International Journal on
"Technical and Physical Problems of Engineering"
(IJTPE)
Published by International Organization of IOTPE

ISSN 2077-3528
IJTPE Journal
www.iotpe.com
ijtpe@iotpe.com

June 2023 Issue 55 Volume 15 Number 2 Pages 37-43

IMPROVING EFFICIENCY OF WIND TURBINES WITH ELECTROMAGNETIC BRAKES

N.A. Aliyev E.N. Ahmadov S.A. Khanahmedova

Azerbaijan State Oil and Industry University, Baku, Azerbaijan
nadir.alili.52@mail.ru, elbrusahmed@gmail.com, samira1009@mail.ru

Abstract- The article considers the problem of modeling an electromagnetic brake, which is proposed to be used in a wind power plant as a stabilizing and damping element when the wind speed fluctuates, by considering it as an object with lumped parameters. As a model for calculating the electromagnetic moment, an equivalent circuit is proposed, which clearly depicts the structure of the object and its operation in dynamic modes. To take into account saturation, it is proposed to use expanded equivalent circuits, in which magnetic couplings between different circuits are replaced by complex electrical resistances, which make it relatively easy to determine the degree of saturation. Using equivalent circuits, a program based on MATLAB was compiled, and the results of the calculation are presented in the form of graphs.

Keywords: Wind Turbine, Electromagnetic Brake, Magnetic Circuit Saturation, Extended Equivalent Circuit.

1. INTRODUCTION

Due to the high cost of electricity and traditional energy carriers, there is a shortage of electricity in homes and farms, which encourages the use of renewable energy sources (RES). The development of RES has now become one of the fundamental postulates of the global new energy strategy [1, 2]. At the same time, it has become a topic of official policy in many nations. Solidly funded state programs in this area have appeared. In a number of countries, regulatory and legislative acts in the field of RES use were adopted, which formed the legal, economic, and organizational basis for this area of technical development. The economic justification is boiled down to policies that encourage the use of renewable energy, which is essential during the energy market's development, design, and adaptation phases.

The basis of RES, as you know, is sources that convert the energy of the sun and wind. These renewable energy sources have both advantages and disadvantages in comparison with traditional energy. The main advantages include the ubiquity of most of their species, environmental friendliness, and low operating costs, since the energy from these sources is free.

The main disadvantages of RES are the low density of the energy flow (specific power per unit area) and the variability in time of most types of RES. The first situation necessitates the construction of extensive power plant regions (the receiving surfaces of solar installations, the area of a wind wheel, etc.). Due to their high material consumption, these devices require more particular capital inputs than conventional power plants do. Lower operating costs eventually make up for the higher capital expenditure.

The most significant issues are connected to the temporal fluctuation of energy sources such solar radiation, wind, tides, runoff from minor rivers, and weather temperatures. The process of the entrance of solar energy has a major element of chance linked with weather conditions even if it is normally regular. For instance, if the change in energy of the tides is precisely cyclical. Even more erratic and fickle is wind energy.

The variability of electricity generation over time RES requires the creation of storage devices, as a rule, their function is performed by batteries. A sufficiently powerful power system, which also includes wind power plants (WPP) and solar power plants, can compensate for changes in the power of these plants. However, at the same time, in order to avoid changes in the parameters of the power system (primarily frequency), the share of unregulated power plants should not exceed 15% in terms of capacity. In general, the use of RES in the world has acquired a tangible scale and a steady upward trend. In some countries, the share of renewable energy in the energy balance is a few percent. According to various forecast estimates, which are currently not lacking, this share will reach or exceed 10% by 2020 in many states.

As can be seen from the above, one of the most accessible sources of renewable energy is wind energy. The use of wind energy in recent years has become even more relevant, following hydropower. The development of technologies and accumulated experience allow us to determine the main directions and methods of development. An analysis of the work carried out in this area allows us to conclude that the main problem of wind energy is obtaining electricity of the required quality. This, in turn, requires the integration of theoretical knowledge of aerodynamics and electromechanics.

