STRUCTURAL ANALYSIS OF LINEAR SWITCHED RELUCTANCE MOTOR DESIGNED EI CORE

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Abstract: In this study, structural analysis of the linear switched reluctance motor (LSRM) the horizontal move axis, made of EI cores were investigated. Designed this linear motor is working as switched reluctance motors. The force is carried out around 1600 N in previous electromagnetic analyzes. In parallel with it, 1600 N force is selected for the structural analysis. Force is applied to the motor's axis of movement (Z axis). Under this force, the deformation of the motor stator and translator, stretch ratio and strength of material has been computed with the structural finite element method (FEM). Especially structural analysis, stretching ratio of the translator poles in z axis and with it structural effects on the bearing diameter of the stator have been examined.

Keywords: Linear Switched Reluctance Motor, EI Core

Introduction

Conventional linear systems are driven by a rotational motor, which is mechanized with a pulley or chain drive system. These types of mechanisms can cause faults, require periodical maintenance and inefficient. Mechanical transmissions that are converted from rotational movement to linear movement cause power losses. Mechanical transmissions are not necessary because linear movement forces are transferred magnetically. The actuator has a simple geometrical structure and it does not require a permanent magnet; therefore, its design and manufacturing costs are low (Amoros & Andrada, 2010).

LSRM is designed with EI core structured, one sided and transverse magnetic flux that is fault-tolerant and energy-efficient. LSRM has 12 stator poles, 3 phases, and 250 W power. This study includes structural analyses with Finite Element Analysis (FEA) of a LSRM. The actuator design has been computed for deformation, flexural rate and reliability of the material by structural analyses with finite element method. In this process, causing permanent damage to the material is aimed to predict during the operating state by the obtained values of the forces as a result of static magnetic analyses.

EI Core Linear Actuator

The iron sheets are stamped out in E and I shapes and are stacked as an EI core with a 3-legged structure. Coils can be wound around any leg, but usually the center leg is used. It is obtained from transformer manufacturers easily and cheaply. The simulator and real prototype models of the actuator are shown in Figure 1. The LSRM is divided into two pairs of their magnetic flux directions, these being transverse or longitudinal flux structurally. Either can be designed as single- or double-sided (Krishnan, 2004). The actuator consists of a stator and translator parts. The stator is the fixed part and is called a passive stator because it has no coils on it (Fenercioglu & Avsar, 2015). The translator is the moving part and is called an active translator because it has coils. The three-phase linear actuator has a 6/4 pole ratio and each phase has two excited coils. Sizes of the proposed linear actuator are presented in Figure 2 and Table 1.

