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Research Article

Fuzzy logic based contactless online performance monitoring machine for single phase induction motor

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Abstract

The performance evaluation of a machine is very crucial especially in application where precision and protection are very important. Whereas the performance of the machine depends on the load conditions, so if the performance for a particular load condition is known then the necessary corrective action can be performed automatically. The various parameters that define the performance of a machine are speed, efficiency & torque. In the already existing system, speed is measured using tachometer with contact but it may not be precise. This is a traditional method of measuring the speed. Any speed measuring device is susceptible to errors. The efficiency & the torque are calculated using some manual calculations. These manual calculations will also lead to some errors. To avoid these errors, a meter is developed using the Fuzzy Logic Controller (FLC) which shall indicate these values for a particular load condition through a seven segment display. The proposed meter combines the input and output relationship and the advantages of the FLC (imitativeness, simplicity, easy implementation and minimal knowledge of system dynamics). Simulation studies are done using the FIS editor, a sub tool of Matlab. As a result in this work, a fuzzy logic based meter is implemented to evaluate the performance, say various output characteristics (like efficiency, speed & output torque) for a 1 Φ induction motor.

Keywords: Fuzzy Logic Controller; Induction motor; Load test; Performance characteristics.

Introduction

For the last two decades researchers are working on the improvement and performance of AC and DC machines. In this work a FLC based meter, which involve the modeling of control skins of human expert and present a meter that can be included in the circuit like an ammeter. The block diagram of the proposed meter using FLC for performance evaluation of a meter is shown in fig. 1.

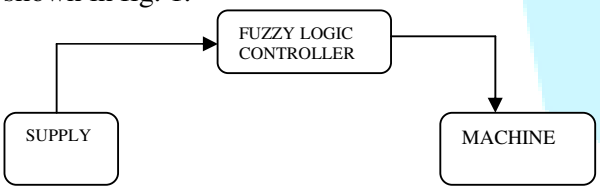

Fig. 1. Block diagram of the proposed meter

Fig.2 having terminals X & Y gives the various details about the component of the developed meter, which is used to indicate the performance characteristics. In a machine on a fully loaded condition current is increased and other parameters like speed, torque and efficiency are varied. On a no-load condition the current is decreased to maintain the voltage as constant which is dependent on the type of machine used.

The line current can't be directly given to the Power Circuit Board (PCB), so a current transformer is used. A current transformer is a type of instrument transformer steps down the current proportional to the alternating current flowing in its primary. Fuzzy Logic (Zadeh, 1965) system provides a solution for a problem in a nontraditional way. FLC is a mathematical system, in which the input values are expressed in terms of logical variables (Aydemir et al., 2004) that take on continuous values, in contrast to classical or digital logic which operates on discrete signal so A/D converter can be used.

Application of FLC on various machines

The FLC (Zadeh, 1965) is implemented in various machines to find the parameters of the machine like speed, torque, efficiency. FLC is implemented for single phase induction motor (IM). An induction motor is a single phase or three phase AC motor and is the most widely used machine in the industries. Among the

various AC motor, IM occupies almost 90% of the industrial drives due to its simple and robust construction and high reliability and efficiency (Kothari and Nagrath, 2004).

