Design and Simulation of Magnetic Levitation System

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Abstract. This paper deals with the designing of magnetic levitation methodology depends on finite element method simulation. Sequences of simulations were performing, by changing the turn’s number of the coil and by varying the current passing through coil to construct the coil capable of generating the field of 0.6016T. From the simulation result it was found that by varying the number of turns of the coil and current passing through coil, magnetic field generation also varied to levitate the body.

Keywords: Levitation, magnetic field, current, turns density.

1. Introduction
This magnetic levitation system is an advanced technology used in transportation system and in industrial areas [2]. The advantages of this system are dirt free, frictionless these advantages leads to the evolution of magnetic levitation system [9].

Due to frictionless, in transport system the vehicle can high speeds. Main aim of this paper was to suggest the maglev system modelling for levitating the body of certain mass. The FEMM (Finite Element Method Magnetics) simulation allowed explaining an optimal coil to levitate the body of certain mass. Hence the simulation will helpful to develop a methodology for designing the magnetic levitation coil to a known mass.

To attain good results with less cost different geometries and various types of materials were simulated. This software is an 2D open source package, it solves the problems of both magnetostatic and AC problem [3]. This maglev is used for measuring the densities of samples in industries without knowing the mass and volume of the sample [4]. In axial maglev system by varying the distance between magnets the sensitivity of the system also can vary [5].

For triangular arrangement of high temperature superconductor bulks have the good performance [1]. The six degree of freedom maglev system is simple in view of communication and number of coils [2]. Any conductor which carries current is enclosed by the path must flow through surface once [7]. This FEM software is advantageous tool which can be used for formulation and analysis of problems of engineering [8].

FEM is applied to the problems of electromagnetism by using basic concepts of calculus [8]. In MAGLEV transport system the Linear-quadratic regulator cause more stability and uniform response compared to other controllers [9].
2. Methodology
In FEMM software [6] the simulation for coil was performed. The objective of simulation is to develop a methodology of magnetic levitation coil design. Simulation will helpful to design perfect coil for hanging the body of known mass without any mechanical support. The magnetic field produce by the coil can be varied along varying the turn’s number and electric current flowing through that coil. Thus by varying the number of turns of the coil and current passing through the coil most suitable coil can design for levitating the body of known mass.

![Figure 1. Representation of coil.](image)

Figure 1 shows the representation of designed coil. For designing the MAGLEV system, Neodymium magnet and coil with 3000 turns and with the gauge of 10 AWG, and air is used as a medium. At constant number of turns the current flowing through the coil is varied as 5A, 5.5A, 6A, 6A, 7A, 7.5A and at constant current number of turns also varied as 500, 1000, 1500, 2000, 2500, 3000.

Figure 2 shows the mesh analysis of the system; this mesh analysis is an integral part in engineering simulation which makes the complicated geometries into simple. This mesh analysis effects the accuracy, convergence, and speed of simulation.
3. Results and Discussion

Initially coil with 500 turns with the medium of air were simulated. This below table 1 and 2 shows the variation of magnetic field by variation of turn’s number of the coil and current flow through coil respectively. As the turn’s number of the coil was varied from 500, 1000, 1500, 2000, 2500, 3000 magnetic field varies from 0.007376 T to 0.270092 T. Similarly by varying the current flowing through the coil from 5A to 7A with the interval of 0.5A magnetic field varies from 0.270092 T to 0.6099T.

Table 1. Variation of magnetic field density with coil turns

| No. of turns of the coil | Magnetic flux density (T) |
|-------------------------|--------------------------|
| 500                     | 0.007376                 |
| 1000                    | 0.029787                 |
| 1500                    | 0.06726                  |
| 2000                    | 0.119801                 |
| 2500                    | 0.1874                   |
| 3000                    | 0.270092                 |
Table 2. Variation of magnetic field by variation of current

| Coil Current (A) | Magnetic flux density (T) |
|-----------------|--------------------------|
| 5               | 0.270092                 |
| 5.5             | 0.32681                  |
| 6               | 0.38893                  |
| 6.5             | 0.4564                   |
| 7               | 0.52937                  |
| 7.5             | 0.6099                   |

4. Conclusions
From the simulation results it was concluded that by increasing the turn’s number of the coil and current flow through coil magnetic field produced by the coil also increases. In some systems where space is main constraint, varying the turn’s number of the coil is not possible in such cases the magnetic field produced by the coil is varied only by varying the current flowing through the coil.

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