

Software to Research the Static Mechanical Characteristic of DC Motors

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Abstract — The present work aims to create a modern software product that can run on modern operating systems on which to draw the static mechanical characteristics of direct current motors. This software product was developed thanks to the dynamically developing object-oriented programming language – C#, and the Windows platform of Microsoft Corporation, which allows the construction of applications that run on Windows-based operating systems. Microsoft Visual Studio 2019, a product of the Microsoft Corporation range, was used as the code development environment. The creation of such a product will allow to study the characteristics of DC motors in different control modes, which will contribute to the improvement of software products in the department of electric drive, and from there students will have the opportunity to work and learn with it.

Index Terms — DC motor, mechanical characteristic, C#

I. INTRODUCTION

DC motor with separated excited

The DC motor with separated excited has an armature winding and an excitation winding, which in the general case receive power from an independent source. Figure 1 shows schematically the motor with its two windings. [1][2].

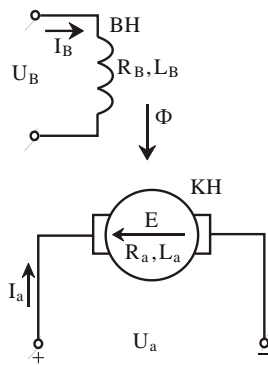


Fig. 1. DC motor with separated excited

Used symbols in this figure are:

- U_B и I_B – voltage and current on excited;
- L_B и R_B – Inductance and resistance on excited;

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- Φ – magnetic flux;
 - U_a – voltage on armature winding;
 - I_a – current on armature windings;
 - L_a и R_a – inductance and resistance on armature windings;
 - E – induced EMF (electromagnetic force).
- ($E = c\Phi\omega$, where c e construction constant, ω e angular velocity).

$$\omega = \frac{U_a}{c\Phi} - \frac{M \cdot R_a}{(c\Phi)^2} \quad (1)$$

The last expression represents the mechanical characteristic of DC motor with separated excited ($\omega = f(M)$) – this is also an equation of line in the coordinate system $\omega - M$ which shown in fig. 2.

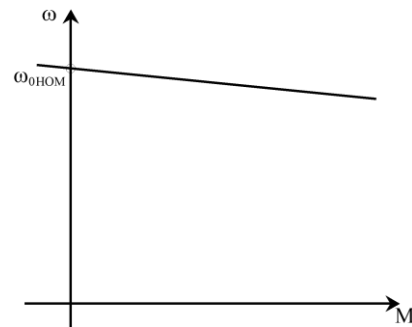


Fig. 2. Mechanical characteristic on DC motor with separated excited

DC motor with series excited

In the case of a DC motor with series excitation, the excitation winding is connected in series to the armature (Fig. 3), due to which the excitation current I_a and the magnetic flux F are determined by the current through the armature I_a , I_B from the loading of the motor shaft. Because the addition $\Phi=f(I_B)$ is nonlinear (fig. 3), a $I_B=I_a$, then the flow will change nonlinearly from the current through the armature. Then the equations that describe the processes in the motor in static mode are shown in fig. 4. [1][2].

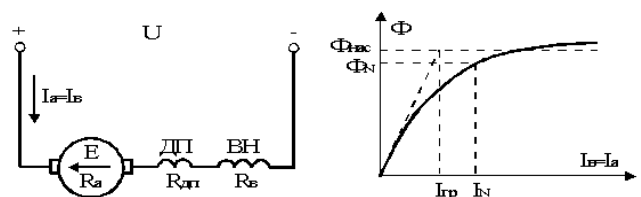


Fig. 3. DC motor with series excited

The static electromechanical ($\omega = f(I_a)$) and mechanical ($\omega = f(M)$) characteristic is shown Fig. 4.

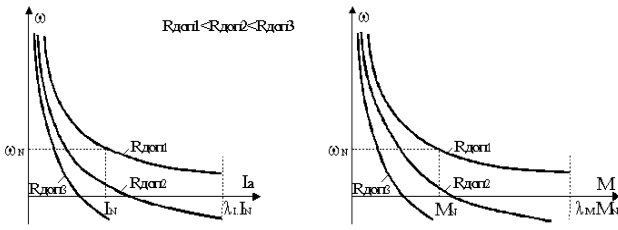


Fig. 4. Electromechanical and mechanical characteristic on DC motor with series excited

DC motor with mixed excitation

The DC motor with mixed excitation has two excitation windings – separated excited and series. Its scheme of inclusion (Fig. 5) in the motor mode of operation is realized in such a way that emf to add the two excitation windings. [1][2]. Then the total field in F in the machine will be:

$$F_B = F_{HB} + F_{ПВ} = w_{HB} \cdot I_{HB} + w_{ПВ} \cdot I_{ПВ} , \quad (3)$$

where:

- F_{HB} и $F_{ПВ}$ – are emf on excited and series winding;
- w_{HB} и $w_{ПВ}$ - number of turns on excited and series winding;
- I_{HB} и $I_{ПВ} = I_a$ – current on excited and series winding.

