

Technical Economy Analysis And Energy-Saving Study On Solar-Energy Heat-Pump Air Conditioning

Fangqin Li ¹, Jianxin Ren ¹, Xianbing Zhao ²

¹ Energy and Environment Engineering institute, Shanghai University of Electric Power, Shanghai, China

² Thermal Energy Engineering institute, Tongji University, Shanghai, China

Abstract: With the development of economy, energy conservation has become an urgent problem to be solved. Solar energy was a kind of sustainable clean natural energy. An important problem to be solved was how to take use of it. In this paper, the combination of solar-energy air conditioning and air-cooled heat-pump air conditioning was studied. Heat performance of heat pump was improved. This system could refrigerate and heat; on the other hand, it could supply living hot water perpetually with solar energy. This system had three parts: heat-pump unit, accessorial heat source system and solar-energy heat-collected system. Computer controller was used to regulate this system. Thus, cool-hot air conditioning and daily living hot water were realized. In solar-energy heat-pump system, when it was heat running, solar energy was accessorial heat source. Through increasing the temperature of air entering into evaporator, efficiency and output power of heating was improved. Thus, heat-pump air conditioning with air as accessorial heat source was suitable for low temperature area in winter. Moreover, with accessorial heat source of solar energy, systemic evaporating temperature was high, which improved the compressor's working atmosphere. It was found that COP could be up to 1.8. Compared with general air-cooled heat-pump system, the operational efficiency of solar-energy heat-pump system was higher more than 30% with the working temperature above -10°C.

Keywords: solar energy, heat pump, air conditioning

1. INTRODUCTION

As it was known to all, solar energy was inexhaustible and clean natural energy. Research on how to use it better to serve human being has been an important tendency. In order to improve application of solar energy in ecological buildings, U.S.A, Japan, Hong Kong, etc has made a lot of studies for many years. Solar-energy absorption air-conditioning system has been studied deeply. But it was difficult to use it popularly. Therefore, many studies and discussions have to be done to make use of solar energy. In this paper, solar-energy heat-pump air-conditioning system was discussed. Using this system, the energy problem of air conditioning, heating and hot water supply was solved.

Today, there were two ways to realize solar-energy air conditioning: solar-energy photoelectric conversion, convert electric energy to refrigeration; solar-energy photothermal conversion, convert heat energy to refrigeration. First way, the cost was very high. According to the price of photoelectric cell at present, at the same refrigeration power, its cost was four or five times higher than that of the latter. The latter could supply not only refrigeration, but also heat, and its utilization ratio of solar energy was high. Now, the solar energy was mainly used by latter way.

2. OPERATING PRINCIPLE OF SOLAR-ENERGY HEAT-PUMP AIR CONDITIONING SYSTEM

Air conditioning and hot water supply were combined by solar energy in solar-energy heat-pump air conditioning system. This system not only supplies refrigeration in summer and supplies heat in winter, but also supplies domestic hot water.

Since there were a lot of advantages of solar energy, solar-energy heat-pump air conditioning system offers a broad prospect to air conditioning industry. Products of solar-5000 series just about meet the need of market development, which classifies three series: solar-5100, solar-5200 and solar-5300.

In this paper, series of solar-5100 was studied. This system combined with the solar-energy collector system and air-cooled heat-pump system. The problem of integrated energy management of hot water of air conditioning system in buildings was solved. Schematic diagram of this system could be seen in figure 1.

2.1 Scientific-Technical Value of This System

The combination of solar energy and air-cooled heat-pump air conditioning could increase the thermal behaviour of heat pump. This system supplies not only cooling and heating, but also living hot water in four seasons. This system was made up of heat-

pump unit, solar-energy collector and accessorial heat source system. At same time, computer was used to control this system. New clean energies of solar energy and air energy were made the best of to meet the buildings' need of air conditioning and living hot water in four seasons. Thus, healthy and comfortable living environment was created.

