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High Efficiency Inverter Scroll Compressors

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ABSTRACT

We have to consider the global warming and the energy saving to reduce the environment load when the new product is going to be developed.
Improving the compressor efficiency is the essential factor for air conditioning for buildings, which are widely spreading now, to reduce the environment load.
Needless to say, it is very important to improve not just the efficiency of compressor at the rated condition but also at the small load condition.
In this paper we explain the technic of inverter scroll compressor, aiming the dramatic improvement of efficiency compared with the one of the traditional compressors, by employing the back pressure control structure and injection mechanism with check valve.

1. INTRODUCTION

The protection of environment is becoming a big issue from the destruction of the ozone layer, the global warming and the energy saving point of view.
On the other hand, there is expectation of improving the comfort of the room environment as well, so that we have to contribute the environment protection by developing the air conditioning technic.
The improvement of energy saving technic is now also expected for the widely spreading air conditioning for buildings. In Figure 1 it shows the load ratio and the operation time of outdoor unit for an office.
About 90% of the yearly operation time is at 50% or less load rate, which means that for the further energy saving, it needs to improve the efficiency of the operation at the low load rate.
When the load rate becomes low, the operation compression ratio also becomes low, which leads the low rotation speed of the inverter compressor. The traditional inverter scroll compressor had huge drop down of its efficiency due to the leak loss when the load rate becomes less than about 30% with its low compression ratio and low rotation speed.
We contributed to the energy saving of air conditioning for buildings by improving the efficiency at the low compression ratio, low rotation speed and even under the comparatively high load rate condition and contributed.
We have developed high efficiency and high reliability, high-pressure dome type inverter scroll compressors, which are for the building air conditioning use.
With the new technologies: back pressure control structure and injection mechanism with check valve, as compared with the conventional scroll compressor, in a wide operation range from a low compression ratio operation to high compression ratio operation and from low-speed operation to high speed operation, efficiency and reliability were significantly improved.

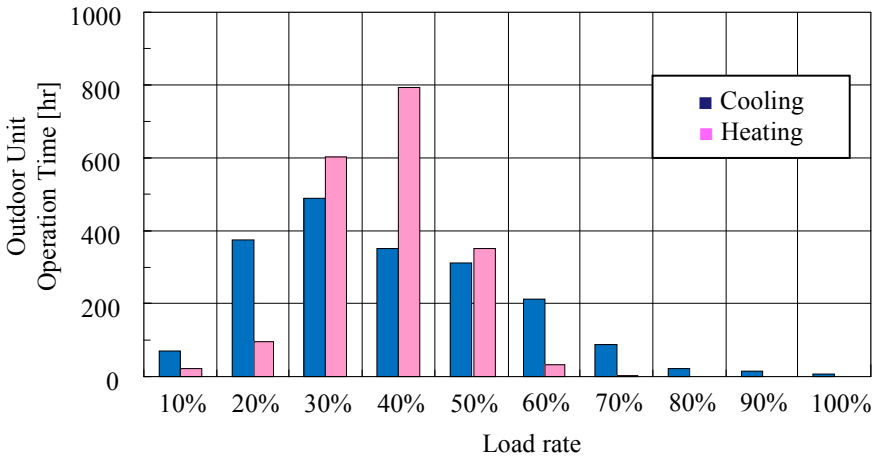

Figure 1: Load Rate / Operation Time
(Office in building :"airnet" data of Daikin)

2. STRUCTURE OF COMPRESSOR

The traditional technology, which we employed to achieve high efficiency and high reliability, such as,
- The high-low pressure dome structure to suppress the suction overheat
- The high thrust mechanism to suppress the increase in the surface pressure by introducing the high pressure oil between thrust sliding surface of the fixed scroll and the orbiting scroll.

In addition to these technologies we employed the following technology as well.
- The back pressure control in order to prevent the turnover of the orbiting scroll even at a low compression ratio operation,
- The injection mechanism with check valve to achieve high efficiency both at rated condition and a low compression ratio condition by minimizing the dead volume of the compression chamber.

