RESEARCH ARTICLE OPEN ACCESS

A Comprehensive Study on Speed Control of DC Motor with Field and Armature Control

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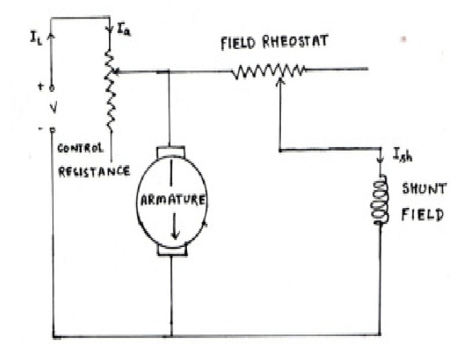
Abstract:

The aim of this paper is to describe the principle of DC motor speed control using armature control methods and field control methods and stopping the DC series motor immediately in case of emergency. For the armature control mode, the field current is held constant and an adjustable voltage is applied to the armature. In the field control mode, the armature voltage is held constant and an adjustable voltage is applied to the field. The speed variation of series motor by armature control method requires that voltage applied to the armature terminals shall be changed, without alternating the field current. In field control method the field is weaken and strengthen according to the requirement. The mathematical model of a separately excited DC motor (SEDM) with independent armature/filed control can be obtained by considering the electrical system, electromagnetic interaction and mechanical system. The main idea behind this paper is to understand how the speed of the Dc series motor can be controlled by armature and field control method.

1.0 INTRODUCTION

DC motors consist of rotor-mounted windings (armature) and stationary windings (field poles). In all DC motors, except permanent magnet brushless motors, current must be conducted to the armature windings by passing current through carbon brushes that slide over a set of copper surfaces called a commutator, which is mounted on the rotor. DC motors are used in many applications like electric railway traction and many more industrial fields such as rolling mills, paper industries etc, because they can provide a high starting torque. In DC motor we can control the speed below and above the rated speed by using different methods and techniques. The speed control above the rated speed can be achieved by using field current control method and below the rated speed by varying the armature voltage known as armature voltage control method. The speed of DC motor is directly proportional to the armature voltage (Va) and inversely proportional to the field current (If). In armature voltage control, the rage of speed control is from zero to rated speed. While in the field control, the speed control range from constant reference speed up to 120%-130% rated can be achieved but with loss of the motor developed torque.

Circuit Diagram:



OBJECTIVES:

(i) A Study on to find out the speed control of DC Motors with field and Armature Control methods

(ii) A study on Speed control of separately excited DC motor

(iii) A study on angular speed and the field current of the DC motor.

WORKING PRINCIPLE:

From the above circuit diagram, we can conclude that if we want to increase the speed of the shunt motor, we will vary the field resistance. As resistance increased, the value of the field current will reduce. On weakening of field current, flux of the field will reduced results in increase of speed. If we want to decrease the speed, firstly we should keep the field resistance at minimum value and then we will increase the armature resistance. As armature resistance increases, the voltage drop across armature increases. Because the supply voltage is normally constant. So by this method we can deal with ranges of speed and entire phenomenon can be analyzed.

2.0 LITERATURE REVIEW:

Syllignakis J (2016) This work presents a simple speed control application for a DC motor in laboratory use. The purpose of this application is to maintain the desired speed on a generator operating on the same axis to the motor.

Wisam Najm Al-Din Abed (2015) The aim of this work is to design and simulate an armature and field control systems using state feedback controller based on bacterial foraging optimization technique for controlling the speed of separately excited dc motor (SEDM). First the SEDM is simulated feeding back the armature current and angular speed (armature control method), second the SEDM is simulated with feeding back the field current and angular speed (field control method). For both controlling methods the controller's gains are tuned.

Vijay Singh et al (2014) In this paper, the performance of DC motor is tested/ evaluated with conventional controller such as PID controller and the results have been compared with the fuzzy based PID controller. When compared to conventional controller we found that Fuzzy based PID controller provides better speed response but conventional controller provides better speed response by changing load at the cost of very long settling time. MATLAB/SIMULINK environment is discussed to verify the above investigation.

Dr.Ch.Chengaiah et al (2013) The attempt is made to simulate a speed control of separately excited DC motor with PID and fuzzy controller. The aim of this paper is providing efficient method to control speed of DC motor using analog Controller. With the availability of MATLAB/SIMULINK, Fuzzy Controller for comprehensive study of modeling analysis and speed control design methods has been demonstrated.

