Analysis and Performance Evaluation of the Solenoid as an Injector for 2-Liter Diesel Vehicle

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Abstract — This paper presents the analysis and performance evaluation of the solenoid which is the main part of an gasoline injector in EURO diesel vehicle. The topology of the presented solenoid is given and the FE analysis is performed to predict the performance. Performance evaluation of the solenoid, taking eddy current into account, has been presented, indicating that the characteristics of material seriously affect the generated force characters. The experimental test platform is setup and the testing results are given, validating the foregoing analysis and performance evaluation.

I. Introduction

A solenoid, which features a high-speed response and ragged structure, has found more and more applications in industrial devices and vehicles[1]. A typical solenoid structure consists of the armature, coils and the shaft. The armature is usually known as the plunger, which is made of ferromagnetic materials with high permeability. The force is generated and proportion to the change of inductance of the coil with respect to the plunger's position. The generated force always tends to move the armature in the direction that increases the inductance of the coil, thus creates linear motion[2].

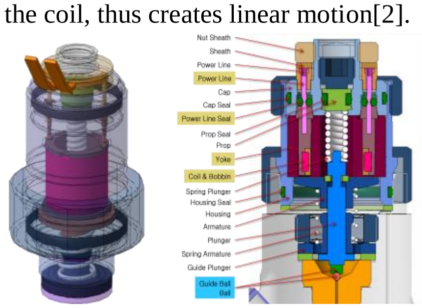

Fig.1 (a) 3-D overview and (b) Cross-section view of solenoid

This paper presents the analysis and performance evaluation of the solenoid which works as a main part of gasoline injector in diesel. FE analysis is employed to predict the static performance of the solenoid with different current excitation and plunger position. The performance is compared to that with and without considering core loss. Then different kinds of materials are applied to the yoke, which mainly carry the flux, to investigate the influence of the material on force profiles. At last, the experimental platform is setup and the traction force of the prototype solenoid is measured. The results are compared to that obtained by foregoing analysis, verifying the results obtained by simulation.

II. Analysis and Performance of the Solenoid

Figure.2(a) shows the topology of the solenoid we analyzed in this paper, whist the mesh grid for FE simulation is given in Figure2(b).

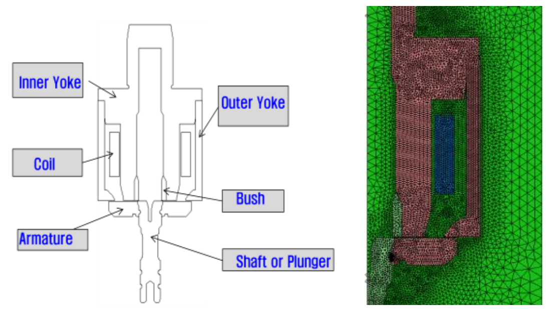

Fig. 2 (a) Structure of the solenoid in this paper and mesh-grid

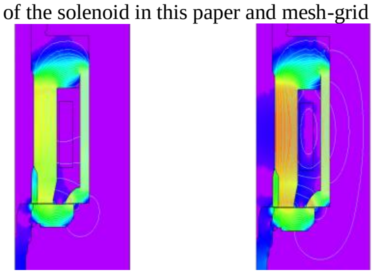

Fig.3 Magnetic field with (a) 5A and (b) 37A excitation

In this paper, the traction force of the solenoid is calculated with respect to different plunge position and excitation current. Fig.3 shows the distribute of magnetic field with 5A and 37A DC current excitation, respectively. The traction force with different airgap length, which denotes the plunge position is shown in Fig.4. It is obvious that the traction force is decreased while the airgap increases.

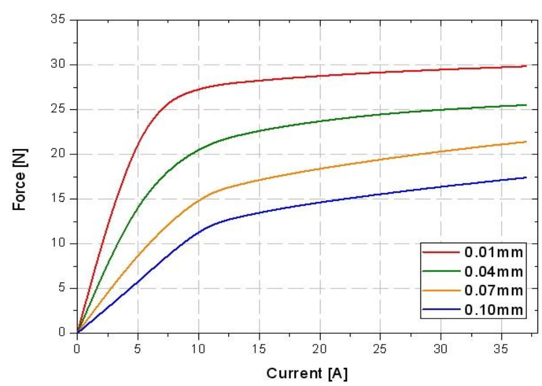

Fig.4 Traction force with variation of plunge position calculated by FEM

In a solenoid, it requires extremely high-speed response with respect to the pulse current. In this case, there exists critical instantaneous state for the field distribution which is very complicated and different to describe by analytical model. In order to investigate the influence of the core loss upon traction force characteristics, FE analysis with and without taking the core loss in account is performed to obtain the traction force and analyze the force characters. Fig.5 gives the instantaneous force profile with and without considering the exciting current at the given current. It can be seen that the force profile without considering the core loss is significantly changed compared to that considering real core loss.

