

Ministry of Education and Science of Russian Federation  
Federal State Autonomous Educational Institution of Higher Education  
Tomsk Polytechnic University  
Institute of Power Engineering

Electrotechnical  
Complexes and Materials  
Department

## **REPORT**

### **Laboratory session 2 TESTING OF SHUNT WOUND DIRECT CURRENT MOTOR**

Student - \_\_\_\_\_, group - \_\_\_\_\_,

I certify that my answers here are my own work, and that I have appropriately acknowledged all external sources (if any) that were used in this work.

Signature \_\_\_\_\_, date \_\_\_\_\_.

Consultant - \_\_\_\_\_, position - \_\_\_\_\_,

Signature \_\_\_\_\_, date \_\_\_\_\_.

Tomsk – 2014

### **Purpose of laboratory session**

The purpose of the given work is to study construction and working principle of the shunt wound direct current motor, to carry out experiments under load and obtain working performance, speed torque characteristics while armature resistance and field current vary.

### **Operating program**

1. To examine the working principle of the shunt direct current motor and to classify the types of direct current machines.
2. To define the laboratory unit.
3. To start the shunt direct current motor.
4. To make experiment of load test and build characteristics.
5. To calculate speed torque characteristics while armature resistance vary.
6. To provide experiment while field current vary and build speed current characteristics.
7. To analyze the motor characteristics under load test and make conclusions.

### **Self-instruction**

Direct current motor – *(give the definition)* \_\_\_\_\_

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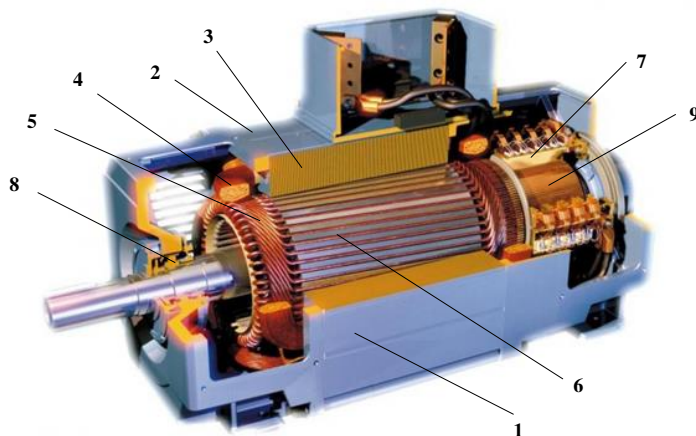
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Direct current motor consists of following main components *(write title, purpose and material)*:

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_

According to the fig. 1 name all components of direct current motor:



1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_
7. \_\_\_\_\_
8. \_\_\_\_\_
9. \_\_\_\_\_

Fig. 1. Construction of the direct current motor

The working principle of direct current motor is based on \_\_\_\_\_

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The voltage equation of direct current motor:

where 
$$\text{_____} = \text{_____},$$
  
$$\text{_____} - \text{_____},$$
  
$$\text{_____} - \text{_____},$$
  
$$\text{_____} - \text{_____},$$
  
$$\text{_____} - \text{_____},$$
  
$$\text{_____} - \text{_____},$$

The main construction differences between induction motors with squirrel-cage and wound rotors are the following:

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The direct current motor starting methods are the following:

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_

The induction motor speed changing methods are the following:

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_

The idle running of shunt direct current motor is \_\_\_\_\_

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To idle running losses could be included following \_\_\_\_\_

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The short circuit test of shunt direct current motor is \_\_\_\_\_

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To short circuit losses could be included following \_\_\_\_\_

\_\_\_\_\_

The load test of shunt direct current motor is \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

The armature reaction in the direct current motor is: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

To reduce the armature reaction effects and to improve the machine's performance, following methods are used: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Commutation in direct current motor is: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

To improve the commutation in direct current motors following methods are used: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Methods of direct current machines excitation are the following:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Draw the energy flow diagram of shunt direct current motor and make all necessary notes.