There is a wide variety of electromechanical converters used in wind power plants. In terms of their energy performance, a special place among them is occupied by a synchronous generator with excitation from permanent magnets [3, 4]. However, their dynamic performance leaves much to be desired. Wind gusts causing significant oscillations of the wind turbine shaft and, accordingly, the synchronous generator leads to oscillations of electromagnetic power. As you can see, the reaction of a synchronous generator to gusts of wind is very strong, which often leads to it falling out of synchronism. The inability to influence this process through the excitation of the generator exacerbates this disadvantage.

The most important energy characteristic of the wind is its speed. It is known that the speed and direction of the wind change according to a random law, and the kinetic energy is proportional to the cube of its speed. Another major disadvantage of wind is its instability. Switching between low and high speeds is frequently required to maximize the effectiveness of the utilization of wind turbines due to the fluctuation of the wind speed. Wind generators must maintain the established parameters of the generated energy under any energy impact. Therefore, solving the problem of stabilizing the energy output is always an urgent task.

2. FORMULATION OF THE PROBLEM

Electromagnetic brakes (EMB) or electromagnetic slip clutches (EMC) are widely used in industry. In lifting and lifting equipment, EMTs provide a smooth descent of loads at the required speed, controlled by changing the excitation current of electromagnets [5, 6]. In various tests of engines and other propulsion systems, EMBs are used as a load, creating the necessary adjustable load moment. In the electric power industry, EMB has not yet found its application. However, its potential advantages give grounds for using it as a means of improving the conditions for dynamic and static stability of the electric power system (EPS), including WPPs.

The principle of operation of the EMB (Figure 1) is based on the occurrence of eddy currents in a massive metal disk when an alternating electromagnetic field is created in the EMB. The electromagnetic field penetrating the disk is created by DC electromagnets. When the shaft of the generating unit rotates, an alternating electromagnetic field is induced in the EMT disk, which causes eddy currents in the steel of the disk, the direction of which prevents a change in the flux of the magnetic induction vector. The interaction of the magnetic field and eddy currents leads to the appearance of a braking torque. When eddy currents flow through a disk with a finite resistance value, energy losses occur, which is accompanied by heat release in the EMB disk. Thus, the kinetic energy of the mechanical work of the EMB metal disk is transformed into thermal energy [3].

The EMB has a low inertia and directly affects the balance of moments on the shaft of the generating unit, and its parameters do not depend on the parameters of the WPPs mode and network. In addition, the EMB control system can have an independent power source (accumulator battery; generator integrated into the EMB), which makes it possible to provide an autonomous power supply to the EMB excitation system [3].

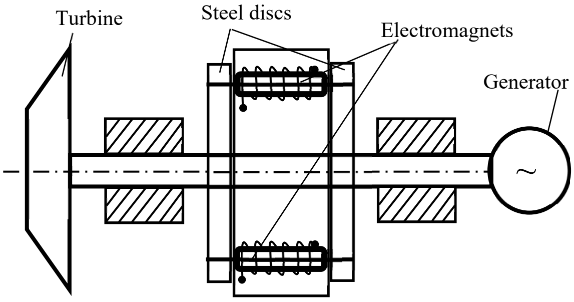


Figure 1. Electromagnetic brake device

Such advantages of EMB as speed, impact directly on the balance of moments on the shaft of the generating unit, independence of operation from the parameters of the external electrical network, give reason to believe that EMB can be used as a means of improving the conditions for the dynamic stability of wind farms and damping undamped and weakly damped oscillations of transient processes by intersystem connections caused both by emergency events and by the operation of automatic control systems for WPPs elements. The task of controlling electromechanical processes is to ensure the static and dynamic stability of the WPPs, as well as the required quality of attenuation of transient processes. Management in emergency mode is provided mainly by relay protection and automation devices. The control of the WPPs mode with the help of EMB can be attributed to the prevention of violation of the stability of the system.

One of the main tasks standing in the way of using EMB in EPS is the search for EMB power control. To control the braking power of the EMB, it is necessary to control the excitation current of the EMB. The WPPs' behavior is described by a system of non-linear differential equations. The task of synthesizing the EMB control law is complicated due to the unipolar characteristic of the EMB torque (it develops only a braking torque, regardless of the direction of the current in the excitation winding). Despite the fact that, at present, there are many methods for synthesizing the control laws of nonlinear systems, taking into account various limitations, there are no universal methods.

