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Structural Mechanics Analysis on Automobile Electromagnetic Control Valve on ANSYS

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Abstract-A finite element modelfor ECV built with ANSYS software. The stress of the ECV was analyzed. The model was analyzed respectively for structural statics distribution and deformation under corresponding operating conditions. ECV is used in automotive air-conditioning control system. By ECV control air / pressure changes of the refrigerant flow inside the compressor. 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. The solenoid force is important for ECV operation as the force related to the movement of the internal feature i.e. plunger

Keywords: Electromagnetic Control Valve (ECV),Finite element simulation, Analysis of structural statics

Introduction

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. At present, automotive industries prefer variable capacity compressors instead of fixed capacity compressors because of its low energy consumption and highly efficient characteristics [1].Variable displacement compressors runs constantly when the air conditioning system is switched on and refrigerant flow is controlled by effectively changing the displacement of the compressor to suit the prevailing operating conditions [2].A solenoid valve is an electromagnetically actuated control valve that controls

a plunger stroke according to the amount of current supplied from the external controller in the solenoid coil. The solenoid valve is driven by PWM input signal from an external source
that is free of ripple pressure [3].

For the development of new ECV, various internal parts are designed by CAD application. Fig. 1 shows the basic design of ECV. The main components are magnetic coil, plunger, plunger spring, plunger pin, plunger housing, cover plate, core, valve guide, bellows assay, bellows cap etc [4].

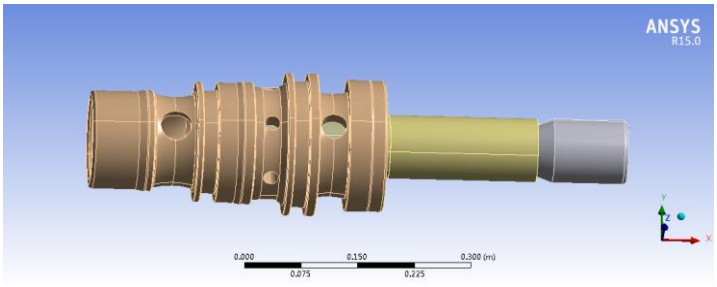

Fig. 1Electromagnetic Control Valve CAD model

Finite Element Modeling

ECV valves made of C3604 copper material, the density is 8.5g / cm, tensile strength / MPa: ≥335, Vickers hardness HV (≥0.5): ≥80. Other parts of the valve mainly used in SUS303 stainless steel,Tensile strength (MPa): ≥520,Conditions yield strength (MPa): ≥205,Elongation δ5 (%): ≥40.

For the analysis of the electromagnetic force, the piston force is calculated. Fig.2 shows previously applied experimentally derived Pistons into the simulation, analysis of the forces and the possible distortion of the valve.

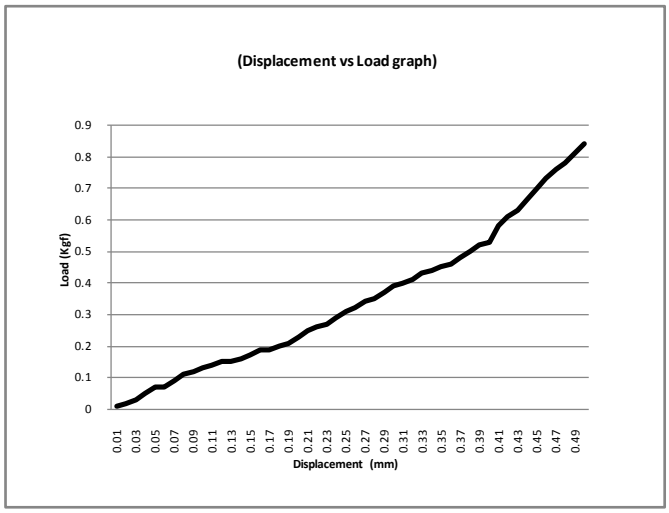

Fig.2 Bellow compression test

Simulation and analysis

The obtained data into the ANSYS structural mechanics analysis, the greatest load of 0.9kgf, then gradually reduced to 0.1kgf, divided into 10 steps.For the time ECV work under pressure in 0.6MPa, so the back pressure simulation environment for the same pressure.

The Cauchy strain or engineering strain is expressed as the ratio of total deformation to the initial dimension of the material body in which the forces are being applied. Fig.3 shows the total deformation of Electromagnetic Control Valve, and Fig.4 is the directional deformation of ECV.