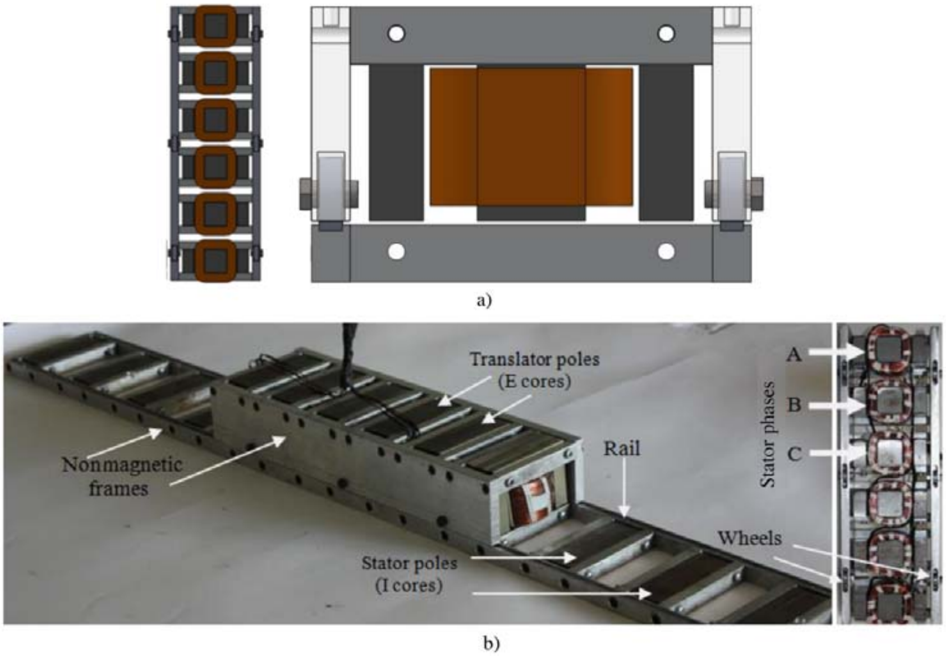


Figure 1. Simulator and real prototype models of the linear actuator: (a) front-rear view, (b) real prototype model.

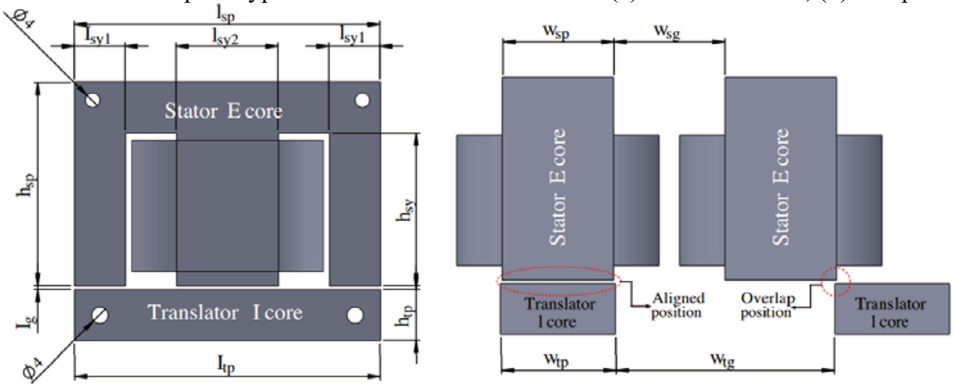
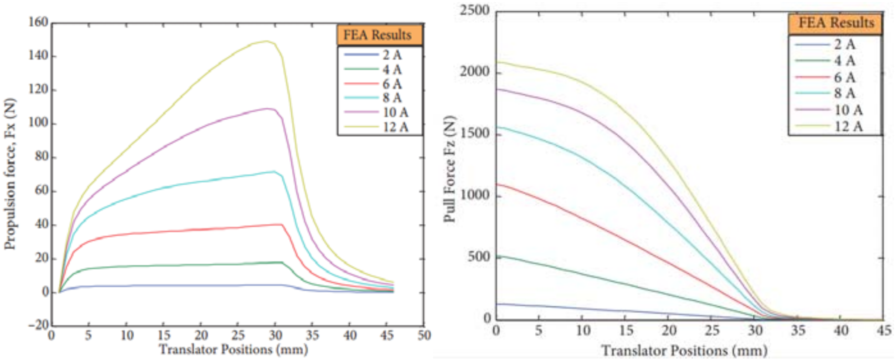


Figure 2. Sizes of proposed linear actuator.

Table 1. Geometrical sizes of the actuator.

Symbol	Dimensions	Size (m)	Symbol	Dimensions	Size (m)
l_{sp}	Length of stator pole	0.084	w_{sp}	Width of stator pole	0.030
l_{sy1}	Length of stator yoke 1	0.014	w_{sg}	Gap of stator poles	0.030
l_{sy2}	Length of stator yoke 2	0.028	w_{tp}	Width of translator pole	0.031
l_{tp}	Length of translator pole	0.084	w_{tg}	Gap of translator poles	0.059
h_{sp}	Height of stator pole	0.056	l_s	Length of overall stator	0.33
h_{sy}	Height of stator yoke	0.042	n_{sp}	Number of stator poles	6
h_{tp}	Height of translator pole	0.014	n_{tp}	Number of translator poles	12
l_g	Length of air gap	0.001	m	Number of phase	3



a) b)

Figure 3. a) The propulsion force (Fx), b) the pull force (Fz)

As a result of the magnetically FEM analysis, EI cores 2000 At magnetomotive force and 1.5 tesla flux values are observed. These values are start of the saturation point on the BH curve. When EI core reaches 2000 amper-coil, Fx force reaches 70 N propulsion force. Fz force has reached 1600 N pull force (Fenercioglu & Avsar, 2015). The thus obtained Fz force has referenced to structural analyses with finite element method. Consist of Fz force on the actuator design has ben computed for deformation, flexural rate and reliability of the material by structural analyses with finite element method. In this process, causing permanent damage to the material is aimed to predict during the operating state by the obtained values of the forces because of static magnetic analyses.

