Design and Simulation of DC speed regulation system

Yinhuan Li

School of North China Electric Power University, Baoding 071000, China

18730217961@163.com

Abstract

As we all know, compared with AC speed regulation system, DC speed regulation system has a high speed regulation accuracy, a wide range of speed regulation, and a simple converter control. It has long been dominant in speed regulation drive. DC electric drive is generally used in the occasions requiring high speed regulation performance. At present, through the control of motor, the new electric drive automation technology, which converts electric energy into mechanical energy and then controls the working machinery to run according to the given motion law and make it meet the specific requirements, has been widely used in various fields of national economy. Double closed-loop DC speed regulation system is the most widely used DC speed regulation system with good performance. By using this system, excellent static and dynamic speed regulation characteristics can be obtained. The control law, performance characteristics and design method of this system are the important basis of various AC and DC electric drive automatic control systems.

Keywords

DC motor; Adjust speed; matlab.

1. Introduction

DC speed regulation is an early technology in modern electric drive automatic control system. At present, DC speed regulation system is still the main form of automatic speed regulation system, which is widely used in many industrial sectors, such as steel rolling, mining, textile, paper making and other occasions requiring high-performance speed regulation. However, the traditional double-closed-loop DC motor speed control system mostly adopts the conventional PID control technology with simple structure and relatively stable performance. In the actual drive control system, the parameters of the motor itself and the driving load (such as the moment of inertia) do not remain unchanged as the model, but in some specific situations will follow the working conditions. At the same time, the motor as the controlled object is non-linear, and many driving loads contain non-linear factors such as clearance or elasticity. Therefore, the parameters of the controlled object are changed or the non-linear characteristics make the linear constant parameter PID controller often neglect one another.

2. Construction of Open-loop DC Speed Regulation System

2.1 Parameter calculation[1]

The average out-of-control time Ts of three-phase bridge rectifier circuit is equal to 0.00167s.

Amplification factor of three-phase bridge rectifier circuit is calculated:

$$K_s = \frac{\Delta U_d}{\Delta U_c} = 6 \times \frac{1.35 \times 380 \times (\cos 0^0 - \cos 180^0)}{180} = 34.2$$

The setting values of motor parameters are as follows : rated voltage and excitation voltage UN=Uf=220V, rated load torque TLN=50N*m, overload coefficient A=1.5, armature resistance Ra=0.6, armature inductance La=0.012H, total mechanical inertia J=0.2kg*m2, shaft viscous friction coefficient Bm=0.02N*m*s, and other parameters are set as shown in Fig. 1.