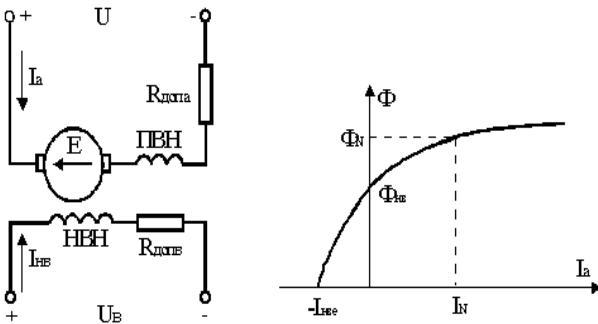


Fig. 5. DC motor with mixed excitation

The magnetic field Φ on DC motor with mixed excitation is determined by F_B , which depend on armature current I_a , and consequently from the moment of the shaft of the engine, such as at dc series motor. Due to the action of separated excited, the relation $\Phi = f(I_a)$ (Fig. 5) is differs from that of dc series, as it is displaced along the abscissa axis to the left of the beginning of the coordinate system. This dependence is determined by reducing the parameters of the separated to the number of windings of the series. [1][2].

II. BLOCK SCHEMES TO ALGORITHM

In Fig. 6. is present the block schemes to algorithm [3][4].

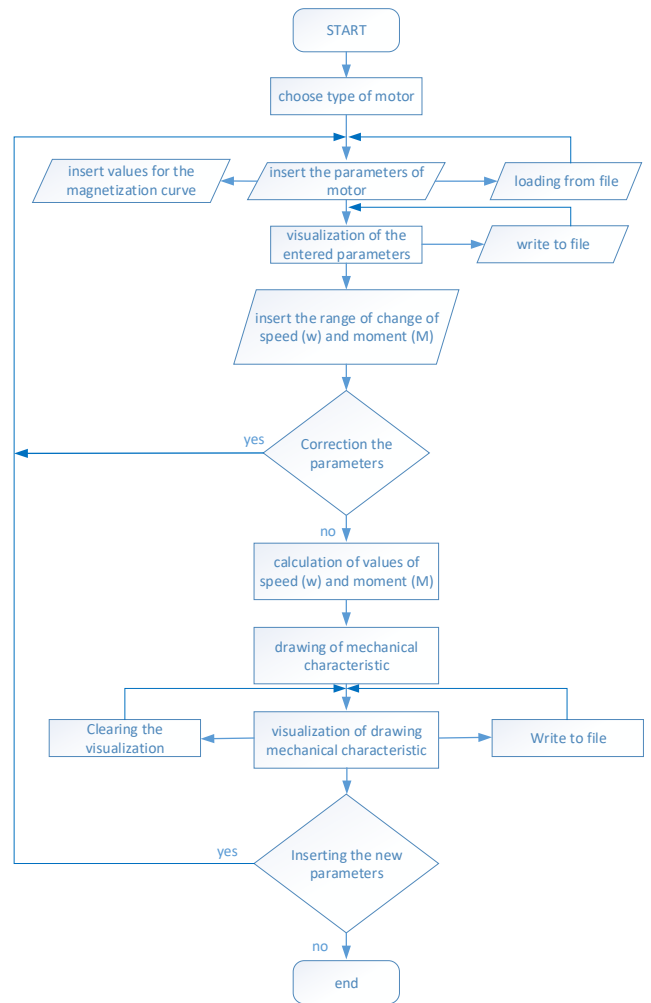


Fig. 6. Block schemes to algorithm

III. INTERFACE

Motor type selection window sis shown on fig. 5.