Structural Analyses of Translator and Actuator

Which will be applied to the translator pole is selected by 6/4 structured switched reluctance motor. Because in the state of stator with 6 poles 3 phases, due to everytime 2 poles are triggered also corresponding 2 poles of translator has been triggered. As the highest point will be the center close to the point of stretching translator pole to pole force has been given to 2 translator poles. This force is distributed by dividing the threshold value which is 1600 Newton equally to 2 translator. Figure 4. shows ANSYS finite element fixing point of the pole with translator programs and force values are given.

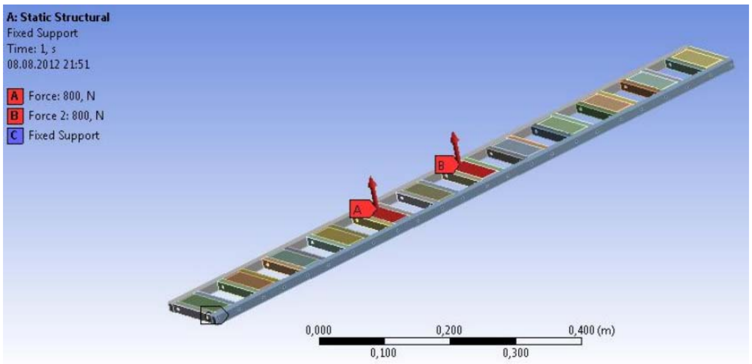


Figure 4. Fixing points and force values of the translator pole in ANSYS

Although the translator flexing forces in the structural analysis of a translator 1600 Newton aimed on determining deformations and stretching may occur aluminum. As a result of FEA by a method in general amount of spring force applied despite flexing in Figure 6 and a maximum stretching amount of the material are given in millimeters.

After computing total stretch ratio is computed durability of the material in response to these forces. The aluminum alloy is used as a fixing element for damage computing at 1600 Newton on the material. Aluminum alloy yield strength (Yield Strength) is approximately 280 MPascal. So finite element method with equivalent stresses exceed the yield strength in the analysis took place (Equivelent (von-Mises) stress) values are not irreversible formation of a tear or damage to the material. Translator_ equivalent stress (Equivelent (von-Mises) stress) values and highest tensile values are given in Figure 7.

In the FEM structural analysis of the material actuator 1600 Newtons is required to be calculated deformation on the bearing shaft and also material. As a result of finite element analysis by a method with the highest stresses in the material it is given in Figure 8.

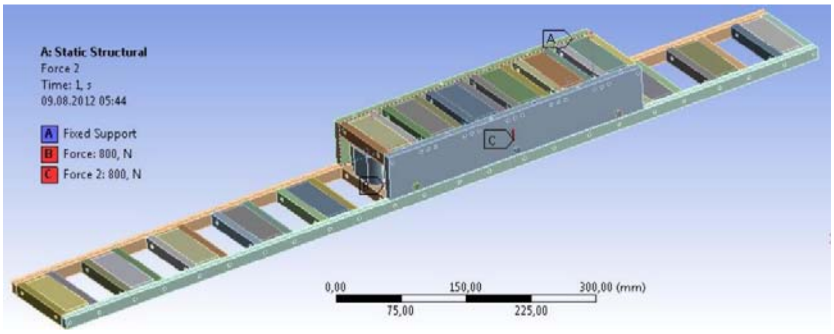


Figure 5. Fixing points and force values of the actuator in ANSYS

Results

The total deformation rate of return changing the total space is computed in ANSYS. As the highest value of the deformation, force applied by this calculation is 0.0141 mm. This result is a small value enough to be ignored.

