

Air-Source Heat Pump and it's Season Operating Efficiency

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【**Abstract**】 According to operation characteristic for air-source heat pumps, this paper presents recommendations that air-source heat pump products should give its season energy efficiencies indices in China, and discusses the necessity, the importance, pressing and possibility to formulate test standard on air-source heat pump performance in our country. On the basis of current developing level of heat pump technology internationally, this paper gives suggestions about introducing new techniques and improving product structure design, and discusses the necessity and the importance setting up advanced laboratory of air-source heat pumps in manufacturers and making up test centers in nationwide. In order to developing air-source heat pump industry, also need attentively use air-source heat pumps. Author also presents suggestions for improving design selection and operation management in this paper.

【**Keywords**】 Air-source heat pump, Season operating efficiency, Season energy efficiency indexes, Air/air heat pump, Air/water heat pump.

1, Introduction

Air-source heat pump is one type of air-conditioning equipment with annual more long operating time. As everyone knows; because the performance of air-source heat pump relies strongly on variation of outdoor air temperature, it leads to “converse effect” on its performance. In summer, when outdoor temperature is increasing, air-conditioning cool load also is increasing, but the refrigeration capacity of heat pump unit and its efficiency decrease and reduce with temperature increasing. In winter, when outdoor temperature is decreasing, air-conditioning heat load also is increasing, but the heating capacity of heat pump unit and its efficiency decrease and reduce with temperature decreasing. Just because this reason, we can not simply use EER or COP under certain conditions (even standard conditions) to evaluate priority and inferior of heat pump unit performance. Not only the distribution of frequency hours of temperature and humidity in annual 8640 hours for each region is different, but also the distribution of frequency hours of outdoor temperature of its practical operation is different, since operation scheduling of different types of buildings is different, even in same city.

For every user of heat pump units, what concerned must not be one efficiency under certain temperature, but is annual operating cost, that is to say, annual operating efficiency ----summer cooling energy efficiency ratio (SEER) and winter heating season performance factor (HSPF). Therefore, season efficiency has became one of important and indispensable technology economic index for measuring air-source heat pump performance. It also is one energy efficiency index mostly concerned by governments of air-conditioning powerful nation, manufactures, users.

China joining WTO has became foregone conclusion. Nearly 10-20 years, the rapid development of civil air-conditioning buildings in our country has made China becoming an air-conditioning large country recognized in world. Chinese air-conditioning market has became a battlefield contended by well-known manufactures of air-conditioning and refrigeration in world.

But Could China use the opportunity that China join WTO to participate in international competition as soon as early and to make our country progressively coming from air-conditioning large country into powerful nation? The answer is affirmative, but its premise is that first require own product performance standards keep up with advanced abroad standard.

The Ministry of Construction has published 《Standard of Climatic Regionalization for Architecture 》 (GB 50178--93) in 5 July 1993 and begun implement in 1 February 1994; National Standard 《Code for Design of Heating, Ventilation and Air Conditioning 》 is revising and planing include annual hour by hour weather data of more 100 cities in our country. These conditions have provided science basis for researching and developing season efficiency index system of air-source heat pump in our country. But want to attempt this “possible” become “reality”, we also need make a great quantity of hard work. This paper will tell some of myself view and hope cause further deep discussion.

2, Evaluation index of season efficiency

Although in early 1950's it has be developed that air-source heat pumps were studied and applied in engineering ^{[1][2]}, but begin commercial-scale production and engineering applications until early 1990's because a variety of reasons. In end 1990's the productive forces of air-source heat pumps were formed. Now there are 30 of manufactures with producing 10~300 kW capacity unit in China. In 2000, they sold 8595 units with worth of RMB 960 million ^[3].

Now available products of air-source heat pump may be roughly divided into three sorts ^[4]: (1)family air-conditioners with heat pump---- there are three types of window, through-wall, split, its capacity range from 2 kW to 6 kW; (2)unitary air-source heat pump equipment (air/air heat pump units) ----there are two types of self-contained and split, its capacity range equal or less 19 kW; (3)air/water heat pump units ---- there are two types of vertical and horizontal, its capacity range from 15 to 700 kW. Because family air-conditioners with heat pump belong to family electric industry and are limited by this paper length, later two types of heat pump will be limited to discuss in this paper.

On unitary air-source heat pump equipment, more complete season efficiency index system had been set up in 1980's under initiation of DOE of US. At the core of summer cooling season energy efficiency ratio (SEER) and winter heating season performance factor (HSPF), ASHARE and ARI developed concerned standards for unitary air-source heat pump units:

ANSI/ASHRAE 116----1983 Standard 《Methods of Testing for Seasonal Efficiency of Unitary Air-Conditioners and Heat Pumps》 ^[5]

ANSI/ASHRAE 37----1988 Standard 《Methods of Testing for Performance of Unitary Air-Conditioning and Heat Pump Equipment》 ^[6]

ANSI/ARI 210-240----1989 Standard 《Unitary Air-Conditioning and Air-source Heat Pump Equipment》 ^[7]

Above three standards provide testing conditions, test devices, testing methods, testing procedures, and calculation formulations for determining capacity, EER, COP, SEER, HSPF of Unitary Air-Conditioning and Air-source Heat Pump Equipment.

