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Simulation of Magnetic Field in Automotive ECV by Finite Element

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Abstract

The distribution of magnetic field strength (H) in the ECV with electromagnetic coils was simulated with two dimensional finite element software ANSYS MAXWELL. Air conditioning control system is an important issue in automobiles as it is directly related to the passengers comfort. Variable capacity compressors are used for air conditioning control system in vehicles because of its low energy consumption and highly efficient characteristics. Solenoid operated electromagnetic control valve (ECV) in the compressor controls the air conditioning system by means of a pulse width modulation (PWM) input signal from an external source [1]. This article is the use in ANSYS software to do analysis, according to the structural parameters of the coil, analytical materials, the coil current and the magnetic field strength distribution. The results show that: based on the work of the current direction of simulation results is consistent with the principles of the coil.

Keywords: Electromagnetic Control Valve (ECV), Finite element simulation, Magnetic field intensity, Magnetic field distribution

1. Introduction

At present, it is required that the automotive air conditioning system must keep the

cabin temperature comfortable in spite of engine speed and improvement in fuel consumption during all seasons [2]. The design therefore needs to be very precise and accurate. Built-in mold design and manufacture of magnetic field are very complex. Finite element simulation can be easily adjusted to optimize the shape and size of the components of the mold and all kinds of magnetic parameters, to obtain information about the magnetic field, greatly improving the R & D efficiency.

The next generations of variable displacement piston compressor technology, Compact Variable Compressors (CVC), are based on a swash plate simple harmonic motion mechanism. The enhanced mechanism performance makes the CVC adaptable to both pneumatic and electronic control.

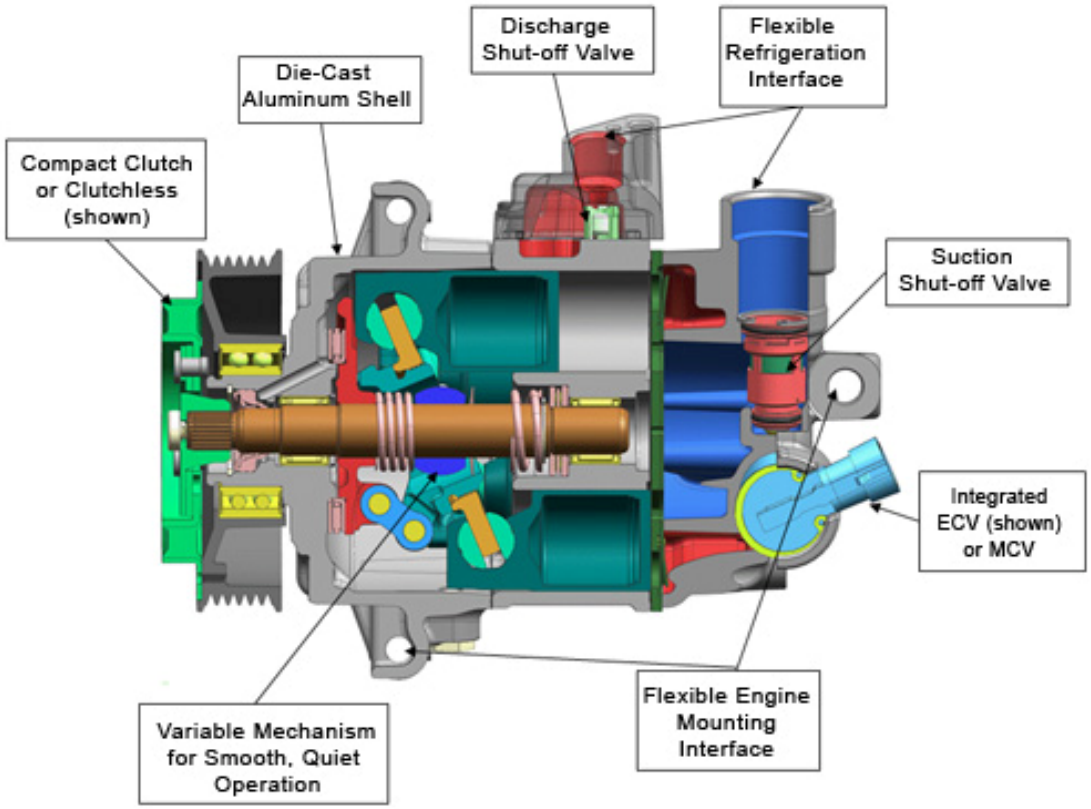

Fig.1 Compact Variable Compressors

CVC is adaptable to a full range of vehicles. While our current product portfolio includes CVC ranging from 100 cc displacement to 185 cc displacement, Delphi can design and validate a CVC for a specific application. The CVC can be applied to both thermostatic expansion valve and orifice tube systems [3].

