Determination of Geometric Dimensions of a Double Sided Linear Switched Reluctance Motor

Dursun M., Koc F., Ozbay H.

Abstract—In this study, a double-sided linear switched reluctance motor (LSRM) drive was investigated as an alternative actuator for vertical linear transportation applications such as a linear elevator door, hospital and subway doors which move linearly and where accurate position control and rapid response is requested. A prototype sliding elevator door that is focused on a home elevator with LSRMs is designed. The motor has 6/4 poles, 3 phases, 8A, 24V, 250 W and 250 N pull forces. Air gap between rotor and translator poles of the designed motor and phase coil’s ideal inductance profile are obtained in compliance with the geometric dimensions. Operation and switching sections as motor and generator has been determined from the inductance profile.

Keywords—Linear switched reluctance motor, sliding door, elevator door, linear motor design.

I. INTRODUCTION

Linear motion with rotary motors and linear mechanical interfaces has backlash due to gears and problems such as hysteresis [1]. Linear motors eliminate the need for rotary to linear mechanical interfaces resulting in simpler and robust conversion of electrical input into linear motion. With linear motors, additional benefits of quietness and reliability are obtained. Linear motors have been applied in conveyor systems, people mover, sliding doors, and airport baggage handling, to mention a few [2].

Opening and closing time of elevator doors significantly affects the elevator’s service quality and waiting time of the passengers. Due to this reason, it is need to new design of sliding door drive systems which both quickly open and close and have low failure rate and at the same time high efficiency. Conventional elevator doors consist of an electromechanical lock and sliding door system connected to gear box, belt and pulley system. Air gap between rotor and translator poles of the designed motor and phase coil’s ideal inductance profile are obtained in compliance with the geometric dimensions. Operation and switching sections as motor and generator has been determined from the inductance profile.

In this study, the geometric properties of an optimal LSRM motor (LSRM) drive was investigated as an alternative actuator for vertical linear transportation applications such as a linear elevator door, hospital and subway doors which move linearly and where accurate position control and rapid response is requested. A prototype sliding elevator door that is focused on a home elevator with LSRMs is designed. The motor has 6/4 poles, 3 phases, 8A, 24V, 250 W and 250 N pull forces. Air gap between rotor and translator poles of the designed motor and phase coil’s ideal inductance profile are obtained in compliance with the geometric dimensions. Operation and switching sections as motor and generator has been determined from the inductance profile.

In 2010, Fenercioglu A. and Dursun M. have published the design of a double-sided linear switched reluctance motor and its 3 dimensional magnetic analysis [12]. Similar studies are encountered in the literature [13]-[23]. LSRMs have simple construction, low cost, high pull forces, and accurate position.

In this study, the geometric properties of an optimal LSRM motor (LSRM) drive was investigated as an alternative actuator for vertical linear transportation applications such as a linear elevator door, hospital and subway doors which move linearly and where accurate position control and rapid response is requested. A prototype sliding elevator door that is focused on a home elevator with LSRMs is designed. The motor has 6/4 poles, 3 phases, 8A, 24V, 250 W and 250 N pull forces. Air gap between rotor and translator poles of the designed motor and phase coil’s ideal inductance profile are obtained in compliance with the geometric dimensions. Operation and switching sections as motor and generator has been determined from the inductance profile.

In 2010, Fenercioglu A. and Dursun M. have published the design of a double-sided linear switched reluctance motor and its 3 dimensional magnetic analysis [12]. Similar studies are encountered in the literature [13]-[23]. LSRMs have simple construction, low cost, high pull forces, and accurate position.

In this study, the geometric properties of an optimal LSRM motor (LSRM) drive was investigated as an alternative actuator for vertical linear transportation applications such as a linear elevator door, hospital and subway doors which move linearly and where accurate position control and rapid response is requested. A prototype sliding elevator door that is focused on a home elevator with LSRMs is designed. The motor has 6/4 poles, 3 phases, 8A, 24V, 250 W and 250 N pull forces. Air gap between rotor and translator poles of the designed motor and phase coil’s ideal inductance profile are obtained in compliance with the geometric dimensions. Operation and switching sections as motor and generator has been determined from the inductance profile.