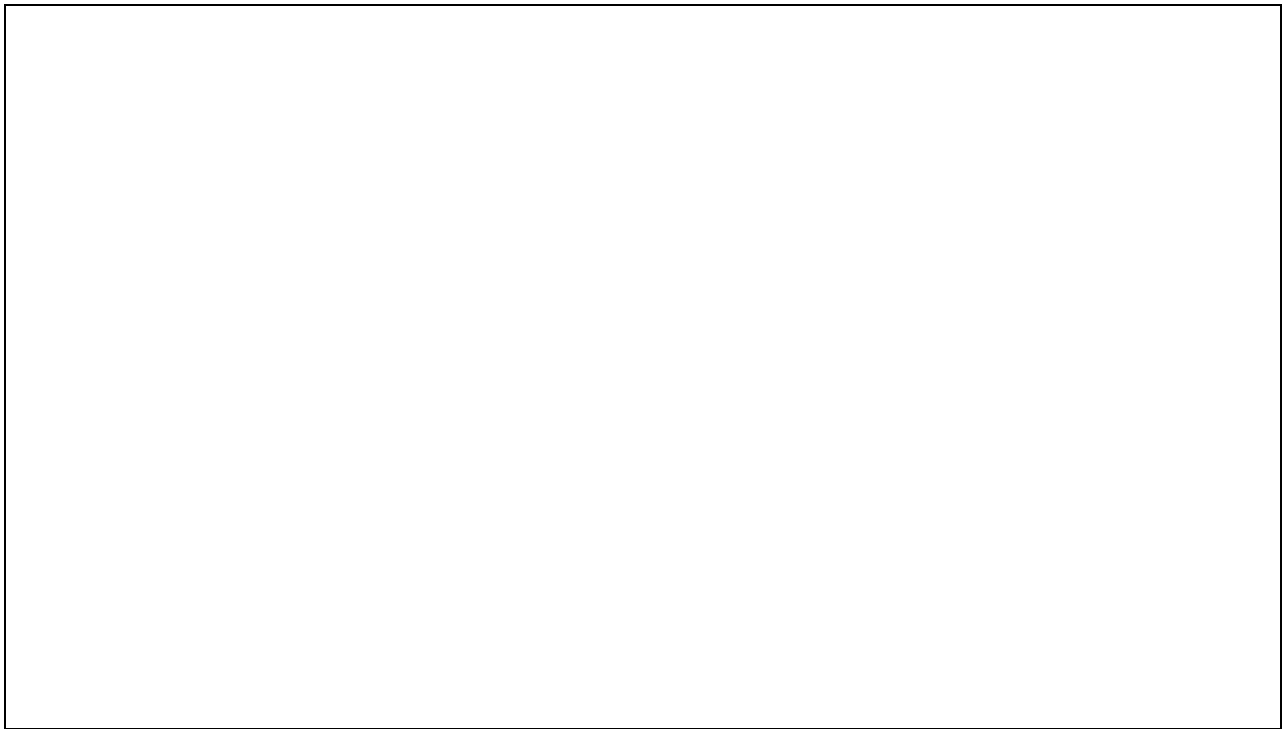


Fig. 2. Energy flow diagram of the shunt direct current motor

Fig. 2. Notes \_\_\_\_\_

\_\_\_\_\_  
 \_\_\_\_\_

The efficiency of the shunt direct current motor is \_\_\_\_\_

\_\_\_\_\_  
 \_\_\_\_\_

where  $\eta = \frac{\text{_____}}{\text{_____}}$ ,  
 \_\_\_\_\_ - \_\_\_\_\_,  
 \_\_\_\_\_ - \_\_\_\_\_.

**Testing of the shunt direct current motor**

**Caution! When actual equipment is used, high voltages may be present. NEVER make or modify any connection with the power ON unless otherwise instructed.**

**Starting of the shunt direct current motor**

In fig. 3 the physical arrangement of a shunt direct current motor testing is presented, where M is the tested shunt direct current motor; Q1 – motor starting switch;  $R_1$  – resistor connected to the field winding of the tested motor;  $R_2$  – starting resistor or external resistance  $R_{ext}$  of the tested motor; G – load generator; Q2 – switch of the load generator;  $R_3$  – load resistor;  $R_4$  – resistor in the field winding of the load generator; BR - tachogenerator; FW.M – the field winding of the tested motor; FW.G – field winding of the load generator.