Figure 2: The structure of new model compressor

3. HIGH EFFICIENCY TECHNOLOGY

3.1 Back Pressure Control

There is a problem that efficiency goes down by increasing leak loss, which is caused by the orbiting scroll's overturn at the low compressing ratio operation. It happens because the compression chamber is formed with the orbiting scroll pressed against the fixed scroll.

The gas during compression is employed to the back surface of the orbiting scroll to solve this problem and the orbiting scroll is pushed by the pressure of the discharge gas and the arbitrary gas pressure during compression (Middle pressure).

Figure 3 shows the structure of back pressure control.

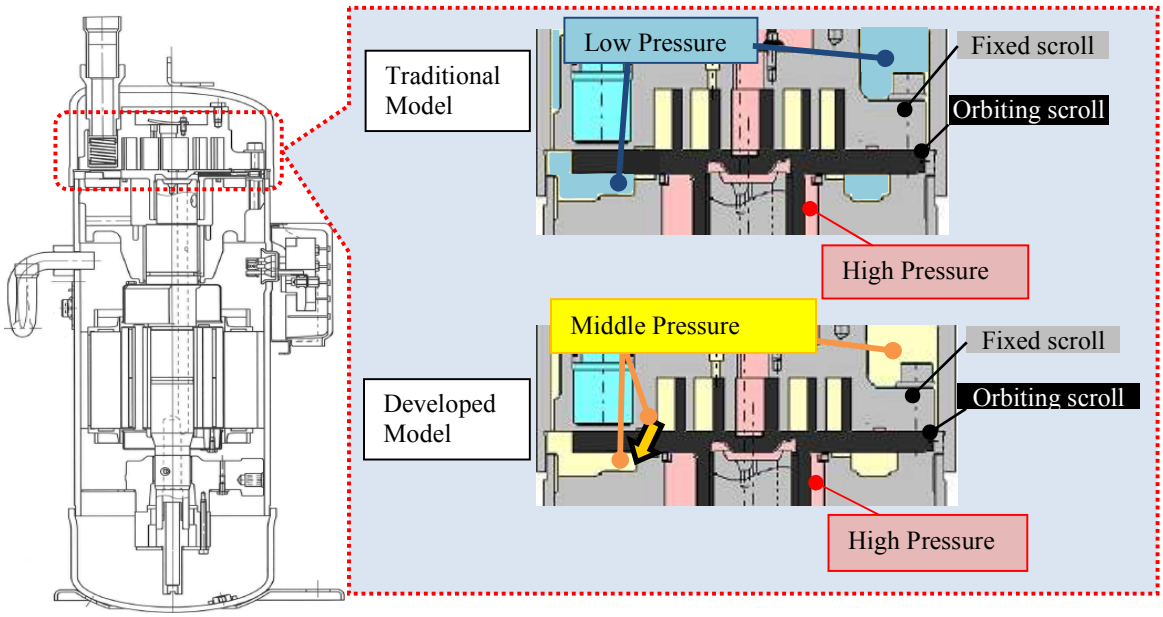

Figure 3: The structure of back pressure control

To adjust the value of the middle pressure, we have examined the pressure which makes the compressor input become smaller.
Figure 4 is the result of the test which we evaluated the compressor input by changing the value of middle pressure. It shows that the compressor input at each condition become smaller when the ratio of middle pressure to suction pressure is between 1.4-1.6. We have improved efficiency of the developing model by setting the middle pressure within this area.