Anurag Dwivedi (2013) DC Motors plays an important role in energy conversion process. It is a machine which converts electrical energy into mechanical energy. In mechanical system, speed varies with number of task so speed control is necessary to do mechanical work in a proper way. The main problem of this method is bulky rheostat is required across the armature so a large amount of power is wasted in the controlling resistance and poor speed regulation results for the lower speed.

3.0 METHODOLOGY:

SPEED CONTROL OF SEPARATELY EXCITED DC MOTOR

The expression of speed control of DC motor is given by equation

$$\omega = \frac{(Vt - Ia * Ra)}{K\phi}$$

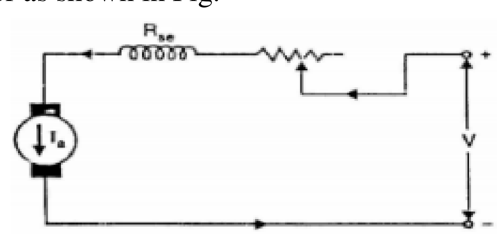
Therefore speed (ω) of any type of DC motor – series, shunt, compound and separately excited can be controlled by changing the quantities on right hand side of the expression. So the speed can be varied by changing:

(i) Terminal voltage of the armature Va
(ii) External resistance in armature circuit Ra
(iii) Flux per pole .

The first two cases involve changes that affect the armature circuit and the third involves change in magnetic field. Therefore speed control of DC motor is classified as armature control methods and field control methods.

Armature resistance control:-

In this method, a variable resistance is directly connected in series with the supply to the complete motor as shown in Fig.



This reduces the voltage available across the armature and hence the speed falls. By changing the value of variable resistance, any speed below the normal speed can be obtained. This is the most common method employed to control the speed of DC series motors. Although this method has poor speed regulation, this has no significance for series motors because they are used in varying speed applications. The loss of power in the series resistance for many applications of series motors is not too serious since in these applications, the control is utilized for a large portion of the time for reducing the speed under light-load conditions and is only used intermittently when the motor is carrying full-load.

COMBINED ARMATURE AND FIELD CONTROL OF SEDM

The speed of a separately excited dc motor could be varied from zero to rated speed mainly by varying armature voltage in the constant torque region. Whereas in the constant power region, field flux should be reduced to achieve speed above the rated speed. Torque and limitations in combined armature voltage and field control can be shown in figure 1.

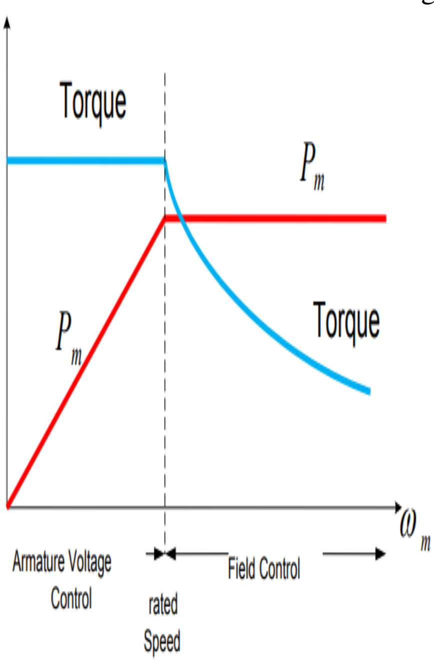


Fig. 1: Combined armature voltage and field current control

MODELING AND CONTROL OF SEDM USING MATLAB/SIMULINK

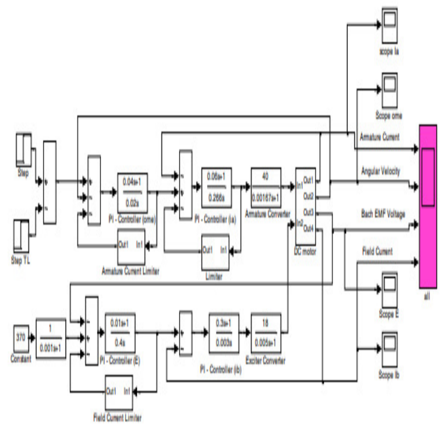


Fig. 2: Block diagram of combined armature voltage and field current control

4.0 SIMULATION RESULTS

A comparative simulation results are presented for the two cases:

a). Step response of armature and field current

b). Combined armature and field control

The waveforms of armature current and field current in combined armature and field control of separately excited DC motor is shown in fig.