On air/water heat pump air-conditioning units, because capacity of this sort of units is larger, all-weather testing devices are difficult to set as same as that of Unitary Air-Conditioning and Air-source Heat Pump Equipment. Therefore, in following standards of ARI of US:

ANSI/ARI 340----1986 Standard 《Commercial and Industrial Unitary Heat Pump Equipment》(capacity 19~40 kW) ^[8]

ARI 500----1990 Standard 《Variable Capacity Positive Displacement Refrigerant Compressors and Compressor Units for Air-Conditioning and Heat Pump Applications》(capacity > 40 kW) ^[9].

provide requirements of testing conditions only for EER and COP and calculation formulations of Integrated Part Load Value (IPLV) .

Above evaluation methods and index system of seasonal efficiency can not say that they are fully perfect, but more science and more reasonable. When developing the standards of testing methods and its seasonal efficiency evaluation methods for air-source heat pumps in our country, above standards are worth to reference and to study.

3, Study and Development ---- Purposes and Objectives

Manufacturing industry of air-source heat pump in our country although have made considerable progress and larger development five years ago, soberly say, it still is in stage of “plagiarism”. The study and development of products was made relatively less. After enter WTO, if so develop for a long time, we not only can not go out “national gate”, but also the existing share in home market also could gradually lose. I believe that we must enhance throw into in study and development and turn round present aspect that they are willing to expend more millions or ten millions on advertisement propaganda and public relation, but not on setting up laboratory in oneself factory. The purposes of study and development of our products first should base oneself upon home and develop multi-series of products appropriate to Chinese Climatic Regionalization for high-efficiency air-source heat pump. The special objectives are suggested following: (1) continuous to increase and perfect product quality and annual energy efficiency; (2)to develop series products of air-source heat pump appropriate to cold areas in our country; (3)to add series products of air-source heat pump with recovery condensation heat and supply hot-water.

4, Structure Innovation ---- Introduce New Technology

In order of improving annual operating efficiency of air-source heat pump, extending suitable area and increasing use functions, we must perform an operation for existing products, introduce new technology and redesign for inside structure. According to innovation train of thought of air-source heat pump abroad and home, this innovation may be roughly put one's hand to following five aspects:

(1), According to suitable area data of temperature profile in winter and summer and humidity ratio distribution in low temperature section, dispose or rearrange ratio of transfer heat area between outdoor air/refrigerant heat exchanger and refrigerant/ indoor air heat exchanger, as well as theirs spaces.

(2), Introduce electronic expansion valve technology. The supply and distribution liquid return circuit scheme of outdoor and indoor air/refrigerant heat exchangers would be revised, so that decrease traditional expansion valve quantity and simplify line join, but and shorten time of melting frost and reduce fluctuation of supply air or water temperature in second side. If again add intellectual control system, annual operating energy efficiency could be increased.

(3), Select scroll type compressor. Except for minimum of spares quantity and higher energy efficiency, the air-source heat pump system consisted of scroll type compressor have more smooth characteristic for winter heating and summer cooling, thus help improve annual operating energy efficiency of heat pump unit or entire system.

(4), Introduce frequency conversion technology. Selecting high-efficiency converters and appropriate motors of compressors are effective ways that reduce fluctuation of supply air or water temperature in second side and increase stability of system operation under part loads.

(5), In order of entering European market, need screening alternative of R-22 for air-source heat pump. Study and develop heat pump units suitable for European climate. This is a strategy loop must not lack in international competition.

5, Measuring and Test

As viewed from understanding for manufactures of existing producing air-source heat pump, their level of measuring and test heat pump performance now on the whole could be divided into following four grades:

(1), There is a testing laboratory for air-source heat pump products, which was meticulously design and have good equipment. Testing capacity and simulated ability of outdoor conditions and indoor load only can meet testing winter and summer design conditions, but still have not ability that perform all-weather test and season efficiency test.

(2), There is a testing device only able to measure heating capacity and cooling capacity under winter and summer design conditions. Before leave the factory, each unit was performed routine test.

(3), Only there is a test run field, on which perform normal long time run and on-off test after heat pump unit is fit together. It has not measuring means of cooling and heating capacity, only to sure it could normal run after carrier to field.

(4), Basically there are not test means. After assemblage were completed, in summer it is electrified and run some time under cooling conditions, in winter under heating conditions. If all could run, it may be sent out factory.

Once if some factories are understood the true situation by adept users, our air-source heat pump products not only are difficulty of participate in competition of international market, but also they would not believe in data in their product sample book.

Therefore, in order of developing air-source heat pump products in our country, providing reliable performance data and high-efficiency season efficiency, we first should make

manufactures to know importance of measuring and test. The manufactures that have foresight and wise must set up advanced laboratory without stint. It either is one test field of its products, and is one basis of development of new products. Without advanced laboratory, there are not any advanced products.

