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SPEED CONTROL OF DC MOTOR A REVIEW

Prabha Malviya(PG Student) *, Menka Dubey(Sr. Asst.prof.)
EX department, Malwa institute of Technology, Indore
R.G.P.V. ,Bhopal, India

ABSTRACT

This paper deal with various method of speed control of DC Motor and literature review on speed control of DC motor is presented. DC motors are widely used in industry applications, robotics and domestic appliances because of its low cost and less complex control structure and wide range of speed and torque. So wide range of position control is required. Proportional Integral Derivative (PID) controller is used in industries for wide number of applications .The tuning of PID controller parameters is very important for desired out response there is so many techniques for tuning of PID controller.

KEYWORDS: *DC motor,PID controller .*

INTRODUCTION

The brushed DC motor was invented in 1856 by Werner Von Siemens in Germany. Variable speed by armature voltage control was first used in the early 1930s using a system involving a constant speed AC motor driving a D.C. generator. The generator's DC output was varied using a rheostat to vary the field excitation and the resulting variable voltage DC was used to power the armature circuit of another DC machine used as a motor. This system was called a Ward-Leonard system after the two people credited with its development. The Ward-Leonard method of DC variable speed control continued until the late 1960s when Electric Regulator Company brought to market a practical, general purpose, static, solid state controller that converted the AC line directly to rectified DC using SCR (thyristor) devices. That technology was adopted by virtually all manufacturers and still is in use today. It is a very simple power control concept and uses the fewest number of parts possible to produce variable speed from an electric motor. Speed control means intentional change of the drive speed to a value required for performing the specific work process. Speed control is a different concept from speed regulation where there is natural change in speed due change in load on the shaft. Speed control is either done manually by the operator or by means of some automatic control device.

1) Armature control method.
2) Field control method.

MODELING OF DC MOTOR

To analysis the electrical rotating machine it required the mathematical modelling which involved the various phases or windings of the machine are identified as coils having certain resistance, self inductance and mutual inductance. The circuit equations are written for voltage balance. They contain ohmic drop in the resistance of coil , voltage induced in coil due to rotation[24].

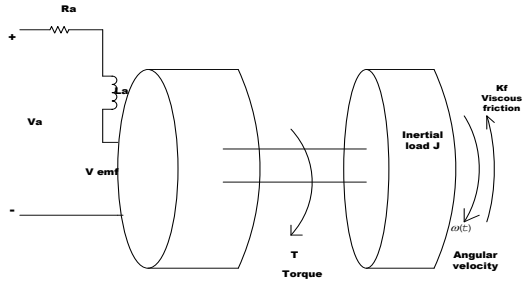

Fig.1 Modeling of DC Motor

$$V = i_a R_a + L\frac{d\, i_a}{dt} + E_b \quad (1)$$

$$E_b = K\phi\omega \quad (2)$$

$$\omega = \frac{V - i_a R_a}{K\phi} \quad (3)$$

$$T = k_t \phi i_a \quad (4)$$

$$J\frac{d\omega}{dt} = T - T_l - \mathrm{B}\omega \quad (5)$$

Where V is terminal voltage in volt, i_a is armature current in amp, L is armature inductance in hennery E_b back emf of motor in volt, R_a is armature resistance in omh, $\frac{dia}{dt}$ is rate of change of armature current in amp/sec, ω is speed in rad/sec,T is motor torque in Nm, k_t is torque constant.

Most basic requirement of a motor is that it should rotate at the desired Position , the steady state error of the motor position should be smaller than 1%. The other performance requirement is that the motor will accelerate to its steady –state Position quickly after it's turned on. In this case, we want it to have a setting time of 2seconds. Since a Position faster than the requirement may damage the equipment , we also want to have an overshoot smaller than 5%[23].

SPEED CONTROL OF DC MOTOR

The expression of speed control dc motor is given as,

$$N = KV - \frac{Ia(Ra + R)}{\phi} \quad (6)$$

- circuit resistance R
- flux per pole ϕ

Armature terminal voltage and external resistance in armature circuit involve change that affects armature circuit and the flux per pole φ involves change in magneticfield. Therefore speed control of dc motor is two type

- Armature control method
- Field control method

3.1 Open Loop Speed Control of DC motor

In open loop system output speed of armature controlled dc motor is proportional to the applied voltage.

