International journal of imaging science and engineering

ISSN: 1934--9955 www.ijise.net

Vol-19 Issue-01 Mar 2024

Improving an Energy-Efficient HVAC System with an Air-Source Heat Pump

Sravani M,India

Abstract: Efficiently analyzing and optimizing energy savings involves evaluating both the amount and quality of energy, in addition to the quantity itself. You may save a ton of money on your energy bills by installing an air source heat pump, which is a multi-function space conditioner that also heats water. We find that the exergy loss of the compressor is 20.5% of the unit energy consumption and that the exergy loss of the condenser is nearly 30% of the total energy consumption in an air source heat pump air conditioning system. We then use this information to identify the sources of large exergy loss in the system. Our proposed optimization strategies for air source heat pump air conditioning systems are based on these evaluations, and they aim to maximize efficiency while reducing energy consumption.

Keywords: Energy evaluation, air conditioning, and heat pumps that draw from the airIntroduction

Figure 1 shows the basic components of an air source heat pump (ASHP), which are a compressor, condenser, throttle valve, and evaporator. This kind of space conditioning equipment may also heat water. Similar to a conventional heat pump, it consists of an external unit and an internal air handler that converts air into refrigerant (R-AHX). Because the condenser's waste heat may be used for

effort that is both valuable and practical, demonstrating the increased use and worth of this energy. This form of energy should therefore be prioritized for conservation.

Equation (eq.) defines exergy efficiency as an index that measures the technical or thermodynamic perfectibility of a system or piece of equipment.

heat pump water heating and by offering specialized heat pump water

heating capacity, ASHPs may accomplish substantial

e and e represent the exergy of the used or received or paid for resources.

cutting down on energy use [1]. q:

The heat pump's refrigeration cycle and the air source heat pump's heat supply cycle are the

ISSN: 1934--9955 www.ijise.net

Vol-19 Issue-01 Mar 2024

inverse Carnot cycles in an ASHPACS system. Changing the direction of refrigerant flow in the air conditioner is as simple as adding a four-way reversing valve to the refrigeration system [3]. Instead of relying on a massive cooling water system—which may be problematic in places where water is scarce—air source heat pump devices employ both interior and outdoor air as heat and cold sources. To explore the exergy efficiency of ASHPACS, we do exergy analysis in section 1. Section 2 delves into the process of determining the distribution of energy consumption for ASHPACS. We conclude by proposing optimization strategies for ASHPACS that maximize efficiency while simultaneously reducing energy consumption.

1. Exergy Analysis of ASHPACS

Exergy of a system is the maximum useful work possible during a process that brings the system into equilibrium with a heat reservoir. When the surroundings are the reservoir, exergy is the potential of a system to cause a change as it achieves equilibrium with its environment [2]. Thus exergy is the energy that is available to be used. The greater exergy of the energy, the more parts of energy can be converted intoor consumed, respectively. It is clear that the closer the exergy efficiency is to l, the better the thermodynamic perfectibility of the equipment or system is, the smaller the exergy loss is. So by exergy analysis method we can accurately reveal the weakest link in the equipment or system and thus obtain the measures to improve the equipment and save energy.

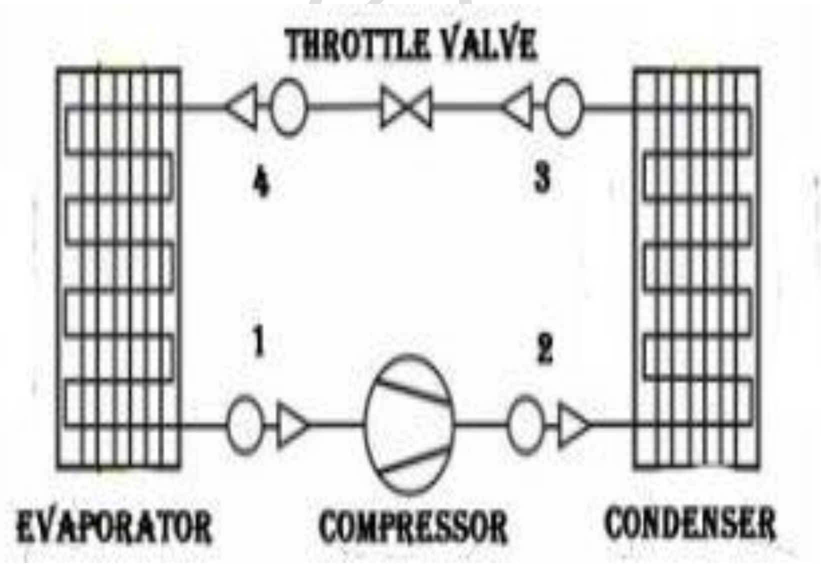

Figure 1: Schematic diagram of air-source heat pump valve.