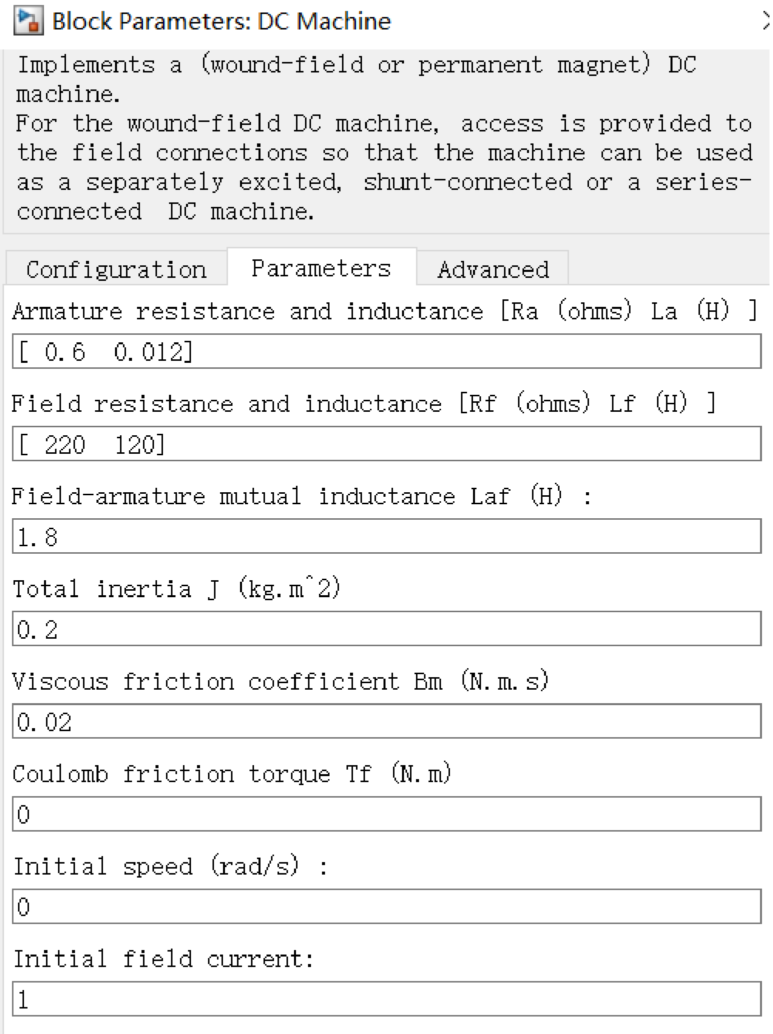

Fig. 1 DC motor parameter setting

The rated speed and rated current of the motor can not be obtained directly. It is necessary to use oscilloscope to observe the simulation results to get the required data. The simulation results of open-loop system are shown in Fig. 2.

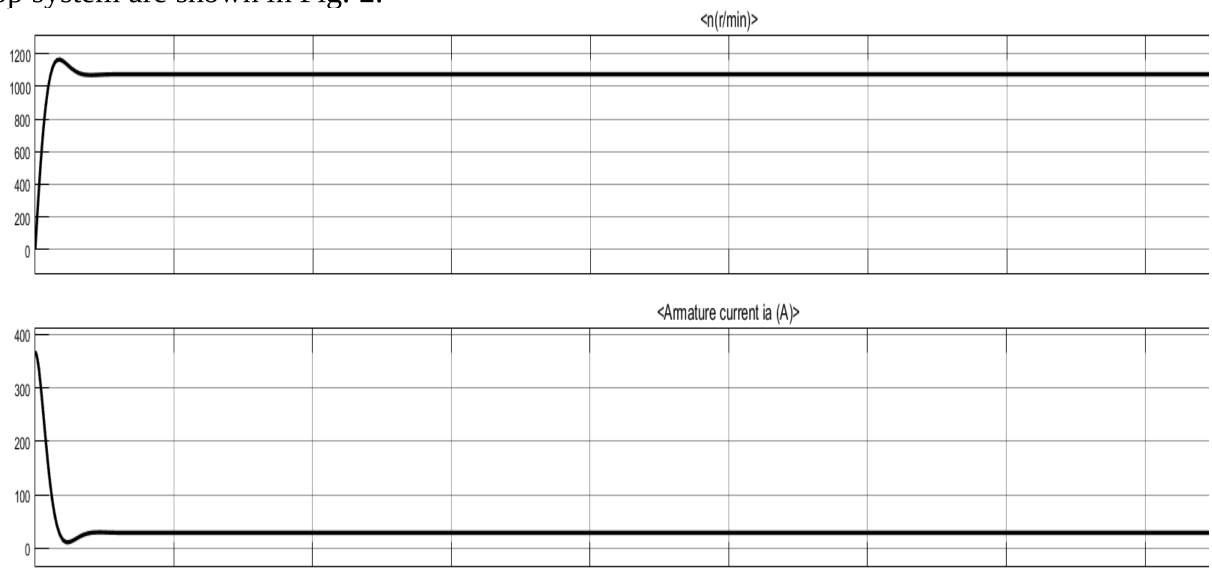

Fig. 2 Open-loop simulation results of speed control system

2.2 Modeling

The open-loop DC speed regulation system consists of DC motor and controllable DC power supply. The characteristic is that by controlling the input signal of the adjustable DC power supply, the armature voltage of the DC motor can be continuously adjusted, and the smooth speed regulation of the DC motor can be realized. However, when starting or large-scale step-up, the armature current may exceed the rated current of the motor, may damage the motor, and may cause the overcurrent of the DC adjustable power supply to burn up. Therefore, we must try to limit the amplitude of armature dynamic current. The rated speed drop of the open-loop system is generally large, which makes the speed range D of the open-loop system very small, and most of the production machinery that need speed regulation can not meet the requirements. Therefore, the closed-loop feedback control method must be adopted to reduce the rated dynamic speed drop in order to increase the speed range. Open-loop system has static error for load disturbance. Closed-loop feedback control must be used to eliminate disturbance statics. Its simulation model is shown in Fig. 3:

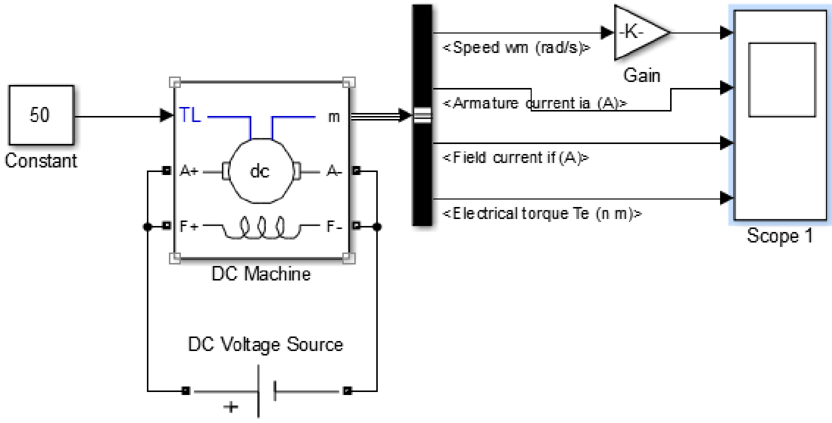

Fig.3 Simulation Model of Open-loop DC Speed Regulation System

3. Construction of Double Closed Loop DC Speed Regulation System

3.1 Parameter calculation

After consulting the data, it is found that the filtering time constant of speed feedback link is Ton=0.005s, the ASR limiting range is [-10,10], and h=5[2].

$$C_e\phi = \frac{U_N - I_N R_a}{n_N} = \frac{220-29\times 0.6}{1075} = 0.1885$$

The speed feedback coefficient is calculated as follows:

$$\alpha = \frac{U_m^*}{n_N} = \frac{15}{1075} = 0.014$$

The time constant of the rotating speed ring is calculated:

$$T_{\Sigma n} = 2T_{\Sigma i} + T_{on} = 2\times 0.0037 + 0.005 = 0.0124s$$

The open-loop amplification factor of the rotating speed ring is calculated:

$$K_N = \frac{h+1}{2h^2 T_{\Sigma n}{}^2} = \frac{5+1}{2\times 5^2 \times 0.0124^2} = 780.437$$

However, the I calculated here has been simplified several times, and the error is very large if it is used in practice. Therefore, the I parameter in the PID must use empirical value here. After many experiments, I = 5.5[3] was finally selected. The parameters of ASR are set as shown in Fig.4:

Fig.4 ASR parameter setting

3.2 Modeling[4]

The double closed-loop DC speed regulation system consists of "DC motor"+ "controllable DC power"+ "current feedback loop"+ "speed feedback loop". After setting the parameters according to 4.3.1, the model is shown in Fig.5.