3.1.1. *Armature Control of DC Shunt Motor*

Motor speed is directly proportional to back emf E_b, $E_b = V - i_a R_a$ if supply voltage and armature resistance are kept constant then speed is directly proportional to armature current, if some resistance is add in series with armature current decreases therefore speed is decreases Speed control by this method involves two ways .

3.1.1.1. *Armature Resistance Control*

In this method armature circuit is provided with a variable resistance. Field is directly connected across the supply so flux is not changed due to variation of series resistance.This method is used in printing press, cranes, hoists where speeds lower than rated is used for a short period only.

3.1.1.2 *Armature Voltage Control*

This method of speed control needs a variable source of voltage separated from the source supplying the field current. This method avoids disadvantages of poor speed regulation and low efficiency of armature-resistance control methods. The basic adjustable armature voltage control method of speed d control is accomplished by means of an adjustable voltage generator is called Ward Leonard system. This method involves using a motor –generator (M-G) set. This method is best suited for steel rolling mills, paper machines, elevators, mine hoists, etc. There is some advantages of Armature voltage control method like Very fine speed control over whole range in both directions and Uniform acceleration is obtained it provided Good speed regulation but its needed Costly arrangement and required more floor space.

The speed of dc series motor control using the integral cycle control method of thyristor (or triacs) triggering has some advantages over that using the phase angle one however the integral cycle controlled motor suffer from the

relative high speed ripples, at low ratios of ON/OFF motor applied supply cycle. In proposed method of controlling the speed of dc series motor using modulated phase angle controlled single triac is introduced. The suggested method has reduced the motor speed ripple to prescribed value. A single triac is connected in series with ac supply lines. The triac is connected to motor through a rectifier bridge to unify the motor current[29].

Speed control of separately excited DC motor using different single phase AC/DC converter. It is observed that the range of non linearity is small in semi converter as compared to half wave and full converter drives, so semi converter drives can be preferred for the wide range of load torque Rohit Gupta et.al. presents Speed torque curves for three type of single phase AC/DC converter (half wave, semi, full wave converter) are obtained for a wide range of loading conditions. From the results, it can be conclude that the reason of non linearity in speed torque curve is discontinuity in armature current which is highly non desirable for industrial applications to remove the discontinuity in armature current continuous [11].

The open loop speed control scheme for the speed control of a permanent magnet DC motor using an AVR microcontroller. The microcontroller has been programmed to automatically vary the duty cycle of H-bridge chopper depending upon the set/required speed of motor by controlling the PWM duty cycle is equivalent to controlling the motor terminal voltage which adjust the speed of motor .[25]

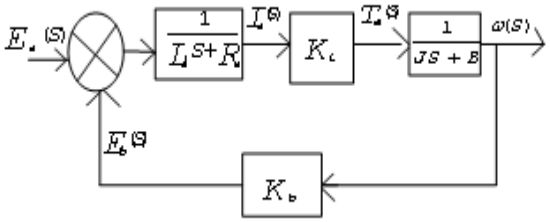

Fig.2 Block diagram of DC Motor

3.1.2 *Field Control Of DC Shunt Motor*

Speed of motor is inversely proportional to flux by decreasing the flux Speed can be increases. Speed control by this method involves two ways

3.1.2.1. *Field rheostat control of DC Shunt Motor*

In this method. Speed variation is accomplished by means of a variable resistance inserted in series with the shunt field . An increase in controlling resistances reduces the field current with a reduction in flux and an increase in speed. This method of speed control is independent of load on the motor. Power wasted in controlling resistance is very less as field current is a small value.

Limitations of this method of speed control:

1. Creeping speeds can't be obtained.
2. Top speeds only obtained at reduced torque.
3. The speed is maximum at minimum value of flux, which is governed by the demagnetizing effect of armature reaction on the field.

3.1.2.2. *Field voltage control*

This method requires a variable voltage supply for the field circuit which is separated from the main power supply to which the armature is connected. Such a variable supply can be obtained by an electronic rectifier.

The speed control of DC Motor by controlling the field current and a comparison between armature voltage and field current method is presented by MATLAB Simulink and result show the field control method is accurate in controlling the speed of dc motor[28].