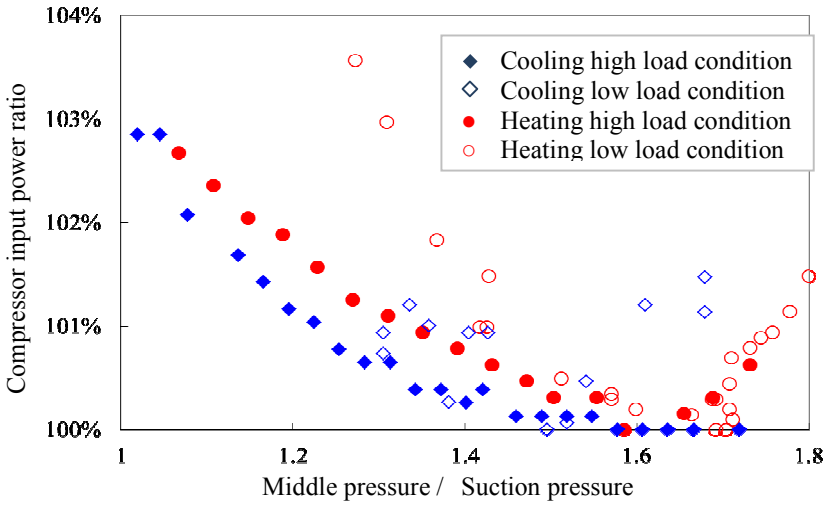

Figure 4: Relation between middle pressure and compressor input ratio

3.2 Injection mechanism with check valve

Traditionally the middle pressure injection structure has been employed for scroll compressors to improve the heating capacity and also system efficiency under the rated condition or high compressing ratio. But when the air conditioning load is small such as under the low compressing ratio and the injection is not employed, the injection structure between the system and the compressing chamber becomes the dead volume, which ends up the dramatic decrease of the compressor efficiency. To employ the injection structure with check valve, which minimizes the dead volume, we can suppress the efficiency drop at low compressing ratio condition without gas injection.

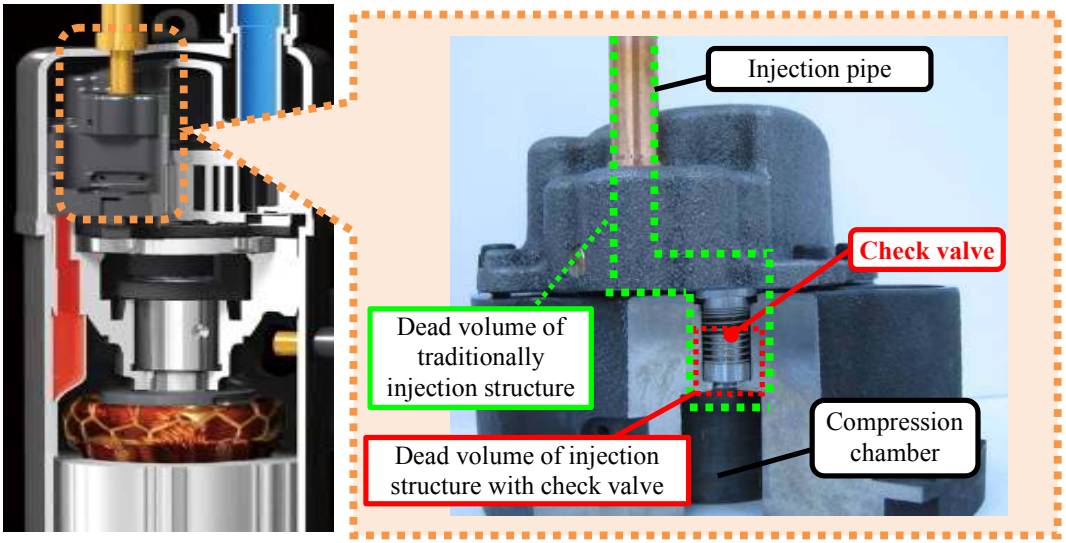

Figure 5: The structure of injection mechanism with check valve

Figure 6 shows the calculation of dropping amount of indicated efficiency ratio to the suction volume ratio of dead volume under the condition where the compression ratio is 1.8, which is comparatively low compressing ratio. Compared with the dead volume of the traditional injection structure, which is considered as the cause of efficiency drop, the dead volume becomes now less than 1/20 by employing the new structure with the check valve set nearby the compressing chamber.

