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Simulink simulation of DC motor

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***Abstract* — In the first part, we will describe the basic properties of a DC motor. Subsequently, using known and measured engine features, we create a DC motor model in Simulink. In the last part we compare the measured values of the engine with the values obtained by the simulation. The first simulation will be used to simulate other processes that will use the DC motor.**

***Keywords* — DC motors, Matlab, Simulink, encoder, induction**

I. Introduction

The DC motor is often used in practice. In our case, the DC motor is used as a friction spindle. We need a suitable engine model to calculate the heat generated by the engine. The largest amount of the heat in the DC motor is generated by current passing through the motor winding. Since the current value depends on the load, it is necessary to know the operation of the DC motor at different loads. The goal is to develop an accurate model of the DC motor which will be used to predict the value of the supply current.

II. Measurement of DC motor features

Fig. 1 shows a DC motor with a permanent magnet. This engine is used as a spindle CNC milling machine. During the milling operation, the DC motor feed current has a variable value. It depends on the amount of milled material, feed rate and the properties of the material that is machined by milling and also the properties of the machine tool. These parameters change the spindle feed current values during milling. Before starting to deal with these properties, it is necessary to create a simulation model with specific engine parameters that can predict the current value during constant load.

Fig. 1 DC motor

The basic features of the engine include winding resistance, winding inductance, inertia torque constant and back-EMF constant. When creating a model, we have several options for defining its parameters. We will design the model in Matlab Simulink software. We will discuss the possibilities of model definition in the chapter: simulation in Simulink. Now we will focus on measuring the basic unknown parameters of our engine.

One of the parameters we needed to find is the rotor inductance. We used the LCR meter to measure inductance and resistance. We have measured the inductance of the rotor by another indirect measurement. The inductance measurement is shown in Fig. 2. We engage motor winding in to series with the capacitor, thus we created a series RLC circuit which we excite by H-bridge. By gradually changing the frequency, we found a resonant frequency. In resonance, the voltage on the capacitor and on the coil is shifted about 180 °. This means that the voltage of both components in the circuit is compensated. In resonance, the circuit behaves as if it contained only a resistive component.

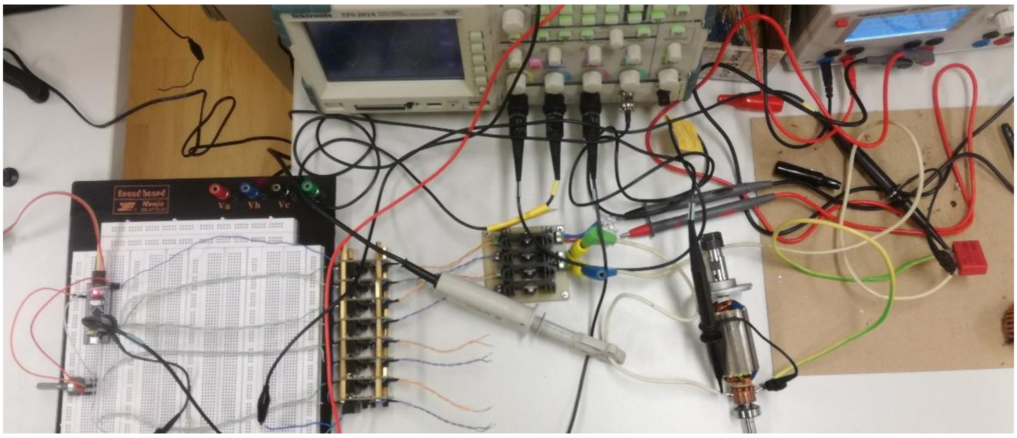

Fig. 2Measuring of the resonant frequency

Subsequently, after determining the resonance frequency, we have only one unknown L from the equation for calculating the resonant frequency (1), which represents the motor rotor inductance. After expressing L from equation (1) we obtained the formula to calculate the winding inductance (2). After entering the measured values we determined the value of the inductance.

$$f_r = \frac{1}{2\pi\sqrt{LC}} \tag{1}$$

$$L = \frac{1}{4\pi^2\, C f_r^2} \tag{2}$$

Measured values by LCR meter: $L=533\mu H$, $R=3{,}299\Omega$, $C_r=998nF$
Inductance calculated by resonant frequency: $L_r=533{,}756\ \mu H$