2. Governing equations

Maxwell solves the electromagnetic field problems by solving Maxwell's equations in a finite region of space with appropriate boundary conditions and user-specified initial conditions in order to obtain a solution with guaranteed uniqueness.

$$\Delta \times \mathrm{H} = \mathrm{J} + \frac{\partial \mathrm{D}}{\partial \mathrm{t}}$$

$$\Delta \times \mathrm{E} = -\frac{\partial \mathrm{B}}{\partial \mathrm{t}}$$

$$\Delta \cdot \mathrm{D} = \rho$$

$$\Delta \cdot \mathrm{B} = 0 \qquad (1)$$

Finite element refers to the method from which the solution is numerically obtained from an arbitrary geometry by breaking it down into simple pieces called finite elements.

The desired field in each element is approximated with a 2nd order quadratic polynomial (basis function):

$$H_x(x,y,z) = a_0 + a_1x + a_2y + a_3z + a_4xy + a_5yz + a_6xz + a_7x_2 + a_8y_2 + a_9z_2 \quad (2)$$

Once the tetrahedra are defined, the finite elements are placed in a large, sparse matrix equation.

$$[S][H]=[J] \qquad (3)$$

For each solver, there are some basic definitions formula that provides a field for solving error evaluation. The error term energy generated is calculated in volume of the whole solution. This is calculated to made the total energy by comparing the percentage of error.

3. Simulation and analysis

We first through the use of design drawings for modeling. Model by solidworks program to complete, in order to more efficient and accurate modeling, all sketches are copied directly from the original files over.

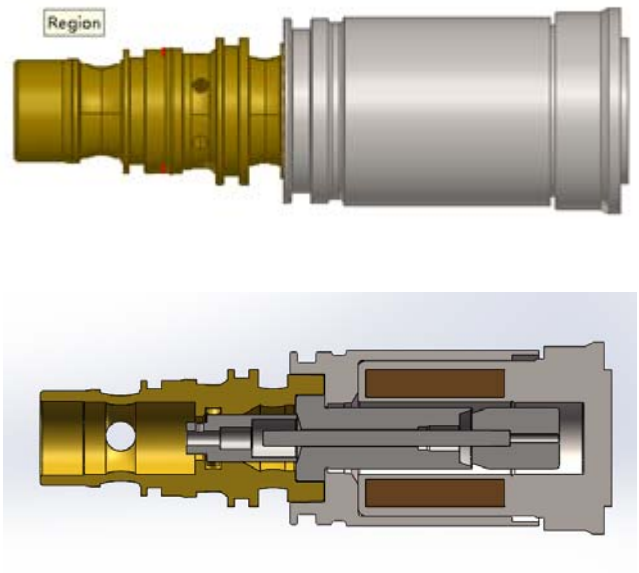

Fig.2 Electromagnetic Control Valve 3D model

In order to obtain accurate data, starting directly MAXWELL 3D mode of modeling and meshing. However, because of the complexity and precision, meshing ECV structure were not smooth. At fig.3 and fig.4 can see, under the basic constraint arises 2,000,000 grid. Very long computation time, and calculated to the middle, it is often because of insufficient computer memory and hard disk space, resulting in computing crash out.

