Advance Physics Letter

"Design, Development and Comparison for speed control of DC shunt motor using PI, Fuzzy and PSO Controllers"

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ABSTRACT - Brushless DC motor is used in many applications as battery operated vehicles, wheel chairs, machine tools, aerospace and in many more applications .It has the best electrical & mechanical characteristics[2] Non-linearity arises out of variation in system parameters and change in load in conventional controllers to produce desired performance. It operates at constant and accurate speed without having any impact of load [7].In this paper a comparison is made for speed control of dc motor by using different controllers such as PI, Fuzzy Logic , PSO controller in Matlab /Simulink environment. Fuzzy Logic Controllers were proposed to achieve the speed control of a DC motor using combined armature voltage and field current by varying the armature voltage in the constant torque region and the field current in the constant power region [11] .In this I have made the compared the result of speed control of DC Motor by using particle swarm optimization & compared the results of fuzzy & PSO controller in Simulink. The simulation result shows that the PSO controller is superior controller than PI, fuzzy for the controlling the speed of DC motor.

KEY WORDS - DC Motor, Fuzzy logic controller & PSO controller.

I. INTRODUCTION

DC motors are used because of characteristics like fast adjustment, preciseness, smooth operation, high torque capabilities, high power density, electrical efficiency. DC motor is suited due to changeable speed variation, frequent starting, proper speed regulation. A revolution began with in the area of power electronics due to advancement of the speed control of DC machines. Armature voltage control for speeds under the rated or by field excitation variation for beyond rated speeds controls the motor. It is adjusted such as to provide simple control and high performance[4]. In today's era various different conventional and numeric controller types are proposed to control the DC motor speed. Various different controllers used are as follows PID-Genetic Algorithm, PID-Ants Colony Optimization PID-Particle Swarm Optimization, Fuzzy-Particle Swarm Optimization,, PID-Neural Networks .In industrial application due to simple & robust PID controllers are broadly used .In this steady state offset is eliminated through integral action.PID controller[8]. Anticipation of error is controlled through derivative action. Parameters and parameter perturbations subjected to difference in industrial application, which makes the system unstable. Automatic tuning is done by control engineers. PID controller tuning. For complex system or nonlinear systems a conventional PID controller have poor control performance for which no accurate mathematical models are there. Thus to reduces same type of problem Fuzzy logic controller (FLC) is used which is based on fuzzy logic theory. For control design FL (Fuzzy Logic) is adopted. Human thinking is closer to fuzzy logic in comparison to traditional logic system. A non-linear system is applied to fuzzy logic due to the knowledge of nonlinear structural characteristics. Here for the tuning of the parameters of fuzzy logic controller membership functions, a Particle Swarm Optimization PSO algorithm has been used for speed control of DC motor. In this many values are chosen for efficient results in order to optimize the result.

II. BASIC INTRODUCTION OF DC MOTOR

An electric motor is used for transferring electric energy to mechanical energy by using interacting magnetic fields. Industrial and domestic applications also use dc motor such as robotics & actuators [31]. The requirement for such applications is accurate speed control of the motor. The electric circuit of the DC motor is shown in Fig. 1. Our aim is to control the speed of the motor by armature voltage control[29]. The reference signal determines the desired speed. For simplicity, a constant value as a reference signal is given to the system to obtain desired speed.

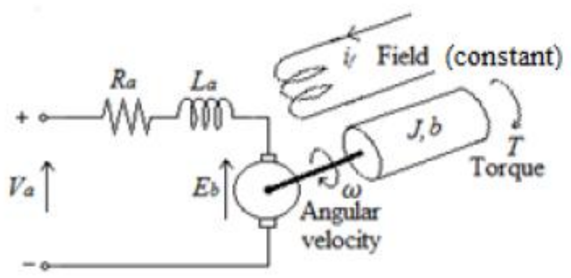

Fig -1 Electric circuit of dc motor

The differential equations governing the dynamics of the system is given by

$$T(t) = J\frac{dw(t)}{dt} + bw(t) \quad (1)$$

Where w represents angular velocity in rad/s, *J* represents the moment of inertia in Kg m2/s2 and b is the coefficient of viscous friction which opposes the direction of motion in Nms.

