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DC Motor Speed Control using PID Controller

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ABSTRACT

DC motors are widely used in variable speed applications in industry due to their simple control aspects and characteristics including their high speed torque. A research study describes a technique for controlling the speed of a DC motor using a PID controller. Industrial processes are subject to parameter disturbances and parameter fluctuations. In this study, we will select the PID parameter to regulate speed of DC motor. This paper describes the construction of a PID controller and the selection of PID parameters depending on the system response. A PID controller is used to control the speed of the DC motor, and the Matlab program is used for calculations and simulations. The parameter has been shown in several contrast experiments and explains how to adjust the value of the PID parameter.

KEYWORDS: *PID controller, DC motor, Matlab representation, P control, PI control, PID control*

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INTRODUCTION

Over the years, DC motors have been used in many domestic and industrial applications due to their wide speed control limitations. Feedback control loops react slowly but are absolutely necessary for better and desirable system performance. We use control strategies to provide feedback solutions for control systems for faster response (Bansal & Narvey, 2013). For best performance, the DC motor must control the speed correctly. In recent years, controllers such as Proportional Integral (PI), Fuzzy Logic Controllers, Proportional Derivative (PD) Controllers, Neutral Grid Controllers, and PID Controllers have proven useful in manipulating and automating the speed of DC motors[1]. DC motors are highly controllable electric drives used in robotic manipulators, steel mills, overhead cranes, cutting tools, and tracking electric guided vehicles. However, DC cars are cheaper and simpler[2].

However, this controller can be used with other things like space rockets and kitchen ovens. This is an example of motor loop control. It is often used in robotic applications. In today's world, the second case is the most important, since PIDs are also implemented on microswitches. The written code pleases the program part loaded into the microcontroller. The microcontroller board receives a command from the microcontroller and applies that command to the motor as a current signal. This includes a closed-loop system that includes a feedback control system that uses a fixed point to generate an error signal to evaluate the feedback variables. Otherwise, the procedure continues until the error reaches zero and the value of the fixed point equals the value of the feedback variable. The figure below (Fig-1) shows a feedback system in which the speed of the DC motor in the device is precisely controlled[3].

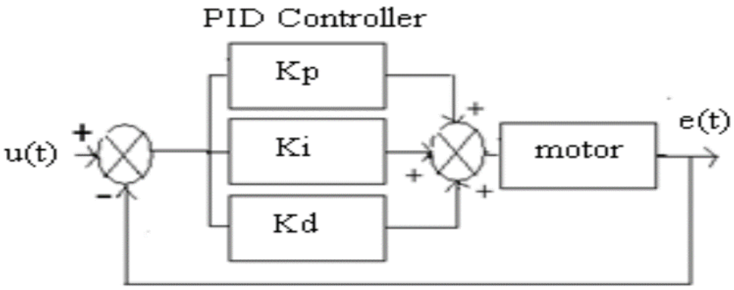

Fig- 1 PID controller with motor

Block diagram of armature-controlled DC motor: Armature-controlled DC motors are preferred over field-controlled DC motors because they use closed-loop systems compared to field-controlled DC motors which use open-loop systems. Field driven DC motors are advantageous due to their small size and require very little power due to their small armature and are driven by expensive constant current amplifiers. For large motors, it is cheaper to use armature control because the back EMF provides additional tipping in addition to the load friction[4].