In 2010, Fenercioglu A. and Dursun M. have published the design of a double-sided linear switched reluctance motor and its 3 dimensional magnetic analysis [12]. Similar studies are encountered in the literature [13]-[23]. LSRMs have simple construction, low cost, high pull forces, and accurate position.

In this study, the geometric properties of an optimal LSRM motor (LSRM) drive was investigated as an alternative actuator for vertical linear transportation applications such as a linear elevator door, hospital and subway doors which move linearly and where accurate position control and rapid response is requested. A prototype sliding elevator door that is focused on a home elevator with LSRMs is designed. The motor has 6/4 poles, 3 phases, 8A, 24V, 250 W and 250 N pull forces. Air gap between rotor and translator poles of the designed motor and phase coil’s ideal inductance profile are obtained in compliance with the geometric dimensions. Operation and switching sections as motor and generator has been determined from the inductance profile.

In 2010, Fenercioglu A. and Dursun M. have published the design of a double-sided linear switched reluctance motor and its 3 dimensional magnetic analysis [12]. Similar studies are encountered in the literature [13]-[23]. LSRMs have simple construction, low cost, high pull forces, and accurate position.

In this study, the geometric properties of an optimal LSRM motor (LSRM) drive was investigated as an alternative actuator for vertical linear transportation applications such as a linear elevator door, hospital and subway doors which move linearly and where accurate position control and rapid response is requested. A prototype sliding elevator door that is focused on a home elevator with LSRMs is designed. The motor has 6/4 poles, 3 phases, 8A, 24V, 250 W and 250 N pull forces. Air gap between rotor and translator poles of the designed motor and phase coil’s ideal inductance profile are obtained in compliance with the geometric dimensions. Operation and switching sections as motor and generator has been determined from the inductance profile.

In 2010, Fenercioglu A. and Dursun M. have published the design of a double-sided linear switched reluctance motor and its 3 dimensional magnetic analysis [12]. Similar studies are encountered in the literature [13]-[23]. LSRMs have simple construction, low cost, high pull forces, and accurate position.

In this study, the geometric properties of an optimal LSRM motor (LSRM) drive was investigated as an alternative actuator for vertical linear transportation applications such as a linear elevator door, hospital and subway doors which move linearly and where accurate position control and rapid response is requested. A prototype sliding elevator door that is focused on a home elevator with LSRMs is designed. The motor has 6/4 poles, 3 phases, 8A, 24V, 250 W and 250 N pull forces. Air gap between rotor and translator poles of the designed motor and phase coil’s ideal inductance profile are obtained in compliance with the geometric dimensions. Operation and switching sections as motor and generator has been determined from the inductance profile.

In 2010, Fenercioglu A. and Dursun M. have published the design of a double-sided linear switched reluctance motor and its 3 dimensional magnetic analysis [12]. Similar studies are encountered in the literature [13]-[23]. LSRMs have simple construction, low cost, high pull forces, and accurate position.

In this study, the geometric properties of an optimal LSRM motor (LSRM) drive was investigated as an alternative actuator for vertical linear transportation applications such as a linear elevator door, hospital and subway doors which move linearly and where accurate position control and rapid response is requested. A prototype sliding elevator door that is focused on a home elevator with LSRMs is designed. The motor has 6/4 poles, 3 phases, 8A, 24V, 250 W and 250 N pull forces. Air gap between rotor and translator poles of the designed motor and phase coil’s ideal inductance profile are obtained in compliance with the geometric dimensions. Operation and switching sections as motor and generator has been determined from the inductance profile.
II. ELEVATOR DOOR DRIVER SYSTEM DESIGN WITH LINEAR SWITCHED RELUCTANCE

Classical door driver system block diagram is given in Fig. 1. As it is seen in given block diagram, a door moving in linear is driven by using gearbox and v-belt-pulley with a circular motor. In this way, it causes both reduction of the velocity response of door, and decrease of performance because of friction of power transmitter. In Fig. 2, it is seen that an elevator door driver system with two-sided designed LSRM. In this designed system by transferring the power of air gap directly to the sliding door mechanism, frictions to decrease minimum level it is aimed. In this system, there are not any brush and collector in motor. So, while frictions are lowered, production of motor power is increased.