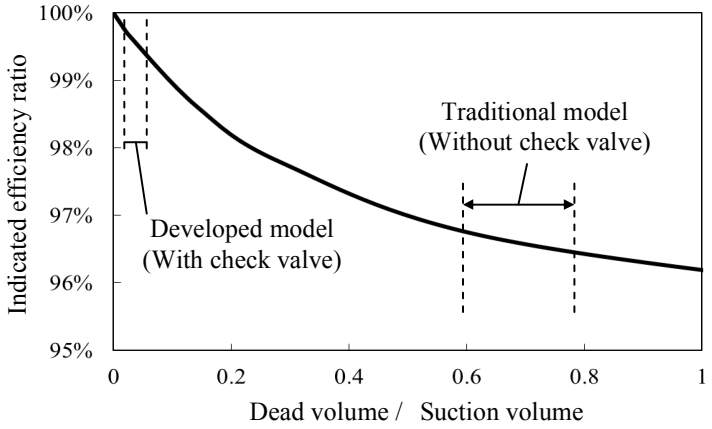

Figure 6: The Relation between dead volume and indicated efficiency

Figure 7 shows the test results of the compressor efficiency change which has injection structure. Under the condition where the compression ratio is 1.8 without gas injection, the compressor efficiency was improved 2.2pt by employing the injection structure with check valve.

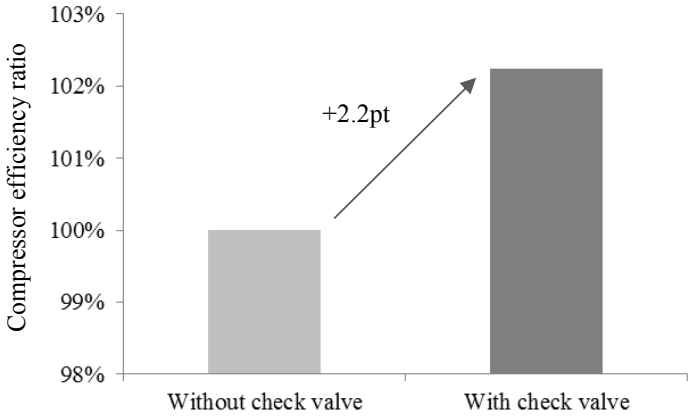

Figure 7: Efficiency ratio between employing injection with/without valve

3.3 Efficiency Improvement Result

Figure 8 shows the efficiency of inverter scroll compressor employing back pressure control and middle pressure injection with check valve.

Compared with the traditional model, the efficiency of the developed model was improved at whole operation area by improving the efficiency at low load ratio employing the back pressure control and the injection structure with check valve, and also by improving the efficiency at high load ratio employing the middle pressure injection.

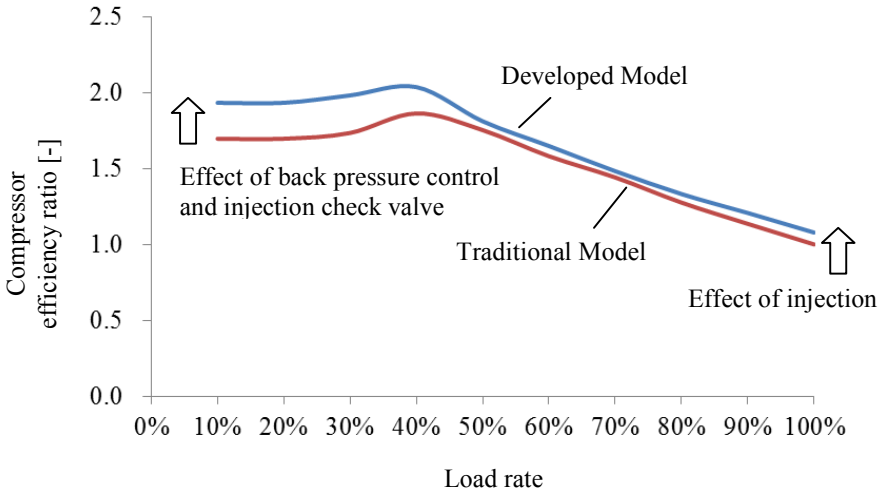

Figure 8: Efficiency of back pressure control and injection with check valve

4. CONCLUSIONS

Here is the summary of improvement efficiency for inverter scroll compressor employing the back pressure structure and injection mechanism with check valve.

- Compared with the traditional model under small load operation condition, the efficiency was dramatically improved by controlling back pressure of middle pressure as the input becomes optimum at each condition.
- By employing the injection structure with check valve, the efficiency was improved at high load operation condition by injection and the efficiency drop down was suppressed at small load operation condition.
- Compared with the traditional model, the efficiency of whole operation area was improved by back pressure control structure and injection mechanism with check valve.

REFERENCES

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