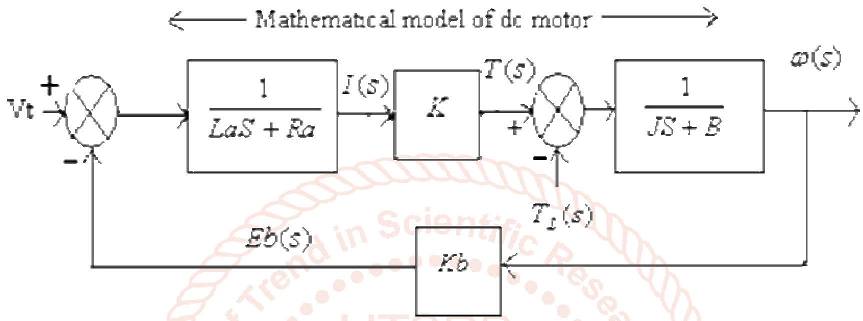

Fig-2 Mathematical model of DC motor

Controlling the speed of DC motor: Voltage regulation is achieved by attaching the appropriate switching device to the armature. Since the motor is connected to a fluctuating voltage source, the armature voltage can fluctuate. An increase in speed leads to an increase in voltage and vice versa. Armature control is achieved when resistance and voltage remain constant. In this case, the velocity is directly proportional to the current (Verma & Padhy, 2019)[5]. Adding a resistor in series with the armature will cause the voltage to drop and slow it down. In flux regulation, the speed of the DC motor increases as the pole drops. This means that reducing the speed will increase the flow rate. A resistor is added in series with the winding to control the magnetic flux more resistance the more the speed and thus reducing the flux[6].

If the flux is weakened beyond the limit, it will adversely affect the commutator and limit the maximum speed that can be achieved. Changing the voltage is very easy and unless you are a DC motor winding pro there is little you can do. Therefore, it requires a current strong enough to supply the various voltages needed to set the speed. One of the most common ways to stop a DC motor immediately is to use dynamic braking. This involves shorting the input wires to each other and generating currents exerting opposing forces to quickly stop the motor from rotating.

The dynamic model of DC motor: This study provided a dynamic engine speed control model. It consists of a presentation of a closed-loop armature controlled DC motor speed control system. This armature driven DC motor simulation was done using Matlab software. A self-excited DC motor dynamic model was used, the design parameters were taken from Carnegie Mellon, and the speed was controlled by individually supplied armature voltage (Va) and constant excitation current. It consists of a DC motor driven by an armature. This DC armature control model should look like this:

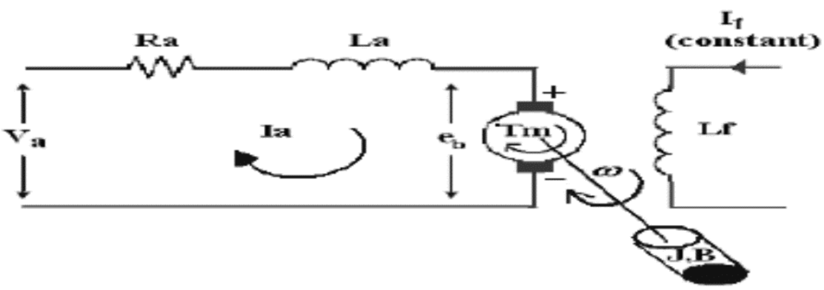

Fig -3 Mathematical modeling of DC motor

The PID controller: Elmer Sperry developed the first PID controller in 1991, and in 1933 the Taylor Instrumental Company introduced an earlier fully adjustable pneumatic controller. The inspection engineer eliminated the steady-state error found in the proportional controller by backtracking the incorrect value all the way until there were zero errors. This included a proportional integration controller error. In 1942, Nicholas and Ziegler presented engineers with instructions for setting up and determining appropriate parameters for PID controllers, and finally in 1950, automated PID controllers became widely used in industry[7].

The proportional integral derivative is responsible for controlling various process variables such as temperature, flow and velocity in industrial applications. In PID controllers, loop feedback is used by the controller to standardize variables in the process. This is the basic system for driving in the direction of the desired location. A closed feedback loop is used to keep the actual output at a fixed point as much as possible. PID controllers are used in systems to help overcome unwanted low vehicle speeds due to various anomalous conditions resulting from load shocks. In this study, the speed control technique of DC motors is clearly stimulated under changing conditions as shown by simulation. For the best results from the whole system, PID controllers are used [8].

