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PI and Fuzzy Logic Controller based Comparative Analysis of Separately Excited DC Motor

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Abstract-- Separately excited dc motors (SEDCM) are generally used in laboratory and industrial applications due to their high efficiency, performance response and high torque. An idea is proposed in this paper by applying the PI and Fuzzy Logic Controller (FLC) to control the speed of SEDCM. Simulink model with and without PI and FLC has been developed in Matlab to analyze the performance of dc motor. Based on simulation results it is said that control characteristics of FLC are better than the conventional PI controller. The modeling of SEDCM and execution of the controllers is carried out in MATLAB.

***Keywords*- SEDCM; PI; Fuzzy Logic; MATLAB**

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I. INTRODUCTION

DC motor is one of the usual motors that were put on the market at the end of the nineteenth century. Compared to other motors like induction motors [1-3], brushless dc motors [4], dc motors have domestic compensation like simple control high electromagnetic torque and speed are widely adjustable. Due to industrial applications dc motor used in mining, transportation, national defense, steel rolling [5].

Due to reasonable cost and the complexity of lower speed and torque control [6 , 7] control configuration, dc motors are frequently used in many applications. DC motors are applied for various ower converters. There are various converters required to operate DC motor. It can be used for high torque loads, as well as the response to high acceleration and deceleration to the load [8].

DC motors are not so complicated; they only need to convert ac to dc power once. DC motors must convert electrical into mechanical energy called rotation. So torque relationships of dc motors are higher than AC motors [9].

The main objective of this research is discussed as

- To control speed by the help of PI.
- To control speed by using fuzzy logic controller
- To comparing both controllers and analysis of their performance of DC Motor.

II. DC MOTOR AND DIFFERENT CONTROLLERS

Motors can be divided into AC motors and DC motors. According to the excitation type and connection type, the dc motor between them can also be divided into two groups.
that all appropriate references are included.

A. Proportional Integral (PI) Controller

PI can be applied to remove the steady state error and to optimized the speed response of motor [10-13]. By selecting different intellectual properties to gain the required speed of DC Motor [14].

Six-decades ago, compared with PID controllers, PI controllers with DC motors were widely used [15]. The output of the PI controller is used as a transformer adjustment indicator, but its output will provide a steady state response to the motor speed for dc motor and is close to the reference value [16, 17].

B. Fuzzy Logic Controller

The control unit is used to modify the behavior of the system to operate in a specific and ideal way over time. One of these controls is the fuzzy logic controller [18]. Due to uncertainty, using traditional methods to analyze and monitor complex, non-linear, and/or variable systems over time is a difficult task [19].

FLC uses the console to apply a series of unclear rules, relying on the communication between input data and output data. These rules include linguistic variables rather than complex mathematical models of the system. The main part of the mysterious console is the database, which is preceded by entries that translate errors and change the errors to language form. The successful part turns the language supervisor into an exit signal [20].

III. RESULT AND DISCUSSION

The dc motor parameters and its specific values are given in the table 1 it is standard values according to its constaints the research were carried out. To the object wise analysis of parameter and comparision were taken in matlab simulation.

TABLE I. **Units for Magnetic Properties**

Parameters	Values
armature resistance	2.58 Ohms
inductance	0.028H
field resistance	281.3 Ohms
inductance	151 Henry
mutual inductance (MI) field-armature	0.94 Ohms
inertia	0.022 J (k g m^2)
coefficient of viscous friction	0.0029 (N m s)
friction torque coulomb	0.51 (N m)
initial field current	1
initial speed	0 rad/sec

A. Simulation model in Matlab DC Motor

Table 1 shows the parameters of SEDCM. By applying these values in Matlab model in figure 1 is formed to certain points to monitor the results.