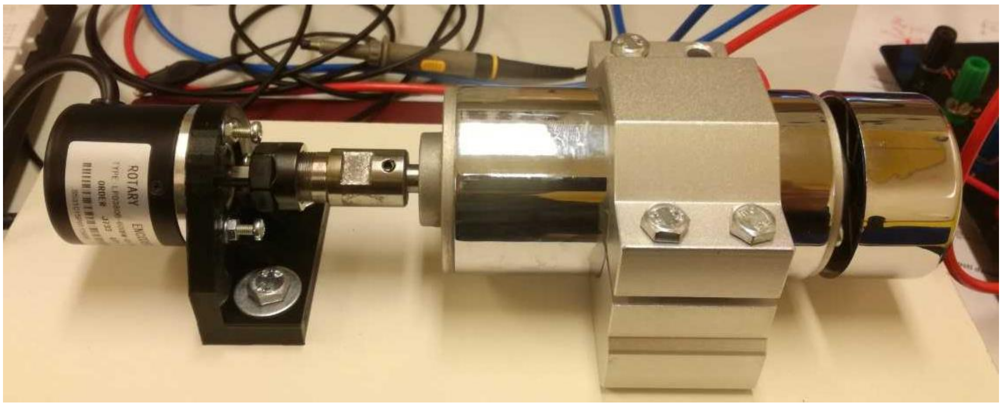

Fig. 3 Motor with encoder

Fig. 3 shows a motor speed measuring device. Measurements have been performed using an encoder that generates 600 pulses per revolution. By measuring the frequency of the pulses and the following mathematical conversion, we found the revolutions per minute. Measurements were made at different supply voltage values, with current and speed values measured without engine load. The measured motor values are shown in Fig. 6, which shows the comparison of the measured values with the simulation.

III. Simulation in Simulink

The main part of the simulation in Simulink is the block of DC Motor which represents our spindle. When we want to parameterize a block, we can choose between: *By equivalent circuit parameters*, *By stall torque & no-load speed*, *By rated power*, *rated speed & no-load speed*. We chose the method By stall torque & no-load speed. By this method of parameterization it is necessary to define the parameters that you can see in Fig. 4. The value we obtained from the manufacturer or from our measurements.

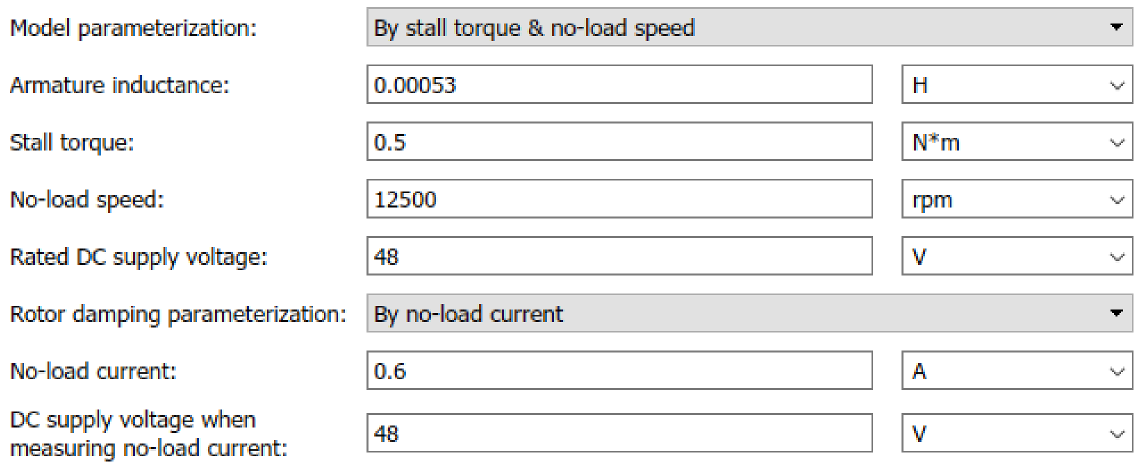

Fig. 4 Parameterization of block DC motor

In Fig. 5, we can see the connection of all the Simulink blocks we used in the simulation. The Block DC motor is powered by a controlled DC voltage source. Next, we have a voltmeter and an ammeter plugged in to determine the values of the power quantities and the probes that plot their waveforms. Simulation simulates engine without load. Block Load Torque presents the load generated by the fan that is part of the engine and torque that needs to be done to spin the encoder.

