MICRO ACTUATOR DESIGN AND ANALYSIS FOR MECHATRONICS SYSTEMS

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ABSTRACT

In this article the design of a finite elemente analysis for a Micro-Actuator is presented. The Micro-Actuator is composed of a micro-solenoid. This paper shows how an analysis of the Micro-Actuator can be performed before the physical prototype is built to understand the device behaviour.

Linear transient analysis is simulated. The analysis determines magnetic flux density, current density magnitude on coil terminal, mechanical angular acceleration, mechanical angular speed and position, include current through the coil as a function of time, animation of current density magnitude instantaneous and time average armature forces and strokes, and inductance of the Micro-Actuator. This paper describes how the understanding of the device behaviour gained from finite elemente analysis before this physical prototype is constructed.

Practical modelling considerations are also addressed in this paper. Assumptions are made to reduce an important 3D component of the magnetic circuit to axisymmetric geometry so that model size can be significantly reduced. This analysis has been used on the ANSYS-Maxwell program.

Keywords Finite Elemente Analysis, Micro-Actuator.

INTRODUCTION

It is a kind of actuator for moving a mechanism or system elements. Electricity according to the energy type (Atomic-molecular forces, Field force), thermal energy (thermal expansion memory effect), this Chemical Energy (Electrolysis Pressure, Burst Pressure) and the Fluid Power (pneumatic, hydraulic) as varies under four main headings. Actuators are used in many areas. For example, we can use to compress of the material or make that material movement. In the practice, smaller signalling may create very high value [1] [2].

One of the important uses of the mechatronic applications. These actuators can be used in robotics and motion applications and that require small force. Mechatronics models consist of mixed moving system. Mechanism that moves, can be in macro and micro size. Modelling and analysis, enabling the cost-effective software and hardware solutions for applications that require complex and computationally intensive problems of information technology. The need for action in the narrow space consisting recently has occurred. Because of this, the actuators in micro size, design, production, analysis phase has gained importance. The need for action in the narrow space recently occurred. Because of this, it is important the analysis of the micro actuator size and design. Micro actuator is particularly increased use in medical and robotics [5].

The purpose of this work, a mathematical model of micro actuators for mechatronic system is analysed by a computer program.

DEVICE DESIGN

The properties of chosen materials for design are given in Table 1. Figure 1. is a schematic drawing of the electrical characteristics and generated force for the micro actuator. Figure 2. is steel core relative permeability. 2D design was drawn as first, then had been converted 3D. Figure 3. is a 2D technical drawing of the micro actuator. 3D design of micro actuators is seen on Figure 4.

Table 1
Properties of the materials used.

Material	Bulk conductivity (Siemens/meter)	Mass Density (kg/m^3)	Relative permeability (Tesla/Ampere/meter)	Magnitude (Ampere/meter)
Steel core	2000000	8933	Fig.2.	0
Magnet	625000	7400	1.0997785406	-890000
Coil	58000000	8933	0.999991	0

Figure 1
Schematic drawing

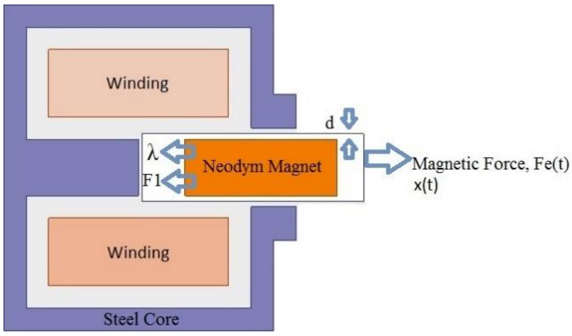
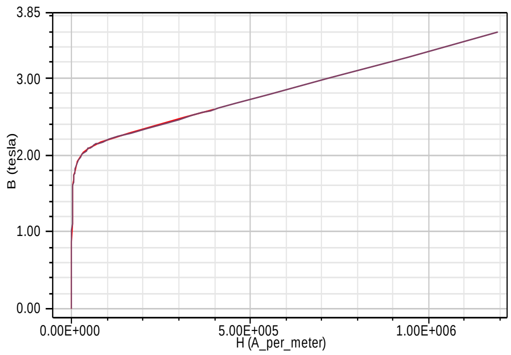