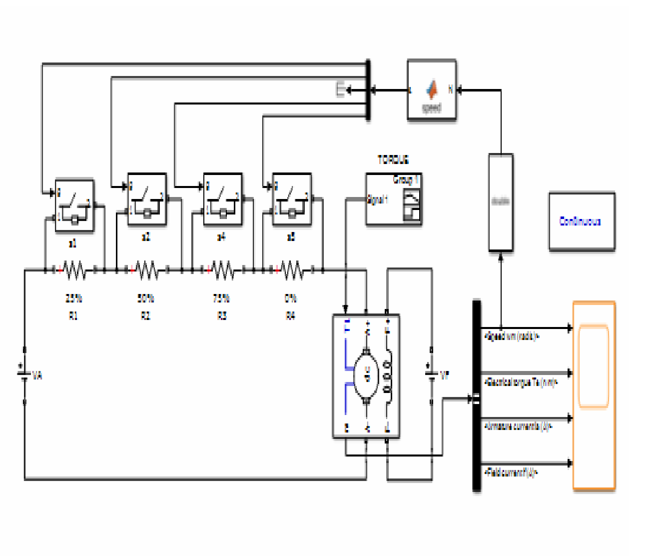

Fig. 1. SEDCM Matlab Model

When figure 2 is investigated and shows that armature current raises to 75 A in a few 1/1000 secs and after 1 sec, it obtains stable and gets value 8 A. Produced torque concurrently with armature current rise at desirable 70 Nm in a few 1/1000 secs and after 1 sec, it acquires steady and obtains 24.4 Nm.

Figure 3 illustrates that the motor speed reaches about 190 rad/s in a 1/1000 sec and it brings stable after 0.03 sec.

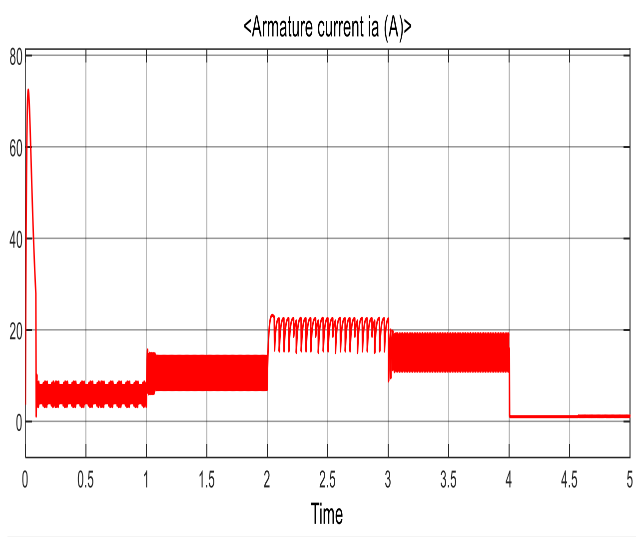

Fig. 2. Graph of Armature Current vs Time of SEDCM

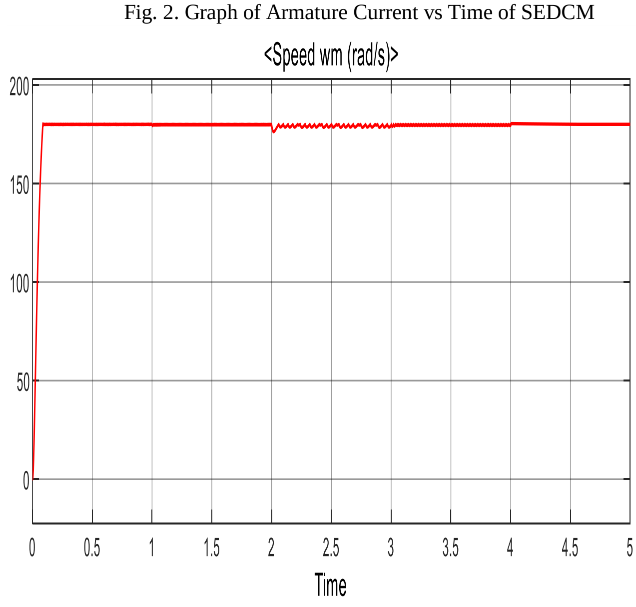

Fig. 3. Graphs of speed vs time of SEDCM

B. Simulation model of PI for SEDCM

PI controller based Model for SEDCM is shown in figure 4. PI controller is a combination of proportional controller (P) and integral controller (I). The output of the current loop is fed first compare with the reference armature current the error signal is then deliver to a PI controller. The output of the PI controller is a fringing angle that is used to control the voltage for phase controlled rectifier. Figure 5 depicts motor achieve the desired speed 1500 in 0.4 sec, at the beginning motor with PI has overshoot 0.6 percentage which unacceptable. If the input voltage is fixed to a certain level that means the controller requirement of voltage more than a certain level, it means this not satisfy the result.