3. PROBLEM SOLUTIONS

One of the distinguishing features of the use of EMB is its unipolar action - the device creates only a load moment, despite the fact that in the initial state the moment it develops is zero. This, in turn, means a sharply nonlinear dependence of the EMB power on time. The study of the static stability of the system is usually carried out using the method of "small deviations", which implies the linearization of the original system of nonlinear differential equations in the vicinity of the equilibrium point. Linearization describes the properties of the system in a certain neighborhood with respect to the steady value of the parameters.

However, considering the EMB as part of the power system, the linearization of the system of equations will, in turn, mean that the unidirectional action of the EMB is not taken into account. Thus, the use of standard methods for studying the static stability of wind farms, taking into account the operation of the EMB, is impossible. Therefore, the analysis of nonlinear equations was used as a research method.

Some questions about the possibility of using an electro-magnetic brake in a wind power plant are considered in [7, 8]. This is a relatively new approach to the application of special electrical machines in this field with competitive advantages. For example, at maximum wind speed, it is possible to regulate the work process. With an increase in the load on the blades of wind turbines, the speed of rotation of the wind wheel decreases, and the torque increases. Switching to the electromagnetic brake mode, it is possible to slow down and prevent an accident in case of an accidental gust of wind and ensure the safe operation of wind farms.

During the operation of the EMB, the dynamic stability of the wind farm is preserved and the attenuation of the transient process is ensured. A short circuit leads to acceleration of the rotor of the generating unit. As a perturbation causing a negative imbalance and, accordingly, braking of the rotor of the generating unit immediately after the application of the perturbation, one of the four generators in the presented scheme was switched off.

The results of calculations of transient processes are presented in Figure 2 [4]. As can be seen, the EMB does not work at the moment of the occurrence of a disturbance, switching on occurs only when the generator rotor accelerates. An analysis of the calculation results shows that the inclusion of EMB in operation allows improving the conditions for the flow of the transient process in the power system with a given disturbance. The operation of the EMB according to the principle of operation is similar to the operation of the speed controller of the generating unit. The difference is that the speed controller acts on both braking and acceleration, i.e., it has a bipolar action. The unipolar action of the EMB reduces the effectiveness of the influence on transients during disturbances, the EMB can only create a braking torque [9].

It follows from the above that the dynamic moment on the wind generator shaft changes periodically. If we add here the issues of starting and braking, as well as increasing reliability, it goes without saying that a wind turbine is a complex object. One way to dampen dynamic processes in such a system is to use an electromagnetic slip clutch. As shown above, structurally, EMB consists of a massive cylindrical armature and a salient-pole inductor with a massive core. Design features in the field of application of these machines are diverse [10, 11].

When developing electric drives such as wind turbines, it is often necessary to provide specific characteristics and properties of machines intended for these drives. One of the main characteristics of EMB is its mechanical characteristics - the dependence of the electromagnetic torque on slip ($M=f(s)$). Electric drives with EMB having rigid mechanical characteristics can ensure reliable operation of wind turbine mechanisms without the use of complex automatic control systems and limit overloads in the case of wind gusts. It is known that the design and study of EMB operating modes, taking into account changes in magnetic permeability, electrical resistivity of steel, edge effect, hysteresis losses, taking into account saturation, etc., are fraught with great difficulties.

The foregoing indicates the relevance of modeling and research methods for calculating the electromagnetic moment in the dynamic modes of operation of the EMB or electromagnetic slip. EMB used in wind turbines must have characteristics that ensured the possibility of its operation in the specified mode. Depending on the speed of the wind oscillation, the electromagnetic moment of the leading part varies over a wide range. In order to stably maintain the torque of the driven part, it is necessary to change the magnitude of the excitation current. In this case, many variants with highly saturated magnetic circuits are possible. The possibilities of computer technology make it possible to use the methodology of a computational experiment to study various modes of operation of the EMB in wind turbines. Given the initial data, it is possible to conduct a fairly accurate numerical analysis of the mathematical model.