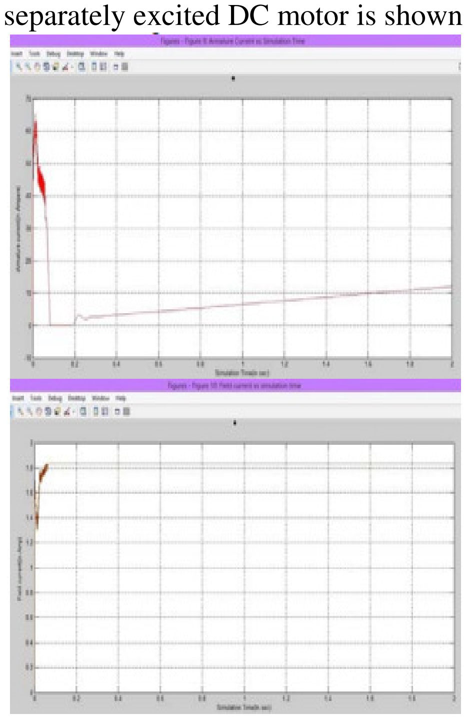


Fig 3. Armature and field current in combined control mode of DC motor

The waveform of armature current armature voltage and speed of a separately excited DC motor is shown in fig

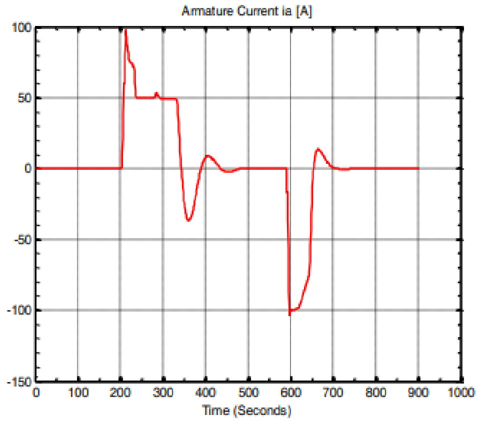


Fig 4. Step response of armature current

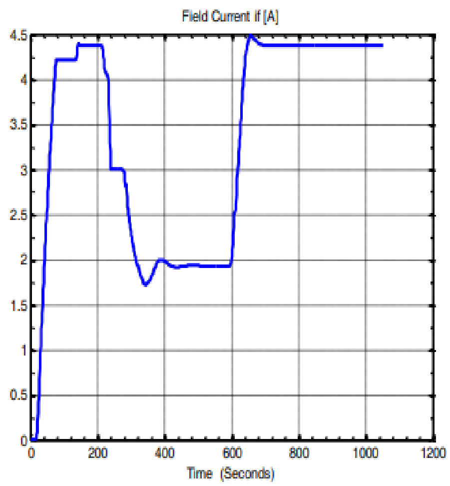


Fig 5. Step response of field current

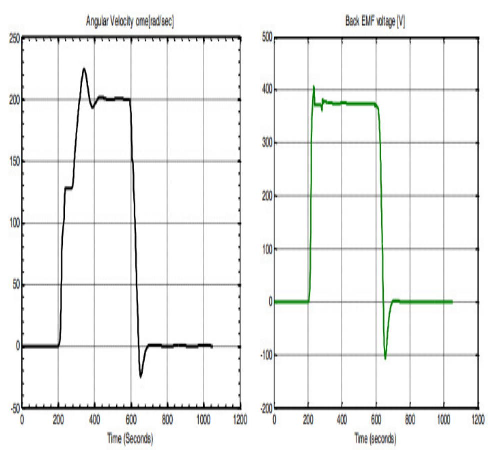


Fig. 6: a) Angular velocity step response b) Back EMF voltage Step response

CONCLUSIONS

Non-linearity of the combined field and armature control system has been studied and carried out using Matlab/Simulink. A DC motor drive for the armature and associated field winding of the motor includes an armature feedback loop responsive to the current flow in the armature, an input command signal such as a speed control signal, and the actual speed of the armature for providing a control of the current supplied by a DC source means to the armature to thereby provide speed control of the motor. The efficiency of the combined armature voltage and field current control of Separately excited DC motor is 1.02 % greater than the efficiency of armature control of separately excited DC motor at full load torque condition. At half load condition the efficiency of combined armature and field control of DC motor is increased by 1.886 % than the armature voltage control of DC motor. The speed of separately excited DC motor is controlled and is not affected with the change in load torque condition

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