Before turning the module ON make sure that:

1. The load resistor  $R_3$  is switched off, as motor should be started under idle running mode.
2. The resistor connected to the field winding of tested motor  $R_1$  is in the “minimum” position that will give the maximum value of field current and magnetic flux and thus the maximum value of starting torque.
3. The starting resistor  $R_2$  or external resistance  $R_{ext}$  of the tested motor is in the “maximum” position, that will give the minimum value of starting current of the motor

After all mentioned starting requirements are fulfilled you may turn the module ON. To obtain idle running point turn the external resistance adjustment knob  $R_2$  in the “minimum” position that conclude the starting process.

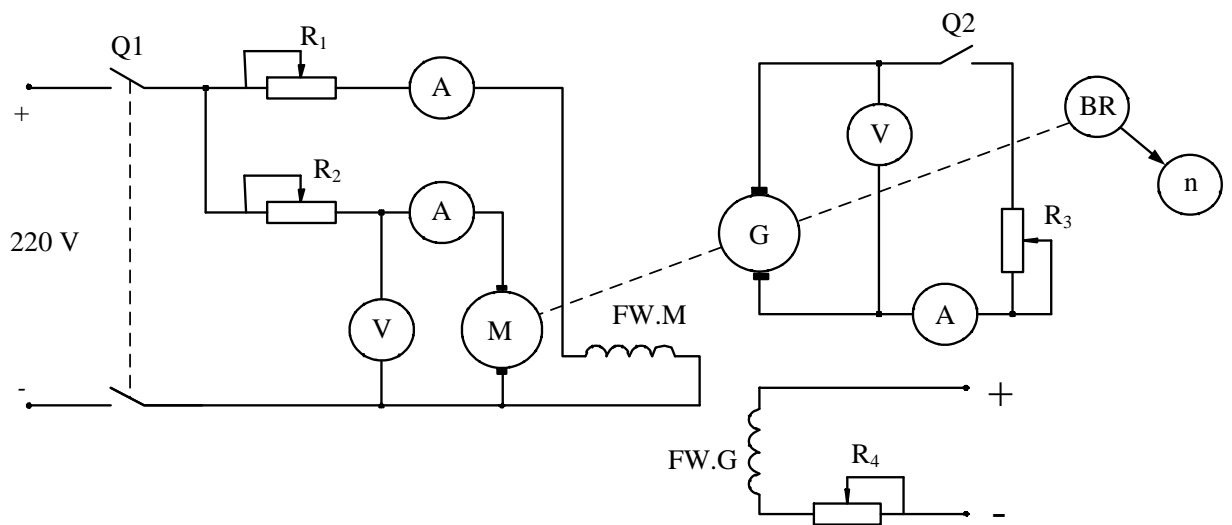


Fig. 3. Physical arrangement

### Working performance and speed torque characteristics of shunt direct current motor

Working performance characteristics of the direct current motor are the dependences between motor armature current  $I_{am} = f(P_{out.m})$ , input power of the motor  $P_{in.m} = f(P_{out.m})$ , motor torque  $M = f(P_{out.m})$ , motor efficiency  $\eta = f(P_{out.m})$ , motor speed  $n = f(P_{out.m})$  and output power of the motor  $P_{out.m}$  when supplied voltage  $U = U_{rated}$ ,  $I_{fm} = I_{fm.rated} = const$  are remain the same during the test.

The experiments are carried out for three values of the resistance  $R_{ext} = 0, R_{ext1}^* > R_{ext}$  and  $R_{ext2}^* > R_{ext1}^*$ . The required value of armature resistance adjusted by resistance  $R_2$  in the armature winding of tested motor.

The first point of each of three characteristics is obtained when motor is under idle running mode, so load resistor  $R_3$  is switched off, and then by adjusting load resistor  $R_3$  other necessary curve points could be defined. According to the results presented in table 1 provide all necessary calculations and build working performance and speed torque characteristics of the motor.

Test results are the following:  $I_{am}$  – armature current of the tested motor,  $n$  – speed of the tested motor,  $U_g$  – generated voltage of load generator,  $I_{ag}$  – armature current of the load generator,  $I_{fm}$  – field current of the tested motor,  $U_m$  – voltage supplied to the tested motor.

Calculation results are the following:  $P_{out.g}$  – output power of the load generator,  $\eta_g$  – efficiency of the load generator,  $P_{in.m}$  – input power of the tested motor,  $P_{out.m}$  – output power of the tested motor,  $\eta_m$  – efficiency of the tested motor,  $M_{out}$  – output torque of the tested motor,  $M$  – output electromagnetic torque of the tested motor.