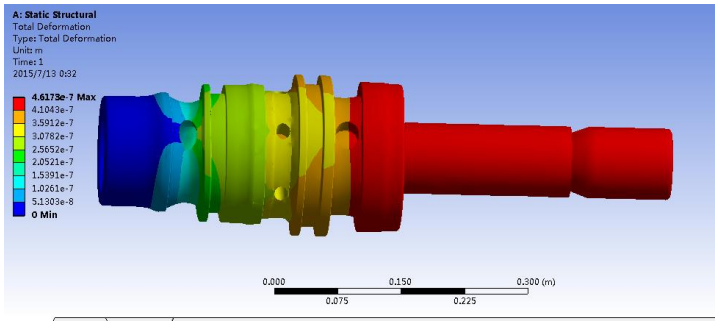

Fig.3 total deformation

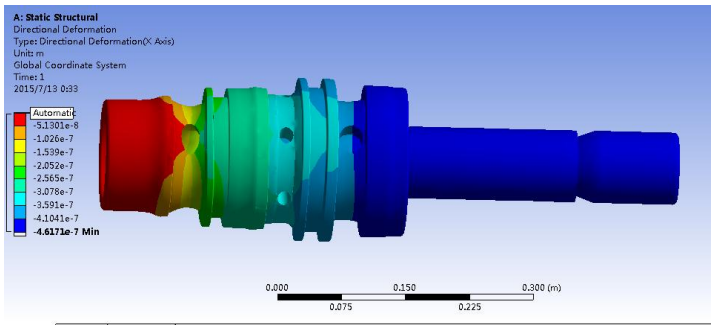

Fig.4 directional deformation

Fig.5 shows the equivalent elastic strain of ECV. Internal strain within a metal is either elastic or plastic. In the case of elastic strain this is observed as a distortion of the crystal lattice, in the case of plastic strain this is observed by the presence of dislocations –the displacement of part of the crystal lattice. Such strain effects can result in unwanted cracking of the material, as is the case with residual plastic strain[5].

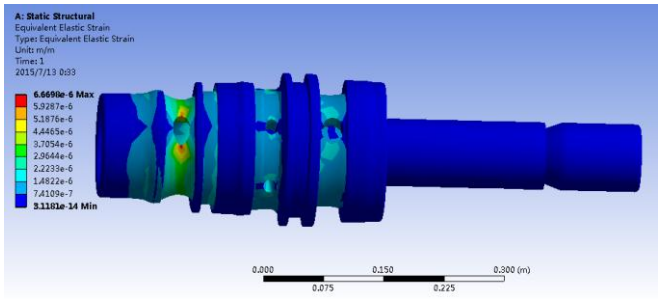

Fig.5show the equivalent elastic strain of ECV.

In order to simulate different test ECV performance under different loads by applying a progressively smaller force to reflect. Fig.6 is different loads corresponding deformation. Total deformation is generally shown as "Mag" which gives

overall deformation of the system. Total deformation=$(X^2+Y^2+Z^2)^2$ (X,Y,Z are directional deformations).

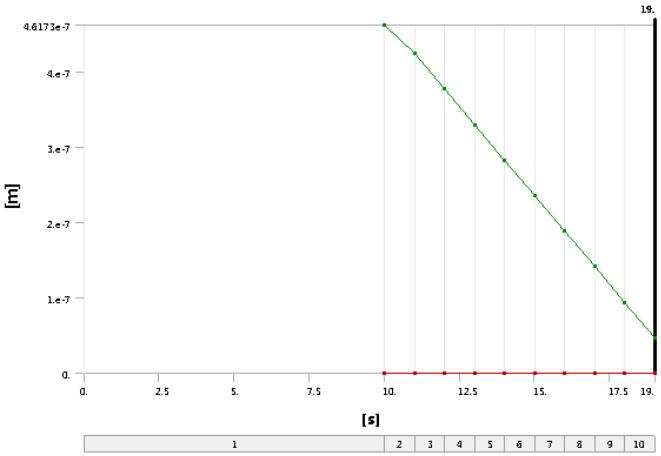

Fig.6 total deformation at different loads

Conclusions

Using ANSYS finite element ECV working conditions carried out structural static analysis, through analysis of the results can be determined under working conditions are safe and stable.Analysis of leakage performance at different load f ECV using in swash plate type compressor are of prime concern in this research.ECV in compressor operation is closely related to the fuel consumption of the vehicle and its efficiency. Design ECV different components shall comply with the technical requirements of the standard cost of production and the economy.Results of simulation and actual test results are obtained in the performance of the ECV design has a good performance.

Acknowledgment

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