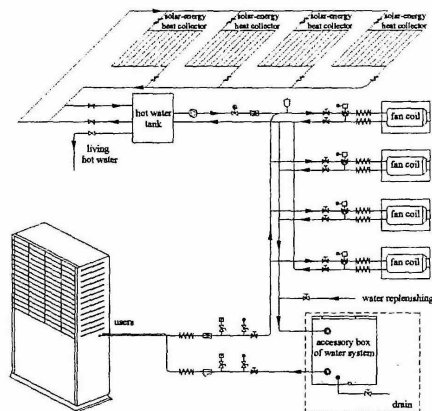


Figure 1: Schematic diagram of solar—5100 solar-energy air conditioning and hot water

2.2 Characteristic of This System

Used many patents, combined solar energy and air-cooled heat-pump air conditioning, and increased the efficiency;

Taken use of solar energy, economized running power cost, increased economy;

Solved the limit of common air-cooled heat pump, and under the condition of below zero 15 degree, this system still could work high-efficiently;

Bettered running conditions of compressor, extended operating life of equipment;

Controlled automatically and intelligently operation, made equipment run safely, reliably and high-efficiently.

3. PERFORMANCE EXPERIMENT OF SOLAR-ENERGY AIR-CONDITIONING HOT-WATER SYSTEM

In order to study the performance of this system, experiment was done in a building. Air-conditioning area was 300 square meter, cooling and heating power was 30 KW, and hot water supply in transitional seasons was 12 ton per day. The system of solar-energy and heat-pump air conditioning was adopted. Temperature of heating medium was 88 degree and Temperature of cooling medium was 7-12 degree. Experimental results indicated: when air conditioning or heating: 35 percent, the average daily

efficiency of heat collector was 40 percent; while when hot waster supplying, the average daily efficiency of heat collector was 51 percent. These were every high.

4. CONCLUSIONS

In this system, when heating, solar energy was used as accessorial heat source of to increase the temperature of air entering into evaporator. Heating efficiency and output power were increased in cold winter. Thus, air-source heat-pump air conditioning system could be used low-temperature areas in winter. Accessorial heat source could increase evaporation temperature and indirectly improved running conditions of compressor. The problem, abnormal work, of compressor under low-temperature condition was solved, and operating lives of whole heat-pump unit were longer. According to primary calculation, the COP (Coefficient of Performance, i.e. cold energy was produced when 1 kW electric energy was consumed) of this system could be up to 1.8. Running efficiency of this system could be increased more then 30 percent than that of common air-cooled heat-pump system under the below zero 10 degree running conditions. Compared with common air-cooled heat-pump system, solar-energy and heat-pump system improved the heating performance from below ways.

Widened the applied range of air-cooled heat pump;

Increased the output power under low-temperature running conditions of this system;

Increased the COP;

Prevented evaporator from frosting, reduced the defrosting time;

Improved the running conditions of air-conditioning compressor, and lengthened operation life of this unit.

Through experiment, it could be found that when this system used in building, the average daily efficiency of this system was high. Therefore, the combination of solar energy and air-cooled heat-pump air conditioning could increase the thermal behaviour of heat pump and widened the applied range of heat pump.

Through increasing the temperature of air entering into evaporator, efficiency and output power of heating was improved. Thus, heat-pump air conditioning with air as accessorial heat source was suitable for low temperature area in winter. Moreover, with accessorial heat source of solar energy, systemic evaporating temperature was high, which improved the compressor's working atmosphere. It was found that COP could be up to 1.8. Compared with general air-cooled heat-pump system, the operational efficiency of solar-energy heat-pump system was higher more than 30% with the working temperature above -10℃.

REFERENCES

- [1] HE Yue-shan, PAN Yang, XI Yang. 2004. Design and Research on Applying Solar Energy to HVAC System in Villa Building. Journal of East

- China Jiaotong University. Vol.21. No.5.p80. China.
- [2] Huang Jinbao,Pu Shaoxuan.2004. Solar Assisted Heat Pump Techniques and Their Applications in Hot Water Supply. Technology exchange.China.
- [3] Zhang Guodong,Sun Jianjun.2004. The Application of Solar Energy in the Development of Heat Pump Air-conditio.Cooling and Air Conditioning.Vol.4.p48. China.
- [4] DONG Yu-ping, YOU Shi-jun, WANG Hong-jun, XU Ai-Dong, ZHU Huan . 2003. Economic Analysis on Solar-Ground Source Heat Pump Comprehensive System. Gas & Heat. Vo1. 23. No. 12.p734. China.
- [5] YANG Qian-ming, YI Qiu-jie, LI Zhi-min, LI Gui-Li.2004. The Operational Principle and Thermodynamics Analysis of A New type of Solar Heat Pump Multifunction of Machine. Journal of Shandong University of Science and Technology. Vo1. 23. No. 4.p46. China