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ECV General Performance in the Finite Element Simulation

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Abstract

Compressors used for vehicle air conditioning control system, consumes a lot of engine power as it is a high efficiency requiring component. Recently, automotive industries prefer variable displacement swash plate (wobble plate) type compressors instead of fixed capacity compressors because of its low energy consumption and highly efficient characteristics, and it is coupled with an electromagnetic control valve (ECV). This paper is summarizing the performance of ECV in different simulation analysis. Base on fluid dynamic, vibration, and magnetic field.

Keywords: Electromagnetic Control Valve (ECV), Finite element simulation.

Introduction

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. The recent changes in the automotive market are evolving in the direction that enables improvement in passenger convenience and vehicle fuel efficiency. Air conditioning system inside the vehicles is one of the important issues that directly related to the passenger comfort. Auto manufacturers are making large investments to increase the efficiency of air conditioning system as a part of their efforts to improve fuel efficiency. One area of these efforts is to change the method of transmitting power to the compressor working for air conditioning control system [1]. ECV refers to Electromagnetic control valve. ECV controls an automobile vehicle air conditioning compressor based on a pulse width modulation (PWM) input signal that supplied from an external controller. The control valve senses suction pressure and controls the swash plate angle based on crankcase-suction pressure differential. The valve is solenoid operated and works in controlling different port pressure and ECU controls the signal from the external source.

Simulation

A. Fluid Dynamic

CFD simulation study is to obtain numerical solution of equations of fluid flow control, it gets the attention of the whole through time and space solving the mathematical description of the flow field. CFD is to build the basis of Navier-stokes equations, which is composed of a series describing fluid flow conservation law consisting of partial differential equations. In order to simulate the movement of gas, the model must be for a gas conservation equation as conservation of mass and momentum equations were solved. Using finite element analysis software ANSYS fluid dynamics module, simulation and analysis of fluid discussed in consideration of viscosity and resistance, the

fluid flow lines and movement. Compared with conventional test methods, simulation methods can be more intuitive fully reflect the fluid flow conditions, and can save costs and improve operating efficiency.

Figure 1 is Switched off condition of Speed sectional drawing and Figure 2 is Switched on condition of Speed sectional drawing. As can be seen where the fastestare concentrated in plunger hole.

This study is about the ECV flow conditions in open and closed state. By using CFD numerical simulation to reproduce the actual situation. Under normal temperature and pressure, test speed of 0.0002512 kg / s. The results show that when fluid enters the laminar flow state is stable, into the valve switch; there are different degrees of vortex[2].

