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Prototype Development Model for Trolley using Linear Induction Motor

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Abstract

The purpose of this project is to increase use of LIM in industry for transportation purpose. The project will show prototype of Linear Induction Motor as a drive which carry 10-15kg weight in which flat rotor move forward direction. We present a linear induction motor (LIM) prototype for education. Firstly the equivalent circuit of SLIM fully considering the end effects, half-filled slots, back iron saturation and skin effect is proposed, based on one dimensional air gap magnetic equations. Furthermore, many optimum style restraint equations of SLIM area unit provided so as to enhance the operational potency and cut back the first weight. The result tries to ascertain a brand new conception for elevators through a brand new construction technique and assembly of the system with counterweight, that will increase the responsibleness and luxury with value reduction. Some experiments area unit bestowed that highlight the projected approach..

Keywords: *Electric motor, SLIM (single sided linear induction motor), design, modeling, application*

INTRODUCTION

In recent years, there have been more than 20 urban transportation lines propelled by single sided linear induction motor(SLIMs) among the word, such as the Kennedy air line in America, linear metro in Japan, Vancouver light train in Canada, Guangzhou subway line 4 in China, and so on.

Electrical energy converts into mechanical energy and linear motion is achieved [1, 2]. The primary, similar to the stator of rotary induction motor (RIM), is hanged below the redirector, which is supplied by the inverter on the vehicle. The secondary equivalent to the rotor of RIM, is flatted on the railway track, that sometimes carries with it 5mm thick Copper/Aluminum electrical phenomenon sheet and a 20mm thick back iron. Once the first 3 part windings square measure input with Ac current, they'll build up air flux linkages, which has eddy current within the secondary sheet. This eddy current can react with aforesaid air gap flux linkage thus on manufacture a horizontal magnetic attraction thrust which will drive the vehicle forward directly while not wishing on the friction between wheel and track.

A linear induction motor is works on the principles as asynchronous linear motor that's associate electrical energy asynchronous linear motor, however is intended to directly manufacture motion in a very line. Linear induction motors have a primary or secondary turns, that generates end-effects, whereas a standard induction motor is generate associate endless loop. As with, linear motors ofttimes operated on three-phase power provide and might offer terribly high speeds [3, 4].

Linear Induction Motors can give a levitation effect. Therefore linear induction motor is used where low maintenance also contactless force is required. This motor is uses in application include magnetic levitation, linear propulsion, and linear actuators. And also been used for pumping liquid metals.

However, the SLIM, which can be considered as evolved from the RIM, has a cut-open primary magnetic circuit. As the primary moves, a new flux is continuously developed at the primary entrance side, while the air gap flux disappears quickly at the exit side. By the influence of sudden generation and disappearance of the air gap penetrating flux density, an amount of eddy current in anti-direction to the primary current will be induced in the secondary sheet, which correspondingly affects the air gap flux profile along the longitudinal direction (x-axis) as illustrated in Fig. This is called “longitudinal end effect” of linear induction motor, As the velocity goes up, which can increase the copper loss, and decrease the mutual inductance. In the end, because of the attenuating air gap average flux linkage, the effective electromagnetic thrust will be reduced [5].

Fig. 1: Air Gap Flux Profile.

WORKING

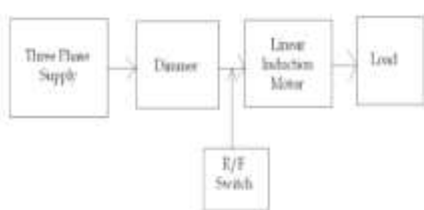

***Fig. 2:** Block diagram of linear induction motor.*

Fig shows the block diagram of our project, It consist of three phase supply, dimmer, reverse forward switch, linear induction motor and the load. The three phase supply is given to the dimmer, then by using dimmer we can give variable supply to the linear induction motor. The reaction plate in SLIM is equivalent to rotor. This is made of a non magnetic highly conductive material. The induced field is maximized by backing up the reaction plate with an iron plate. The iron plate serves to amplify the magnetic field produced in coil. The air gap between the stator and the reaction plate must typically be very small. Otherwise the amount of current through stator becomes undesirable.

When we give AC current to the coils, a travelling magnetic wave is set up. By the travelling magnetic wave create a secondary magnetic field, the Currents induced in the reaction plate. The second field is induced by stator coil, with the reaction between these two fields ,a linear thrust is produced.