6, Confirm and Evaluate

Except of requiring manufactures to set up advanced and perfect test laboratory, we also should set up statewide supervisor laboratory to monitor product quality. We should stop practice that manufactures entrust some of institute or association to hold appraisal meetings. The right of confirming quality of product performance should be given to one independent organization. Relative products should be sent periodical appraisal and be no regular selected examination. The results certified by test should be published half-year or one year, so that to perform social supervise and objective evaluation. At present, National Technical Supervise Bureau although has established several test centers of air-conditioning and refrigeration, also there is not any test centers of air-water heat pump units. With quickly development of middle-size air-source heat pump products and a great quantity gush of foreign similar products, we strongly appeal for National Technical Supervise Bureau as soon as early set up National Heat Pump Test Center. Its funds problem is appropriately solved, so that to sure it's independent, fair and steady.

7, Engineering Selection and Application

Producing high-quality, high-efficiency heat pump products takes aim at better use for practical applications. But in now fundamental construction, there are phenomena that both open strife and veiled struggle for rights of selecting and purchasing equipment as viewed from designers, owners, contractors, even and overseers. In order of “selfish interests” and “relations”, light situations are only to compare “price”, but not compare “quality and performance” when purchasing, serious situations would rather buy substandard products with high price. This unhealthy trend is seriously corroding our ranks of fundamental construction and leaves a variety of hidden dangers to engineering quality. In same time, it also greatly suppresses development of high-quality and high-efficiency heat pump products. In order of changing this trend, the following several aspects of propaganda work should be made in our industry:

- 1, manufactures of air-source heat pump products must provide complete, reliable data for users and design institutes. Not only EERs and COPs would be given, but also SEER and HSPF should be given.

- 2, Designers should fully understand performance characters of air-source heat pump. After more accurately estimating balance point and supplementary heating quantity, they must select suitable heat pump unit through carefully calculation and comparison as viewed from reducing as annual operating electric consumption as possible.

- 3, For owners, on the one hand, we need that they would be popularized knowledge on operating characters of air-source heat pump and be made know relations between SEER, HSPF and annual operating cost. On the other hand, also we make them to know relation between first capital cost and annual operating cost, so that turn round this unilateral inclination that only

compare quoted price but no consider annual operating performance and cost.

8, Operation Management and Service

Because there are two operating conditions for air-source heat pump, their capacity and efficiency are closed with outdoor temperature. With heating mode operating in winter, also there is one problem of frost time and re-frost control. For each sort of products there is a limit of minimum permitted operating temperature still. Above problems all ultimately effect on economic operation and safety operation, as well as use five of air-source heat pump units. In order of well using air-source heat pumps, we must emphasize the importance of improving management level and well making service and maintenance of equipment. Manufactures are responsible for well making following two matters:

- 1, On the basis of structure character and control tactics of oneself products, popular operating instruction would be written. Matters needing attention of operating would be in detail listed. Methods for how improving season operating efficiency would be introduced.

- 2, Service and operation staff of users would be trained for air-source heat pump operating and maintenance by manufactures oneself or industry association. Knowledge and technical ability of economic and safety operating would be improved.

9, Home and Abroad Market

After join WTO, domestic AC&R industry will be faced with two markets of home and abroad. In home market, our middle-small enterprise of producing air-source heat pump also will be faced with competition of international well-known refrigeration and air-conditioning companies. Our superiority is low-priced labour force, low transportation expenses, without bear of import tax. Superiority of foreign companies is that their products all have passed confirmation of international authority organization on the basis of international or advanced country technical standards. After entering WTO, import tax will reducing annually. Foreign companies also will set up their factories in China and may employ Chinese low-priced labour force. Our original superiority will be disappearing. If we would have not clear-headed knowledge and estimation for oneself product quality, performance and their functions, we could be not able to develop country standards of air-source heat pump equate to international advanced standards as soon as possible. Then our middle-small enterprises not only would not sale products to other countries, but also would loss business chances in invite tenders of home applications. I feel that our middle-small enterprises should have “sense of crisis” for this situation. I hope that industry association and institute lead this work. We should take developing advanced enterprise standards as staring point and make middle-small enterprise to establish high-object and high standard, as well as participate in competition of home and abroad markets.

10, Brief Summary

The view of above nine points show three problems:

- 1, On the basis of the character of air-source heat pump performance directly effected by

outdoor temperature, present the suggestion that season energy efficiency indexes would be developed for air-source heat pump in our country. Discuss necessity, importance, pressing and possible of developing performance test standard of air-source heat pump in our country as viewed from user interests, enterprise development, market competition.

2, On the basis of development level of international heat pump technology at present, present the recommendations of introducing new technologies and reforming product structure. And discuss necessity and importance of set up advanced laboratory of air-source heat pump performance and established National Test Center of Air-Source Heat Pump.

3, In order of developing air-source heat pump estate, also need to make well “proper application” works. For this purpose, indicate existing disadvantages in engineering selection now. Present recommendations of well propagating to manufactures, designers, owners and hope that manufactures should help owners well to make two matters of operating management and service.

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