3.2 Close loop speed control of DC Motor

A closed loop speed control system is used to achieve better speed regulation and its able to maintain the same speed in face of fluctuating loads, and a faster response is also achieve.DC drive system are often in many industrial application . Tuning method for PID controller is very important for the process industries. Proportional Integral Derivative (PID) controllers have the advantage of simple of structure, good stability, and high reliability. [22]

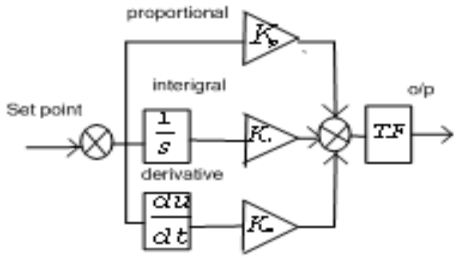

Fig.3 Block diagram of PID controller

Designing 8051 microcontroller based Embedded closed loop speed control system of DC motor proposed by R.Mondal et.al in this scheme a tachogenerator has been used as speed sensor which generates a back emf corresponding to the speed attained by DC motor. This instantaneous value of resulting error is used by the microcontroller to control the firing angle of the SCR for controlling the voltage applied to DC motor which in turn adjusts directly the motor speed to attained the desired value the system is to low cost and is suitable for different industrial application such as subway cars, trolley buses and battery operated vehicles[26].

The self tuning method of PID controller proposed by Toru yamamoto, et. al. it is based on classical control theory which have been widely used for real control system so consider the control parameter as PID gain of proportional, integral, differential actions and the control performance depends on these parameters . In this pole –assignment control scheme reported as useful self tuning control technique for unknown time delay system and speed of DC motor is controlled[1].

A self tuning of PID controller has been developed that use the well known technique of direct enhance tuning. Bria C H lon , et. al. suggested an objective function that measures the quality of control objective function that measures the quality of control performance is optimized by a succession of small adjustments to the three PID tuning parameters because the optimization is driven by actual performance and no assumptions are made about process dynamics and disturbance behavior this technique provides optimal tuning for almost any loop that can be controlled by PID[2].

A self tuning PID scheme for nonlinear system is proposed discrete PID controller and proposed new wavelet network structre called Dynamic Wavelet Network (DWN). Rached Dhaouadi, et.al. Proposed that The DWN consists of static feed forward wavelet network in cascade with an autoregressive moving average (ARMA) model. The learning strategy for the wavelet network and PID controller is based on gradient descent and recursive algorithm is developed to update the weight of DWN and the parameters of the parameters of ARMA model. [8]

PID controller for a process three parameter have to be specified proportional, integral, differential gain parameters. In order to specify the appropriate values of the parameter by using tabu search algorithm which is a general heuristic procedure for guiding search in a complex space to F d global optimal solution for difficult problem and speed of DC motor is control[4].

The Extended Kalman Filter (EKF) an improved PID control algorithm, which could adjust the control gain automatically, which based on singular value Decomposition (SVD) is used for the estimation of an unknown or time-varying parameter and EKF is being used as an observer and the control gain are tuned though EKF. Inhyuk Cha, et.al. suggested controller using the EKF advantages that the EKF work as an observer and noise jilter concurrently. The suggested controller will be useful in tracking control of a system with time-varying or unknown parameters. [3].

The parameters of the controller are calculated and updated every sampling interval based on the identified parameters of system model. The proposed controller is robust to parameters variation and external disturbances. The DC motor design and simulation of robust adaptive discrete variable structure control (AVSC) scheme for a high performance of motor the object of the proposed controller is to control the motor speed and or position to follow the desired value at all times. Unlike the conventional variable structure control (VSC)scheme In addition the chattering in the control input and in the motor current are minimized. Simulation results reported showing the advantages of the proposed control technique compared to conventional VSC scheme [21].

The close loop control of dc motor one quadrant chopper supplied by solar PV equivalent module with dc-dc boost converter Speed control of dc motor by armature voltage is varied by the use of chopper circuit with varying chopping frequency as per requirement and result show in matlab /simulink. [33]

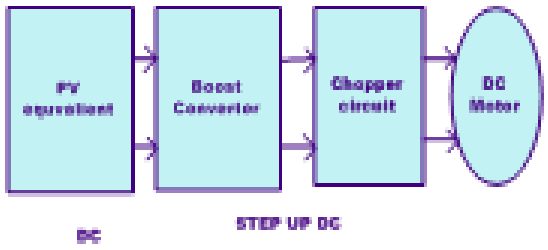

Fig.4 Basic Block diagram

The design and implementation of adaptive neural network controller for DC motor speed control system. Machbub et.al proposed the dc motor is actuated by a pulse width modulation (PWM) based H-bridge actuator by using certain learning methods to the network, changing a plant's parameters can be estimated and used to produce an appropriate control action. The experiment shows that the controller conforms to the adaptive control scheme although there are flaws which relate to feedback resolution. The most interesting result is that the implementation circuit is based on a very simple 8-bit microcontroller system. [17].