Figure 2
Steel core relative permeability



The equation of motion for the plunger as a function of position, x, is:

$$F_e = F_1 + m\ddot{x} + \lambda\dot{x} + kx \quad (1)$$

Where Fe is the electromagnetic force, F_1 is the load force, λ is the viscous damping term and m is the plunger mass. The electromagnetic force is related to the solenoid current and inductance by

$$F_e = \frac{1}{2} i^2 \frac{\partial L(x)}{\partial x} \quad (2)$$

The inductance, which is derived in [3], can be written as:

$$\frac{\partial L(x)}{\partial x} = \frac{-\beta}{(\alpha+\beta x)^2} \quad (3)$$

Where α and β are constants. Plugging the preceding equation into the equation for electromagnetic force gives the force-stroke relationship of the solenoid for a Fig.1. electrical characteristics and generated force current i0:

$$F = \frac{1}{2} i_0^2 \frac{-\beta}{(\alpha+\beta x)^2}$$
(4)

The Micro actuator block solves for α and β by taking the two specified force and stroke measurements and substituting them into the preceding equation. It solves the resulting equations for α and β [4].

Figure 3
2D Technical drawing

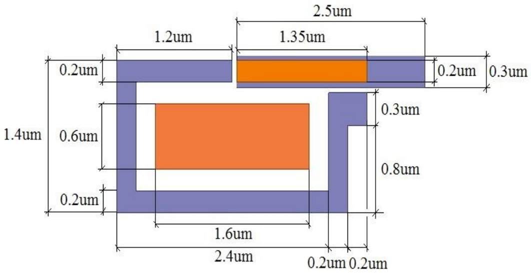
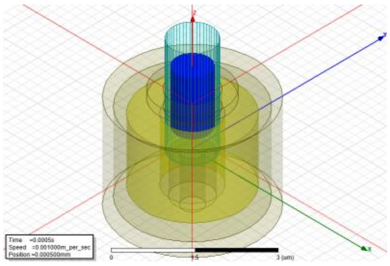


Figure 4
3D design of micro actuators



METHODS

Simple, powerful, reliable, without the need for mechanical converter aimed a linear actuator design. This design is analysed suitability for production. It has been implemented by the method of finite element analysis. Linear transient analysis is simulated. The analysis determines magnetic flux density (B), current density (J) magnitude on coil terminal, mechanical angular acceleration, mechanical angular speed and position, include current through the coil as a function of time, animation of current density magnitude instantaneous and time average armature forces and strokes, and inductance of the Micro-Actuator [6][7]. The analysis was performed with 0.00001 second intervals und movement continues over 0.001 seconds.

RESULTS

This analysis is made with this ANSYS-Maxwell computer program. We can see this Results of the analysis are given in the pictures below.

Figure 5
Magnetic flux density of the magnets (B)

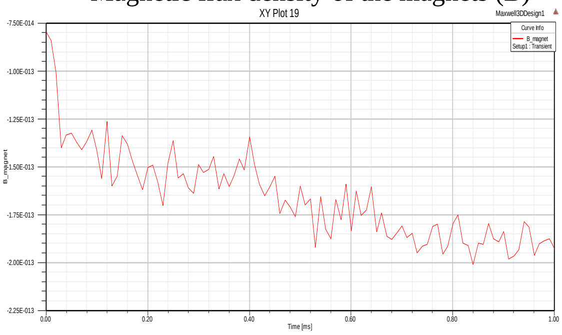
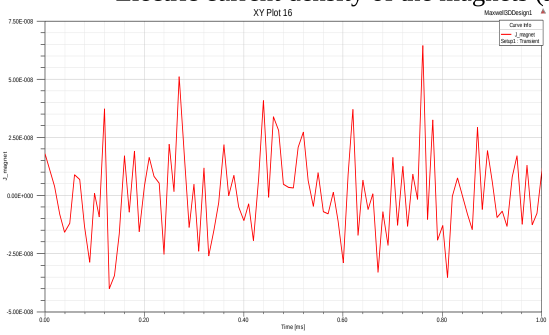


Figure 6
Electric current density of the magnets (J)



The magnetic flux density of the magnet is lowered down from -0.8e-14 to 1.93e-13 in 1 ms. The movement is constant speed completed.