Furthermore, the power loss because of belt, pulley and gearbox in power transfer are prevented and the power transfer elements used more than needed are eliminated and the total cost of system is decreased.

For the motor design according to this standard, a geometric dimension of LSRM which are estimated by using Ansoft Maxwel program and magnetic analysis has been made by means of finite elements method. In design, sliding door has two symmetric parts. The weight of first part is taken as 25kg. In classical systems, the opening and closing time of sliding door is 4 seconds. The force needed to overcome static friction was experimentally founded as 100 N. Moreover, as the standard does not allow more than 150N force during the door closing, the total force to be produced by motor was determined as 250N.

III. INDUCTANCE PROFILE OF LSRM

The ideal inductance profile according to translator position of the designed motor has 5 sections. These sections for the motor obtained versus to translator position were shown in Fig. 4. First section is found by (1). In this section, the minimum and maximum value of Phase A does not change from the initial positions to X1. On the other hand, during the Section 2 inductance increases linearly and the length of this section is calculated by (2). Since the inductance positively changes in this section and positive pulling force occurs by ratio of the square of current which is passed through the coil. Since the inducted force varies by the square of the current, it is independent of the direction of current. Section 3 is the section where inductance is maximum and its length is calculated by (3). Since inductance variation is zero in this section, derivative of inductance is also zero. Therefore, any pulling force is not produced in this section even if current is applied to the phase coil. In order to decrease the any phase current in coil to zero, phase current should be interrupted before the end of section 2. In this section, current interruption point directly depends on the current value, inductance value and vehicle velocity.

In Section 4, the inductance decreases and length of Section 4 is calculated by (4). Since inductance variation is negative, the direction of force is also negative. So, the motor operates as a generator during this section. Properties of section 4 5 are similar to that of Section 1 and its length is calculated by (5).
The minimum value of phase inductance of motor is indicated as 0.001472 mH and maximum inductance as 0.005851 mH for 8A. Consequently, electrical properties of the motor are determined as 250 W, 24V DC, 8 A.

$$x_1 = \frac{w_{po} - w_{os}}{2}$$  \hspace{1cm} (1)

$$x_2 = x_1 + w_{po}$$  \hspace{1cm} (2)

$$x_3 = x_2 + (w_{po} - w_{os}) = w_{po} + \frac{w_{os} - w_{po}}{2}$$  \hspace{1cm} (3)

$$x_4 = x_1 + w_{po} = w_{po} + \frac{w_{os} + w_{po}}{2}$$  \hspace{1cm} (4)

$$x_5 = x_4 + w_{po} - w_{os} = w_{os} + w_{po}$$  \hspace{1cm} (5)

where \( w_{po} \) is width of the translator pole, \( w_{os} \) width of the translator slot, \( w_{sp} \) is width of the stator pole and \( w_{ss} \) is width of the stator slot.

\begin{align*}
\text{Length of LSRM} &= 0.8 \text{ m,} \\
\text{Maximum linear velocity, } v_m &= 1.0 \text{ m/s,} \\
\text{Acceleration time, } T &= 0.167 \text{ s,} \\
\text{Maximum mass for translator} &= 25 \text{ kg.}
\end{align*}

In fact, properties of linear motors are not much different than the electrical and geometric properties of rotational motors. Since the length of prototype of motor to be designed is 235 mm, the machine may be considered as a rotational motor with the circumferential of 235 mm and radius 37.40 mm. The motor is regarded for use in opening and closing an elevator door of weight 25 kg at a distance of 80 cm. Trapezoidal motion profile speed-time and speed-position curve of the door during opening and closing is given in Fig. 6. In addition, a trapezoidal motion profile is used to drive the vehicle smoothly and without jerky motion and to control the positions of the vehicle while its ascent and descent.