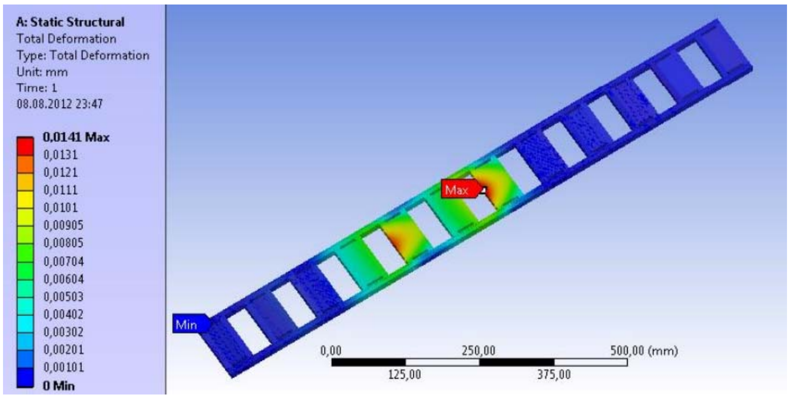
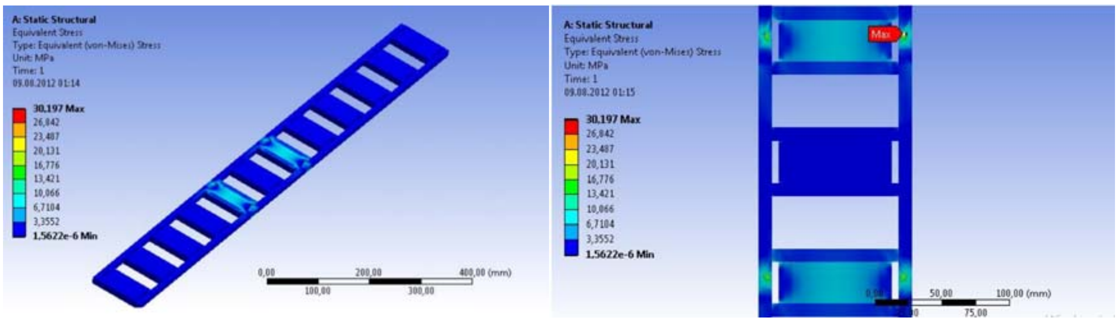


Figure 6. Total deformation rate in ANSYS

The Equivalent (von-Mises) stress of the material as shown in figure 7-a is about 5 MPascals in the FEM analysis. However, as Figure 7-b, where the highest stress experienced was identified as 30.1 MPascal. This situation does not occur even deformation of the material.



a) b)

Figure 7. a) Equivelent (Von-Mises) Stress in ANYSYS
b) Translator regions where the maximum stress occurs

Value is defined as the maximum stress occurs 8722 MPascal in which actuator bearing point. In this case the material has no deformation.

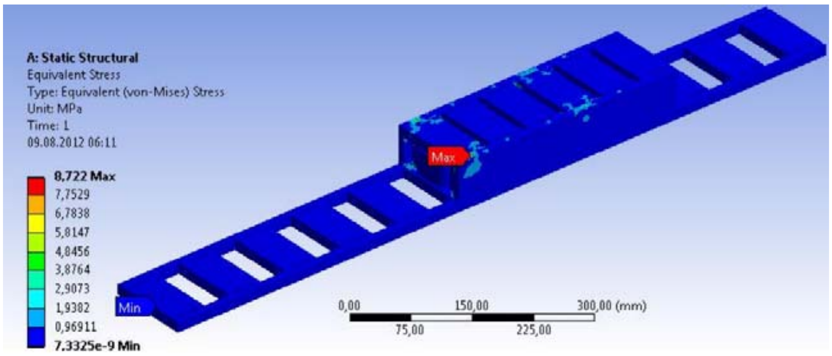


Figure 8. The highest voltage point in ANSYS

Conclusions

Single sided, EI core LSRM was structural analyzed by FEA software in order to determine deformation limits. When the highest force was applied, total deformation is calculated as 0.0141 mm. Under the maximum stress and Equivalent stress material has no deformation. Proposed design is acceptable as safety.

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