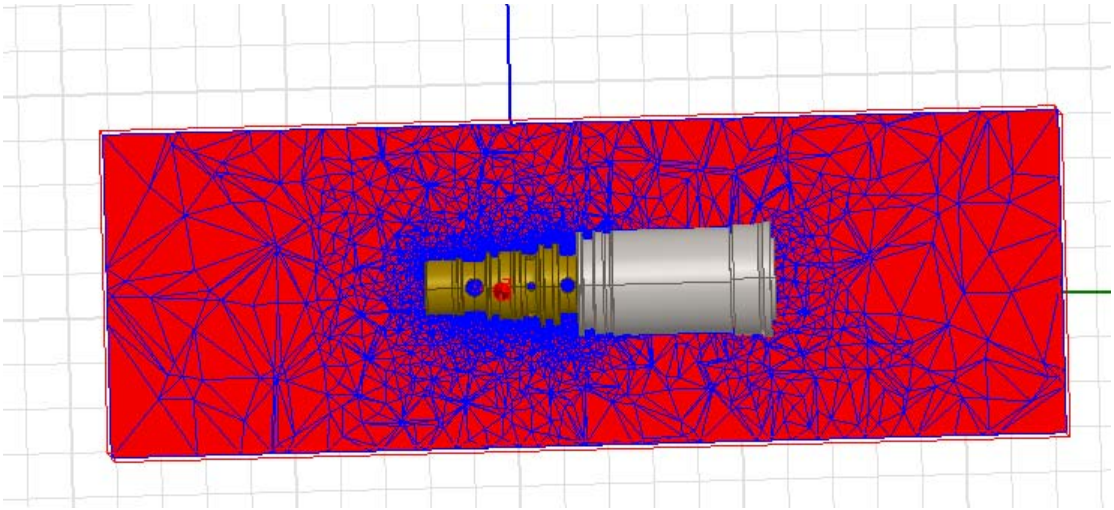

Fig.3 Boundaries meshing

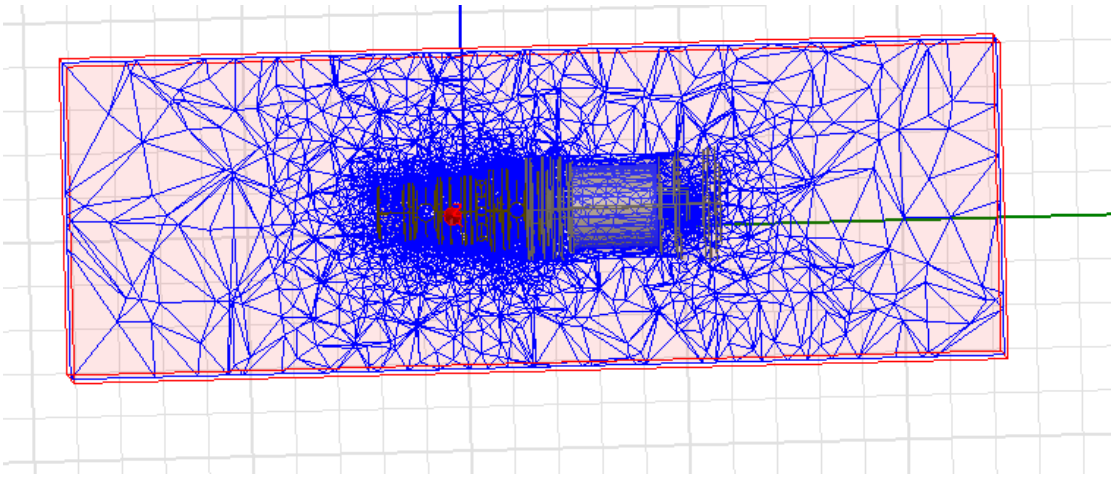

Fig.4 Full bodies meshing

Considering the ECV own axial symmetry and sweep characteristics, the simulation process moves to the next 2D mode. This can guarantee accuracy at the same time, the number of meshes and the calculation time can significantly reduce the chance of errors is also a lot less. While the other part does not affect the results were omitted. The result is:

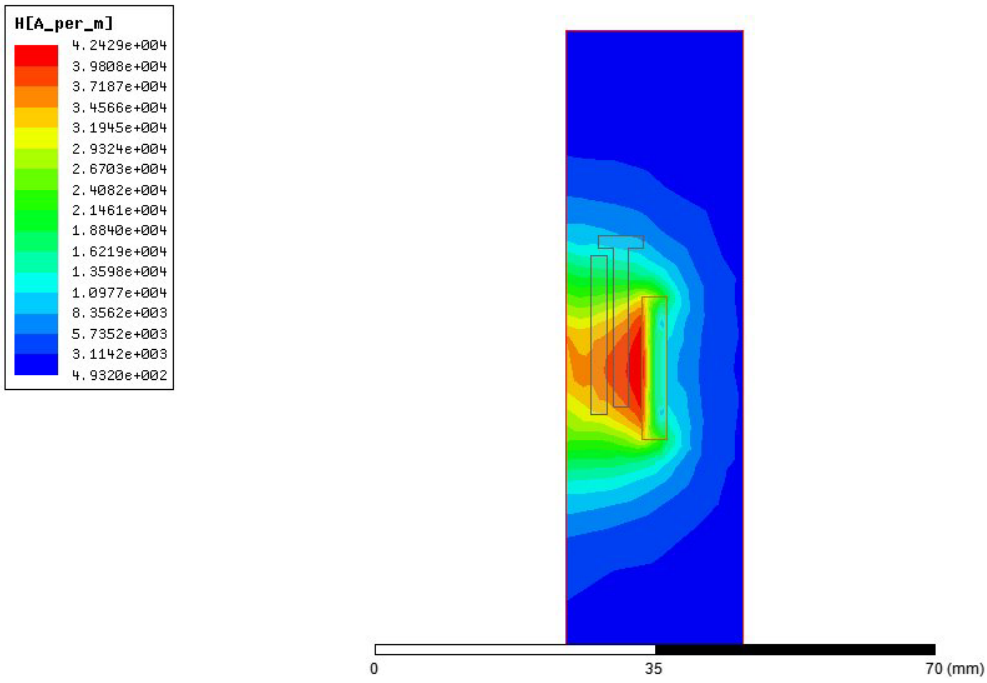

Fig.5 Electromagnetic field intensity graph

After defining the material parameters, to the electromagnetic coil gives a certain current strength can be obtained after the magnetic field distribution of the finite element analysis software operations. The simulation results show that the magnetic field distribution in the valve is uneven, where H is the maximum value at the center of the chamber, the farther away from the center of the lower H.

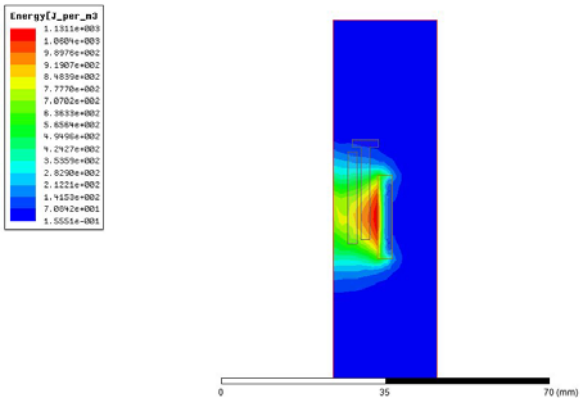

Fig.6 Energy field graph

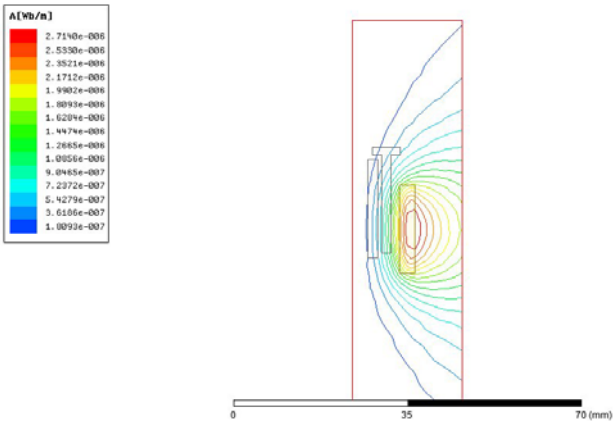

Fig.7 Electromagnetic field Flux Lines

Similar to the ECU vehicle simulation generated PWM signal that the input current and fed into the ECV is the 400Hz. The actual voltage is 12V, but in order to reduce the complexity of the calculation process, the number of turns is set to 1, then amplified current, the effect is almost the same simulation, but it can reduce a lot of time.

4. Conclusions

Analysis of the electromagnetic force and ECV balance of forces in the compressor is the main concern in this study. In this regard it is considered configured by different parameters such as the travel guide, the plunger stroke and other software via computer simulation and experimental work. And with the help equation under development, access to the simulation results and experimental results. Finally, it compares the two results show improved force analysis ECV satisfactory performance. Finite element software MAXWELL can easily simulate H and distribution ECV generated by the electromagnetic coil. Finite element simulation results show that the magnetic field in the valve is non-uniform magnetic field. H the highest value at the center of the valve, the lower the farther away from the center of the cavity H.

Acknowledgment

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5. References

[1] Md. Iqbal Mahmud, Haeng Muk Cho, Manik Hwang, Kyeong Jung Yong and Jong Hun Lee,"analsys of solenoid force in an automobile ecv", International Conference on Mechanical Engineering and Renewable Energy 2013 (ICMERE2013) 1 - 3 May 2014, Chittagong, Bangladesh, ICMERE2013-PI-019

[2] J. Kim, I. S. Park and G. H. Lee, "An experimental study on the performance of variable displacement swash plate type compressor with various pressure of swash plate chamber", Korean Journal of Air © ICMERE2013 Conditioning and Refrigeration Engineering, No.2004-S-127, pp. 765-770, 2004.

[3] http://delphi.com/manufacturers/cv/heatcool/compressors/cvc