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

LG Electronics

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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.
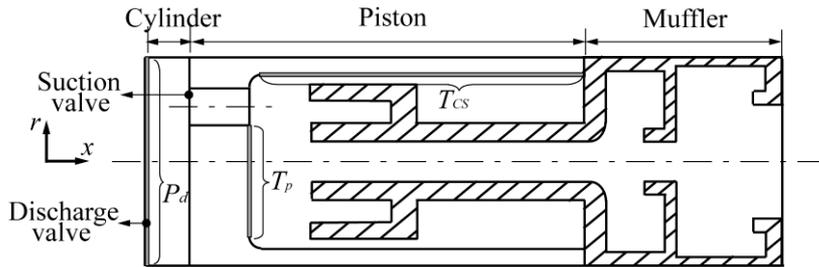- Therefore, household compressor plays an **important role to save energy** in home appliance.

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.

(a) Piston, cylinder and muffler
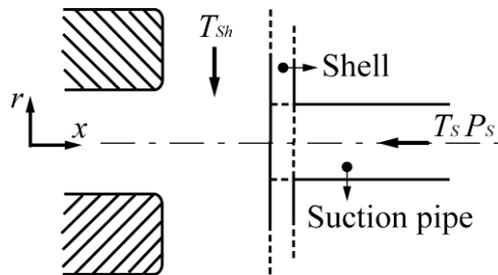
(b) Suction part around shell

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

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

- 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.

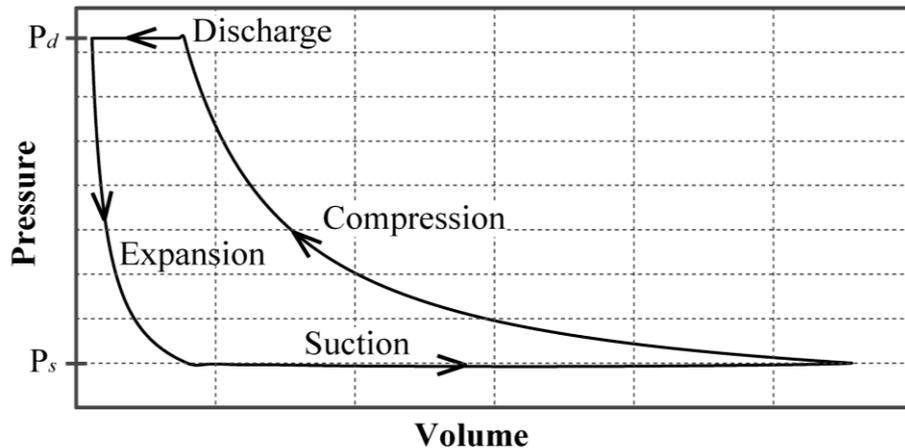- These temperature conditions are obtained by experiment.

Figure 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.
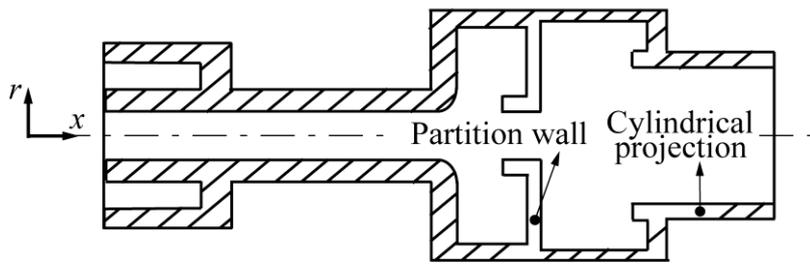
3.1 Validation of the Computational Simulation

