Designing of Double Sided Linear Induction Motor

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ABSTRACT

Linear induction motors are under development for a variety of demanding applications including high speed ground transportation and specific industrial applications including transportation, conveyor systems, actuators, material handling, pumping of liquid metal, and sliding door closers, etc.. These applications require machines that can produce large forces, operate at high speeds, and can be controlled precisely to meet performance requirements. In this project, a double sided linear induction motor prototype has been designed and constructed to identify and study the different concepts and parameters of the motor which are different from other types of electrical machines. The DLIM equations and design procedures are developed and its performance is predicted using equivalent circuit models. The DLIM design choosing various design parameters like the primary voltage, frequency, number of poles, number of phases and many more parameters are considered. Optimum design parameters are obtained by the iterative procedure of the design calculation. The performance curves of the DLIM i.e., thrust and efficiency are drawn and then analyzed for different target thrust values and rated slip. The effect of varying parameters of the DLIM such as air-gap, thickness of aluminum sheet and the number of poles on the performance of DLIM are analyzed and the results are discussed. The linear induction motor is very useful at places requiring linear motion since it produces thrust directly and has a simple structure, easy maintenance, high acceleration/deceleration. The most obvious advantage of linear motor is that it has no gears and requires no mechanical rotary-to-linear converters.

Keyword: - *Attractive Force, Linear Motor, Motion Dynamics, and Linear Magnetic Field.*

1. INTRODUCTION

A Double-sided Linear Induction motor (DSLIM) is a special type of induction motor which gives linear motion instead of rotational motion, as in the case of conventional induction motor.

It operates on the principle of which a conventional induction motor operates. In contrast with its rotary counterpart, a DSLIM may have a moving primary (with a fixed secondary) or a moving secondary (the primary being stationary). In our project stator of DSLIM act as primary and rotor acts as secondary. DSLIM can be a short primary or short secondary, depending on whether the primary or secondary is shorter. In each case, either primary or the secondary can be the moving member in our project, secondary is short.

In addition, the LIM may have two primaries face to face to obtain a double-sided LIM (DSLIM) from the figure 1.1. If the LIM has only one primary, it is called as single sided LIM. The secondary of the DSLIM is normally conducting plate made of either copper or aluminum in which interaction currents are induced. In a single primary system a Ferro magnetic plate is usually placed on the other side of the conducting plate to provide a path of low reluctance to the main flux. However the ferromagnetic plate gets attracted towards the primary on energization of the field and this causes unequal gap length on the two sides of the conducting plate. Depending on the size and ratings of DSLIM they can produce thrust up to several thousand Newton's .The speed of the DSLIM is determined by winding design and supply frequency. Conceptually all types of motors have possible linear configurations (dc, induction, synchronous and reluctance).The dc motor and synchronous motor requires double excitation (field and armature).

This project also focuses on the advantages and drawback of DSLIM along with comparison with conventional rotary motor. LIM belongs to the group of special electric machine that converts electric energy directly into mechanical energy of linear motion. A DSLIM is a non-contacting, high speed, linear motor that operates on the same principal as a rotary, squirrel cage, induction motor. Progress in power electronics and ac variable speed drives has had a strong impact on the development of linear induction drives. Linear electric machines are direct drives, they allow accelerations, and velocity and position-accuracy far better than their rotary counterparts; however, they are usually more expensive. LIM is conceptually a rotary motor is cut and unrolled

2. OPERATION

Whenever there occurs a relative speed between the field and short circuited rotor, current is induced in rotor which results in electromagnetic forces and under the influence of these forces according to Lenz's law the conductor tries to move in such a ways so as to eliminate the induced current. In the simplest form of DSLIM, it consist of field system having three phase double layer windings placed in slots while the secondary can be a reaction plate of aluminum or copper, in which interaction current are induced.

