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A detailed model of disk type linear induction machines

Mohammad Hassan Tosifian[1*,†] and Jalal Nazarzadeh[2]

[1] *Department of Electrical Engineering, Saveh Branch, Islamic Azad University, Saveh, Iran*
[2] *Engineering Facility, Shahed University, Tehran, Iran*

SUMMARY

In this paper, a new dynamic model for disk-type linear induction machines (LIMs) is introduced. In this model, the rotor is divided into two regions where regions 1 and 2 are under and out of stator, respectively. In the second region, the rotor is not magnetically coupled with magnetic circuit of the stator, whereas magnetic circuit of region 1 of the rotor is magnetically coupled with magnetic circuit of the stator. A winding function approach is developed and used for calculation of new model inductances. Also, a prototype disk-type LIM is used to produce the experimental results and show the validity of the introduced model. The results showed that the new model can represent the end effect of LIM, dynamically. Copyright © 2014 John Wiley & Sons, Ltd.

KEY WORDS: dynamic model; end effect; linear induction machine; rotary machine; winding function method

1. INTRODUCTION

In linear induction machines (LIMs), because of asymmetric distribution of stator windings and existence of edges in stator core, end effects phenomena are appeared. Thus, the LIM modeling is not as simple as a rotary induction machine (RIM). Up to now, many researchers have introduced different models for LIM, which reflect the end effects. Most of these models depend on field theory, which is utilized in developing the lumped parameter LIM model [1–3]. However, the resulting models are complicated for practical modeling and control. Lipo and Nondahl used pole by pole method to analyze a LIM based on the winding functions of stator windings [4,5]. Because of the end effect, they introduced independent circuits for each pole of rotor with sinusoidal distributed windings. By using this method, the end effects of the rotor circuit in LIM are equally included over width of poles. However, the end effect in an actual LIM with fewer poles or low speed has local influence over a part of the pole. Duncan introduced a weighing function and modified the magnetizing branch of the equivalent circuit of the RIM [6]. In his model, the equivalent circuits for three phases were the same, and therefore, this model is unable to show asymmetry in three-phase input currents and also braking force as an end effect result. Some models were based on electromagnetic field in the air gap, developed by Fourier series transform [7,8]. Stepping time method is used to determine these models, which make the control process complicated. Faiz and Jafari considered an equivalent circuit and developed its accurateness by adding transverse edge and saturation effects [9]. Haghmaram and Shoulaie introduced a transient model for tabular linear induction motors by current filament method [10]. Selcuk and Kurum calculated the end effects separately by finite element method [11]. They classified the end effects into two groups, namely, static and speed dependent. Hamzehbahmani modeled and simulated single side linear induction motor for high speed studies [12].

In a recent work [13], Wei Xu *et al.* used the air-gap magnetic flux density equations and winding function algorithm. They presented an improved equivalent circuit to analyze single linear induction motors. Also in [14], they introduced a T-model based on Duncan's approach in [6], but they used one-dimensional magnetic equations of the air gap to derive the correction factor for secondary

*Correspondence to: Mohammad Hassan Tosifian, Department of Electrical Engineering, Saveh Branch, Islamic Azad University, Saveh, Iran.
†E-mail: Htosif@iau-saveh.ac.ir