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LOSS MINIMIZATION CONTROL OF THREE PHASE ASYNCHRONOUS MACHINE

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ABSTRACT -Induction motor drives are commonly used for applications with vast variations in mechanical load for torques under nominal values. The most ideal scheme for induction motor drive design should include drive loss reduction, or efficiency improvement, proportional to load torque such that optimal performance of drive is not affected. Induction motors have good efficiencies when operating at full load. However, at lower than rated loads, which is a condition that many machines experience for significant portion of their service life, the efficiency is greatly reduced. This paper describes the use of fuzzy logic to optimize the efficiency of an induction motor drive while keeping a good dynamic response. The proposed fuzzy controller adjusts the magnetizing current component, with respect to the torque current component to give the minimum total copper and iron losses. This model allows us to utilize real control and classical control theory for better performance of drive control system.

KEYWORDS: Fuzzy logic, Loss minimization, Efficiency optimization, Induction motor drive.

1. INTRODUCTION

Electric production cost decrease is an important issue which is absorbed many attentions by electrical engineers. Electrical motors have a great contribution to electric power consumption. In practice, three-phase induction motors consume about 60% of industrial power demand [1, 2]. The ever-increasing growth of using induction motors in servo exciters led to great attention on transient torque-load profile characteristics. Thus, induction motor drives are important in terms of accuracy, efficiency control and low level of power loss. The efficiency increase and power loss reduction are not only important due to reduced power consumption and cooling convenience, but also they are vital for environmental pollution control. Power loss and efficiency of drive is a complex function of motor type, converter structure, type of semi-conductor switches and converter modulation algorithm. Thus, control system is of importance in terms of efficiency and power loss [1, 3].

2. SPEED CONTROL OF THREE PHASE INDUCTION MOTOR

A three phase induction motor is basically a constant speed motor so it's somewhat difficult to control its speed. The speed control of induction motor is done at the cost of decrease in efficiency and low electrical power factor. Before discussing the methods to control the speed of three phase induction motor one should know the basic formulas of speed and torque of three phase induction motor as the methods of speed control depends upon these formulas.

Synchronous Speed

$$N_s = 120\ f/p$$

Where, f = frequency and P is the number of poles The speed of induction motor is given by,

$$N = N_s\,(1-s)$$

Where, N is the speed of the rotor of an induction motor, Ns is the synchronous speed, S is the slip.

The torque produced by three phase induction motor is given by,

$$T = \frac{3}{2\pi N_s} X \frac{sE_2^2 R_2}{R_2^2 + (sX_2)^2}$$

When the rotor is at standstill slip, s is one. So the equation of torque is,

$$T = \frac{3}{2\pi N_s} X \frac{E_2^2 R_2}{R_2^2 + X_2^2}$$

Where,
E2 is the rotor emf
Ns is the synchronous speed
R2 is the rotor resistance
X2 is the rotor inductive reactance

The Speed of Induction Motor is changed from Both Stator and Rotor Side. The speed control of three phase induction motor from stator side are further classified as :

- V / f control or frequency control.
- Changing the number of stator poles.
- Controlling supply voltage.
- Adding rheostat in the stator circuit.

The speed controls of three phase induction motor from rotor side are further classified as:

- Adding external resistance on rotor side.
- Cascade control method.
- Injecting slip frequency emf into rotor side.

3. LIMITATIONS OF CONVENTIONAL CONTROLLERS
4.

● Plant nonlinearity-The efficient linear models of the process or the object under control are too restrictive. Nonlinear models are computationally intensive and have complex stability problems.
● Plant uncertainty-A plant does not have accurate models due to Uncertainty and lack of perfect knowledge.
● Multivariable, multiloops and environment constraints.-Multivariate and multiloop systems have complex constraints and dependencies.
● Uncertainty in measurements -Uncertain measurements do not necessarily have stochastic noise models.
● Temporalbehavior- Plants, controllers, environments and their constraints vary with time. Moreover, time delays are difficult to model.

