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Review and analysis Of Computational Technique on Speed Control of DC Motor

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Abstract— **The purpose was to achieve accurate trajectory control of the speed, specially when motor and load parameters are unknown It has been observed that one of the major challenges in speed control of dc motor is to reduce rise time as well as peak overshoot.introduced an artificial neural network based high performance speed control system for a dc motor. Performance of the identification and control algorithms was evaluated by simulating them on a typical dc motor model.**

Keywords- **Membership function (MF)), proportional–integral–derivative controller (PID), fuzzy logic controller(FLC)**

I. Introduction

1.1 General

DC machines play an important role in industries and in our daily life. The outstanding advantage of DC machines is that they offer easily controllable characteristics. Their main disadvantage is high initial investment. In spite of this, DC machines still hold a strong competitive position for industrial applications because of their attractive features. Large DC motors are used in machine tools, printing press, conveyors, pumps, hoists cranes, paper mills and so forth. Small DC Machines (in fraction horse power rating) are used preliminary as control devices such as tacho-generators for speed sensing and servo motors for positioning and tracking. DC Motors still dominate traction motors used in transit cars and locomotives as torque speed characteristics of DC motors can be varied over a wide range while retaining high efficiency. DC Motors possess excellent torque-speed characteristics and offer a wide range of speed control. Though efforts are being made to obtain wide range speed control with AC motors, yet the versatility and flexibility of DC motor can't be matched by AC motors. Thus, the demand for DC motors would continue undiminished even in future.

1.2 Construction Of Dc Motor

The stator of dc motor has poles which are excited by dc current to produce magnetic field. The rotor has ring shaped laminated iron core with slots. Coils with several turns are placed in the slots. The distance between the two legs of the coil is about 180 electric degrees. The coils are connected in series. To keep the torque on dc motor from reversing every time the coil moves through the plane perpendicular to the magnetic fields, split ring device called a commutator, is used to reverse the current at that point. The commutator consists of insulated copper segments mounted in a cylinder. The electrical contacts to the rotating ring are called "brushes". Modern motor normally use spring loaded carbon contacts. Two brushes are pressed to the commutators to permit current flow. The brushes are placed in neutral zone to reduce arcing. The stator of large DC machine consists of several poles. The interpoles reduce the field in to the neutral zone and eliminate the arcing of the commutator. A compensation winding is placed on the main poles to increase field during hard load. The iron core is supported by cast iron frame. The rotor iron core is mounted on the shaft. Coils are placed in the slots.

A dc motor is rarely installed in a situation where it is required to run at a constant speed under constant load, since an AC induction motor performs such duties satisfactorily with cost only a fraction of price of DC machine of equal power and speed and requires minimum maintenance. Many simple speed variable systems are inherently stable in operation, so that steady state behavior of DC motor is frequently all that an engineer needs to take into consideration. For simple system a DC shunt motor excited from single source is often satisfactory and provides a reasonable range of adjustable speeds and torque.

1.3 Types of dc motor

On the basis of excitation there are in general two types of dc motors:

- Separately excited
- Self-excited
- Separately excited dc motor

When the field winding of dc motor is connected to separate or external DC source motor is said to be separately excited dc motor. The voltage of external dc source has no relation with the armature voltage.

1.3.1 Self-exited dc motor

When the field winding is excited by its own armature, motor is said to be self-exited DC motor. A self-exited DC motor can be sub divided into two forms. Shunt dc motor: In this type of motor, field winding is connected in parallel or in shunt with the armature. Therefore the voltage across armature terminal and shunt field is same.

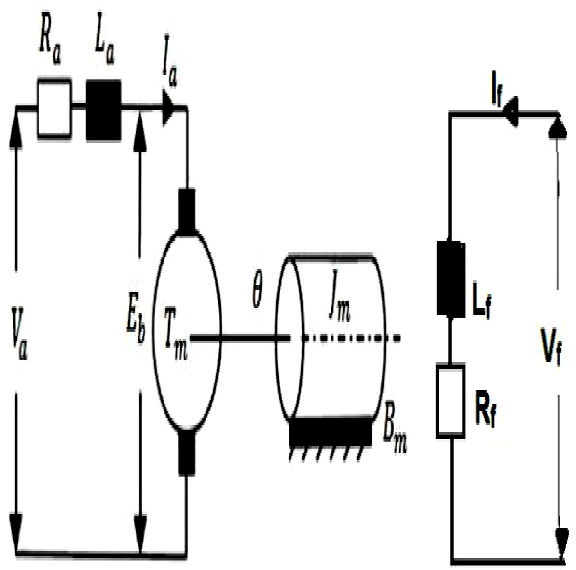
Series DC motor: In this type of motor, the field winding is connected in series with armature. Therefore field current depends on the armature current.