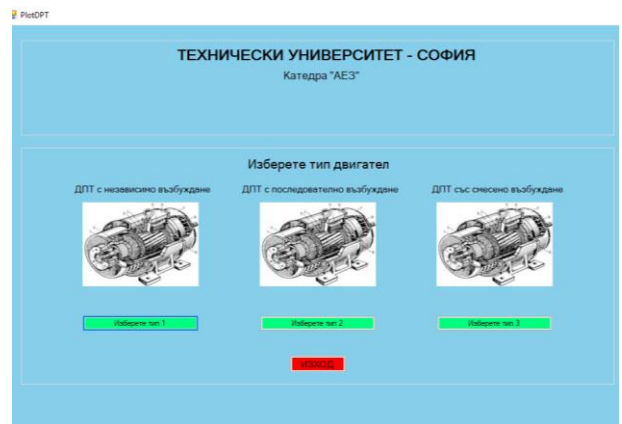


Fig. 7. Motor type selection window

Window for entering the parameters of the selected motor is shown on fig. 8.

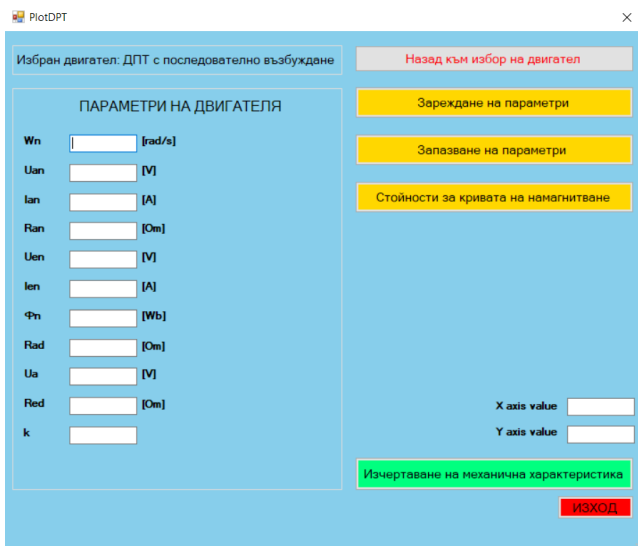


Fig. 8. Window for inserting the parameters of the selected motor

The "Back to motor selection" button returns the program to motor selection mode.

The "Load parameters" button allows you to enter parameters saved in a file.

The "Save parameters" button allows you to save already entered parameters in a file.

The "Magnetization curve values" button opens a window for changing the values for the magnetization curve.

In the "Engine parameters" column, enter the nominal and adjustable data that will be used to read the mechanical characteristic.

In the fields "X axis value" and "Y axis value", values for the abscissa and the ordinate are entered.

The "Exit" button closes the program.

Window for entering the values for the magnetization curve is shown on fig. 9.

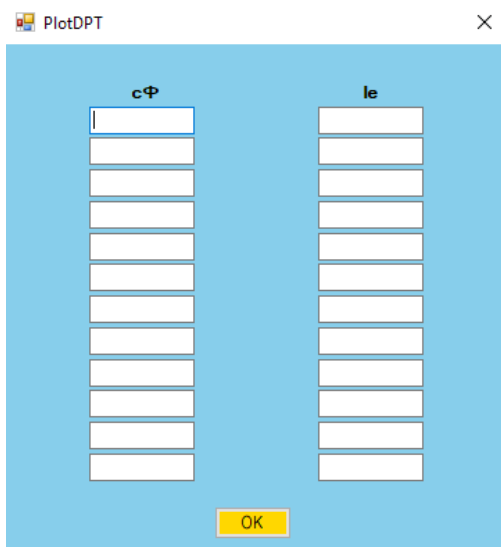


Fig. 9. Window for entering the values for the magnetization curve

Window for drawing and visualization of mechanical characteristics is shown on fig. 10.

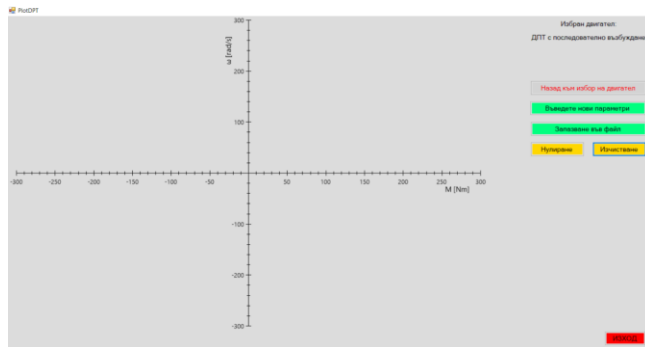


Fig. 10. Window for drawing and visualization of mechanical characteristics

The "Back to motor selection" button returns the program to motor selection mode.

The "Enter new parameters" button returns the program to the mode for entering new parameters.