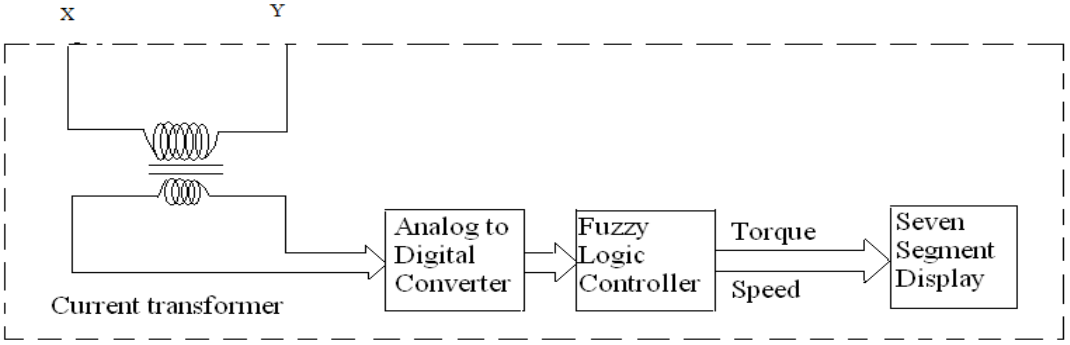

Fig. 2. Detailed diagram of the proposed meter

The most important challenge is to reduce motor power consumption and to properly vary the motor speed, which are designed to run as a constant speed machine. Manufacturing machines, compressors, pumps, fans and most other motor drives, loads vary with time, climatic condition and requirements of the consumer. The efficiency of constant speed IM can drop drastically under reduced loads especially loads below 50% of rated torque. To minimize the power loss it is necessary to control motor speed and thereby match the motor speed to load requirements.

The performance measuring parameters of the IM are measured by introducing a FLC meter. The logic is carried through a fuzzy evaluation block (George, 2008) that receives input from the command signal. In the already existing system, speed is measured using tachometer with contact but it may not be precise. It may have defects and human errors.

Hence a meter is developed, which is programmed through FLC (Vikas et al., 2010) to measure the speed, torque and efficiency of IM. This meter is free from all defects and errors in measurement. The output parameters of induction motor are evaluated by the following equations in table 1. All motor evaluating parameters evaluating formulas are shown in table 2.

Table 1. Expression for evaluating parameter

Description	Formulae	Units
Torque	T=F*9.81*R	N-m
Spring Balance Reading	$F=F_1-F_2$	Kg
Output Power	W=(2*∏*N*T)/60	Watts
Efficiency	ή=(Output power/Input power)*100	%

Table 2. Name plate details of induction motor

Parameters	Description	Value
V	Rated Voltage	230 V
I	Rated Current	7.0 A
N	Rated Speed	1440 RPM
F	Rated Frequency	50 Hz

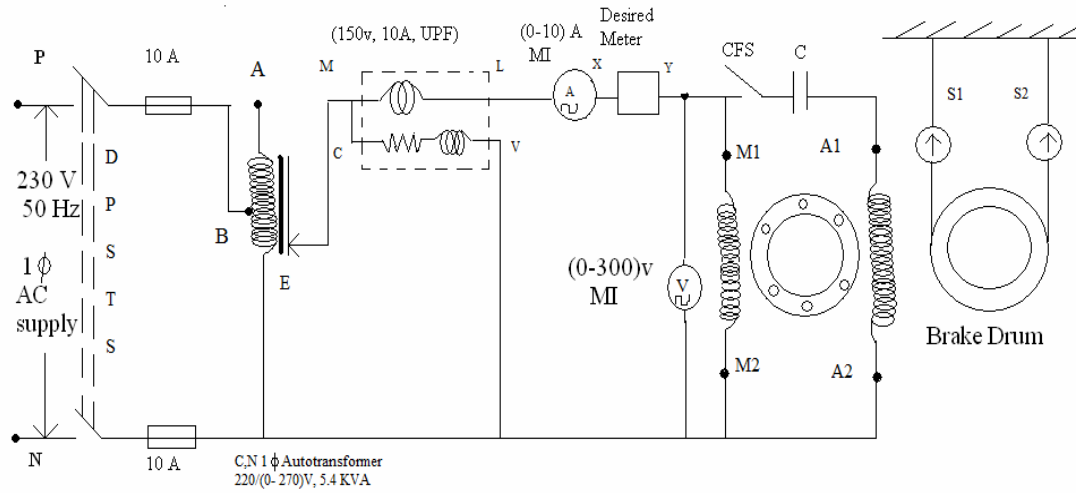

Fig. 3. Circuit diagram of load test of single phase induction motor with proposed meter

An experiment is conducted as shown in figure 3 (Kothari and Nagrath, 2004), to identify the characteristics of the motor by measuring the rotational speed and current were the voltage is kept constant and current as variable. Experimental results show that as current increases speed decreases.