Table 1.

№	Experiment				Calculation							Notes
	Motor		Generator		Generator		Motor					
	$I_{am}$	$n$	$U_g$	$I_{ag}$	$P_{out.g}$	$\eta_g$	$P_{in.m}$	$P_{out.m}$	$\eta_m$	$M_{out}$	$M$	
	A	rpm	V	A	W	pu	W	W	pu	Nm	Nm	
1												$M_0 = Nm$ $I_{fm} = A$ $R_{ext} = 0$
2												
3												
4												
5												
6												
1												$M_0 = Nm$ $I_{fm} = A$ $R_{ext}^* > R_{ext}$
2												
3												
4												
5												
6												
1												$M_0 = Nm$ $I_{fm} = A$ $R_{ext}^* > R_{ext1}$
2												
3												
4												
5												
6												

The example of calculations should be provided for one operational point ( ).

The output power of the load generator defined by:

$$P_{out.g} = U_g \cdot I_{ag} = \quad W.$$

The output power of the tested motor is:

$$P_{out.m} = P_{in.g} = \frac{P_{out.g}}{\eta_g} = \quad W,$$

where  $P_{in.g}$  – the input power of the load generator,  $\eta_g$  - efficiency of the load generator, obtained from the efficiency curve on the fig. 4, where  $P_{out.rated} = 1000 W$ .

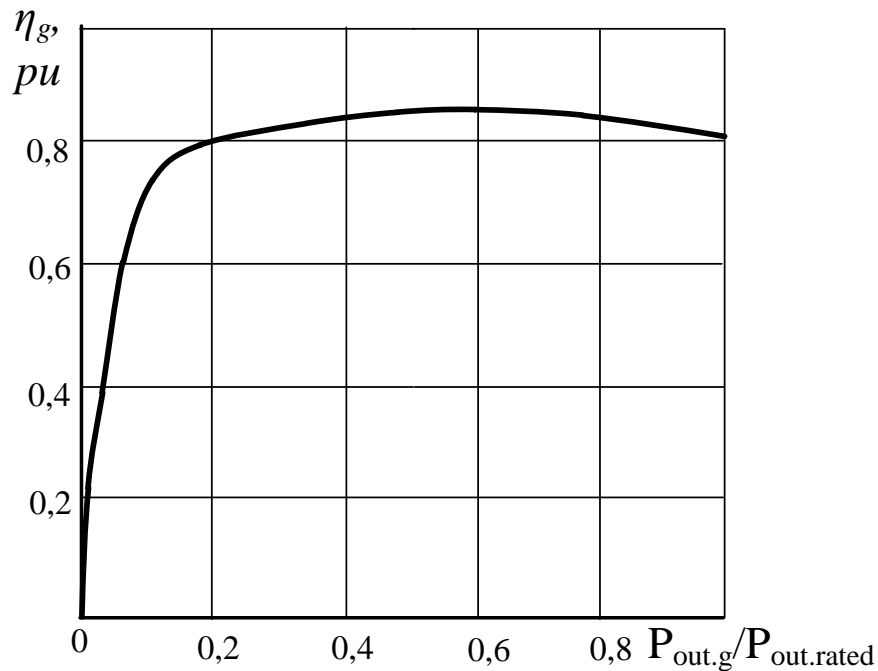


Fig. 4. Efficiency curve of the load generator

The input power of the motor is:

$$P_{in.m} = U_m \cdot (I_{am} + I_{fm}) = \quad = \quad W,$$

where voltage supplied to the tested motor  $U_m = 220 V$ .

Efficiency of the motor is calculated by the formula:

$$\eta_m = \frac{P_{out.m}}{P_{in.m}} = \quad = \quad pu.$$

Output torque of the tested motor is:

$$M_{out} = 9,55 \cdot \frac{P_{out.m}}{n} = \quad = \quad Nm.$$

Idle running torque of the motor equals to:

$$M_0 = 9,55 \cdot \frac{P_0}{n_0} = \quad = \quad Nm,$$

where  $P_0$  and  $n_0$  input power and speed of the motor under idle running mode.

Thus output electromagnetic torque of the tested motor is:

$$M = M_{out} + M_0 = \quad = \quad Nm.$$

According to the results presented in table 1 build a working performance characteristic under the mode  $R_{ext} = 0$ , speed torque characters for different starting resistance  $R_{ext}$  should be built in the same axes.