Figure 3: Schematic of the modified suction muffler

- 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.
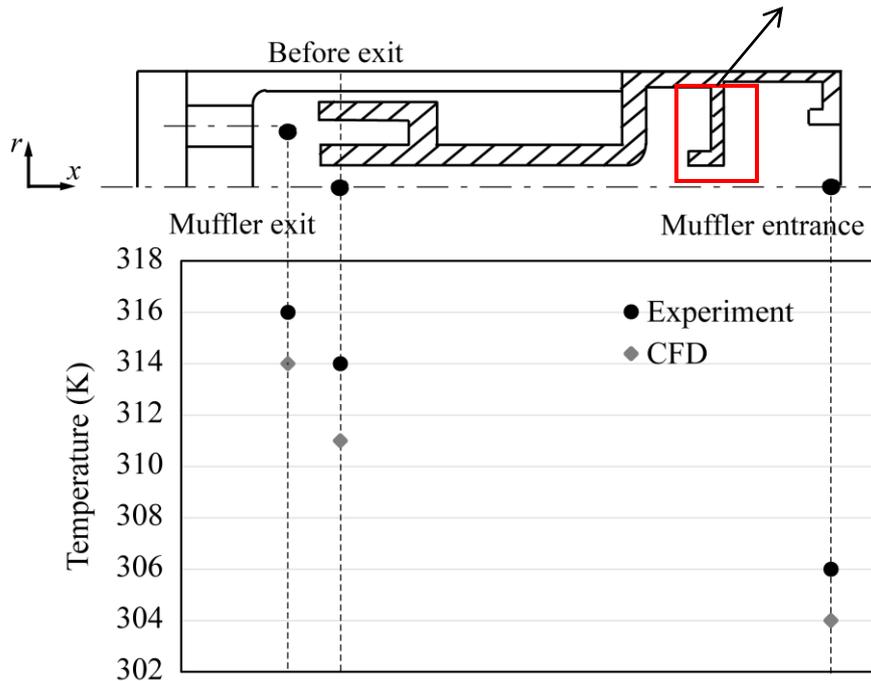
Table 1: The four cases of modified suction muffler

Applied item	case1	case2	case3	case4
Partition wall	none	none	applied	applied
Cylindrical projection	none	applied	none	applied

Only adopted with partition wall.

Before exit

Muffler exit   Muffler entrance

- The temperature difference of experiment and CFD results is about 2Kevin at the all of monitoring point.

- **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 case3

3.2 Comparative Analysis of Modified Muffler
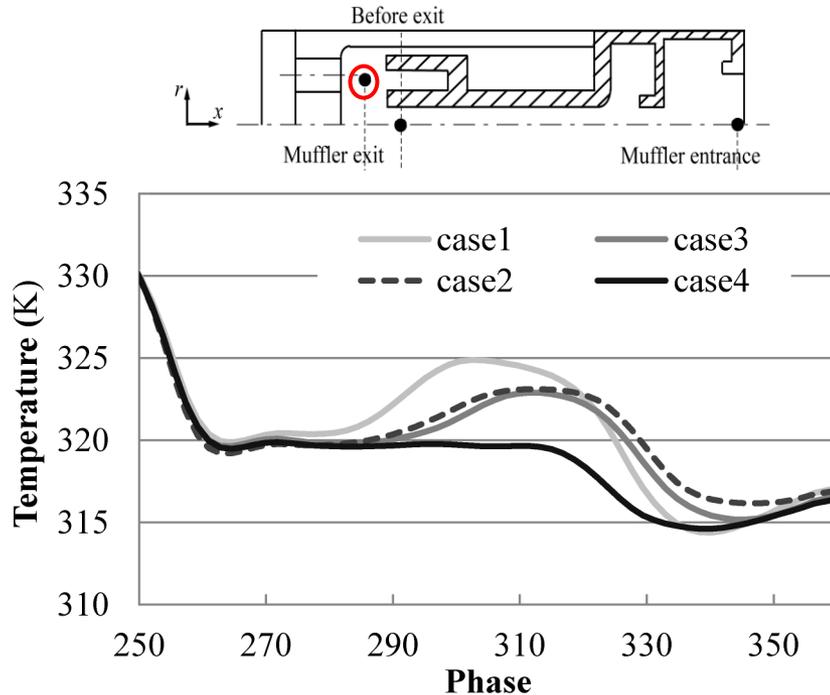

Figure 5: The temperature-phase diagram in muffler exit in case1, case2, case3 and case4 during the suction process

- 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.