4. MATHEMATICAL MODEL

Simplification of the method for calculating the electromagnetic moment without leading to significant errors is important. In addition to the painstaking analytical calculation of mechanical characteristics, we will use the method of constructing these characteristics according to equivalent circuits for EMS with a massive magnetic core. Such equivalent circuits clearly depict the structure of the object and allow you to effectively investigate the parameters and characteristics. To draw up equivalent circuits, consider the voltage balance equations in the circuits of a massive armature along the longitudinal and transverse axes for the steady state [12, 13]:

$$r_b i_b = U_b \tag{1}$$

$$r_d i_d + \omega L_q i_q = 0 \tag{2}$$

$$r_q i_q - \omega M i_b - \omega L_d i_d = 0 \tag{3}$$

where, r_b is the ohmic resistance of the coupling excitation winding; i_b is the excitation current of the coupling; U_b is voltage of the winding excitation of the coupling; r_d is active resistance along the longitudinal axis of the massive armature; i_d is current along the longitudinal axis of the massive armature; ω is angular rotation frequency; L_q is transverse axis inductance; i_q is transverse axis current; r_q is active resistance along the transverse axis; i_d is current along the transverse axis; and L_d is longitudinal inductance.

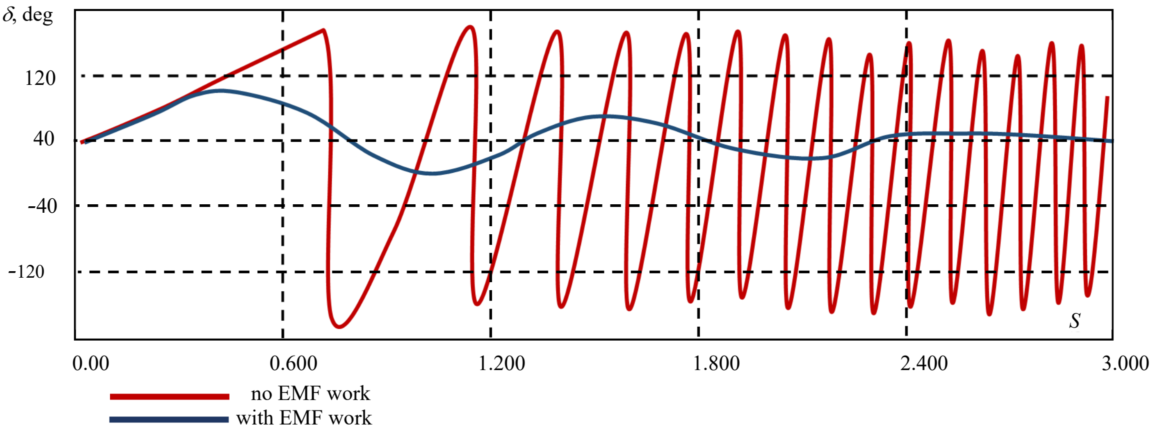


Figure 2. Dynamic stability of the electric power system

It is known that the equivalent circuit exists when the matrix of coefficients of the equation is symmetric. By symmetrizing the matrix of coefficients of Equation (2), we obtain [11, 12]:

$$\frac{r_q}{S} i_d + \omega_0 L_q \frac{r_q}{r_d} i_q = 0 \tag{4}$$

$$-\omega_0 L_d i_d + \frac{r_q}{S} i_q = \omega_0 M i_b \tag{5}$$

where, M is mutual inductance; $\omega = \omega_0 S$, ω_0 and S, respectively, the angular frequency of idle and slip. Equation (5) corresponds to the equivalent circuit shown in Figure 3 [4].