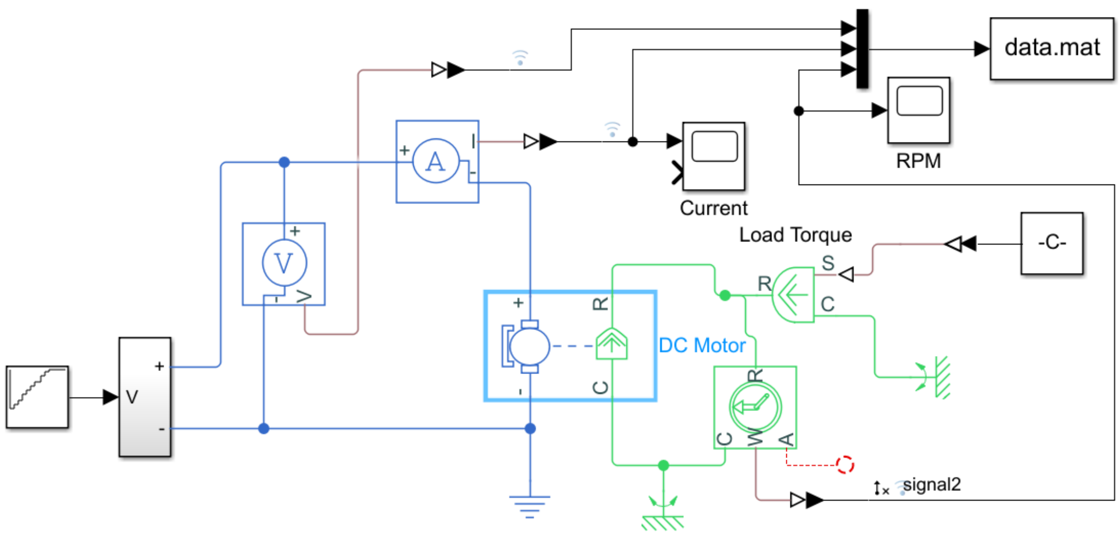

Fig. 5 Simulation model in Simulink

By simulation, we measure the values of the supply current, voltage and motor output speed. The measurement in the simulation is performed by the same values of the supply voltage as in the real measurement. This ensures that the power supply is changed automatically and that data is collected automatically using the *data.mat* block. All data obtained by the simulation are stored in a matrix in Matlab. Subsequently, an m-file was created in Matlab, which provides automatic comparison of simulated and measured engine properties that you can see in Fig. 6.

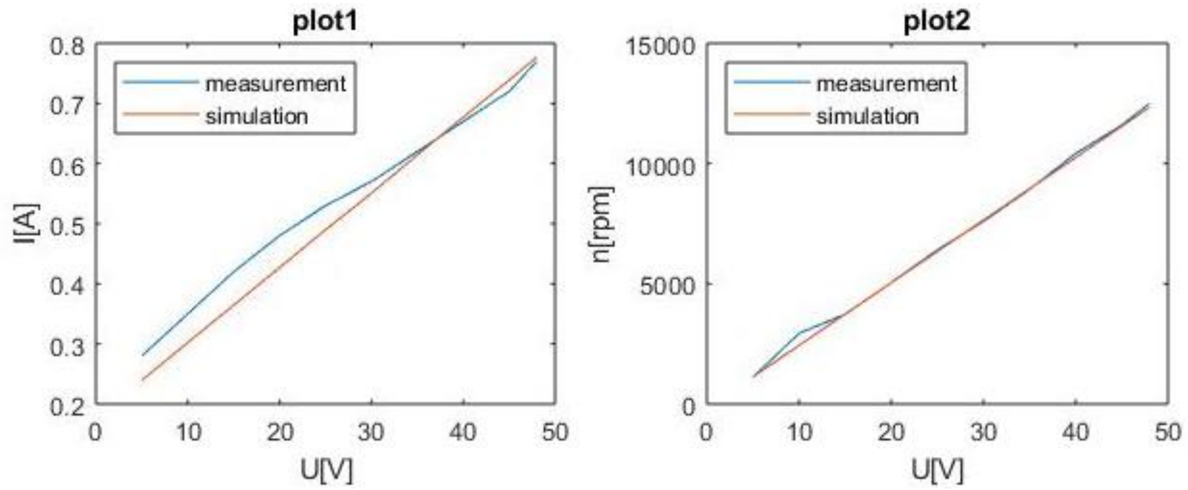

Fig. 6 Comparison of measured data

IV. Conclusion

By comparing the simulated and measured waveforms, we can assert that the model is in good agreement with real DC motor. By creating a model with identical engine parameters, we have developed a suitable tool to implement other engine applications, including the creation of a PID controller for the engine, a model for predicting engine heating, and many other applications that need to know engine characteristics.

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