The "Reset" button transforms the window on which the mechanical characteristics are displayed to the initial state.

The "Clear" button removes the mechanical characteristics drawn so far.

The "Save to file" button saves the drawn mechanical characteristics in a file.

The "Exit" button closes the program.

IV. RESEARCH OF STATIC MECHANICAL CHARACTERISTICS IN DIFFERENT WAYS OF CONTROLLING DC MOTORS WITH THE DEVELOPED SOFTWARE.

In the next figure, it's demonstrated the work of software. DC motor with separated excited

- Wn=104.7 rad/s
- Uan=220 V
- Ian=30 A
- Rad=0.52 Ω
- Uen=220 V
- Ien=0.78 A
- Phi_n=0.0082
- Rad=0 Ω
- Ua=220 V
- Red=0 Ω
- k=2.2

1) A family of characteristics for adjusting the resistance (Rad) in the armature circuit is plotted. Selected values: 0 Ω, 0.25 Ω and 0.50 Ω

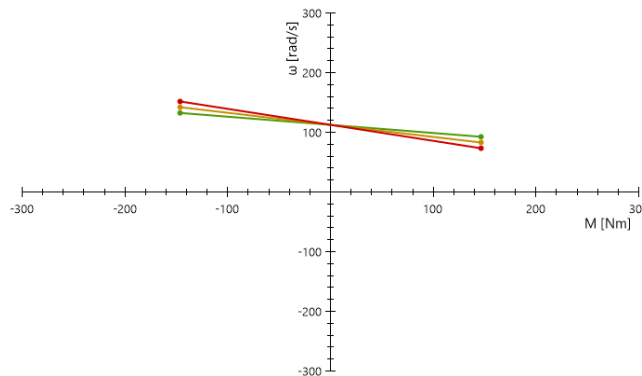


Fig. 11. A family of mechanical characteristics DC motor with separated excited, for adjusting the resistance (Rad) in the armature circuit

2) A family of characteristics is drawn when regulating the excitation field by Red. Selected values: 0 Ω, 50 Ω and 100 Ω

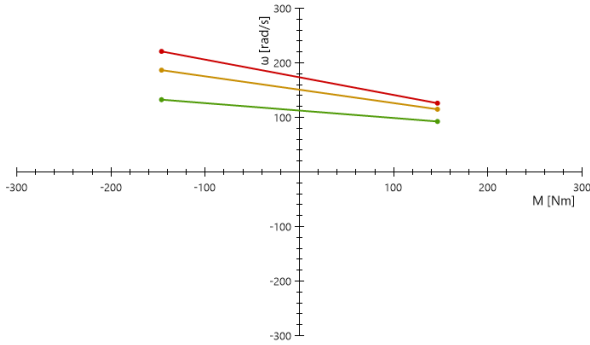


Fig. 12. A family of mechanical characteristics DC motor with separated excited, when regulating the excitation field by resistance Red

3) Draw a family of characteristics for voltage regulation (Ua) in the armature circuit. Selected values: 100 V, 150 V and 200 V.

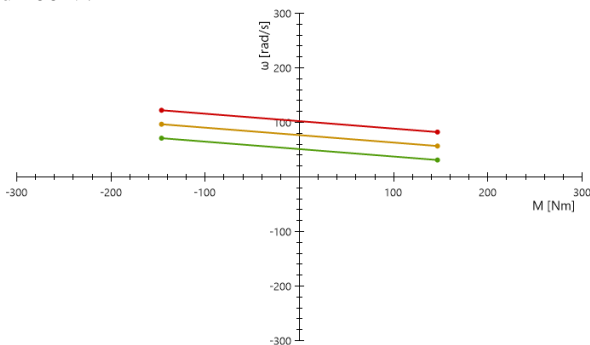


Fig. 13. A family of mechanical characteristics DC motor with separated excited, when voltage regulation in the armature circuit

DC motor with in series excited

- Wn=104.7rad/s
- Uan=220 V
- Ian= 15.6 A
- Rad= 1.33 Ω
- Uen=0
- Ien=0 A
- Φn=0.0053
- Rad=0 Ω
- Ua=220 V
- Red=0 Ω
- k=1.5

1) Draw a family of characteristics when adjusting the resistance (Rad) in the armature circuit. Selected values: 0 Ω, 1 Ω and 2 Ω