The torque T generated by the armature current in Nm is given by

$$T(t) = K_t\, i_a(t) \quad (2)$$

Where I_a (t) is the armature current in Amp and K_t is torque factor constant in Nm/Amp. This in turn is assumed to satisfy Kirchhoff's voltage law

$$V_a(t) - E_b(t) = R_a I_a(t) + L_a \frac{dIa}{dt} \quad (3)$$

Where L_a and R_a are the armature inductance in H and resistance in ohm respectively and E_b represents electromotive force in V given by

$$E_b(t) = K_b\, w(t) \quad (4)$$

Where E_b is the back emf constant in Vs/rad. The input terminal voltage *va* is taken to be the controlling variable.

Using (1-4), it can be said that state model with the ω and *ia* as state variables and Va as manipulating variable, as given below

$$\begin{bmatrix} dw(t) \\ dIa(t) \end{bmatrix} = \begin{bmatrix} -b/J & Kt/J \\ -Kb/La & -Ra/La \end{bmatrix} \begin{bmatrix} w(t) \\ Ia(t) \end{bmatrix} + \begin{bmatrix} 0 \\ 1/La \end{bmatrix} V_a(t)$$

TABLE 1

PARAMETERS OF DC MOTOR [8]

R_a =1.2Ω K_b=0.6 V s/rad

L_a =0.05 H J=0.1352 Kg m^2/s^2

K_t=0.6 Nm/Amp b=0 Nms

Using the parameters given in Table 1, transfer function of the DC motor with angular velocity as controlled variable and input terminal voltage as manipulating variable is determined.

III. PI CONTROLLER

Fig.2. shows the SIMULINK block diagram of speed control of dc motor using PI controller. Step input is given to the controller[13]. The error signal is given to the PID controller. Subsystem signifies the motor model as shown in Fig.2 and output is obtained at scope1.In this PI controller I have used timer and this speed is reference at 1000 rpm. Here Simulink model & result of PI controller is shown in fig 3.In this speed, Torque & current characteristics.

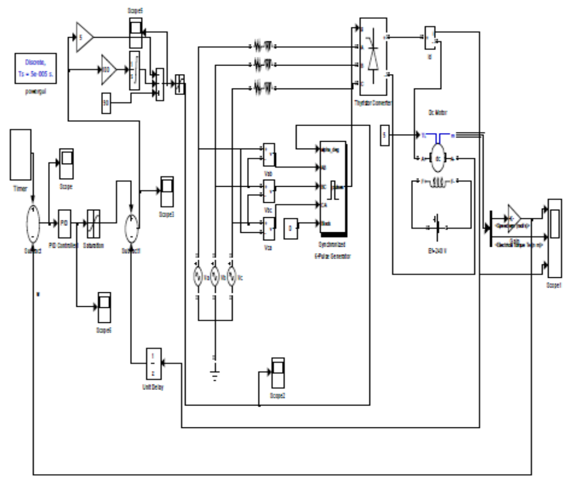

Fig:2 PI controller using Simulink model of DC motor

Simulation result of PI controller for speed control of dc motor is shown in fig 3