In the inductance profile shown in Fig. 5, the sections between 0 – \( X_1 \) and \( X_4 – X_5 \) show the unaligned position, and the section between \( X_2 – X_3 \) shows the aligned position.

The working principle of LSRM and the back EMF occurring, current, and power and pull force versus inductance variation are shown in Fig. 5. The force is produced along the section between \( X_2 – X_3 \) and the machine operates as motor. On the other hand, force is not produced in the section between \( X_5 – X_1 \) and the machine operates as generator.

IV. DETERMINATION OF GEOMETRIC DIMENSIONS OF A DOUBLE SIDED LSRM

In the design of LSRM, the following properties are assumed:

\begin{align*}
\text{Length of LSRM} &= 0.8 \text{ m,} \\
\text{Maximum linear velocity, } v_m &= 1.0 \text{ m/s,} \\
\text{Acceleration time, } T &= 0.167 \text{ s,} \\
\text{Maximum mass for translator} &= 25 \text{ kg.}
\end{align*}

Mass of the door (m) is 25 kg, acceleration time \( (T_a) \) is selected as 0.167 second and velocity of the door \( (v_m) \) is selected as 1.0 m/s. According to these values, the acceleration of the door \( (a) \) is found by (6) and the pull force to accelerate the door is found by (7), respectively as

$$a = \frac{v_m}{T_a} = \frac{1.0}{0.167} = 6 \text{ m/s}^2$$  \hspace{1cm} (6)

$$F_a = ma = 25.6 = 150 \text{ N}$$  \hspace{1cm} (7)

\( F_a \) was selected as 250 N by adding the 100 N force required for the static friction. \( F_s \) is the force which the motor should apply to door, \( m \) is mass of door (kg) and \( a \) is the acceleration determined from (6). Deceleration of the door to stop is equal to its acceleration, but has reverse sign. Accordingly, the LSRM’s power \( (P) \) is calculated by (8) as:

$$P = F_s v_m = 250.1 = 250W$$  \hspace{1cm} (8)

Minimum translator pole width is selected for continuous pull force. Thus, the length of this yoke pole is found by (9) with aid of the circumferential length of the rotating motor:

$$\min[\beta_h] = \frac{4\pi}{P} = \frac{4\pi}{6x4} = 0.5236 \text{ rad} = 30^\circ$$  \hspace{1cm} (9)

By considering, the pole width of the rotational motor is the
same as the linear version; the length of a translator pole is calculated as 19.58 mm. With considering production problems, the pole width was chosen as 20 mm and the total length of motor was determined as 235 mm for 360. Since $\beta_s, \beta_r$ the value of $\beta_s$ is chosen as 36$^\circ$. Therefore, stator pole angle of rotary SRM, $\beta_s = 30^\circ \times 0.5235 rad$, rotor pole angle of rotary SRM, $\beta_r = 36^\circ \times 0.6283 rad$. Then to get the maximum power developed, current conduction angle $\theta_i$ must be equal to the stator pole arc $\beta_s$, $\theta_i = 360 \times 30 \times 4 \times 4 = 20 mm$.

Switching frequency ($f_m$) of the current applied to the coils is calculated by (15) and length of pole pitch $\tau$ is calculated by (16).

$$ f_m = \frac{2P_s N_s}{60} = 2 \times 4 \times \frac{360}{60} = 48 \approx 50 Hz \quad (15) $$

$$ \tau = \frac{v}{f_m} = \frac{1.0}{50} = 20 mm \quad (16) $$

Stack length (L) of rotary LSRM is found by (17).