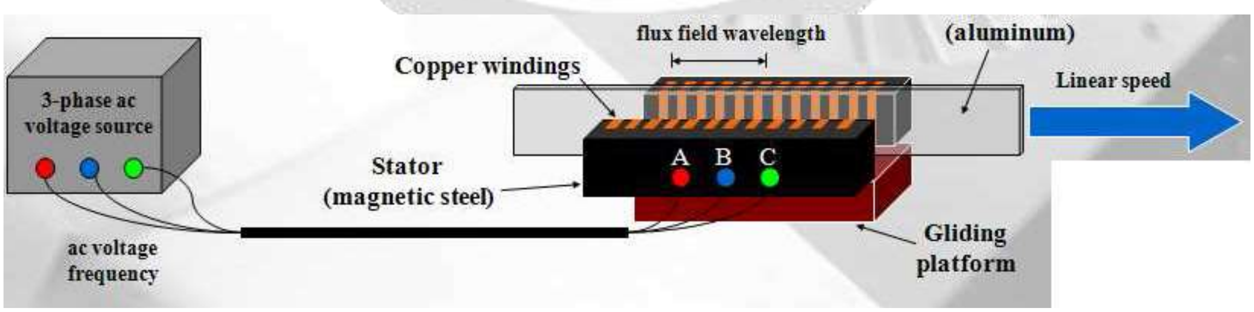


Fig No1. DSLIM Operation

The DSLIM operates on the same principal as a rotary squirrel cage induction motor. The rotary induction motor becomes a LIM when the coils are laid out flat; the reaction plate in the LIM becomes the equivalent rotor. This is made from a non-magnetic highly conductive material. The induced field can be maximized by backing up, the reaction plate with an iron plate (conducting sheet).

If three phase supply connected to both primary side of Double Sided Linear Induction motor a travelling flux is induced in the primary instead of rotating 3 φ flux, which will travel along the entire length of the primary, electric current is induced into the aluminium plate due to the relative motion between the travelling flux and the conductors . This induced current interacts with the travelling flux wave to produce linear force or thrust F.

3. Calculations

(1) Output equation:-

$Q=C_0 D^2 L.V_s$

Where,

$C_o = 10.955\ K_w.\ B_{av}.\ Ac \times 10^{-3}$

C_o = Output Coefficient

B_{av}= Specific magnetic loading

K_w=Winding factor

Assume**:**

$B_{av}=0.4 wb/m^2$

[*Note: It should be with value B_{av} = 0.35 to 0.55wb/m²*]

Ac=21000Amp/m [The Value of ac should be in Between 5000 to 25000 amp/m]

K_w=0.95 [for full pitch3 phase machine kw = 3/π]

(2) Linear synchronous speed:

$V_s=2T_pf$ m/s

Where,

V_s= Linear synchronous speed (m/s)

T_p=pole pitch

F=frequency (Hz)

(3)Find the output coefficient (C0)

We know $D^2\ L = \frac{Q}{C0\ ns}$

(4) KVA Input:

$Q = \frac{P}{n\ Cos\emptyset}$

D^2 L find out from above output equation.

(5) For Design ratio $\frac{Lc}{Tp}$ should be assume 1.5:

Assuming ratio Lc/Tp=1.5, considering linear induction motor which should have Ls greater than L ,as in the case of LIMs unlike rotary machines it is D(D) which is taken as length and L is taken as width of LIM , the height of LIM is kept near to the width of DSLIM in our case.

$\frac{Lc}{Tp} = 1.5$

But $T_p = \frac{\pi Ls}{P}$

Where,
L_c = axial length of core
T_p = Pole pitch
P = No of Pole

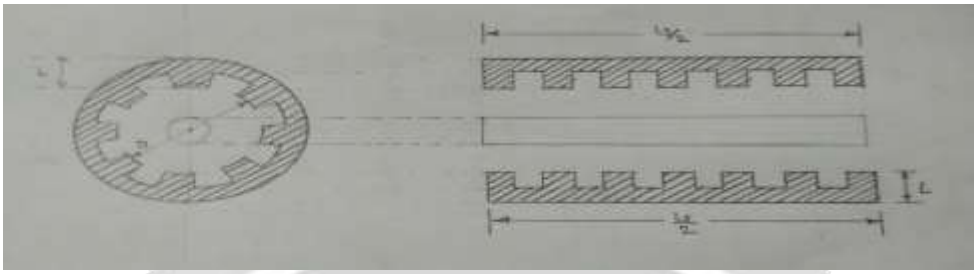


Fig. conversion of rotary dimension into linear dimension

$L_S = \pi * D = 2\pi R$
In DSLIM stator length= $L_s/2$
L= width of stator core

(6) Stator Design:

The machine is to be design for star connection
Stator voltage per phase E_s= 415 volt
Flux per pole = $B_{av} * T_p * L$ Wb

(7)Stator turn per phase:

$Ts = \frac{Es}{4.44 * F * \varphi m * Kw}$

(8) Slot / pole / phase

(9)Total stator slot = Total no. of poles

(10) Stator slot pitch:

$Y_{ss} = \frac{\pi D * 10^3}{Total\ stator\ slot}$

(11) Total stator conductor = $6 * T_s$

(12) Conductor / slot = Total stator conductor/ total slot

(13) Each coil total conductor contain

(14) Dimension of conductor

Stator current per phase = $I_s = \frac{Kw}{3*V*Cos\varphi*n}$

Consider current density = 6 amp/mm^2 $\partial = \frac{I}{A}$

Where $\partial = Current\ density$

A = Area of conductor

$\frac{\pi d^2}{4}$ =A

We get value of diameter of conductor in mm(d)

(15) Stator winding Gauge

From standard gauge meter find out gauge respective conductor diameter in mm.