The PID controller allows only two control states, which is absolutely sufficient for target control. The PID controller holds the output in a manner between the desired output in closed loop mode and the process variable. It uses basic control behavior including D, PI controller. The P controller makes a comparison between the set value and the actual feedback value. An output proportional to the current error is available. A multiplication calculation is performed and the proportionality constant is multiplied by the resulting error to obtain the output. Controller I will take the necessary steps to remove the persistent error condition. The offset between the process variable and the setpoint is very important. If a negative error occurs, the integral control will reduce the performance. Prediction of future operating errors is performed by the D controller. The output of this controller depends on the rate at which the error changes over time and is multiplied by a constant derivative. This contributes to starting the output and increases the system's responsiveness[9].

MATLAB /Simulink: A DC motor can be used for speed control. Therefore, you can adjust the torque, direction of rotation and speed at any time to be fair in the new situation. The figure -4 below shows the free body of the rotor and armature circuits.

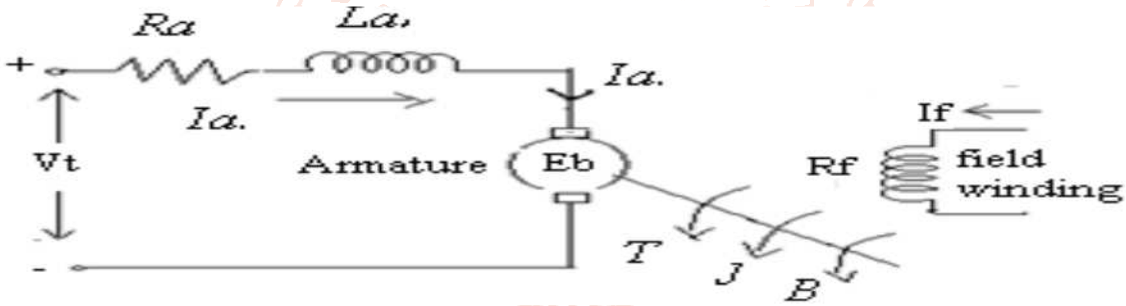

Fig -4 Dynamics of DC motor

LetRa=Armature Resistance,

La=Armature self- inductance caused by armature flux, ia=Armature current,

if= field current,

Eb=Back EMF in armature=Applied voltage,

T=Torque developed by the motor,

θ=Angular displacement to motor shaft,

J=Equivalent moment of inertia of motor shaft &load referred to the motor

B=EquivalentCoefficientoffrictionofmotorshaft&loadreferredtothemotor.

DC motors are important in the linear region of the magnetization curve. Therefore, the magnetic flux of the air gap Φ is proportional to the excitation current. The input signal can be any signal step, ramp or other signal, depending on the system requirements.

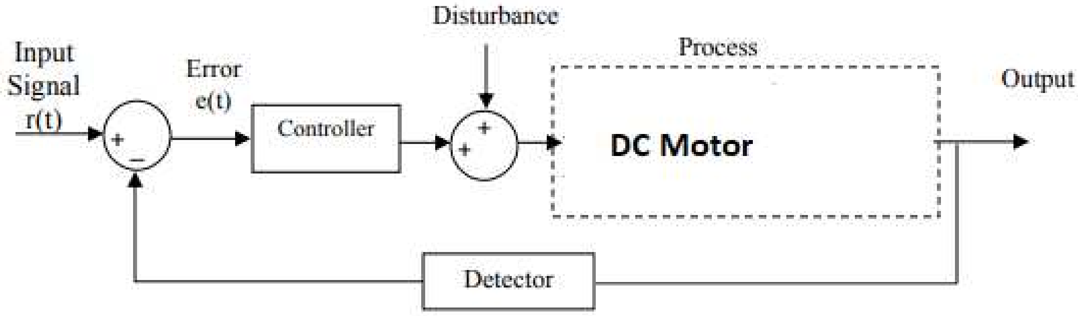

Fig-5 Block diagram of process controller

Drivers can use different structures and different variable values to achieve the desired level of performance. P, PI, PID and type controllers can be used with most industrial PID controllers. Assuming that the input is a step signal, the controller equation is:

$u(t)= K_p e(t)+\frac{1}{Ti}\int_0^t e(t)dt+ K_d\frac{de(t)}{dt}$

K p = Proportional gain and Ti = Integral time.