$$ L = kD = 0.65 \times 0.76 = 0.494 mm \quad (17) $$

Thickness of stator yoke, $b_{sy}$ is found as by (18),

$$ b_{sy} = \frac{DB \beta_s}{2} = \frac{76 \times 0.5236}{2} = 19.90 mm \quad (18) $$

and taken approximately as 20. Assuming that outer diameter of stator is 118 mm, height of stator pole ($h_s$) is found by (19).

$$ h_s = \frac{D}{2} - \frac{D}{2} - b_{sy} = \frac{118}{2} - \frac{76}{2} - 24 = 20 mm \quad (19) $$

Rear copper width of the rotor, $b_{ry}$ is by (20) and top of rotor pole are found, $h_r$ is by (21);

$$ b_{ry} = \left(\frac{D}{2}\right)\beta_r = \left(\frac{76}{2}\right) \times 0.6283 = 23.88 mm \quad (20) $$

$$ h_r = 2\left(\frac{D}{2} - 2\beta_s - b_{ry}\right) = \left[\frac{76}{2} - 2 \times 0.6 - 23.88\right] = 26 mm \quad (21) $$

Magnetic field intensity in the air gap ($H_g$) is calculated and found by (22) as

$$ H_g = \frac{B}{\mu_r} = \frac{1.7}{4 \times \pi \times 10^{-7}} = 1352817.016 A/mm \quad (22) $$

For a peak phase current of $I_p = 8 A$ allowable in the machine, the number of turns per phase is by (23).

$$ T_m = \frac{H_g (2\beta_s)}{I_p} = \frac{1352817 (2 \times 0.6)}{8} = 203 turn / phase \quad (23) $$

Assuming the current density as 5 A/mm$^2$, the area of the conductor is found by (24).

$$ a_c = \frac{I_p}{J \sqrt{q}} = \frac{8}{5 \sqrt{3}} = 0.92 mm^2 \quad (24) $$

$a_c$ was selected 1 mm$^2$. The number of total sectors of LSRM is found by (25) and the resultant total number of stator poles ($n$) are by (26).

$$ N_w = \frac{L_{c1}}{\pi D} = \frac{0.8}{\pi \times 76 \times 10^{-3}} \approx 4 \quad (25) $$

$$ n = P_s N_w = 6 \times 4 = 24 \quad (26) $$

Active operation of stator of LSRM and passive operation of its translator reflects the stator and translator of LSRM versus the stator and rotor of rotating SRM. The width of the stator pole is by (27) and the width of the stator slot are obtained as (28).
The width of the translator pole is by (29) and the width of the translator slot are calculated as (30)

\[ w_p = b_p = 20 \text{mm} \]  

\[ w_s = \left( \pi D - P_s w_p \right) / P_c = \left( \pi \times 76 - 4 \times 20 \right) / 4 = 39.69 \approx 40 \text{mm} \]

The core stack width of the LSRM is obtained by (31)

\[ L_w = L = kD = 0.65 \times 76 = 49.4 \text{mm} \]

Translator slot window area is by (32)

\[ d_s = \frac{4a_s}{\pi} = \frac{4 \times 0.92}{\pi} = 1.08 \text{mm} \]

The total stator length is found by (37)

\[ P_s \times W_{sp} + P_s W_s = 6 \times 20 + 5 \times 23 = 235 \text{mm} \]