ASSEMBLY

It consists of mainly two important parts:

Phase Coil Assembly

The coil assembly consists of a 3 phase winding that is wound into a steel lamination stack. These lamination are insulated from each other with fine materials, such as paper or adhesive glue. The size of wire is of 20 Gauge made by super enameled copper. The coil assembly will require some form of mounting to ensure stability during operation. The single side linear induction motor consists of a single coil assembly, that is used with an Aluminum or copper plate backed by a steel reaction plate. The coil configuration can be connected to AC line for single speed application.

Fig. 4: *Assembly of Coil.*

Fig. 3: *Aluminum or Copper Plate.*

Fig. 5: *Assembly of Stampings.*

Reaction Plate

A reaction plate is required for proper operation of linear induction motor. The reaction plate for single sided motor operation is made from standard steel(3 mm), aluminum(2 mm), and or copper(6 mm) thick ferrous steel plate.

Fig. 6: *Assembly of Stamping with Coil.*

PROPERTIES OF LIM

Linear Synchronous Speed

Linear synchronous speed is equivalent to synchronous speed of rotary induction motor. The linear synchronous speed is given by:

$$Vs=2pf$$

Where

Vs-linear synchronous speed(m/s)

p - width of one pole pitch

f - frequency (Hz)

Consider two machines where the radii are R & 2R respectively. The rotational field speed for is w for both of them, While the linear speeds are different.

$$Vs = wR$$

$$Vs = 2wR$$

$$= 2\pi fR$$

$$= 4\pi fR$$

$$= 2f^* \text{ pole pitch}$$

$$= 2f^* \text{ pole pitch}$$

It clearly indicate that linear synchronous speed does not depends on the number of poles, but depend on pole pitch.

To increase synchronous speed of LIM designer could:

a. Design a longer pole pitch
b. Increase the supply frequency

Slip

The slip formula for LIM is identical to RIM. The per unit slip is expressed by:

$$S= (Vs-V)/Vs$$

Where

S – slip

Vs- synchronous linear speed (m/s)

V – speed of rotor (m/s)

Forces

The main forces involved with the LIM are thrust, normal and lateral.

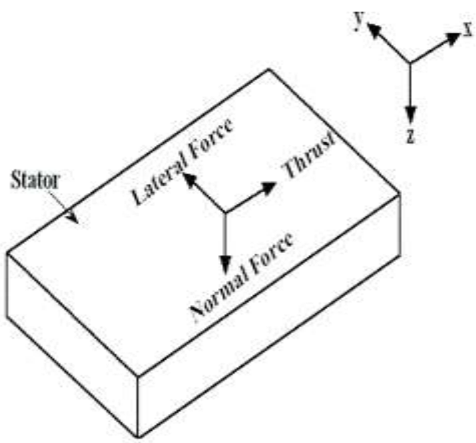

Fig. 7: *Forces.*

Thrust

Under normal operation, the LIM develops a thrust proportional to the square of the applied voltage and reduces as the slip is reduced.

The amount of thrust produced by LIM as follows:

F=P1/Vs

Where,

F – Thrust

P1– power transmitter to the rotor(W)

Vs- Linear synchronous speed (m/s)

Normal

The normal force is force between the stator and reaction plate. It is large in SLIM this is because of asymmetrical topology. At synchronous speed, the force is an attractive force and its magnitude is reduced as the speed is reduced. At certain speeds the force will become repulsive, especially at high frequency operation.

Lateral

Lateral forces occur due to asymmetric positioning of the stator in a LIM. Lateral forces moves in the y direction. Generally small displacement will only result in very small lateral force. Any displacement from the central positioning will result in an unstable system. At high frequency the lateral forces are quite chaotic. A set of guided mechanical wheel tracks is sufficient to eliminate small lateral force.

DESIGN AND CALCULATIONS OF MODEL

Consider a design for 1HP,440v,50Hz Linear induction motor,

Output equation:

kVA input Q = C_d.D^2.Ln

Co =Output coefficient

=1.1kw.B_{av}.ac*10^{-3}

Here, assuming a data

Kw=0.933

B_{av}=0.4Wb/m^2

Ac=30000

C_o=11*0.933*0.4*30000*10^{-3}

=123.156

Q =kVA I/P

=$C_o D^2$Ln

=123.156*D^2Ln

&

Q =kW/Efficiency*cos fi

=0.735/0.64

=1.1492 (Assuming efficiency=0.8 & cos fi=0.8)

D^2L=1.1492/123.156*2.5

=0.3732*10^{-3}

For overall good design

L/toe=1 , L/nD/p =1

L/D=pi/p;

