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Modulation method of scroll compressor based on suction gas bypass

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ABSTRACT

The air conditioners and heat pumps tend to work in much mild environments and part load situations rather than provide the rated full capacity under severe rated testing conditions. Both the capacity and inner compression ratio of the compressor should be regulated according to the working condition for higher energy efficiency and occupants' comfort. A potential modulating technology of the scroll compressor, suction gas bypass, is investigated in this paper. The principle and operation method are illuminated and the adaptability is validated by experiments and simulations. As a conclusion, an appropriate suction gas bypass can reduce the inner compression loss of the scroll compressor under over compression conditions, enhance the system COP and also largely decrease the heating/cooling capacity of the refrigeration/heat pump system.

1. Background

Building, industry and transportation are three main commercial energy consumers. The building accounts for 30% of the total energy use in some industrialized countries. Under the international background of saving energy and decreasing greenhouse gas emission, more and more attentions are paid to the building energy efficiency. Deceasing the energy consumption of the HVAC systems, which is responsible for more than half of the building energy use, becomes a very important approach of building energy-saving. Besides decreasing the cooling and heating demand by some passive technologies, such as the intelligent fabric, and using free or waste energy by thermal recovery, increasing the whole season performance of the HVAC equipment becomes the main way-out.

Scroll compressors have been widely used in the small to middle capacity direct expansion air conditioners and heat pumps due to high efficiency and low noise. For most of these systems, one of the heat exchanger is air-cooled and installed in the ambient directly. So the operation of the air conditioner is heavily impacted by the outdoor environment, which is varied in a large range from winter to summer. On the other hand, the heating or cooling load of the room is changing during the whole season due to the variation of the heat transferred through the external fabrics and heat taken by the fresh air. In general, both the demand to the air conditioner or heat pump and its working conditions are changing.

However, an obvious feature of the scroll compressor is constant inner volume ratio. The inner discharge pressure of the compressor is directly decided by the suction pressure and the geometry of the compressor, and not related with the system condensing pressure. Actually, the system condensing pressure is largely determined by the cooling media temperature and the heat transfer temperature difference of the condenser. As a result, sometimes the inner discharge pressure is higher than the condensing pressure and sometimes the inner discharge pressure is lower than the condensing pressure, which leads to the appearance of the over compression and under-compression. Inner compression efficiency due to over compression loss and under-compression loss is the most important factor affecting the seasonal performance of the scroll compressor [1,2].

Surveys [3,4] show that the air conditioners and heat pumps always work in part load conditions and in much mild environments rather than the severe design conditions. So, if the scroll compressor has an active modulating mechanism to continuously decrease the cooling/heating capacity to exactly match the requirement, not only the comfort level of the occupants can be increased, but also the system energy efficiency can be enhanced through reducing start–stop loss and decreasing the heat transfer temperature difference of the evaporator and condenser. At the same time, if a method can actively adjust the inner compression ratio to adapt the variation of the working conditions, the compressor efficiency can be largely enhanced. A modulating technology integrating these two functions can markedly enhance the seasonal performance of air conditioners and heat pumps and eventually affect the energy-saving of the residential building and office building.

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