Cylindrical projection
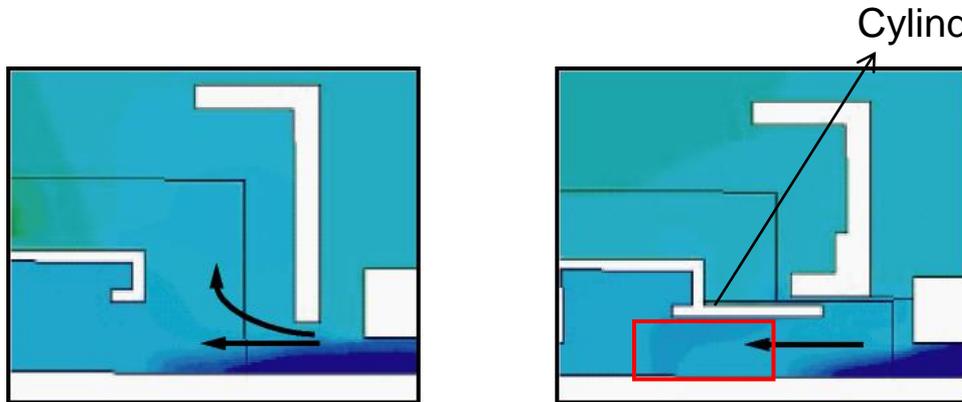

- Cylindrical projection interrupts cool refrigerant with going out in the shell space.
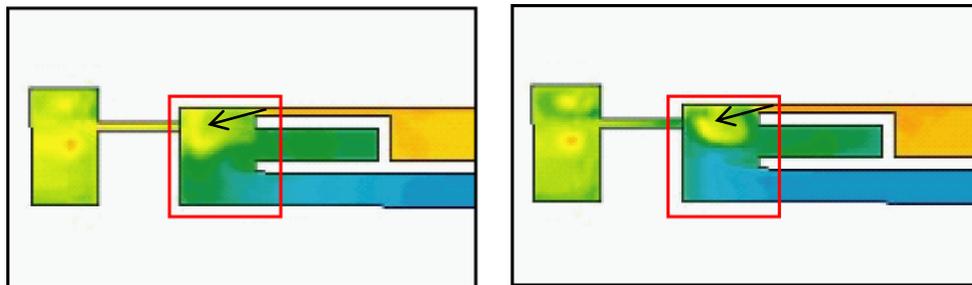- The temperature in case4 can be lower than that in case3.

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

- 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 7: The temperature contour of case1(left) and case4(right) in the suction process
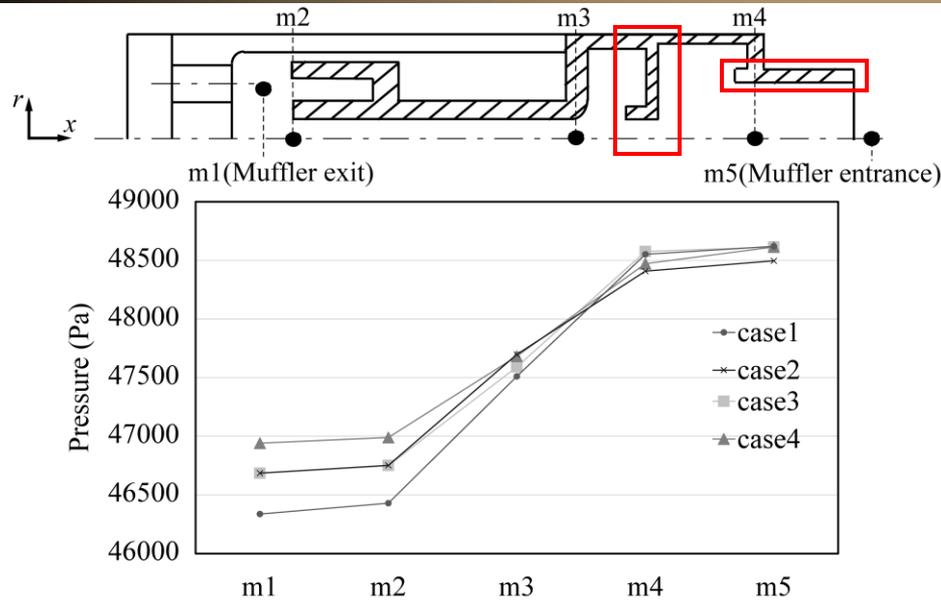
Figure 8: The pressure averaged time-monitoring point diagram in the suction process
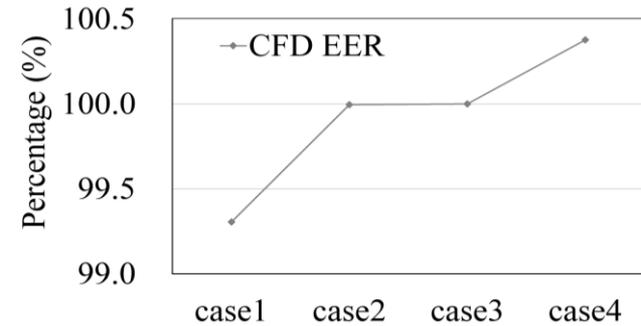
Figure 9: The percentage of the compressor EER for CFD data in case3 and case4

- 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.

- 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.