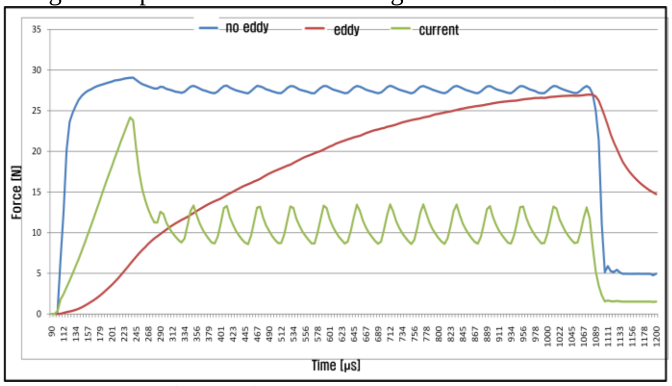

Fig.5 Instantaneous force profile with and without considering iron loss

For investigating the influence of the core loss upon force characters further, different conductivities have been applied to the assigning materials tentatively. Fig.6 compares the traction force profile with conductivities multiplied by 1, 0.5 and 0.1, respectively. It reveals that the core loss play a main part among the factors which have influence on force characters.

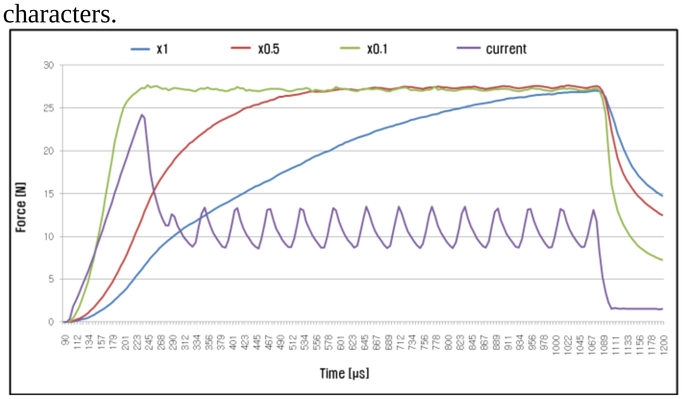

Fig.6 Force profile with and without considering core loss

Fig.7 Prototype solenoid

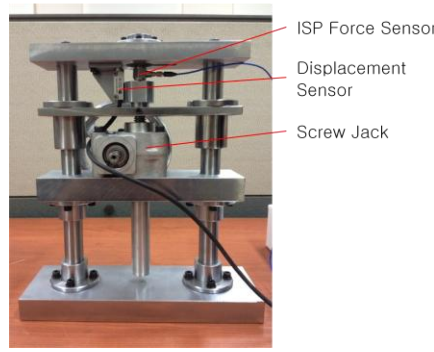

Fig. 8 Experimental platform

The prototype solenoid and experimental platform is shown in Fig.7 and 8. Based on that, the experimental results are obtained, which is given in Fig 9 and 10. In the full paper, the relationship between the experimental results and FE=simulation results will be discussed in detailed.

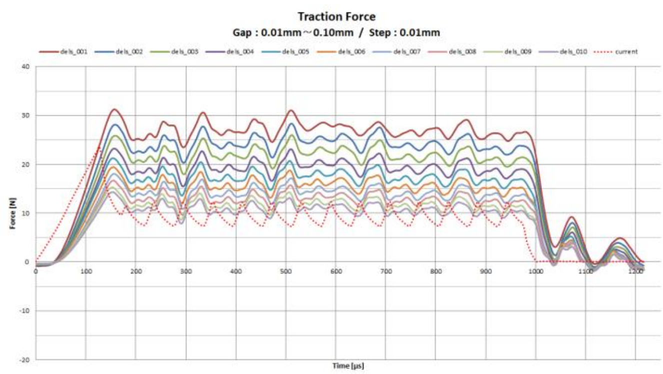

Fig.9 Experimental force profile with respect to plunge position

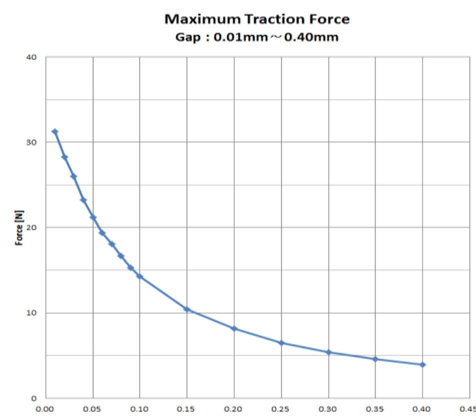

Fig.10 Experiment peak force with respect to the plunge position

III. REFERENCES

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