Microcontroller performance for DC motor speed control system implementation of the MC68HC11E9 microcontroller for speed control of DC motor fed by a DC chopper has been investigated by Ali, Y.S.E. et.al. The chopper is driven by a high frequency PWM signal. Controlling the PWM duty cycle is equivalent to controlling the motor terminal voltage, which in turn adjusts directly the motor speed . Experimental result have been obtained that show the employment of microcontroller for speed control and over current protection of DC motor. [13].

A fuzzy based DC Motor speed control system is designed using PIC microcontroller it maintained desired speed even what ever the load. fuzzy PI able to achieve smooth speed control with less overshoot and no oscillation and its hardware part fuzzy logic control algorithm was developed by using Mikro C ,high level programming language for programming a PIC microcontroller. The C-Structure programming overwhelm the difficulties may encountered if programming the microcontroller using Embedded C language. fuzzy logic control algorithm programmed will be compiled into the memory system . As result , fuzzy controller developed is able to provide precise PWM signal in order to drive the DC driver. then PIC microcontroller is interfaced between the DC motor and DC speed drive to run in real time and debug[27].

A two level optimization based into account the method for deriving tuning guidelines for PID controllers that take explicitly presence of nonlinear behaviour The central idea behind the proposed method is the selection of PID controller tuning parameters so as to best "emulate" the control action and closed loop response under a given nonlinear controller for a broad set of initial conditions and set point changes and first level involves using classical tuning guidelines to obtain reasonable bounds on the tuning parameters in order to satisfy various design criteria such as stability and performance and robustness. These bounds are in turn incorporated as constraints on the optimization problem solved at the higher level to yield tuning parameter values that improve upon the values that improve upon the values obtained from the first level to better emulate the closed loop behavior under the nonlinear controller[5].

A closed loop system of motor speed control, adopted the algorithm of PWM to control the armature voltage and motor speed is controlled by regulating of armature voltage. The system has a good response Helei Wu et.al. proposed a DC motor speed control system the controller is ARMS3C2410, and the operating system is muC/OS-II, a real time operating system is designed [16].

Sliding mode control (SMC) technique which is used to control the speed of DC motor the performance of SMC is judged via MATLAB simulation using linear model of the DC motor and known disturbance. SMC is then compared with PI controller the simulation result shows that the sliding mode controller (SMCr) is superior controller than PI for the speed control of DC motor. Since the SMC is robust in presence of disturbance, the desired speed is perfectly tracked the problem of chattering resulting from discontinuous controller, is handled by pseudo sliding with smooth control action [14].

The PI controller and SVM controller are applied to DC motor system for speed control by changing the values of controller parameters K=1/J and a=B/J within definite limits respectively. Designed SVM controller is compared with the linear PI controller's The DC motor speed control performance that Shown result, the dc motor speed control performance of designed SVM controller is very high control performance of designed SVM controller better than linear PI controller's. The rise and settling time obtained by the SVM controller system can be considered to be best values [10].

The use of an adaptive PID controller to reduce a DC motor speed pulsation such that the robust stability for the closed- loop system is guaranteed. Shumei Zhang et.al investigates The PID control scheme tunes the PID controller parameters by using the theory of adaptive interaction. Aneural network was applied in the adaptive algorithim to regulate a set of PID controller parameters by minimizing an error function. Both computer simulations and bench test rig experiments are used to validate the proposed control scheme [18].

The speed control of a separately exited DC motor using fuzzy logic control (FLC) based on Lab VIEW (Laboratory Virtual Instrument Engineering Workbench) program. Lab VIEW is a graphical programming environment suited for high level or system level design. Therefore, the principle that are data flow model, different from text-base Programming and a sequential model. The user friendly interface and toolbox design are shown the high level of suitableness and stability of Lab VIEW and fuzzy logic on speed control of DC motor. The fuzzy logic controller designed to applies the required control voltage that sent to DC motor based on fuzzy rule base of motor speed error (e) and change of speed error(ce). The result show the control as a FLC that do the comparison with PI and PID controller [19].