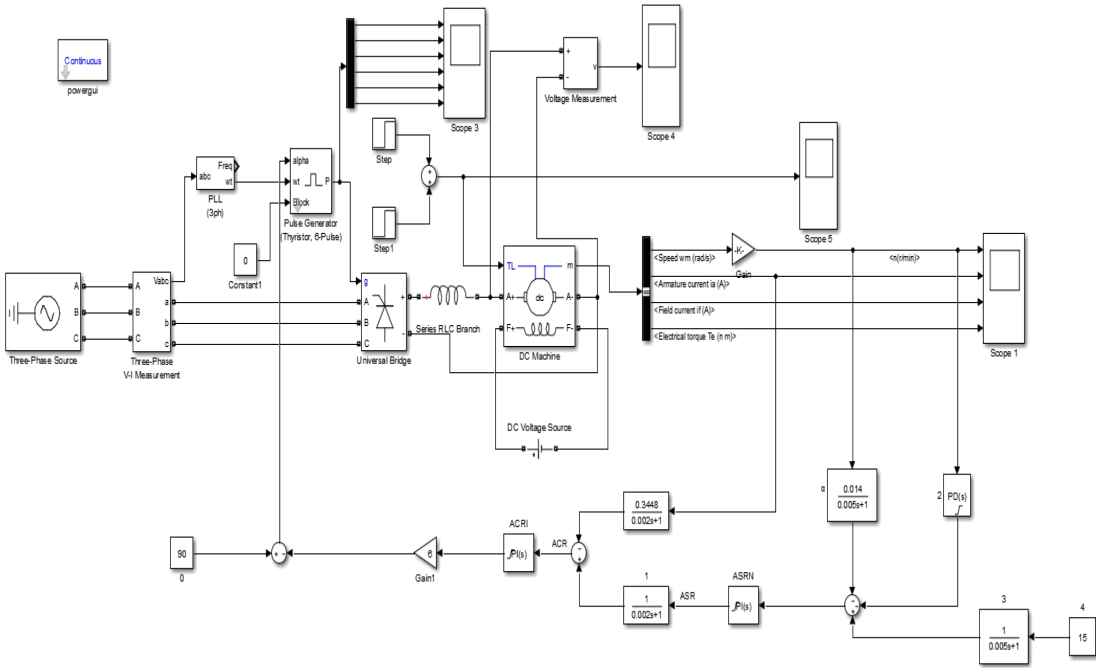

Fig.5 Simulation Model of Double Closed Loop DC Speed Regulation System

4. Experimental result[5]

4.1 Speed and Current Waveform of Open-loop DC Speed Regulation System

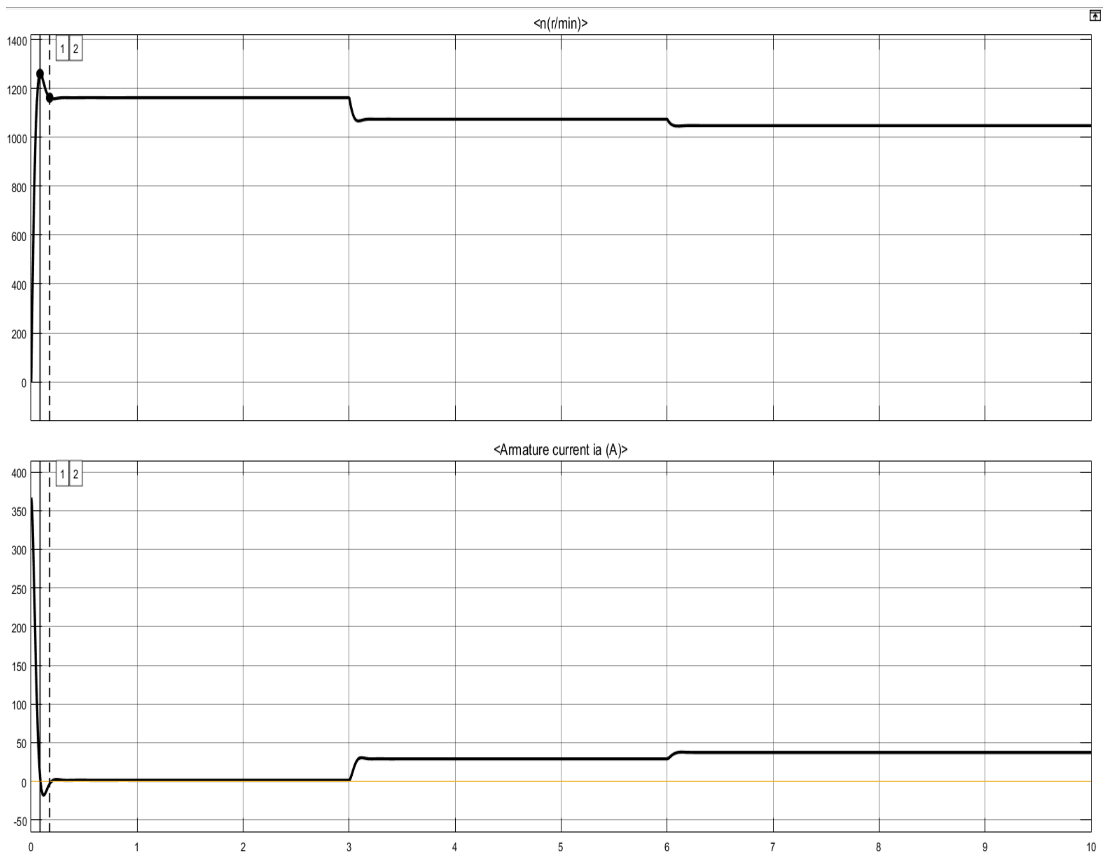

Fig.6 Waveform and Speed Data of Open-loop DC Speed Regulation System

4.2 Waveform of Double Closed Loop DC Speed Regulation System

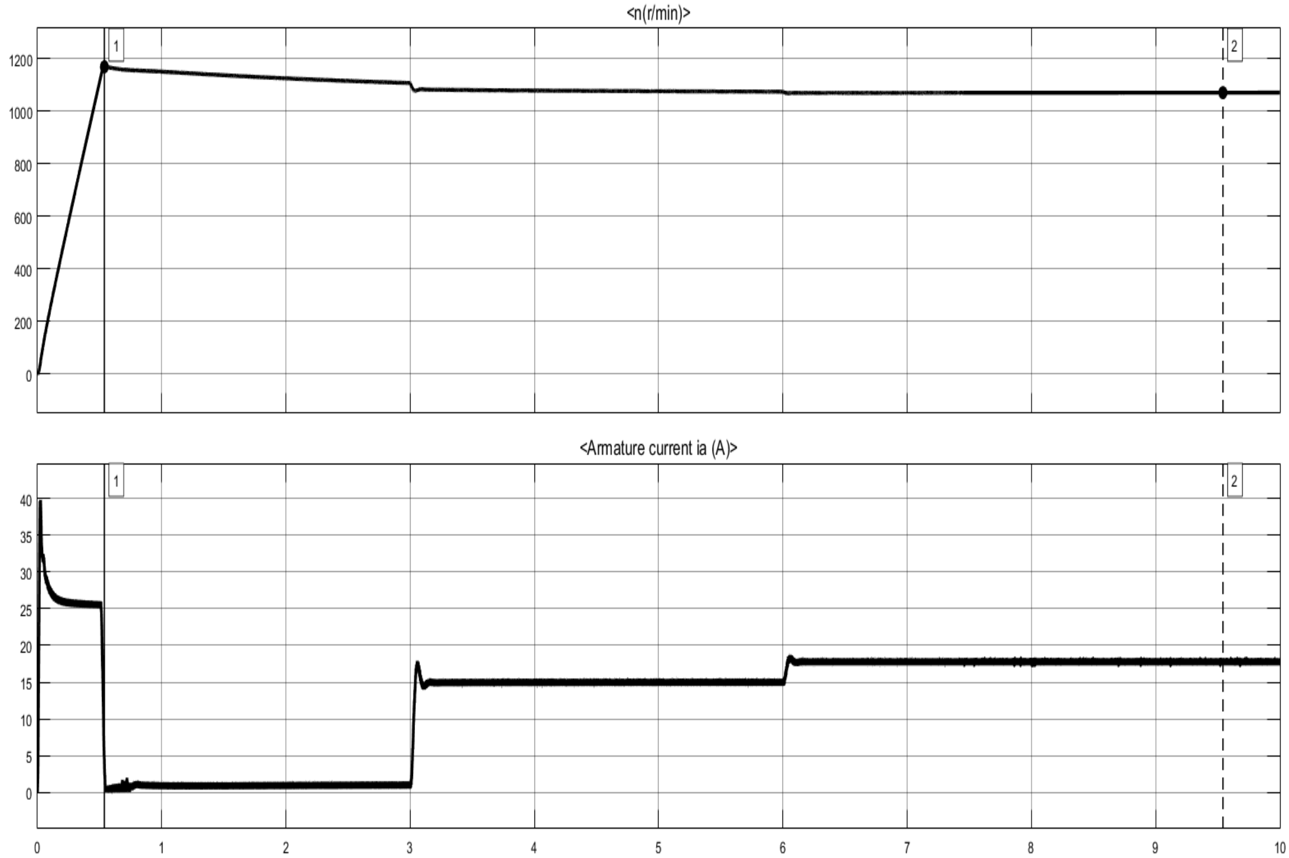

Fig.7 Waveform and Speed Data of Double Closed Loop DC Speed Regulation System

5. Summary

In the design of double closed-loop DC speed regulation system, the choice of parameters has always been very distressing to me. Initially has been blind, resulting in poor waveform, after the teacher's instructions to clear the direction: first of all, to adjust the current loop, so that the starting process of the current basically remains the maximum current unchanged. Through exploring with my classmates, I found that the book "Electric Drive Automatic Control System: Motion Control System" edited by Mr. Chen Boshi has all the formulas for calculating the parameters we need. According to the formula explained in this book, I calculated all the parameters such as the feedback coefficient of current and speed, filter time constant, and determined the values of P and I in PI regulator according to these parameters. The parameters provided in the book are based on the ideal model which has been greatly simplified, with some errors, and the simulation results are sensitive to the I parameters, so the initial results are very poor. Knowing this, I kept experimenting near the calculated value of parameter I, and finally got a more suitable parameter value. After bringing it into the model simulation, it was found that the result was greatly improved, and was encouraged and praised by the teacher.

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