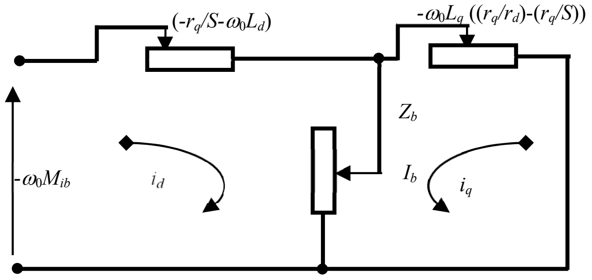


Figure 3. Synchronous generator equivalent circuit

Considering that the electromagnetic moment is defined as the Equation (6),

$$M = \frac{i_d^2 r_d + i_q^2 r_q}{\omega} \tag{6}$$

To calculate it, you need to determine the currents in the circuits d and q of the massive armature. Solving the system of Equation (5) for i_d and qd, we get Equations (7) and (8) [12]:

$$i_d = i_b \frac{\omega_0^2 M L_q r_q}{r_d \left[\left(\frac{r_q}{S} \right)^2 + \omega_0^2 L_d L_q \frac{r_q}{r_d} \right]} \tag{7}$$

$$i_q = i_b \frac{\omega_0^2 M r_q}{S \left[\left(\frac{r_q}{S} \right)^2 + \omega_0^2 L_d L_q \frac{r_q}{r_d} \right]} \tag{8}$$

Multiplying the numerator and denominators of Equations (7) and (8), respectively, by the value $\frac{L_d S^2}{r_q^2 r_d}$ and $\frac{S^2}{i_q}$ after a series of transformations we get Equation (9) [11]:

$$i_d = i_b \frac{\omega_0^2 T_d T_q M}{L_d \left(1 + \omega_0^2 T_d T_q \right)} \tag{9}$$

where, T_d and T_q are the time constants of the longitudinal and transverse axes, respectively. Thus, knowing all the EMC parameters, it is possible to calculate and build the mechanical characteristic $M=f(s)$ at various values of the excitation current. It should be noted that the equivalent circuit (Figure 3) was drawn up when considering EMS from the side of the excitation winding and when applying the theory of synchronous machines. Under normal operating conditions, the coupling flux is non-linear. This circumstance sharply complicates the calculation of characteristics taking into account saturation. Disregarding saturation leads to large errors. The operating modes of EMC and EMB with saturated magnetic circuits cannot be considered fully investigated until now [12].

To solve this issue, we will use expanded equivalent circuits with saturated armature and inductor cores as a mathematical model, which is one of the most convenient and intuitive methods. The essence of the method lies in the fact that when drawing up equivalent circuits, magnetic connections between different circuits are replaced by electrical connections, that is, by various electrical circuits with complex electrical resistances. To establish a connection between complex magnetic and electrical resistances, the known relations are used [7, 13]:

$$z = jk\frac{1}{z};\;\; Z = \frac{F}{\Phi} \tag{10}$$

where, *k*= 4*pf*(*w*1*kw*1)2 / *p* is the reduction coefficient, *z* and *Z* are the complex electrical and magnetic resistances of equivalent circuits, *F* and magnetic dynamic force and magnetic flux, respectively.

Given the similarity of the magnetic circuits of EMC and an asynchronous machine with a massive rotor, it is possible to compose a magnetic circuit (Figure 4).

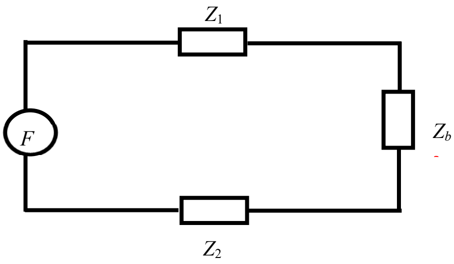


Figure 4. Magnetic circuit of an electromagnetic brake

The complex resistances Z_1, Z_2 and Z_b, respectively characterize the magnetic resistances of the armature, inductor and air gap circuits. The magnetic resistance of the entire magnetic circuit is defined as

$$Z = Z_1 + Z_2 + Z_b \tag{11}$$

Taking into account (88) and (99), we obtain

$$1/z \;= 1/z_1 + 1/z_2 + 1/z_b \tag{12}$$

From (11) and (12), it can be concluded that the reduced resistances corresponding to a series-connected section of the magnetic circuit are connected in parallel during the transition to an electric one (Figure 5).

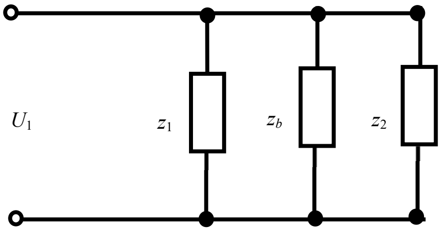


Figure 5. Electrical equivalent circuit of the magnetic circuit

Accordingly, the equivalent electrical circuit of the clutch is shown in Figure 6, and the calculated equivalent circuit is shown in Figure 7.