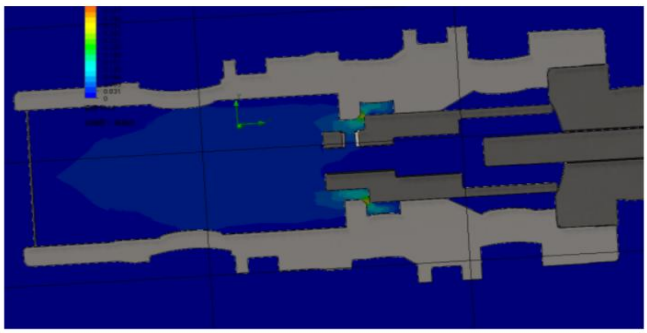

Fig.1Switched off condition

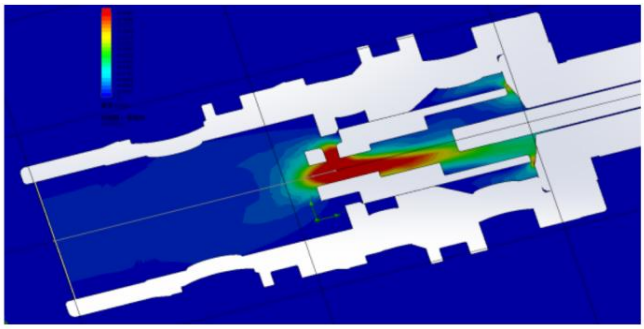

Fig.2Switched on condition

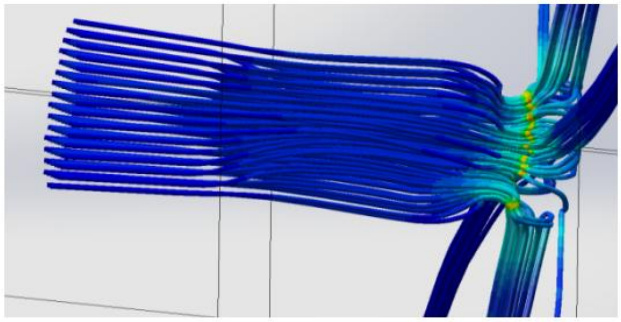

Fig.3 The flow trajectory of ECV

B. Vibration Characteristics

Because of ECV needs to control, the pressure at different pressure ports locate on the valve body; the design therefore need to be very precise and accurate. Generally, the tolerance for each component of ECV is ±0.02mm to ±0.05mm, whereas some of the components associated with the leakage performance are assembled within a tolerance of±0.002mm which is definitely a challenging issue to obtain[3].

To calculate the valve vibration valve, to avoid resonances, consistent fluid piping systems in time the natural frequency of the excitation frequency, so it should be calculated to advance to the natural frequency of fluid piping systems, thus avoiding fluid resonance and piping vibration reduction is significant.

Because of the need to control pressure port ECV positioned in the valve body at different pressures. Therefore, the design requires very precise and accurate. By the compressor fluid flow inside the tubes of a constant effect, this process will produce pulsating fluid flow may result in vibration of the tube, thereby reducing the efficiency of the fatigue of the pipeline, structural vibration, resulting in structural damage and even pipes.

From the finite element analysis of the curved duct can also be seen, the fluid passes through the curved portion, due to mutation of fluid pressure and velocity direction, the valve will have a great additional force, if the fluid is pulsed, the valve will have stimulated vibration force, causing pipe vibration.

Figure 4 is the fluid movement into the front of the results obtained to the frequency analysis inside. The fluid energy of the excited mainly in 4, 5, and the high frequency disturbances caused by the movement of the valve, there is little impact on the pipeline pressure pulsation.

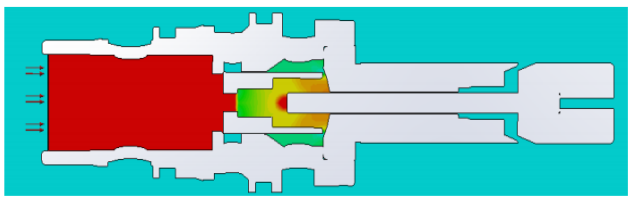

Fig.4 Static pressure distribution in the valve

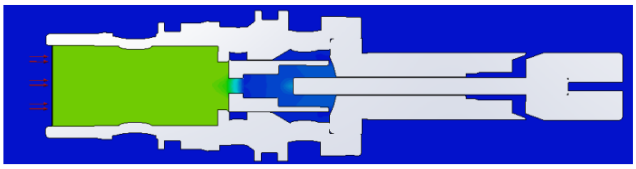

Fig.5 Relative pressure distribution in the valve

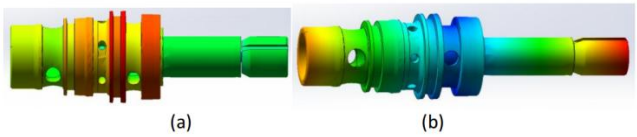

Fig.6 fluid movement

C.Magnetic Field

Magnetic forming process is complicated a complex electrical, electro magnetics, structural mechanics, dynamics. Deformation of the object will cause the mutual inductance of the entire system, the system changes, resulting in different Lorentz force. Theoretical studies of electromagnetic forming process of interaction since the forming process electrical and mechanical processes to make very complicated. Therefore, the application of numerical analysis of the electromagnetic forming process accurate description is almost impossible. Thus, in recent years the application of finite element method to describe the electromagnetic forming process becomes the first choice of domestic and foreign scholars.