4. FUZZY CONTROL

Fuzzy logic is an innovative technology that enhances conventional system design with engineering expertise. The use of fuzzy logic can help to circumvent the need for rigorous mathematical modeling. Fuzzy logic is a true extension of conventional logic, and fuzzy logic controllers are a true extension of linear control models. Hence anything that was built using conventional design techniques can be built with fuzzy logic, and vice-versa. However, in a number of cases, conventional design methods would have been overly complex and, in many cases, might prove simpler, faster and more efficient. The key to successful use of fuzzy logic is clever combination with conventional techniques, also a fuzzy system is time-invariant and deterministic. Therefore any verification and stability analysis method can be used with fuzzy logic

5. OPTIMIZATION PRINCIPLE

The efficiency optimization controller is implemented in a classical structure of an induction motor .The fuzzy controller adjusts the Im component with respect to the torque current so as to adjust the power factor to its better value. The goal is to achieve the balance between copper and iron losses. Figure illustrates the control strategy, assuming that the motor initially operates at rated flux in steady state. The flux is decremented by reducing the stator current magnetizing component.

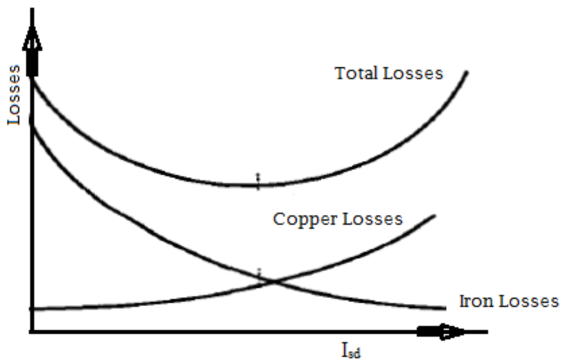

Fig.1

This leads to an increase of the torque component so that the developed torque remains constant. The core losses decrease with the decrease in flux while the copper loss increase, but the total loss decrease improving the overall performance and hence efficiency.

6. MATLAB MODEL

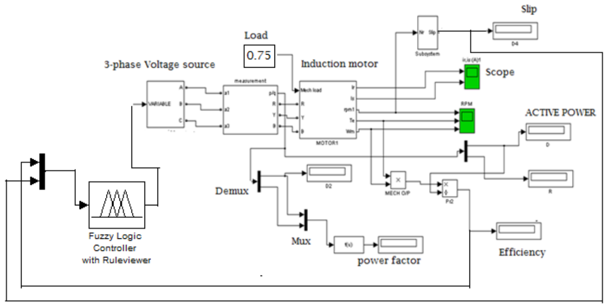

Fig. 2

The SIMULINK Model for poly phase squirrel cage induction motor drive is show in Fig. 2. In this model two scope and six digital display are connected to show the value of output signal in analog and digital form.

Simulink is a software package that utilizes the computational tools of Matlab to analyze complex dynamic systems. The program is capable of solving both linear and non linear processes so it is perfectly suited to simulating asynchronous motors. This work investigates whether any electrical energy will be saved and, if so, how much by reducing the terminal voltage of induction motors, when they partially loaded..

Mech.load (N-M)	line voltage (PU)	Efficiency (PU)	Slip (PU)	Speed (RPM)	PF (PU)
0.75	1	0.8348	0.001	1798	0.097
	0.9	0.8598	0.0016	1797	0.0115
	0.8	0.8844	0.0025	1795	0.143
	0.7	0.9124	0.0041	1792	0.197
	0.6	0.94	0.0248	1755	0.62
	0.5	0.675	0.231	1384	0.805

Table 1

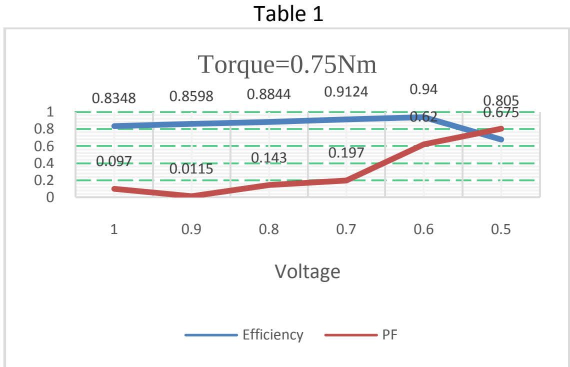

Fig.3

Slip and Efficiency is considered as a membership function for fuzzy controller. The Fig 3 and Table 1 shows that efficiency and power factor improves with reduction in stator voltage at light load condition.

7. CONCLUSION

The proposed controller manipulates the value of stator voltage that maximizes the efficiency at any given operating point. The designed controllers are applied to the induction motor which is considered as a difficult engineering problem. The proposed controllers are evaluated under simulations for a variety of operating conditions of the drive system and the results demonstrate the effectiveness of these control structures to improve the performance and robustness of the drive system.

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