2. Energy saving measures of ASHPACS

International journal of imaging science and engineering

ISSN: 1934--9955 www.ijise.net

Vol-19 Issue-01 Mar 2024

By above analysis, we propose the following measures to save energy for air source heat pump air conditioning system:

(1) Selection of Compressor with High Efficiency and Low Energy Consumption. From the exergy analysis of air source heat pump air conditioning system, it can be seen that the exergy loss of compressor accounts for 20.5% of the energy consumption of the unit, because the compressor is conducting

an irreversible adiabatic compression process. Therefore, compressor energy saving is particularly important in this system. This requires that the compressor with high thermal efficiency, such as screw compressor or or scroll compressor, should be selected in the design of air source heat pump air conditioning system. When the boost ratio is large, two-stage compression should be adopted to reduce the loss. The two-stage compression process is divided into two stages. The gaseous working substance from the evaporator is compressed in the low-level compressor first. When compressed to the intermediate pressure of the intermediate cooler, it enters the intermediate cooler for cooling, and then enters the high-level compressor for compressing to the condensation pressure. Because the two-stage compression adopts the intermediate cooling, the exhaust temperature of the high-pressure stage is not too high, thus reducing the compressor exergy loss.

(2) Selection of Condenser with High Heat Exchange Efficiency. The exergy loss of condenser is close to 30% of total energy consumption, which is mainly due to the large temperature difference between refrigerant and air, so the temperature difference of heat transfer should be reduced. From the heat transfer process, it can be seen that for a certain heat load, in order to reduce the temperature difference, the heat transfer area and coefficient must be increased, and the increase of heat transfer area is limited by the volume and quality of the condenser, so the heat transfer coefficient can only be increased. To increase the heat transfer coefficient, the following measures can be taken: A. to increase the flow rate in the pipe; B. to adopt the threaded tube with high finning coefficient; C. to reduce the thermal resistance of scale and grease scale, or to adopt a new plate heat exchanger to improve the heat transfer coefficient and efficiency, so as to greatly reduce the volume and quality of the pipe.

(3) Super cooling steps for liquid in front of throttle valve. Due to the undercooling of the liquid in front of the throttle valve, the loss of throttle valve accounts for less than 10%. Refrigerant in throttle valve is an irreversible adiabatic throttling process. After undercooling measures are taken, throttle loss can be reduced and thermal efficiency can be improved.

(4) Reducing Heat Transfer Loss of Evaporator. The exergy loss of evaporator is relatively small (10.32%), mainly because of the utilization of refrigerant cooling capacity. The loss of evaporator is also caused by the temperature difference between refrigerant and chilled water. To reduce this exergy loss is also to minimize the temperature difference between refrigerant and chilled water, to improve the heat transfer coefficient, or to adopt a new type of plate heat exchanger.

3. Conclusion

ISSN: 1934--9955 www.ijise.net

Vol-19 Issue-01 Mar 2024

Using the perspective of the second rule of thermodynamics, we disclose the amount and quality of energy consumption in this study. By accurately reflecting the system's overall performance, we can determine the energy saving potential of each component in an air source heat pump air conditioning system. The exergy losses are highest in condensers and compressors. Consequently, in order to decrease condenser loss, an efficient compressor should use measures to improve heat transfer, raise the heat transfer coefficient, and decrease the heat transfer temperature difference. Concurrently, heat pump units' surrounding environments should be improved.

4. Acknowledgement

the authors would like to thank anonymous reviewers for their valuable comments and suggests improving the quality of the article. The first author thanks for the careful guidance of the corresponding author teacher Qian Dai.

References

[1] The Air Conditioning, Heating, and Refrigeration Institute (ANSI/AHRI) published the 2008 Standard for Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment in 2012. The institute is located in Arlington, VA,

[2] USA.
In 2016, B. Shen and C.K. Rice published the DOE/ORNL Heat Pump Design Model. Guiyin Fang (3). Evaluation of the HVAC System's Ice Storage Capability! Low-Tempera Vacuum Research, 1999, 5, 3, pp. 49–52.