Numerical Simulation for the Internal Flow Analysis of the Linear Compressor with Improved muffler

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I. INTRODUCTION

- Many countries have been strengthening the regulation of energy savings.
  - Interesting about energy consumption is growing in the global home appliance markets.

- Especially, Household refrigerator consumes about 5% of using home energy.
- Energy consumption of the compressor accounts for up to 90% of the household refrigerator efficiency.
- Therefore, household compressor plays an important role to save energy in home appliance.

This paper focuses on increasing the efficiency of linear compressor by improving muffler by using CFD.

To study for increasing the efficiency of linear compressor…..

1. We analyze a fluid flow in a suction line of linear compressor by using a CFD.
2. The simulation of compressor is carried out two dimensional axis-symmetry, unsteady, compressible and turbulence flow.
3. Numerical simulation results are compared with experimental data to validate an accuracy of simulation.
4. We consider four cases to evaluate the effect of suction muffler.
II. NUMERICAL METHODOLOGY

(a) Piston, cylinder and muffler

- $T_{cs}$ represents the inner piston’s cylindrical surface, which is about 333 Kelvin.
- $T_p$ represents the inner piston’s surface on suction port entrance, which is about 336.5 Kelvin.
- $P_d$ represents discharging pressure on discharge port.

(b) Suction part around shell

- $T_s$ and $P_s$ respectively represent the temperature and the pressure of refrigerant flowing from evaporator.
- $T_{sh}$ represents temperature of muffler entrance connected shell space.
- $T_s$ is about 298 Kelvin and $T_{sh}$ is about 310.7 Kelvin.
- These temperature conditions are obtained by experiment.

Figure 1: Schematic in suction system of the linear compressor and boundary conditions for temperature and pressure.
Ⅱ. NUMERICAL METHODOLOGY

Figure 2: The pressure-volume diagram of whole processes by using the scheme language

- We use ANSYS ICEM program and ANSYS FLUENT V.15.
- The number of mesh is about 65000.
- Unsteady, compressible, viscous flow.
- real-gas-isobutan.
- Dynamic mesh including layering and re-meshing method.

- Whole process of the linear compressor is continuously generated by using user defined function and scheme-language.
- The suction valve and discharge valve are assumed as ideal valve.
- Two dimensional axis-symmetry method.
3.1 Validation of the Computational Simulation

- We apply partition wall and cylindrical projection to analyze the internal flow of the linear compressor with improved muffler.
- The partition wall is located between muffler entrance and exit.
- The cylindrical projection is connected to the muffler entrance.
- The internal and an external diameter of the partition wall is 0.008m, 0.025m, respectively.
- The length and diameter of cylindrical projection are 0.015m.

**Figure 3:** Schematic of the modified suction muffler

**Table 1:** The four cases of modified suction muffler

<table>
<thead>
<tr>
<th>Applied item</th>
<th>case1</th>
<th>case2</th>
<th>case3</th>
<th>case4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partition wall</td>
<td>none</td>
<td>none</td>
<td>applied</td>
<td>applied</td>
</tr>
<tr>
<td>Cylindrical projection</td>
<td>none</td>
<td>applied</td>
<td>none</td>
<td>applied</td>
</tr>
</tbody>
</table>
III. RESULTS AND DISCUSSION

The temperature difference of experiment and CFD results is about 2 Kevin at all monitoring points. This is less than 1%. Therefore, CFD results are sufficiently reliable.

Figure 4: Temperature-monitoring point diagram for comparing experiment results with CFD data in case 3.

- Only adopted with partition wall.
3.2 Comparative Analysis of Modified Muffler

- In case 1,
  325K in about 300 degree of phase
  314.5K in about 340 degree of phase

- In case2 and case3,
  323K in about 310 degree of phase
  316 and 314K in about 340 degree of phase, respectively.
  The trends of temperature are greatly similar.

- In case4,
  320K in about 313 degree of phase
  314.5K in about 338 degree of phase
  the lowest temperature during the suction process.

**Figure 5:** The temperature-phase diagram in muffler exit in case1, case2, case3 and case4 during the suction process
### RESULTS AND DISCUSSION

![Cylindrical projection](image)

- Cylindrical projection interrupts cool refrigerant with going out in the shell space.
- The temperature in case4 can be lower than that in case3.
- The temperature in case1 is higher than that in case4 due to the effect of the hot refrigerant coming from the upper side of the muffler.

**Figure 6:** The temperature contour of case3(left) and case4(right) in the muffler entrance

**Figure 7:** The temperature contour of case1(left) and case4(right) in the suction process
### RESULTS AND DISCUSSION

**Figure 8:** The pressure averaged time-monitoring point diagram in the suction process

- The narrow suction line made by cylindrical projection and partition wall increases the pressure field in the suction line.
- The hot refrigerant the upper side of the muffler is interrupted into muffler exit. Therefore, the relatively low temperature refrigerant flow in cylinder.
- The pressure differences between the muffler exit and the cylinder increase

We expect to increase the compressor efficiency when the pressure can be high at the muffler exit and the superheating loss is reduced in suction line.

**Figure 9:** The percentage of the compressor EER for CFD data in case3 and case4
IV. CONCLUSION

- Numerical results showed that in case in which partition wall and cylindrical projection are adopted, the compressor efficiency increased.

- We suggested improving suction muffler of the linear compressor by using CFD.

- The refrigerant of low temperature flows into the cylinder when the pressure in muffler exit is highly maintained during the suction process.

- The efficiency of compressor improved when refrigerant flows in the suction line without superheating loss.
Thank you very much for your kind attention.