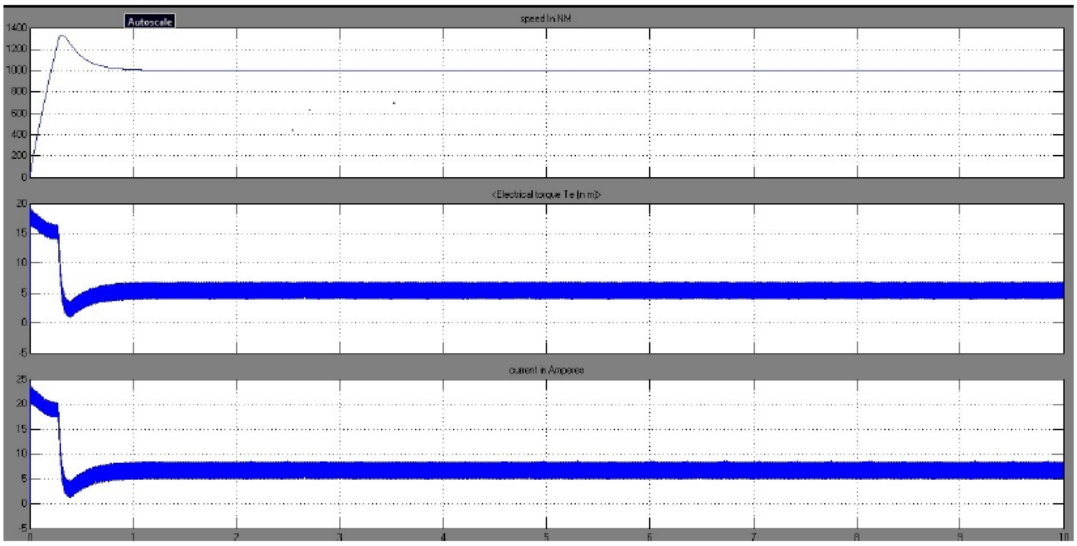

Fig :3 Simulation result of speed control of dc motor by PI Controller

Fuzzy Logic Controller- Popular reason of Fuzzy Logic Controllers is its similarity of logical replica to a human operator. It is operated on the basis of foundations to a knowledge base which in turn relied on the various if then rules, similar to a human operator [33]. Unlike other control strategies, this is simpler as there is no complex mathematical knowledge required. The FLC is required with a qualitative knowledge of the system thereby making the controller not only easy to use, but also easier design.

Fuzzy logic is closer to control problems how decisions are made much faster. Fuzziness function is connected with the degree to which events arise rather than possibility of its occurrence. It has some advantages compared to other controller like: low cost and the possibility to design without knowing the precise mathematical model of the process. Fuzzy Logic (FL) incorporates another way of thinking which allows complex design systems using superior level of abstraction originating from the knowledge and experience. Attribute Components of a Fuzzy Logic Controller are: Preprocessing, Fuzzification Rule, Defuzzification,

Post processing

Preprocessing:

The inputs of fuzzy logic are essentially often tough measurement from a number of measuring equipment rather than linguistic. In a pre-processor block is illustrated in Figure:4

Fuzzification*:*

Next block in the fuzzy logic is fuzzification which has the utility to convert all part of input data to degrees of membership by a lookup in more than one membership functions. Rule Base*:* It is just collection of rules[16]. The rules base condition is “If Then” format. Primarily “If” side is conditions whether “Then” side is called the conclusion

Defuzzification*:* After the rule data base the it is considered, and all the activated procedures are combined and converted to a single non-fuzzy output signal which is a system control signal[30]. The output values depend on the rule data base which the systems have and the position dependence on the non-linearity’s offered to the systems [26].

Post processing*:* The post processing contains an output gain from the fuzzy controller that can be tuned and also become as an integrator. A development of the skilled operator flexible control mechanism "not very suitable, suitable, high, little much high”.

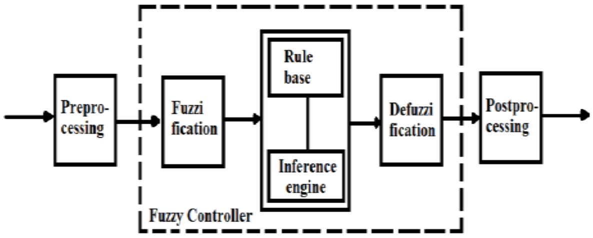

Fig:4 Block diagram of Fuzzy controller

Simulink model of fuzzy controller is shown in fig 5.In which Simulink model is shown in fig

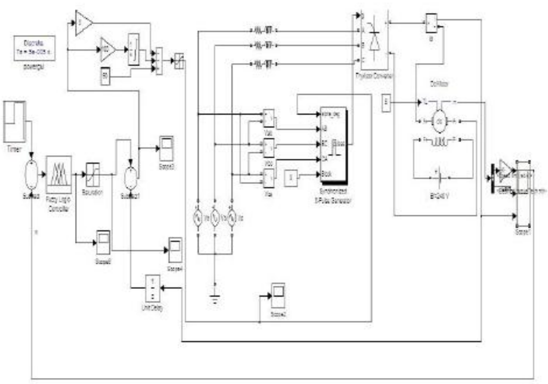

Fig :5 Simulink Model of speed control by using Fuzzy logic controller

Simulation result of fuzzy logic controller for speed control of dc motor shown in fig: 6