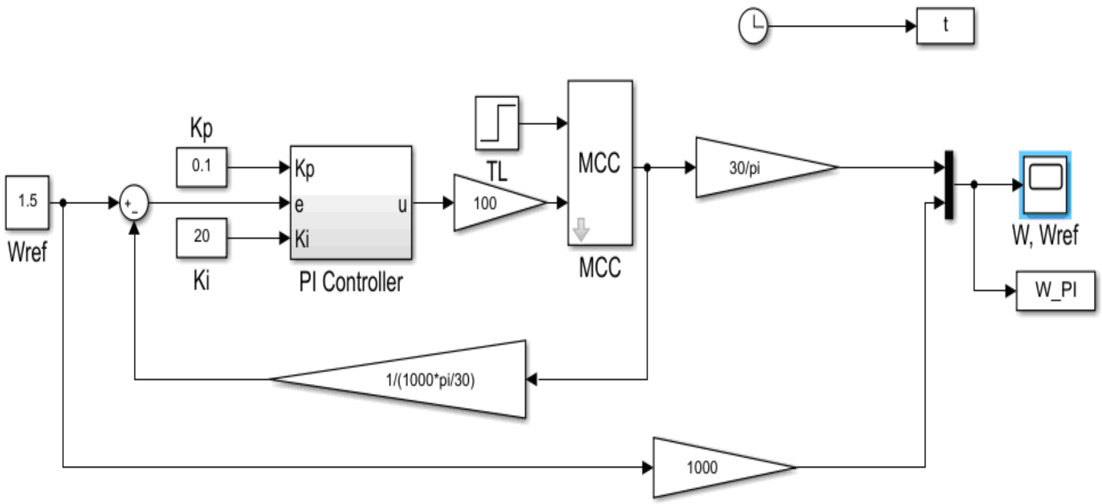

Fig. 4. PI-based Matlab model of SEDCM

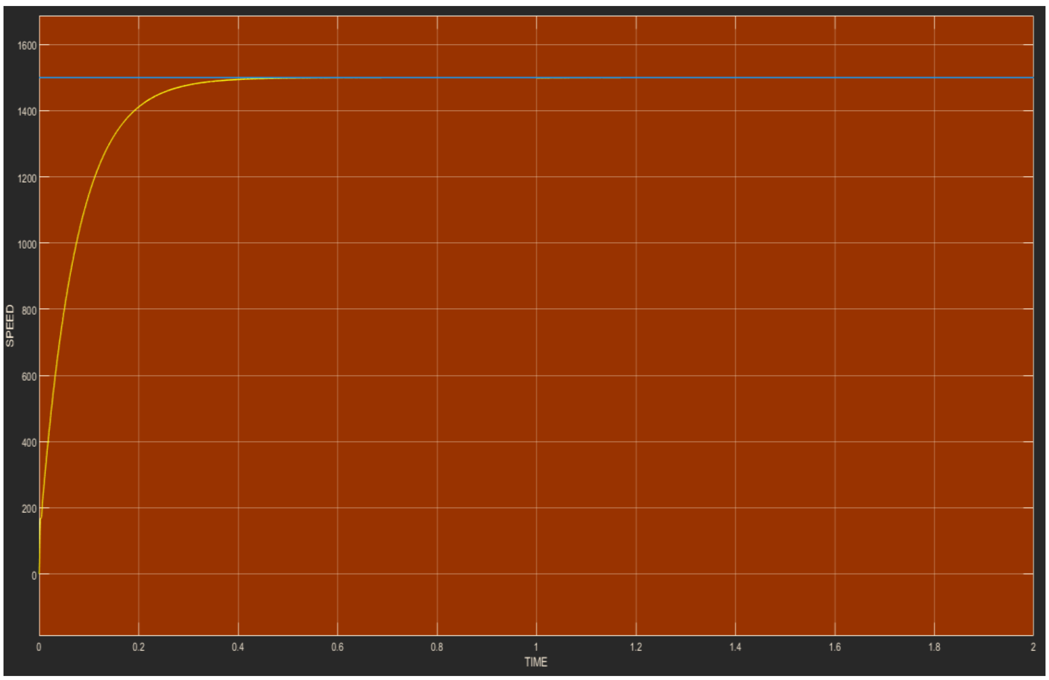

Fig. 5. Speed vs time response of SEDCM with PI Controller

C. Simulation model of FLC for SEDCM

In designed model the two inputs for Fuzzy Logic is change in current error and current error and its output is firing angle for phase controlled rectifier for controlling of separately excited DC motor.Acknowledge Fuzzy speed control system, where the input signals of PI are kp and ki and the output is firing angle reference are Fuzzed by selecting corresponding member ship functions to each signal.