Here we analyze both controllers P and PI individually and compare them to each other to find the wife of the unique controller. The PID controller is a combination of three members, the sum of which forms a complete controller. The output of the PID controller is the sum of the proportional controller, the integral controller and the derivative controller. There are three controller structures: interactive algorithms, non-interactive algorithms, and parallel algorithms[10].

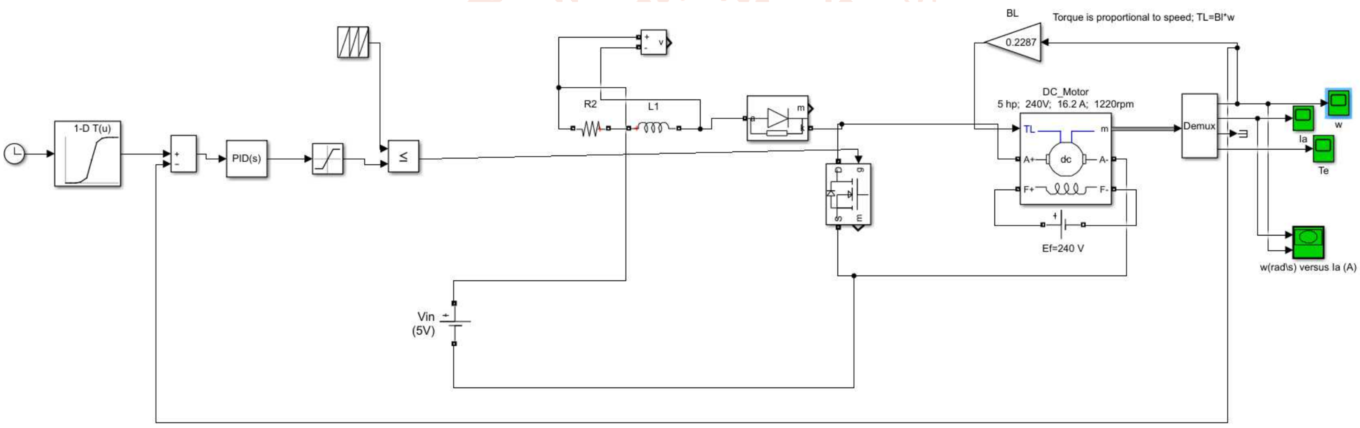

Fig-6 DC motor with PID controllar

Fig-6 shows the MATLAB simulink diagram for speed control of DC motor where as fig -7 repersents the step response of DC motor with PID controller.