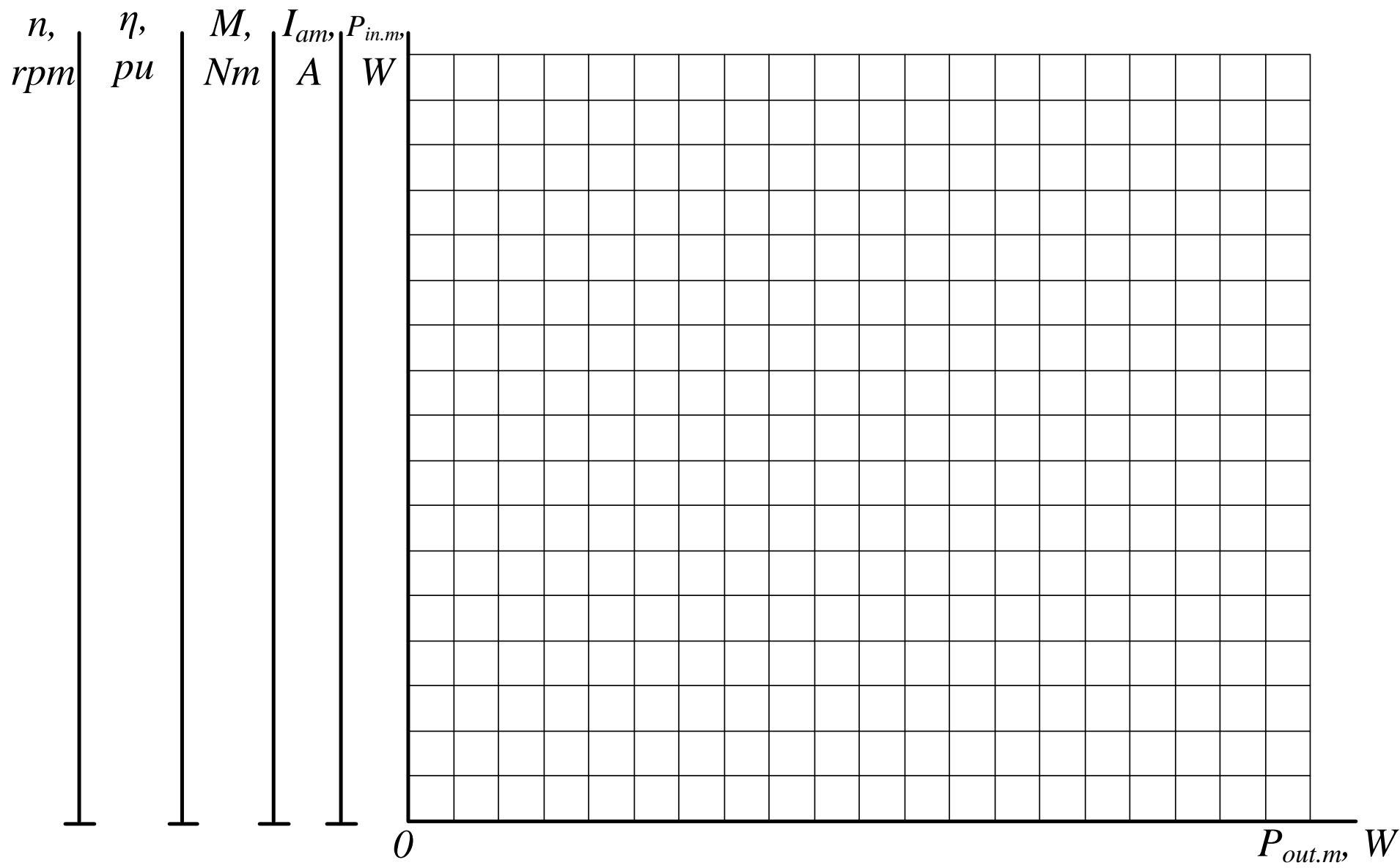


Fig. 5. Operating performance curves of direct current motor at  $R_{ext} = 0$

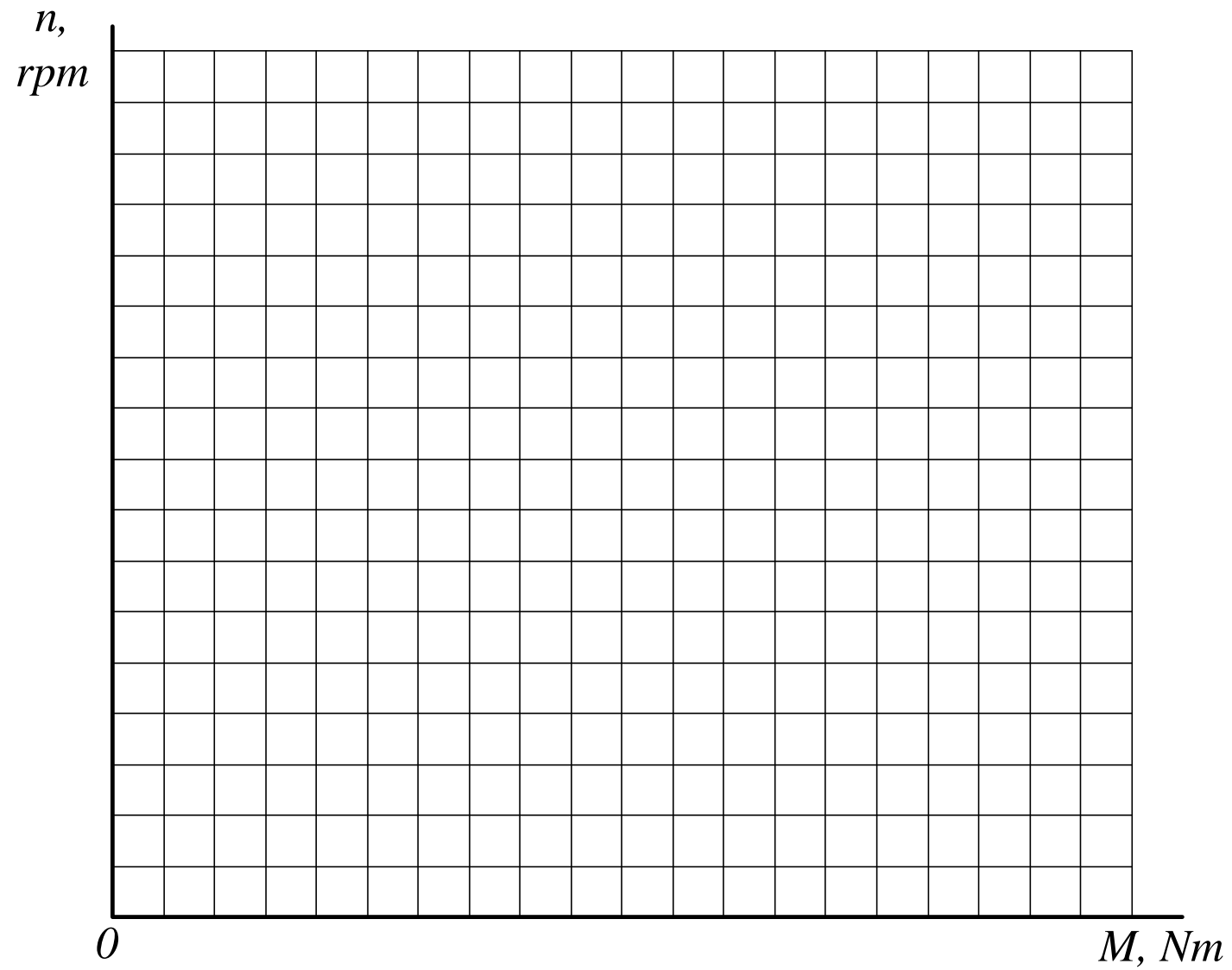


Fig. 6.

### Speed current characteristics of shunt direct current motor

Speed current characteristics of the direct current motor is the dependence  $n = f(I_{am})$ , when supplied voltage  $U = U_{rated}$ , resistance in armature circuit  $R_{ext} = 0$ ,  $I_{fm} = const$  are remain the same during the test. The experiments are carried out for three values of the field current  $I_{fm} = I_{fm.rated}$ ,  $I_{fm} = 0,8 \cdot I_{fm.rated}$  and  $I_{fm} = 1,2 \cdot I_{fm.rated}$ . The required value of motor field current adjusted by resistance  $R_1$  in the field winding of tested motor.