where \( P_s \) is stator pole number and it is 6, \( P_s \) is stator slot number and it is 5. In conclusion, it is observed that the above equation is satisfied with the LSRM design.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Design Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>Length of LSRM</td>
<td>0.8 m</td>
</tr>
<tr>
<td>( V_m )</td>
<td>Maximum Linear Velocity</td>
<td>1 m/sec</td>
</tr>
<tr>
<td>( t_a )</td>
<td>Acceleration time</td>
<td>0.167 sec</td>
</tr>
<tr>
<td>( m )</td>
<td>Maximum mass for translator</td>
<td>25 kg</td>
</tr>
<tr>
<td>( F )</td>
<td>Pull force</td>
<td>250 N</td>
</tr>
<tr>
<td>( P )</td>
<td>Power of LSRM</td>
<td>250 W</td>
</tr>
<tr>
<td>( I )</td>
<td>Current</td>
<td>8 A</td>
</tr>
<tr>
<td>( W_{tp} )</td>
<td>Width of translator pole</td>
<td>23 mm</td>
</tr>
<tr>
<td>( W_{sp} )</td>
<td>Width of stator pole</td>
<td>20mm</td>
</tr>
<tr>
<td>( W_{st} )</td>
<td>Width of stator slot</td>
<td>20mm</td>
</tr>
<tr>
<td>( W_{ts} )</td>
<td>Width of translator slot</td>
<td>40mm</td>
</tr>
<tr>
<td>( q )</td>
<td>Number of phase ( i )</td>
<td>3</td>
</tr>
<tr>
<td>( f_{sw} )</td>
<td>Switching frequency</td>
<td>50 Hz</td>
</tr>
<tr>
<td>( \tau )</td>
<td>Pole pitch</td>
<td>20 mm</td>
</tr>
<tr>
<td>( P_s )</td>
<td>Stator slot number</td>
<td>5</td>
</tr>
<tr>
<td>( D )</td>
<td>The hole diameter</td>
<td>76 mm</td>
</tr>
<tr>
<td>( \lambda_s )</td>
<td>Stator and translator slot</td>
<td>0.6 mm</td>
</tr>
</tbody>
</table>

V. MAGNETIC ANALYZES OF MOTOR

The appropriate mechanical and electrical parameters was designed the motor has been visualized as 3 dimensional upon these parameters. 3-d Figure of the motor as been drawn with a computer aided design software, and it is shown in Fig. 8.
VI. CONCLUSION

In this study, the method of geometric dimensioning method for a double sided, 6/4 poled, 3 phase LSRM of 250 W power to be used in places such as elevator, hospital and subway doors where accurate position control and rapid response are requested and the parameters obtained by this method are calculated. Operation and switching sections as motor and generator are determined by obtaining the ideal inductance profile according to the geometric dimensions of air gap, stator and translator in compliance with the power of motor.

As seen, the power of air gap is directly transferred to the sliding door and friction is minimized in the system. Since in this system friction is reduced because there is not any brush collector in the motor, the motor efficiency is high. In addition, the losses arising from belt, pulley and reducer in power transfer are prevented and cost is reduced by removing the power transfer elements used in excess.