This part is the use in 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.

This is based on ANSYS analysis of electromagnetic - Structural strong coupling model. Model takes into account the deformation of the pipe on the magnetic field calculations can accurately simulate electromagnetic forming process. Analysis of the electromagnetic process tube size and distribution of the magnetic force different deformation state of the system, discuss the tubes occurrence point maximum magnetic field strength, gives mold vortex and magnetic force distribution.

First, choose the analysis method of finite element analysis of electromagnetic problems, ANSYS there are three kinds of methods: magnetic scalar potential method, the magnetic vector potential method, cell-based assays side. As the model motion effects need to be considered, and thus choose the magnetic vector potential method as the analysis in this paper. Because electromagnetic system is axially symmetric, so it can be equivalent to 2D models 3D models, so it is also more efficient operation and easier to set up model. Based on the analysis method node in the magnetic vector potential method to simulate a 2-D transient magnetic force.

Magnetic field is distributed throughout the space, so go for air modeling, modeling of the air after the impact of magnetic flux leakage can be considered. Air isotropic medium can be regarded as a homogeneous medium, the resistivity of infinity, and the vacuum magnetic permeability is approximately the same (relative permeability 1). Tube can also be regarded as approximate uniform isotropic medium, which can significantly improve processing speed, reduce memory costs. In order to obtain the magnetic force on the tube, to analyze the induced current (eddy current) on the tube, the tube must be regarded as short-circuit conductor, given resistivity fittings and relative permeability, there is no voltage drop within the closed loop vortex formation .

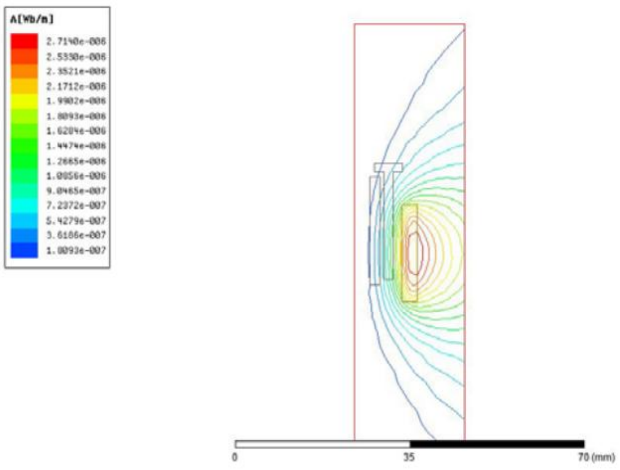

Fig.7 Electromagnetic field Flux Lines

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 [4].

CONCLUSION

This paper is by using finite element method simulation to see the ECV general performance in different situation. On the fluid dynamic shows in the off state, the fastest place in parallel to the surface of the valve and the pin, in the open state, the largest local flow velocity in contact with the valve port and core areas. In the closed state, the maximum flow rate of about 0.3 m / s, while in the open state, the maximum flow speed of more than 0.8 m / s. On the vibration characteristics shows the pipeline issue vibration abatement work has played a guiding role. For some supporting transmission fluid conduit to clarify as a model to establish the effect of the mathematical model within the occupied range of free vibration, as well as the natural frequency of the fluid purposes. We introduced the application of finite element software valve modal analysis methods and procedures, the establishment of a finite element model, finite element calculation, the duct system modal frequencies and mode shapes. On the magnetic is configured by different parameters in this respect, for example to guide the plunger stroke and other software by computer simulation and experimental work. And it is being developed with the help of the equation, simulation and experimental results obtained. Finally, compare the two results show improved dynamic analysis ECV satisfactory performance. Maxwell finite element software can easily be simulated H Distributed by ECV electromagnetic coil. Finite element simulation results show that the magnetic field is not uniform magnetic field in the valve. Valve at the center, the farther from the center of the chamber at the height H of the highest value.

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