1.4 Principle Of Operation

In any electric motor, operation is based on simple electromagnetism. A current carrying conductor generates a

magnetic field when placed in an external magnetic field; so it will experience a force proportional to the current in the conductor and to the strength of the external magnetic field. The internal configuration of a DC motor is designed to harness the magnetic interaction between a current carrying conductor and an external magnetic field to generate rotational motion.
The geometry of the brushes, commutator contacts and rotor winding are such that when power is applied the polarities of the energized winding and the stator magnets are misaligned and rotor will rotate until it is almost aligned with the stator's field magnet. As the rotor reaches alignment the brushes move to the next commutator contact and energize the next winding. Current.
direction change as the conductor passes through the neutral zone

Figure.1.1: model of Separately excited DC motor model



1.5 Torque Speed Charateristic Of Dc Motor

In case of DC shunt motor, for larger torque, larger armature current is required and this has the effect of reducing the air gap flux due to saturation and armature reaction. As a result, the speed drops more rapidly with the increase of torque. In case of dc series motor if saturation and armature reaction are neglected then speed torque characteristic is a hyperbola. Above a certain value of torque speed torque characteristic approaches a straight line i.e. speed drop at increased load torque is almost negligible. Figure 1.2 shows the relation among speed ,torque and power.

For ω_{base} to the be the base speed which corresponds to the rated V_a, rated I_a and rated I_f. the complete region can be divided into two sub regions:

• Constant Torque region ($\omega > w_{base}$) In this region I_a and I_f are maintained constant to meet torque demands. V_a is varied to control the speed. As a result power increases with speed.

• Constant Power region ($\omega > w_{base}$) In this region V_a is maintained at the rated value and I_f is reduced to increase speed. However, the power developed by the motor (= torque x speed) remains constant. This phenomenon is known as field weakening

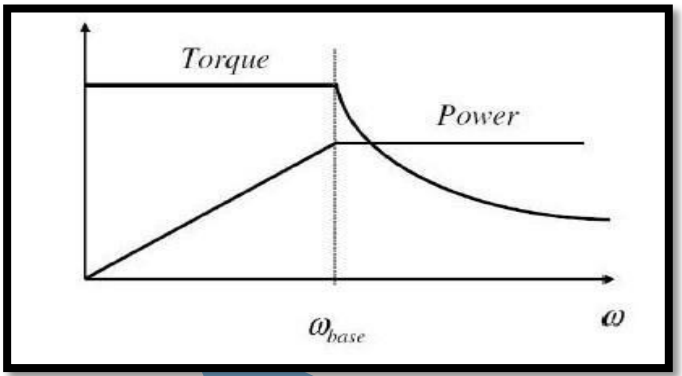


Figure 1.2 The relation among speed ,torque and power

1.6 Speed Control Of Dc Motor

For DC motor there are basically three method of speed control and these are

- Armature control
- Field control
- Chopper control

II. RELATED WORK

2.1 Introduction

DC motor possesses excellent speed torque characteristics and offers a wide range of speed control. Major problem in applying a conventional control techniques in speed controller are the effect of nonlinear characteristics of dc motor. Lots of effort has been made to use intelligent techniques such as fuzzy logic and neural networks for this purpose, because they do not require a precise model. The literature survey done in this field can be summarized as:

2.2 Early Development

In 1976, T. Krishnan and B. Ramaswami [1] described the design, construction and testing of a closed-loop system for the speed control of a separately excited d.c.motor ted from a dual converter. The dual converter makes possible regenerative braking and reversal of direction of rotation. There is only one firing unit and the firing pulses are diverted to the appropriate converter by a master controller. There are three control loops: one for armature current control, one for adjusting the firing angle of the oncoming converter, and one for speed control. Proportional plus integral type of controllers have been used to achieve good dynamic and steady-state responses.
In 1977, W. Lord and J. H. Hwang [3] showed that linear modeling techniques are applicable to separately excited dc motors if the model parameters are obtained under dynamic operating conditions. They used Pasek's technique in order to identify the model type and all the model parameters from single current response of the motor to a step input of armature voltage.
In 1983, R. Schulz [4] introduced a frequency response technique for measuring the parameters of high-performance dc motors. A second-order motor model, under certain conditions, is shown to be equivalent to a series resonant

electrical circuit. Frequency response measurements of the motor, when treated as electrical impedance, form the basis of a measurement technique which has certain practical advantages. Results are compared to measurements made using conventional methods.