(16) Calculation of length air gap:

L_g=1.6$\sqrt{Ls} - 0.25$

(17) Thrust (N)

F=P_r/V_s (N)

Where,

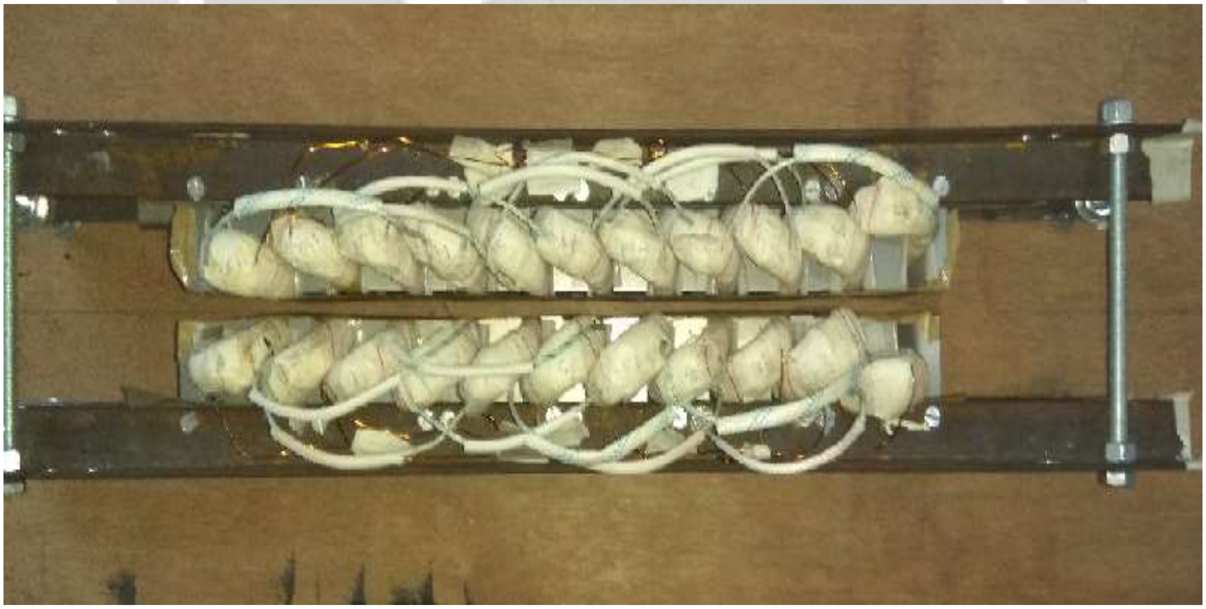
F= Thrust (N)

P_r= Power transmitter to the reaction plate (W)

V_s= Linear synchronous speed (m/s)

4. RESULT

Thus, designing of double sided linear induction motor is completed as per above calculations.



The final model of double sided linear induction motor is shown in figure below.

5. CONCLUSIONS

Thus the project concludes showing the working model of Double sided linear induction motor. The direction of the reaction plate can be changed by using limit switch, or we can use as a conveyer belt in only one direction.

From this Double-sided linear induction motor with reduced mechanical losses and Constructed DSLIM with high starting thrust force and easy maintenance.

6. ACKNOWLEDGEMENT

We take this opportunity to express our hearty thanks to all those who helped us in the completion of the paper. We express our deep sense of gratitude to our guide Prof. P. B. Zurale Asst. Prof., Electrical Engineering Department, Sir Visvesvaraya Institute of Technology, Chincholi for her guidance and continuous motivation. We gratefully acknowledge the help provided by him on many occasions, for improvement of this project report with great interest. We would be failing in our duties, if we do not express our deep sense of gratitude to Prof. N. B. Shaikh, Head, Electrical Engineering Department for permitting us to avail the facility and constant encouragement. Lastly we would like to thank all the staff members, colleagues, and all our friends for their help and support from time to time.

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