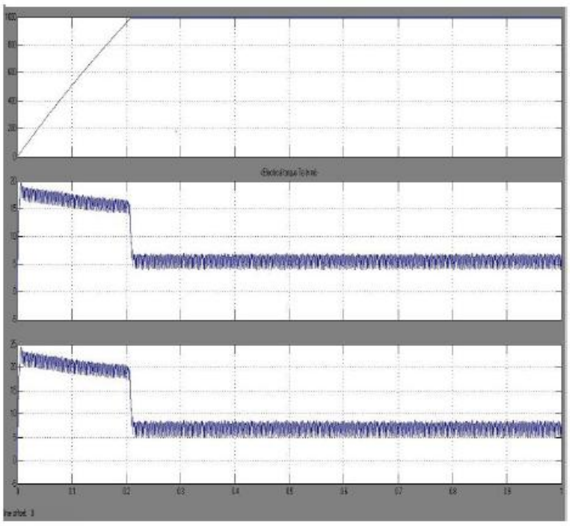

Fig:6 Simulation result of speed control of dc motor by Fuzzy Controller

IV. PARTICLE SWARM OPTIMZATION

It was discovered by, Kennedy and Eberhart In 1995. It is a kind of evolutionary computation technique and the optimization techniques. This optimised method is robust in problem solving ,featuring nonlinearity and non differentiability, multiple optima, and high dimensionality through adaptation, which is derived from the social-psychological theory[21]. The features of the method are as follows

• The method is used earlier for research on swarm such as fish schooling and bird flocking [14].It has computational efficiency. Instead of using evolutionary operators to manipulate the particle (individual), like in other evolutionary computational algorithms, each particle in PSO flies in the search space with velocity which is dynamically adjusted according to its own flying experience and its companions' flying experience[18].

Simulink model of pso controller for speed control of dc shunt motor is given in the fig:7

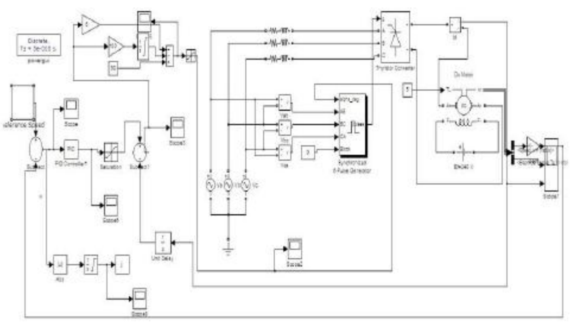

Fig:7Simulink Model of dc motor speed control by using PSO Controller

Simulation result comparison of speed control of dc motor by using pso controller & fuzzy logic controller is shown in fig:8

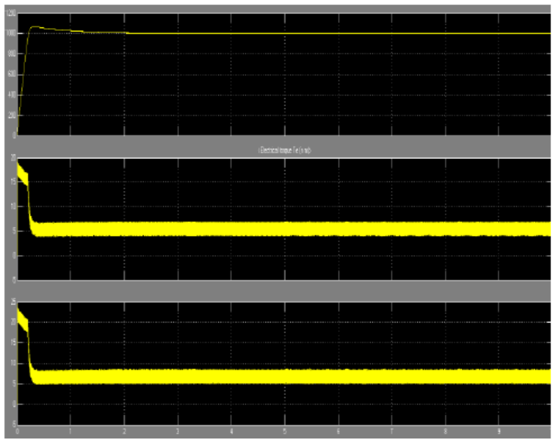

Fig:8 simulation result of PSO controller

V. SIMULATION RESULT COMPARISON

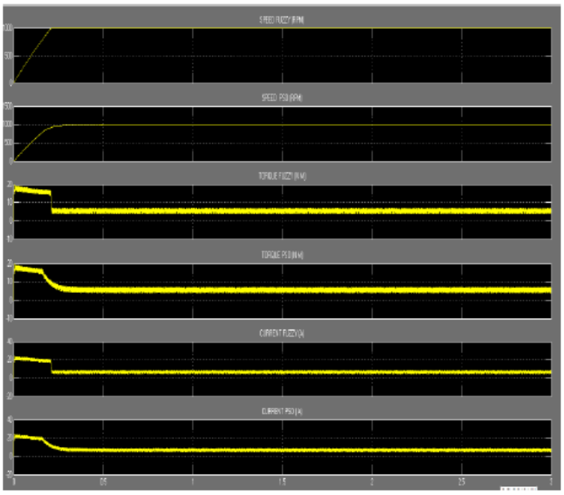

Fig : 9 Simulink result comparison of fuzzy & PSO controller

By this observation of result we can conclude that result of speed control of dc motor by PSO controller is much better because it settles a little bit early & torque of dc motor in PSO controller is decaying gradually.

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