In 1988, A. D. Rajkumar and R. Somanatham [5] proposed that practical determination of direct current (dc) motor transients is generally possible only by using sophisticated transient recorders or storage oscilloscopes. In this paper a method is presented to determine dc motor transients using an 8085 based microcomputer.The scheme was tested in the laboratory and results verified.

In 1991, S. Weerasooriya and M. A. El-Sharkawi [6] introduced an artificial neural network based high performance speed control system for a dc motor. The purpose was to achieve accurate trajectory control of the speed, specially when motor and load parameters are unknown. The unknown nonlinear dynamics of the motor and the load were being captured by an artificial neural network. Performance of the identification and control algorithms was evaluated by simulating them on a typical dc motor model.

1999, Rajani k Mudi and Nikhil R Pal [8] have proposed a simple but robust model independent self-tuning scheme for Fuzzy logic controllers. Here, the output scaling factor(SF) has been adjusted on-line by fuzzy rules according to the current trend of controlled process. The rule base for tuning the output SF is defined on error and change of error of the controlled variable using the most Neutral and unbiased membership function.

In 2000, Ahmed Rubaai et.al [9] tackled problem of the speed control of a dc motor in a very general sense. Use is made of the power of feed forward artificial neural networks to capture and emulate detailed nonlinear mappings, in order to implement a full nonlinear control law. The random training for the neural networks was accomplished online, which enables better absorption of system uncertainties into the neural controller. An adaptive learning algorithm, which attempts to keep the learning rate as large as possible while maintaining the stability of the learning process was proposed. This simplified the learning algorithm in terms of computation time, which was of special importance in real-time implementation.The effectiveness of the control topologies with the proposed adaptive learning algorithm was demonstrated. It is found that the proposed adaptive learning mechanism accelerates training speed. Promising results have also been observed when the neural controller was trained in an environment contaminated with noise.

In 2001, S. Saab and R. Abi Kaed-Bey [12] showed that the parameters of a dc motor can be estimated experimentally by employing discrete measurements of an integrated dynamometer. The dynamometer outputs are the discrete measurements of the armature current, angular velocity, armature voltage (system input), and the torque developed by the motor. They employed least-squares algorithm to implement the parameter identification of dc motor without the use of a D/A converter and a power amplifier. A Kalman filter is also implemented, as a state observer, to estimate the angular acceleration and the derivative of the armature current. In addition, to improve the overall identification performance, the DC parameters were first estimated by decoupling the AC parameters using a DC input signal.

In 2008, Maher M.F. Algreer [13] designed a self tuned PID controller. The controller includes two parts: conventional PID controller and fuzzy logic control (FLC) part, which has self tuning capabilities in set point tracking performance. The proportional, integral and derivate (K_P, K_I, K_D) gains in a system can be self-tuned on-line with the output of the system under control. The conventional PI controller (speed controller) in the Chopper-Fed DC Motor Drive is replaced by the self tuning PID controller, to make them more general and to achieve minimum steady-state error, also to improve the other dynamic behaviour (overshoot).

In 2008, Moleykutty George [16] described speed control of a separately excited dc motor varying armature voltage. Also Speed control of a separately excited dc motor (SEDM) using NARMA L2 controller. The performance of the proposed system has been compared with the traditional one using conventional controllers. The entire system has been modeled using MATLAB toolbox.

III. PROBLEM FORMULATION

Above literature survey has initiated the basic idea for the present work. It has been observed that one of the major challenges in speed control of dc motor is to reduce rise time as well as peak overshoot. So in this work, an attempt is made to achieve this objective. For this purpose, the methodology used can be summarized in the following steps:

1 To develop the mathematical model and to design Simulink model of separately excited dc motor fed by chopper.

2 To design a Simulink model of PID controller for speed control with the help of MATLAB.

3 To design intelligent controllers such as fuzzy, neural, neuro fuzzy for the same purpose.

4 To optimize the performance of controller by using hybrid techniques.

IV. CONCLUSION

The performance of the proposed system has been compared with the traditional one using conventional controllers. The entire system has been modeled using MATLAB toolbox\

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