The speed monitoring of a DC motor drive using field programmable gate array which provides a faster operation than any other conventional analog methods or digital methods like DSP the work consists of two parts the first part deals with the MATLAB simulation for speed control of a DC motor using fuzzy logic. The most effective method of control is the control of PWM ,generated for triggering the converter circuit. The PWM is given through the driver circuit to the half bridge converter , which controls the speed of the motor . the hardware part deals with the speed monitoring of the DC motor using FPGA. In this implementation, the PWM is generated using XBLINX software, which is given to the converter through the FPGA. The use of FPGA reduces the processing speed and hence increases the efficiency of the motor. The result of the open loop control is compared with the fuzzy logic control [19].

The designed the fuzzy based PID controller for DC motor position control system which show the fuzzy logic designed PID controller is much better in term of peak value and setting time than conventional method [12].

The fuzz auto tuning algorithm for PID controller tuning a new tuning algorithm for the PID controller which has the initial value of parameter Kp, Ki ,Kd by the Ziegler Nichols formula that uses the ultimate gain and ultimate period from a relay tuning experiment which will get the error and the error rate of plant output corresponding to the initial value of parameter and find the new proportion gain and integral time from fuzz tuner by the error rate and error rate of plant output as a membership function of fuzz theory Hyung-Soo Hwang, et.al proposed so the fuzz auto tuning algorithm for PID controller tuning a real parametric uncertainty system and also constitutes an appreciable improvement of performance[6] .

Speed control of DC motor by optimized fuzzy logic controller using particle swarm optimization Rahmani, R.et.al presented the controller model and simulated using MATLAB software and experimentally tested on a laboratory DC motor comparison of the performance of different controllers such as PID controller, fuzzy logic controller and optimized fuzzy logic controller is presented as well with reference to the results of digital simulations and experiment, the designed FLC-PSO speed controller obtains much better dynamic behavior compared to PID and normal FLC designed. Moreover, it can acquire superior performance of the DC motor and also perfect speed tracking with no overshoot. The optimized membership function (MFs) are obviously proved to be able to provide a better performance and higher robustness in comparison with a regular fuzzy model, when the MFs were heuristically defined. Besides, experimental results verify the ability of proposed FLC under sudden change of the load torque which leads to speed variances [14].

By Using Genetic Algorithm to perform the tunning of controller will result in optimum controller begin evacuated for system every time in order to solve this problem a PID controller under Genetic Algorithm with self tuning using Ziegler and Nichols applied by Nikhileshwar P. Adhikari. et.al. which will perform high efficiency position control of DC motor. The efficiency of control Algorithm is presented through a simulation and compared with quality of PID controller [20].

Speed control of dc motor by using and Genetic Algorithm. M.Jaiswal et.al. Suggested optimize the PID controller by Genetic Algorithm. The algorithm functions on three basic genetic operators of selection, crossover and mutation base on these operators GA has many variant like real coded GA and binary coded GA binary coded GA find the value of crossover and mutation of PID controller[31].

Design a Fractional order PID controller for speed control of DC motor to obtain the optimal values of integer order and derivative order different optimization techniques can be implemented by R.Singhal et.al.[30]

Artificial Bee Colony optimization for tuning the PID controller for speed control of DC motor Suggested by A.Kumar Mishra et.al. and show that rise time and settling time to be less as compare to conventional controller[32].

M.Singh et.al presented the sped control of dc motor by using PID controller the two different method of determining the fuzzy controller parameter using PSO algorithm and also PID PSO controller while comparing with both the result the fuzzy PSO show the better output as compared to PID PSO[34].

CONCLUSION

This paper present the modelling and analysis of DC Motor with classical method of speed control .A review on theory of speed control is also present with their advantages, disadvantages and limitation.

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AUTHOR BIBLIOGRAPHY

Prabha Malviya
is student of M.Tech in Power Electronics from Malwa institute of Technology Indore, M.P She recived her B.E in Electrical Engg. From S.A.T.I. Vidisha, RGTU M.P in 2006

Menka Dubey is Sr. Asst. prof. in Malwa institute of Technology, Indore She recived her B.E. in Electrical Engg. IGC, Sagar, RGTU, & M.E. in Power Electronics SGSITS,Indore
She has published various paper in national international conference/journal