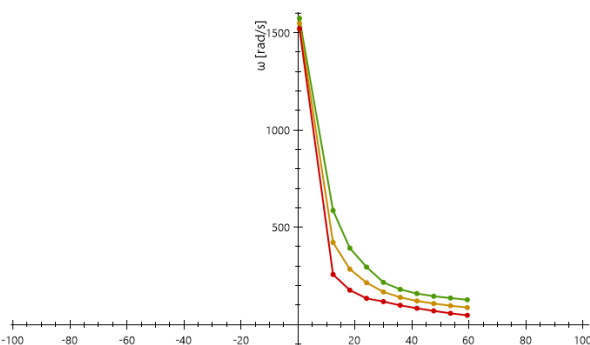


Fig. 14. A family of mechanical characteristics DC motor in series excited, when adjusting the resistance (Rad) in the armature

2) A family of characteristics is drawn when regulating the supply voltage. Selected values: 100V, 150V and 220V.

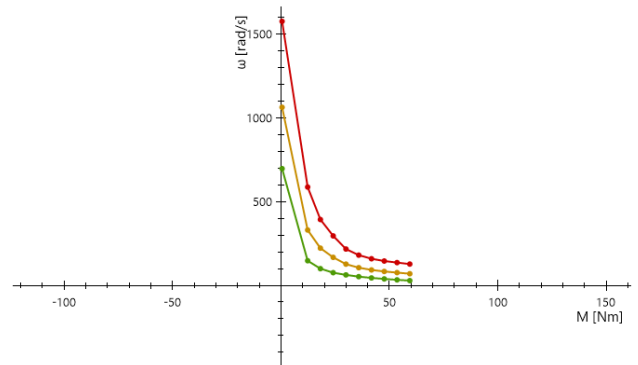


Fig. 15. A family of mechanical characteristics DC motor in series excited, when regulating the supply voltage

DC motor with mixed excitation

1) Draw a family of characteristics when adjusting the resistance (Rad) in the armature circuit. Selected values: 0 Ω, 2 Ω and 4 Ω

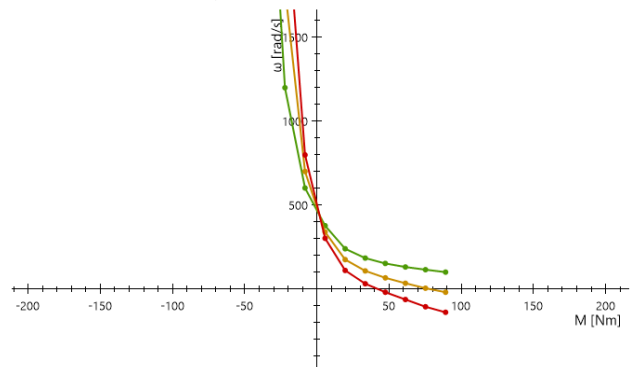


Fig. 16. A family of mechanical characteristics DC motor with mixed excited, when adjusting the resistance (Rad)

2) A family of characteristics for voltage regulation in the armature circuit is plotted. Selected values: 100 V, 150 V and 220 V

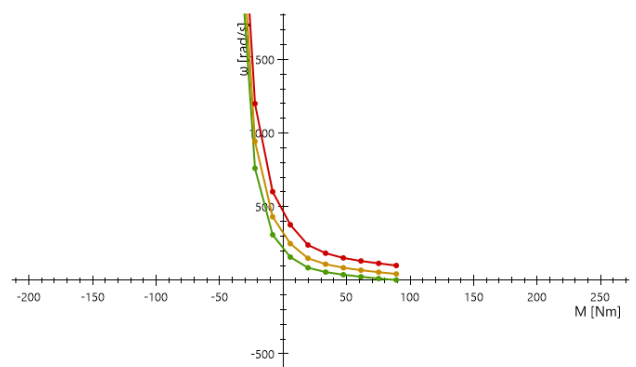


Fig. 16. A family of mechanical characteristics DC motor with mixed excited, when voltage regulation in the armature circuit

V. CONCLUSION

The software product is an easy and convenient tool for studying the mechanical characteristics of DC motors in different excitation modes.

From the conducted experiments it is seen that the application calculates and draws the correct desire mechanical

characteristics. In addition, the program allows you to save the data used and the drawn characteristics in an appropriate format. Thus, the obtained results are practically usable.

This software product was developed thanks to the dynamically developing object-oriented programming language – C#, and the Windows Forms platform of Microsoft Corporation, which allows the construction of applications that run on Windows-based operating systems. Microsoft Visual Studio 2019, a product of the Microsoft Corporation range, was used as the code development environment.

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