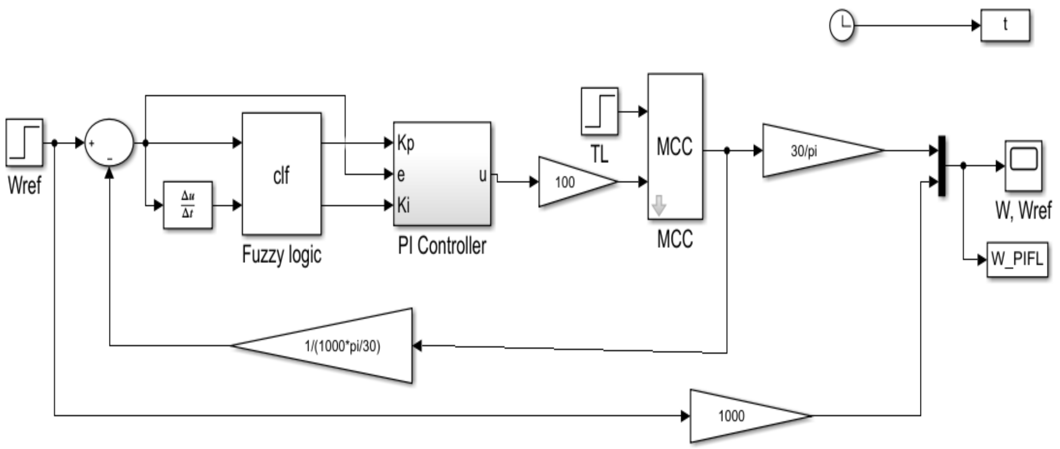

Fig. 6. PI and FLC based Matlab Model of SEDCM

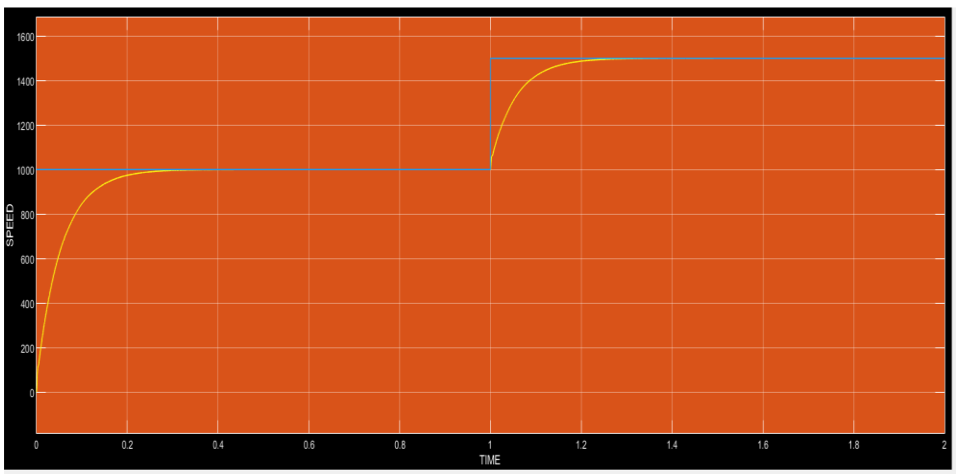

Fig. 7. PI and FLC based Matlab Model of SEDCM

Figure 7 shows the graph comparative analysis between PI and Fuzzy with time. The speed of SEDCM with fuzzy increase 0 to 1000 in 0.3 sec unstable after it gets stable. From 1 to 1.2 sec it is unstable with PI Controller after it gets stable and the speed of SEDCM is controlled.

IV. CONCLUSION

This work has examined the basics of SEDCM and discussed the advantages of the fuzzy controller over PI controllers with their suitable parameters. Also, the sp`eed response graphs of DC motors using PI and Fuzzy controllers are successfully simulated in MATLAB R2019a and their speed responses concerning time are compared. Based on this comparative study and analysis, finally, from Figure 5 and Figure 7, it is clearly showing that the Fuzzy controller is much efficient in performance over PI controller for the speed of separately excited DC motors.

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