L/D=3.14159/4=0.7853

L =0.7853D

D^2*0.7853D =0.3732*10^{-3}

D^3 =0.3732*10^{-3}/0.7853

D^3 =0.0004752

ID =0.07803m

L=0.7853*0.07803

=0.06127m

Toe = pi*D/p

= 3.14*0.07803/4

= 0.0614m

Flux per pole

Max. flux =B_{av} *Toe*L

=0.4*0.0614*0.0612

$=1.50*10^{-3}$wb

Stator voltage per phase =440/root of 3

=254.03V

T_s =254.03/4.44*F*flux*kw

$=254.03/4044*50*1.50*10^{-3}*0.933$

=818 Turns/phase

Stator current/phase = Is =735.5/root of 3*440*0.8*0.8

=1.508Amp

Taking current density =3A/mm^2

Area of each stator conductor =1.508/3

=0.5023mm^2

Total no. of stator conductor =3*2Ts

=6*818

=4908

Total no. of stator slots =2*3*4

=24

Let pole pitch = toe =0.0614m

Slot pitch = 0.0614/3*2

= 0.01052m

Slot width =Tooth width = 0.0102/2

=0.00511m.

Let, slot depth = Total slot area/slot width

= 266.03/5.11

=52.06mm

Depth of stator core

Area of stator core = Max flux/flux density in core

Assuming 1.2wb/m^2 flux density

$=1.50*10^{-3}$ /1.2

$=1.25*10^{-3}$m^2

Net iron length = 0.9*L

=0.9*0.06127 =0.05514m

Conductor per slot = 4908/24 =205

Area of each stator conductor = 0.5023mm^2

Diameter of conductor required = 0.813mm

Area of stator conductor used = pi/4*(0.813)^2

= 0.5191mm^2

Slot Dimensions:

Space required for base conductors in slot = Z_{sg}*as

=205*0.5191

=106.415mm^2

Taking space factor = 0.4

Area of each slot = 106.415/0.4
=266.03mm^2

RESULTS

Here the parameters such as voltage, current, speed and weighing capacity have been measured using the millimeters, clip-on meter and speed gun. Our prototype model of trolley using linear induction motor is going to carry a load of 8-10kg. Table shows the output measures which shows the Speed of rotor proportional to input voltage and inversely proportional to load.

Table 1-

I/P voltage(V)	Load(gm)	Current(Amp)
100	0	8.24
100	500	8.18
100	1000	8.14
100	2000	8
100	3000	8.04

And hence the speed decrease

Table 1: *At Constant Voltage.*

Table 2-

I/P voltage(V)	Load(gm)	Current(Amp)
100	3000	8.16
110	3000	8.91
120	3000	9.35
130	3000	10.26
140	3000	11.21
150	3000	12.05

And hence the speed increases

Table 2: *At Constant Load.*

SUMMARY

It can achieve direct propulsive thrust, this is not dependent on the friction between wheel and track. It offers advantages of lower noise and less maintenance and also energy consumption is less. It has smaller turning radius, smaller cross-sectional area for requirement of a tunnel, larger acceleration, and stronger climbing ability. By investigations from some Japanese exporters, the typical SLIM system has 40-60 m turning radius, 22 m2 cross-sectional tunnel area, 1.2 m/s2 acceleration, and 6-8% gradient ability compared with the 80-120 m turning radius, 41 m2 cross-sectional tunnel area, 0.8 m/s2 acceleration, and 3-4% gradient ability in a typical RIM system.

FUTURE SCOPE

1. Automatic sliding doors in electric trains.
2. Mechanical handling equipment, such as propulsion of a train of tubs along a certain route.
3. Metallic conveyor trolleys.
4. For weighing a equipments, transportation of labors in mines.

CONCLUSION

This project of “Prototype model of Trolley by using Linear Induction Motor” is very helpful because here we use linear induction motor to drive the trolley which saves energy consumption and gives very high speed. It reduces cost of equipment, maintenance of machine and pollution.

REFERENCES

1.Linear Electric Machines- A Personal View ERIC R. LAITHWAITE, FELLOW, IEEE, PROCEEDINGS OF THE IEEE, VOL. 63, NO. 2, FEBRUARY 1975.

2. Force Analysis of Linear Induction Motor for Magnetic Levitation System 14th International Power Electronics and Motion Control Conference, EPE-PEMC 2010.

3.A low cost linear induction motor for laboratory experiments, J. Atencia, A. Garcı´a Rico and J. Flo´rez, Department of Electrical, Electronics and Control Engineering, Escuela Superior de Ingenieros Industrials,(Universidad de Navarra), San Sebastia´n, Spain.

4."The magnetic attraction of trains". BBC News. 9 November 1999.

5.Maglev, A film for The People Mover Group.