APPENDIX

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a$</td>
<td>Acceleration ($m/s^2$)</td>
</tr>
<tr>
<td>$a_c$</td>
<td>The area of the conductor ($mm^2$)</td>
</tr>
<tr>
<td>$b_{ry}$</td>
<td>The stator yoke thickness ($mm$)</td>
</tr>
<tr>
<td>$b_{rw}$</td>
<td>Rear copper width of the rotor ($mm$)</td>
</tr>
<tr>
<td>$\beta_s$</td>
<td>Rotor pole angle of rotary (degree)</td>
</tr>
<tr>
<td>$\beta_i$</td>
<td>Stator pole angle of rotary (degree)</td>
</tr>
<tr>
<td>$D$</td>
<td>The bore diameter ($mm$)</td>
</tr>
<tr>
<td>$d_c$</td>
<td>The diameter of the conductor ($mm$)</td>
</tr>
<tr>
<td>$f_{sw}$</td>
<td>Switching frequency ($Hz$)</td>
</tr>
<tr>
<td>$F_c$</td>
<td>Force of LSRM ($N$)</td>
</tr>
<tr>
<td>$H_g$</td>
<td>Magnetic field intensity in the air gap ($A/mm$)</td>
</tr>
<tr>
<td>$h_r$</td>
<td>Top of rotor pole ($mm$)</td>
</tr>
<tr>
<td>$h_s$</td>
<td>Height of stator pole ($mm$)</td>
</tr>
<tr>
<td>$h_t$</td>
<td>Height of translator pole</td>
</tr>
<tr>
<td>$I_p$</td>
<td>Peak phase current ($A$)</td>
</tr>
<tr>
<td>$L$</td>
<td>Stack length of rotary SRM ($mm$)</td>
</tr>
<tr>
<td>$L_{ax}$</td>
<td>Aligned inductance ($H$)</td>
</tr>
<tr>
<td>$L_{ux}$</td>
<td>Unaligned inductance ($H$)</td>
</tr>
<tr>
<td>$L_{ax}$</td>
<td>The total length of the translator ($mm$)</td>
</tr>
<tr>
<td>$L_{sw}$</td>
<td>The core stack width of the LSRM ($mm$)</td>
</tr>
<tr>
<td>$m$</td>
<td>Maximum mass for translator ($kg$)</td>
</tr>
<tr>
<td>$n$</td>
<td>The resultant total number of stator poles</td>
</tr>
<tr>
<td>$N_p$</td>
<td>Rotational velocity (rpm)</td>
</tr>
<tr>
<td>$N_w$</td>
<td>The number of total sectors of LSRM</td>
</tr>
<tr>
<td>$P$</td>
<td>Power of LSRM ($W$)</td>
</tr>
<tr>
<td>$t_a$</td>
<td>Acceleration time ($s$)</td>
</tr>
<tr>
<td>$\theta_l$</td>
<td>Current generating angle (degree)</td>
</tr>
<tr>
<td>$\tau$</td>
<td>Pole pitch</td>
</tr>
<tr>
<td>$P_f$</td>
<td>Packing factor</td>
</tr>
<tr>
<td>$P_s$</td>
<td>Stator pole number</td>
</tr>
</tbody>
</table>

$P_r$ | Rotor pole number |
$T_{ph}$ | The number of turns per phase |
$q$ | Number of phase |
$v_m$ | Maximum linear velocity |
$w$ | Width of the wedges |
$w_{tp}$ | Width of the translator pole |
$w_{ts}$ | Width of the translator slot |
$w_{sp}$ | Width of the stator pole |
$w_{ss}$ | Width of the stator slot |

ACKNOWLEDGMENT

This study is under the supervision and support of 00401.STZ.2009-1 coded SANTEZ project by Ministry of Industry and Trade with EMSA Automation.

REFERENCES


M. Dursun was born in Corum, Turkey, in 1970. He received the BS degree in Electrical Education from Electrical Education, Gazi University, in 1993. The MSc degree in 1996, and the PhD degree 2002 from Department of Institute of Science and Technology, from Gazi University, Ankara, Turkey. He is currently an assistant professor at the Department of Electric Machinery Education, Gazi University. His research interests include Motor Design, Modeling, Motor Control, Switched Reluctance Motors, Brushless DC motors, DC-DC converters, Matrix Converters, Fuzzy Logic Control, Artificial Neural Network, Elevator motors, Motor and Centrifugal Pump Drivers, DSP, PLC, microprocessors and microcontroller programming, serial and parallel active power filters, and photovoltaic systems, photovoltaic irrigating systems, RF control and communications, and distance education material design.

F. Koc was born in 1984, Kocaeli, Turkey. She received the BS degree in 2007 from Gazi University, Ankara, Turkey. She is currently working toward the M.S degree in the Electrical Education Department of Institute of Science and Technology, Gazi University. She is now a lecturer at Department of Electric, Gazi Vocational High School. Her research focused on Linear Switched Reluctance Motors, DC-DC converters, Motor Control, Modeling and simulation.

H. Özbay (M’10) was born in Bursa, Turkey, in 1984. He received the B.S. degrees in electrical education from Gazi University, Ankara, Turkey, in 2008. He is currently working toward the M.S. degrees in the Electrical Education Department of Institute of Science and Technology, Gazi University, Ankara.

He is presently a University Lecturer in the Electrical Department of Vocational High School, Bilecik University, Bilecik. His research interests include the design of switched reluctance motors and their control, linear switched reluctance machine design and their magnetic analyzes.