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Simulation of Energy Efficiency Improvement in Induction Motor Drive by Fuzzy Logic Based Temperature Compensation

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Abstract

This paper proposes a method of improving efficient energy usage in induction motor drive system when operated under high temperature condition. By confining the drive signal to the prospective domain of that compensated by operating temperature range, an optimum point of driving performance and energy efficiency will be met for the given load torque and speed command. In this study, fuzzy logic has been applied as a temperature compensator and incorporated into the system model in MATLAB-Simulink. Simulation results showed that the system can operate and retain its performance together with efficient utilization of energy under high temperature condition.

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Keywords: Energy Efficiency; Induction Motor; Fuzzy Logic

1. Introduction

Energy efficiency in induction machines and drive system is nowadays, becoming an issue concerned considerably in modern industrial and household applications [1]. It is realized from the well-studied both engineering and economic aspects that, if efficiency of induction machine raises above nominal value only a few percentages, the much more one percent gain of energy saving and hence the higher the saving energy costs a billion

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yearly [2]. As a result of efficiency improving, even a small fraction of energy conserving per machine, the great extent of energy reduction is thereby considerably achieving when considered in large scale system [3].

Although induction motor is robust and tolerable to operate in harsh environment, its performance tends to adverse, particularly under high temperature condition or insufficient cooling system [4] and hence efficiency is inferior. In order to maintain the machine drive system operates for the range of speed and load torque including energy efficiency, several approaches had been studied and proposed [5-7] but regardless effects of operating temperature of a machine. This study, therefore, aims to propose a technique of improvement and retaining energy efficiency of induction motor drive system when operated under high temperature condition by application of fuzzy logic based temperature compensator and excitation flux optimizer.

Nomenclature

dq0	direct-quadrature-zero reference axis
p	differentiate operator (d/dt)
V, I	voltage and current
L, R	inductance and resistance
S, R	(subscript) stator and rotor

2. Methodology

2.1 Circuit model of induction motor and space vector transformation

Electric power drawn by three phase induction motor, as well as other variables represent in three phase model, could be considered analogously to as an occurrence in direct current machine. By using transformation via space vector theory [8], input power in three phase model is decoupled and formed by two orthogonal vectors of excitation and load torque fluxes respectively. Those variables are theoretically that, they can be manipulated and controlled independently through the set of transformation [9]. The model of three phase induction motor used in this study is illustrated as an equivalent circuit per phase which connected to voltage source inverter-VSI, and shown in Fig 1(a).

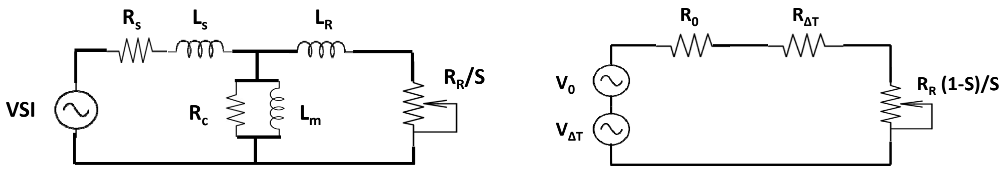

Fig.1 (a) Equivalent circuit per phase of induction motor; (b) Simplified circuit model for power transfer analysis

As a result of space vector transformation of the three phase variables, stator voltage, V_S, together with developed flux, φ, are represented by dq0 in synchronously rotating reference frame as following (1)-(3), and electromagnetic torque, T_e , in (4), which, theoretically, they can be control separately, i.e.,

$$\begin{bmatrix} V_{qS} \\ V_{dS} \end{bmatrix} = \begin{bmatrix} R_S & 0 \\ 0 & R_S \end{bmatrix} \begin{bmatrix} i_{qS} \\ i_{dS} \end{bmatrix} + \begin{bmatrix} p & \omega_e \\ -\omega_e & p \end{bmatrix} \begin{bmatrix} \varphi_{qS} \\ \varphi_{dS} \end{bmatrix} \tag{1}$$

$$\begin{bmatrix} \varphi_{qS} \\ \varphi_{qR} \end{bmatrix} = \begin{bmatrix} L_S & L_m \\ L_m & L_R \end{bmatrix} \begin{bmatrix} i_{qS} \\ i_{qR} \end{bmatrix} \tag{2}$$

$$\begin{bmatrix} \varphi_{dS} \\ \varphi_{dR} \end{bmatrix} = \begin{bmatrix} L_S & L_m \\ L_m & L_R \end{bmatrix} \begin{bmatrix} i_{dS} \\ i_{dR} \end{bmatrix} \tag{3}$$