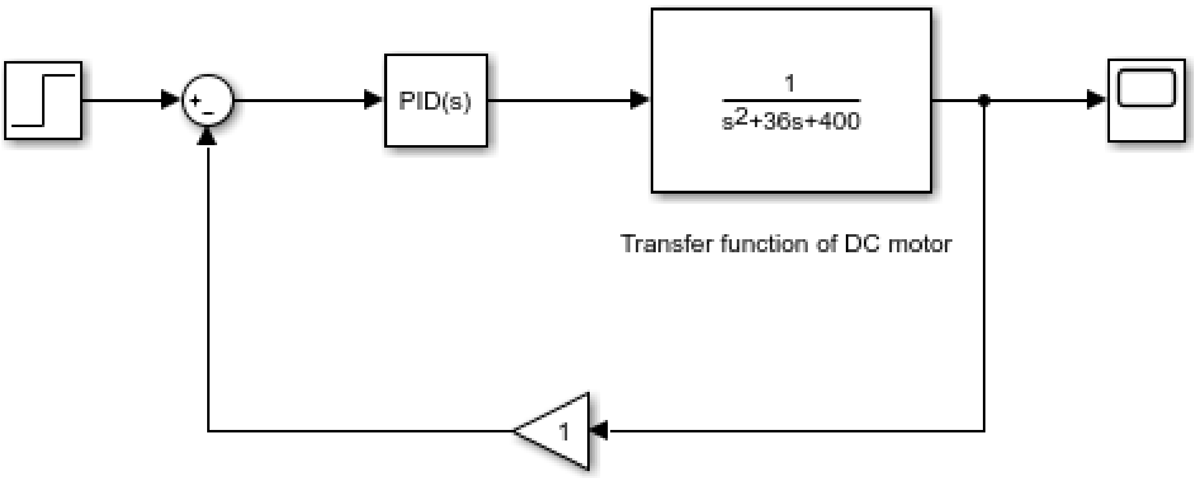

Fig-7 DC motor with PID controller step input

Result:

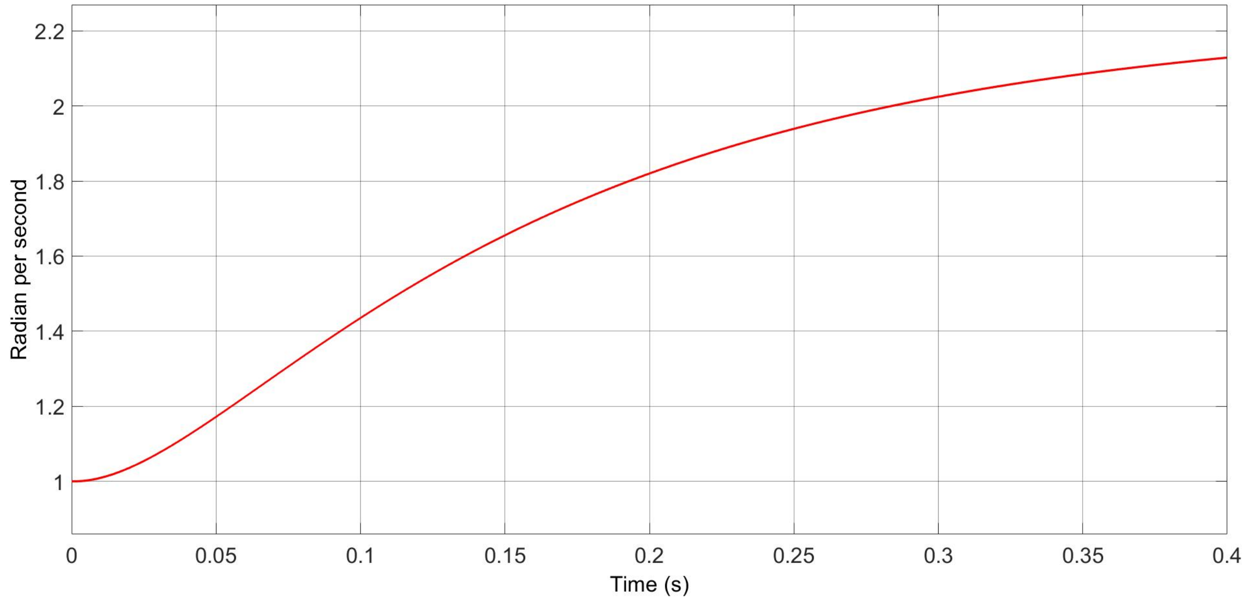

Fig-8 Speed of DC motor rad/ sec for P=10,I=50,d=100

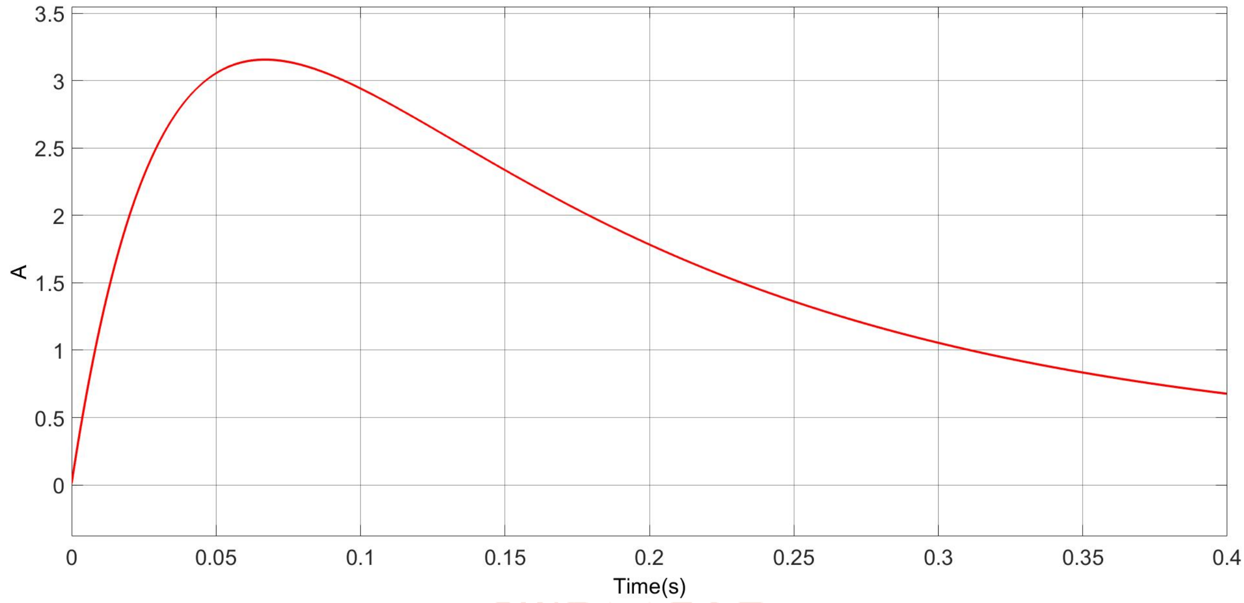

Fig-9 Armature current of DC motor rad/ sec for P=10,I=50,d=100

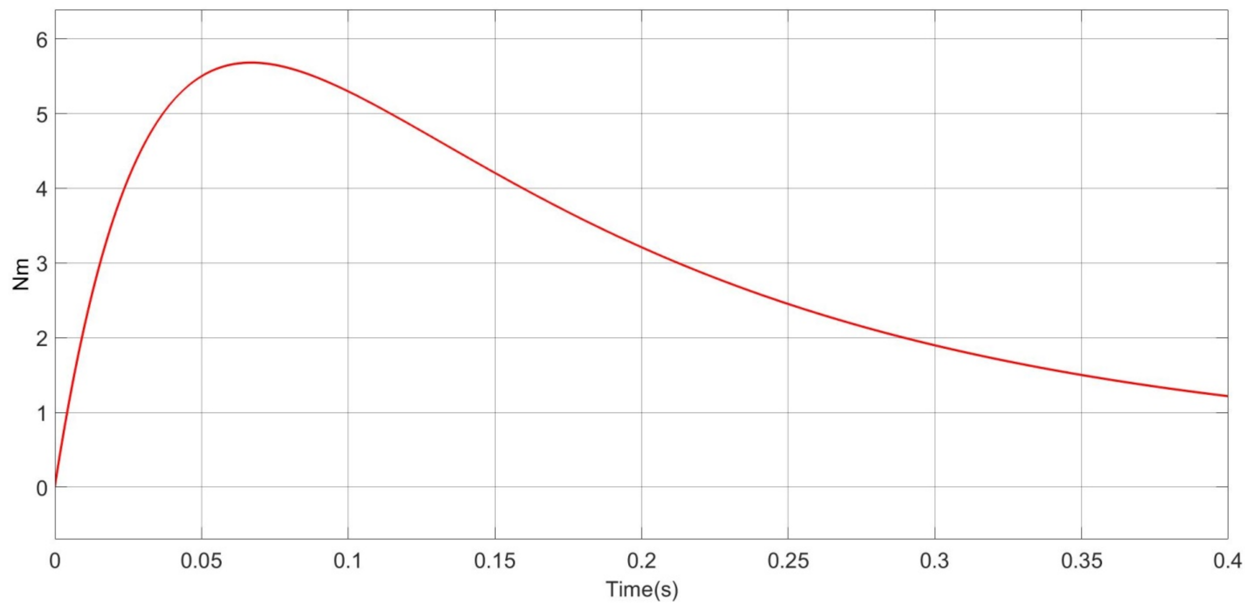

Fig-10 Torque of DC motor rad/ sec for P=10,I=50,d=100

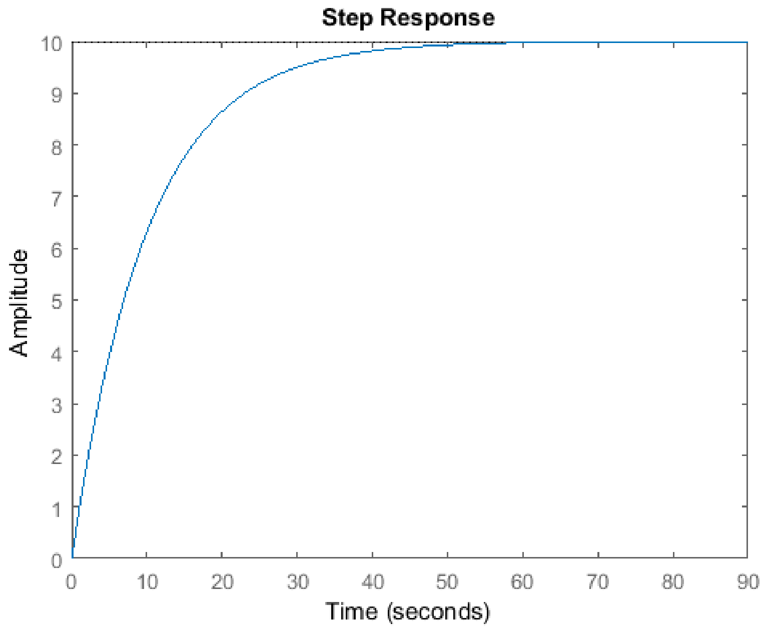

Fig-11 Step repose of DC motor

Conclusion: Accurate motor performance is a desirable feature for any industrial application. Since engine performance deteriorates with age, it is desirable to evaluate engine performance from time to time for efficient operation. The traditional way of calculating the output power index is very time-consuming. The PID-based approach algorithm performed well in the test system. Important observations made during the study are: 1) The resolution time of the proposed PID approach is only a fraction of the time required by traditional algorithms. 2) The proportional controller Kp has the effect of shortening the rise time and reducing the steady state errors, but it cannot be completely eliminated. 3) An internal Ki regulator results in the elimination of steady-state errors, but may degrade the transient response. 4) The Kd differential controller increases system stability, reduces overshoot and improves transient response. 5) The output power obtained by the normalized PID value is very close and close to accurate. 6) MATLAB, which is used to simulate the entire project, is a sophisticated and easy-to-use software. It should be noted that the efficiency of the speed algorithm can be improved by using more efficient learning techniques and dynamic weight selection algorithms. Therefore, it is important to note that the PID controller is a powerful and efficient controller that can control the open-loop speed control system under various conditions of the DC motor. The speed of the DC motor was controlled using MATLAB. The IPD response of the DC motor controller was verified in MATLAB.

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