B) series CO_2 one-way valve
33		ELF08 series dynamic balance electric regulating valve with iron flange
34		DSF series four-way valve
35	Zhejiang Forwon Plate Heat Exchanger Co., Ltd.	High-efficiency heat exchange tank
36	Zhejiang SunCo Heat Exchange System Co., Ltd.	Microchannel heat exchanger
37	Zhejiang Sanhua Intelligent Controls Co.,	Electronic expansion valve with low internal leakage

	Ltd.	
38	Gree Electric Appliances, Inc. of Zhuhai	Integrated intelligent condensing unit

Appendix 2: List of Innovative Products in 2019 China Refrigeration Exhibition

Category I HVAC&R accessories

Serial No.	Product name	Name of the enterprise
1	16HP large DC inverter compressor	Shanghai Highly Electrical Appliances Co., Ltd.
2	DD98PHDG large-volume DC inverter scroll compressor	Johnson Controls-Hitachi Wanbao Compressor (Guangzhou) Co., Ltd.
3	Electric water valve for FMF fan coil	Zhejiang Sanhua Intelligent Controls Co., Ltd.
4	LPF series electronic expansion valve with low internal leakage	Zhejiang Sanhua Intelligent Controls Co., Ltd.
5	NLU8.8DN-R290 piston compressor for heat pump	Nidec Compressor (Tianjin) Co., Ltd.
6	RC2-T ultra-high temperature heat pump compressor	Shanghai Hanbell Precise Machinery Co., Ltd.
7	SRC-S-353 Propane compressor	Fujian Snowman Co., Ltd.
8	SST Two-stage refrigerant compressor	Fu Sheng Industrial (Shanghai) Co., Ltd.
9	*t*Power-IC series central air conditioning frequency converter	Zhuzhou National Engineering Research Center of Converters Co., Ltd.
10	Emerson R32 inverter compressor (80CC)	Emerson Climate Technologies (Suzhou) Co., Ltd.
11	Bitzer semi-closed screw compressor HS95 series	Bitzer Refrigeration Technology (China) Co., Ltd.
12	Danfoss 50TR constant speed scroll compressor	Danfoss Automatic Controls Management (Shanghai) Co., Ltd.
13	Danfoss CO_2 transcritical adaptive liquid injection scheme	Danfoss Automatic Controls Management (Shanghai) Co., Ltd.
14	Danfoss new efficient brazing fish-scale microplate heat exchanger with bimetallic joints C12	Danfoss Automatic Controls Management (Shanghai) Co., Ltd.
15	Ultra-quiet high-durable electronic expansion valve for	Zhejiang Dun'An Artificial Environment Co.,

	multi-split unit	Ltd.
16	Condensing and evaporating fans for electric bus with higher EMC grade	Ebmpapst Fan (Shanghai) Co., Ltd.
17	Copeland ™ZB large commercial refrigeration compressor	Emerson Climate Technologies (Suzhou) Co., Ltd.
18	CO_2 double-rotor compressor for freezing, refrigeration and heat pump	Panasonic Appliances Compressor (Dalian) Co., Ltd.
19	All-aluminum plate heat exchanger	Hangzhou Sanhua Home Appliance Thermal Management System Co., Ltd.
20	Heat pump water heater compressor RDSM89V1TDZ	Guangdong GMCC Refrigeration Equipment Co., Ltd. Guangdong Welling Motor Manufacturing Co., Ltd.
21	New generation industrial screw compressor M	GEA Refrigeration Technology (Suzhou) Co., Ltd.
22	Brushless DC motor	Guangdong GMCC Refrigeration Equipment Co., Ltd. Guangdong Welling Motor Manufacturing Co., Ltd.

Category II General air-conditioning heat pump equipment

Serial No.	Product name	Name of the enterprise
1	E+IoT multi-split unit	Qingdao Haier Air Conditioning electronic Co., Ltd.
2	NH_3 microfilling chilling unit	Moon Environment Technology Co., Ltd.
3	Wall-mounted all heat-exchange fresh air machine FA150-W	Nather Ventilation System Co., Ltd.
4	Roaring flame inverter low-temperature air source heating hot water unit	Guangdong Midea HVAC Equipment Co., Ltd.
5	Ice slurry (water) unit	Moon Environment Technology Co., Ltd.

6	Maglev direct cooling air conditioning unit	Gree Electric Appliances, Inc. of Zhuhai
7	Gas-fired water-fluorine compound air-conditioning heat pump system	Panasonic Appliances Air-Conditioning and Refrigeration (Dalian) Co., Ltd.

Category III General freezing and refrigeration equipment

Serial No.	Product name	Name of the enterprise
1	Control solutions of Semi-welded plate heat exchanger and subsystems	Danfoss Automatic Controls Management (Shanghai) Co., Ltd.
2	High-efficiency CO_2 condensing unit	Carel Electronic (Suzhou) Co., Ltd.

Category IV Air-conditioning heat pump and freezing and refrigeration equipment for special purposes

Serial No.	Product name	Name of the enterprise
1	GWHS-HFO high-temperature integrated water vapor machine	Moon Environment Technology Co., Ltd.
2	Ultra-low temperature freezing conversion cabinet	Qingdao Haier Special Freezer Co., Ltd.
3	Full heat recovery steam generating unit	Jinan Dasen Refrigeration Engineering Co., Ltd.
4	Water vapor screw expansion machine	Wuhan New World Refrigeration Industrial Co., Ltd.