Influence of Different Geometric Parameters on the Static Force Characteristics of an Electromagnetic Actuator for Braille Screen

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Abstract—**The influence of different geometric parameters of a construction of recently developed permanent magnet linear electromagnetic actuator for Braille screen is studied. The static force characteristics and magnetic field distribution are obtained when varying the different parameters, including height of the coils and outer diameter of the actuator.**

Keywords— actuators, permanent magnets, finite element method, static force characteristics, Braille screen

I. Introduction

The problems connected with creating of computer controlled Braille screens, are object of research from many authors. In their works they realize different type of actuators. [1-9]. A linear magnetic actuator designed for a portable Braille display application is presented in [1]. Actuators based on piezoelectric linear motors are given in [2], [3]. A phase-change micro actuator is presented in [4] for use in a dynamic Braille display. Similar principle is employed in [6], where actuation mechanism using metal with a low melting point is proposed. In [7], Braille code display device with a polydimethylsiloxane membrane and thermopneumatic actuator is presented. Braille sheet display is presented in [8] and has been successfully manufactured on a plastic film by integrating a plastic sheet actuator array with a high-quality organic transistor active matrix. A new mechanism of the Braille display unit based on the inverse principle of the tuned mass damper is presented in [9]. Different electromagnetic actuators have been studied by the authors in [10-12].

II. Actuator Construction

The principal actuator construction is shown in Fig. 1. The main parts of the construction are:

1 – Needle (shaft); 2 – Upper core; 3 – Outer core;

4 – Upper coil; 5 – Upper ferromagnetic disc;

6 - Permanent magnet;

7 - Lower ferromagnetic disc; 8 – Lower coil;

9 - Lower core; 10 – Needle (shaft).

The two coils are connected in series in such way that they create magnetic flux of opposite directions in the region of the permanent magnet. In this way, depending on the polarity of the power supply, the permanent magnet will move either up or down. When motion up is needed, the upper coil should create flux in the air gap coinciding with the flux of the permanent magnet. Lower coil at the same time will create opposite flux and the permanent magnet will move in upper direction. When motion down is needed, the polarity of the power supply is reversed. The motion is transferred to the Braille dot using shaft, shown in Fig. 1

The actuator features increased energy efficiency, as the need of power supply is only during the switching between the two end positions of the mover. In each end position, the permanent magnet creates holding force, which keeps the mover in this position.

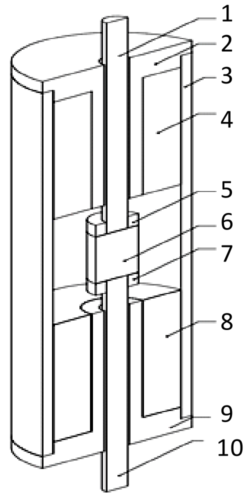

Fig.1. Principal construction of the studied actuator

III. Finite Element Modelling

Magnetic field of the actuator is modelled using the finite element method and the program FEMM [13]. For speeding-up the computations, Lua Script® is employed. Axisymmetric model is adopted as the actuator features rotational symmetry. The electromagnetic force F acting on the moving permanent magnet is obtained using the weighted stress tensor approach. The simulations are made for two different outer actuator diameters and for three different heights of the coils with and without coil supply. The third variable parameter is the stroke of the mover.

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Some of the obtained static force characteristics for maximal stroke 0.8 mm and coil supply causing downward movement (see Fig. 1) are shown in Fig. 2 and Fig. 3 for different coil height *hw* and outer diameter *d*.

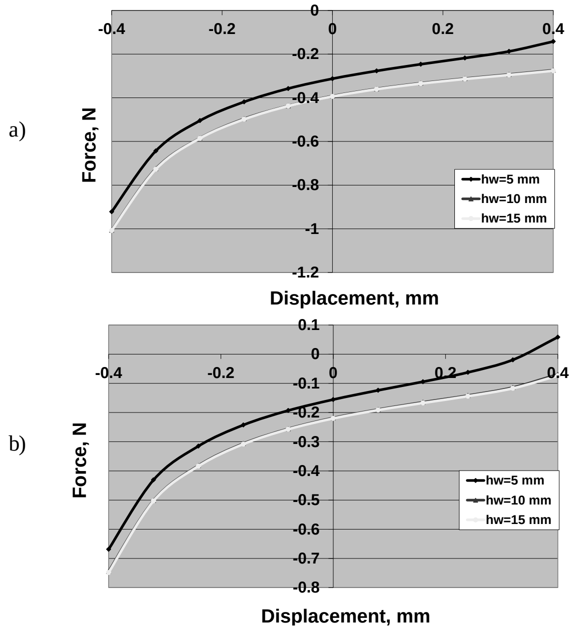

Fig. 2. Force-stroke characteristics for different heights of coils: a) d=7mm; b) d=5mm.

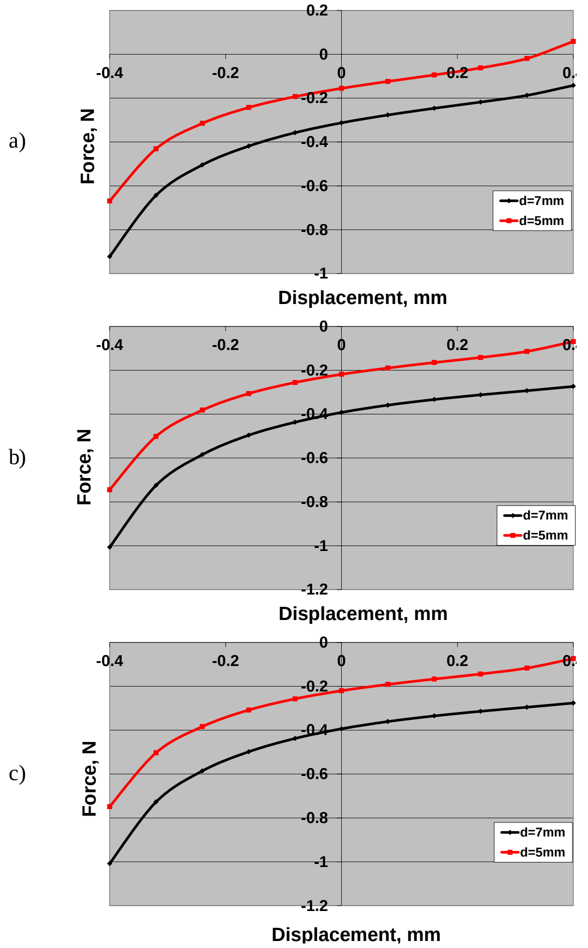

Fig. 3. Force-stroke characteristics for different outer diameter: a) hw=5 mm; b) hw=10 mm; c) hw=15 mm.

IV. CONCLUSION

Based on the results obtained, the following conclusions can be drawn:

- the developed actuator has static force characteristics which are suitable for Braille screen application;
- increasing the height of the coil has important influence on the force-displacement characteristics. Above a certain value, thought, further increase does not lead to significant change.

Further study could include optimization of the actuator and estimation of its dynamic characteristics.

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