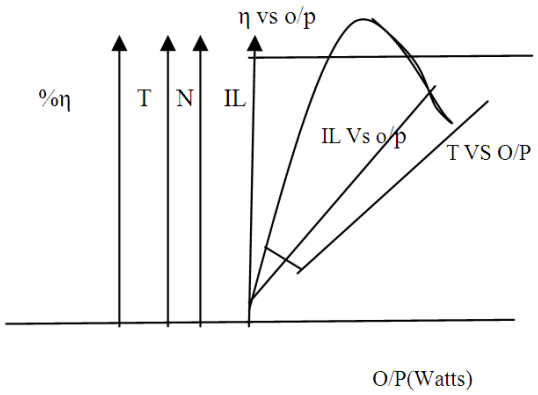

Fig. 4. Performance characteristics of single phase induction motor

The voltage for driving the IM is 230V which is applied to the circuit. The autotransformer is varied and the rated voltage is set. The motor rotates at no load condition. The load can be applied by adjusting the spring balance load for which current and speed is noted. At no load condition current is zero. The maximum speed is 1440rpm. It is shown that as current increases, speed decreases and nearly voltage is constant. The maximum current calculated during the performance of the IM was 7 Amps and efficiency resulted to 86.97% as shown in figure 4. Similarly this can be implemented through the FLC and the performance can be viewed.

Experiment was conducted and readings were taken for various load conditions and based on the metered readings the ranges were set for determining the rules. Based on these readings the if – then rules are framed, which is called a rule base of FLC (Mathworks, 2008). Current and voltage is taken as the input and speed is taken as the output. The linguistic terms used in this example are S – small, A – average, M – medium, B – big and L – large (Yousef and Khalil, 1995). The variables are in FLC are shown in figure 5, figure 6 and figure 7. The rules that were determined are entered in the rule editor window (figure 8) and output is viewed in the rule viewer as shown in figure 9. The FLC is performed with large overlap area (Senthilkumar et al., 2004) such that there is greater variation in the output.