Figure 7
Magnetic field strength of the magnets (H)

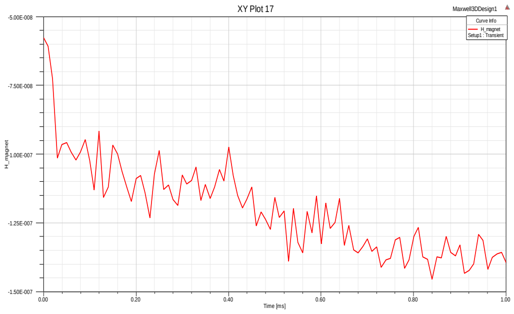
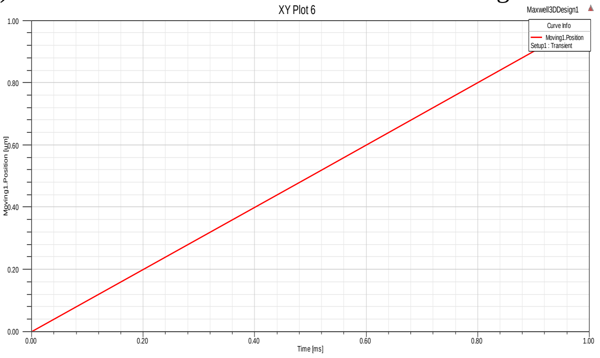


Figure 8
Time and Position of the magnets



The figure 7 illustrates how the magnetic field reacts when the magnet begins to move. This field strength is the some of the neutral field strength of the magnet and the electromagnetic field strength and exists on the magnetic at the beginning of the movement of the magnet this field strength reaches the top point. In the begin of the magnetic pressing, when the magnets going off den power going down.

Figure 9
Force

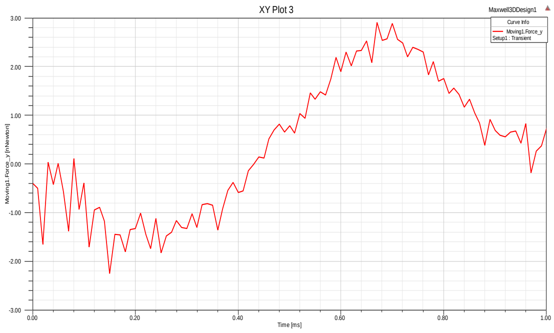
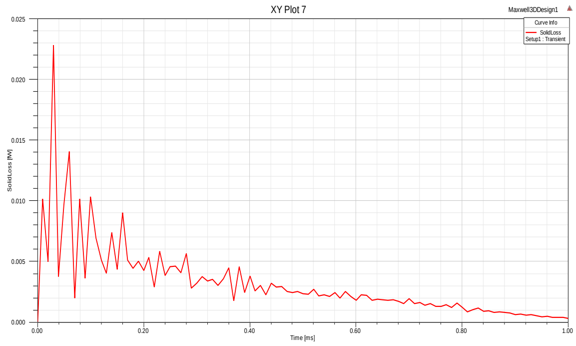


Figure 10
Solid loss



As Figure 9 shows, the performance starts to 0.18 ms, to rise and reached to 0.76 ms 2.234 Nano Newton. This value is the maximum point of this performance.

CONCLUSIONS

The neodym magnet is moving part of the system und analysis was done over. System created up to 2.234 Nano-Newton und completing the move at a constant speed 0.1 mm per second. Neodym magnet is moving 1.1 micro meter on Y axis. Assumptions are made to reduce an important 3D component of the magnetic circuit to axisymmetric geometry so that the model size can be significantly reduced. In this work, by ANSYS-Maxwell developed analyses were performed using the software. The results obtained seem to support the applicability of this design.

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