The first point of each of three characteristics is obtained when motor is under idle running mode, so load resistor  $R_3$  is switched off, and then by adjusting load resistor  $R_3$  other necessary curve points could be defined. According to the results presented in table 2 build a speed current characteristics for different field currents in the same axes.

Table 2.

№	$I_{am}$	$n$	Notes
	A	rpm	
1.			$U_m = \quad V$ $I_{fm} = I_{fm.rated} = \quad A$
2.			
3.			
4.			
5.			
6.			
1.			$U_m = \quad V$ $I_{fm} = 0,8 \cdot I_{fm.rated} = \quad A$
2.			
3.			
4.			
5.			
6.			
1.			$U_m = \quad V$ $I_{fm} = 1,2 \cdot I_{fm.rated} = \quad A$
2.			
3.			
4.			
5.			
6.			

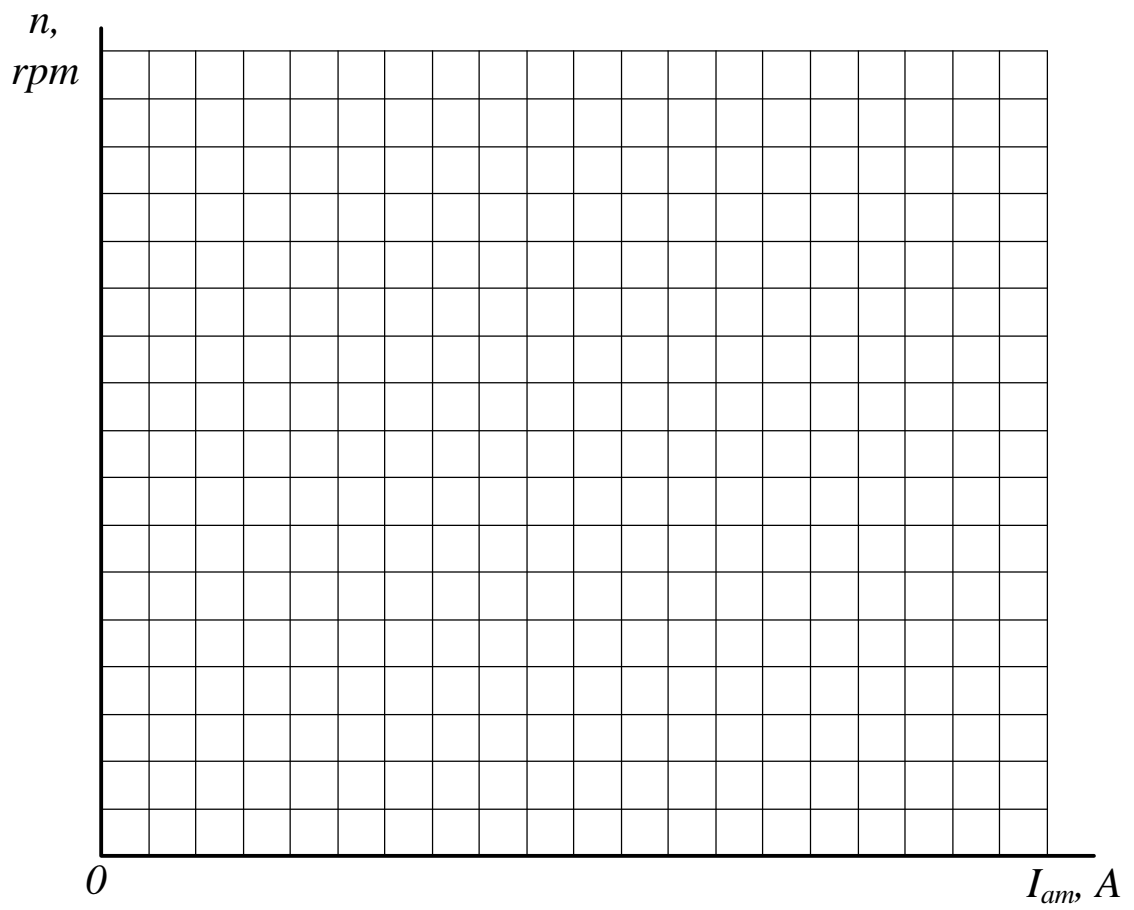


Fig. 7. Speed current characteristics of the shunt direct current motor



## References

1.

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2.

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3.

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