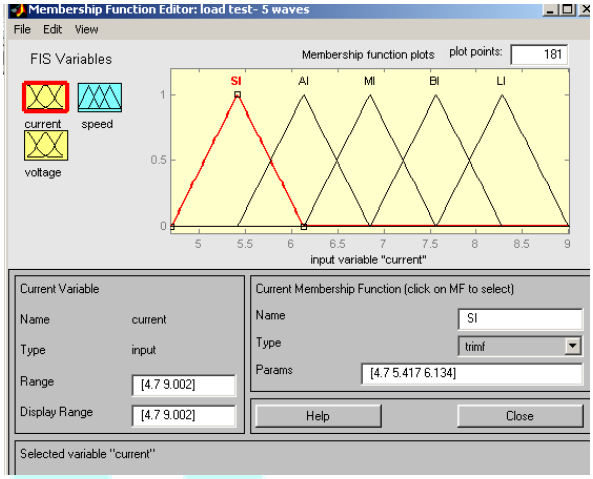

Fig. 5. Single phase induction motor- input-current

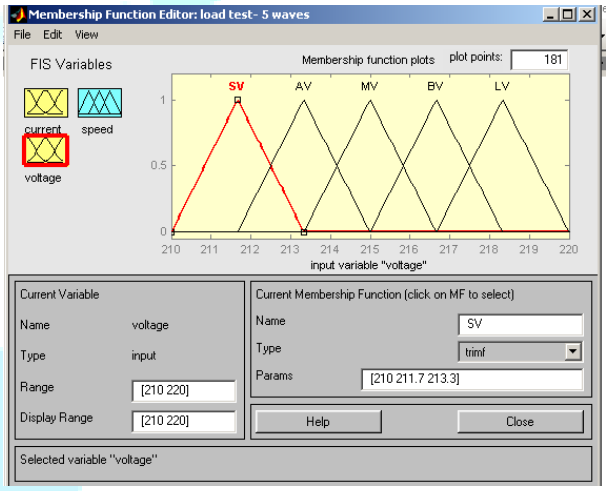

Fig. 6. Single phase induction motor-input-voltage

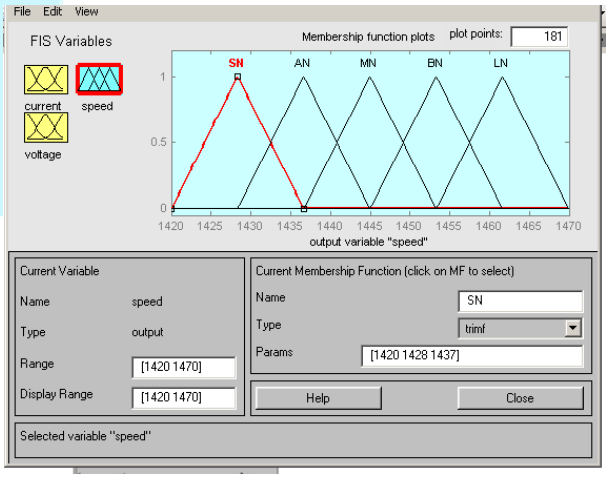

Fig. 7. Single phase induction motor- output-speed

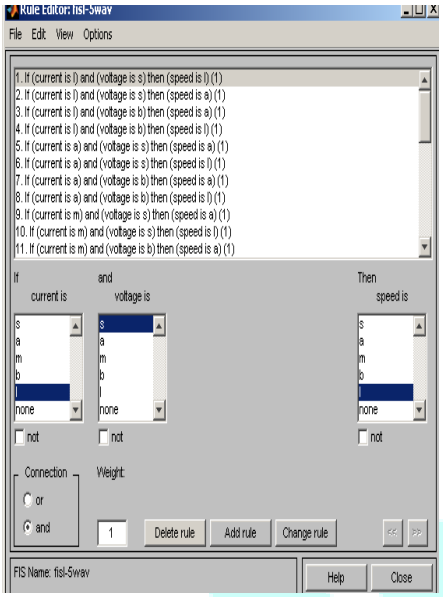

Fig. 8. Rule Editor for single phase induction motor

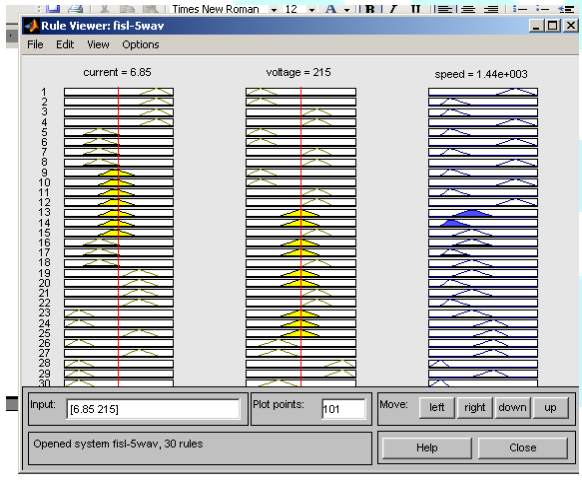

Fig. 9. Rule Viewer for single phase induction motor

Discussion

The main aim of this paper is to find out the various parameters (speed / efficiency / torque) and performance of various machines without using any measuring device. The various methods were thought to find out the above said parameters without using the measuring device. Finally it is decided to use fuzzy logic to achieve the desired motive.

The experiment was done with a rated speed of 1440 rpm manually and the various parameters were measured. As the current was increased, speed decreased. This was experimented using fuzzy logic. While experimenting using fuzzy logic (Dewangan et al., 2012) also the same results were obtained. As the current was increased, speed decreased. As speed and efficiency are important parameters efficiency measured manually was 87% and the efficiency measured using fuzzy logic was 87 %. From this it is inferred that fuzzy logic is used to obtain results on a trial and error method (Namazov and Basturk, 2010). FLC is a type of soft computing technique which tries to mimics the ability of the human and to take rational decisions in an uncertain and imprecise environment. The results obtained are then simulated using simulink technique.

Conclusions

Fuzzy logic is an innovative technology, which is used to design solutions for multiple input & multiple output parameters, even for non-linear control problems. It uses the human experts experience and experimental results rather than a mathematical model, to define a control strategy. As a result the solutions are obtained faster than the traditional design techniques.

Conflict of Interest

Authors declare there are no conflicts of interest.

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