The following parameters apply to the comparable circuit in Figure 4 [3]: where, z is complex resistance, including active and leakage inductive reactance of the excitation winding x_{1S}; x_μ is inductive resistance of the core of the field winding inductor; Z_d is complex resistance of the air gap; r_{20} is active resistance equivalent to magnetic losses in the massive armature; and x_{20} is the inductive resistance of the massive armature.

Thus, in the equivalent circuit, the saturated sections of the magnetic circuit are taken into account by nonlinear resistances, the characteristics of which can be approximated by expressions as a function of voltages and currents.

The calculation of the circuit is carried out at a given value of the excitation voltage U_b of the coupling and functional dependences of nonlinear resistances $Z_1 = f(\dot{I}_1)$; $Z_2 = f(\dot{I}_2)$; $Z_3 = f(\dot{I}_3)$; $Z_4 = f(\dot{I}_4)$.

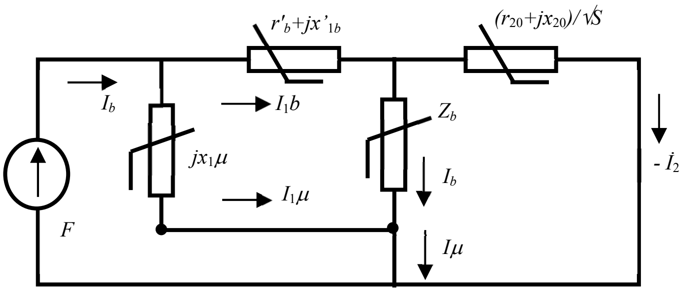


Figure 6. Expanded equivalent circuit with salient pole inductance

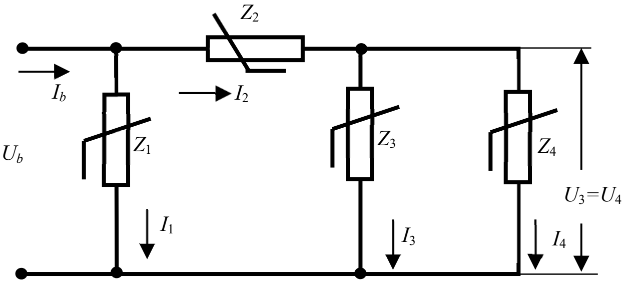


Figure 7. Calculated equivalent circuit of the coupling

The main ratios for the calculation are as Equations (13), (14), (15), (16) and (17):

$$\dot{I}_1 = Y_e U;\, \dot{I}_1 = \dot{I}_B\frac{Y_2}{Y_E};\, \dot{I}_2 = \dot{I}_B - \dot{I}_1 \tag{13}$$

$$\dot{I}_3 = \dot{I}_2\frac{Y_3}{Y_{e1}};\;\; \dot{I}_4 = \dot{I}_2\frac{Y_4}{Y_{e1}} \tag{14}$$

$$U_2 = \dot{I}_2 z_2;\;\; U_3 = U_4 = U_1 \tag{15}$$

$$Y_e = \frac{z_1z_3 + z_1z_4 + z_2z_3 + z_2z_4}{z_1z_2z_3 + z_1z_2z_4} \tag{16}$$

$$Y_{e1} = \frac{z_3 + z_4}{z_3z_4};\;\; Y_3 = \frac{1}{z_3};\;\; Y_4 = \frac{1}{z_4} \tag{17}$$

On the basis of the developed method of analysis, it is possible to create programs for calculating in MATLAB. At the same time, the use of a system of relative units makes it possible to simplify and generalize the results obtained and build an array of current hodographs to study the effect of saturation on parameters that are suitable for a wide range of clutches and brakes of various capacities.

Figure 8 displays current hodographs for various coupling excitation current values. A comparison of the current hodographs allows us to conclude that with an increase in the excitation current, in the case of a saturated armature, it increases much more at large slips.

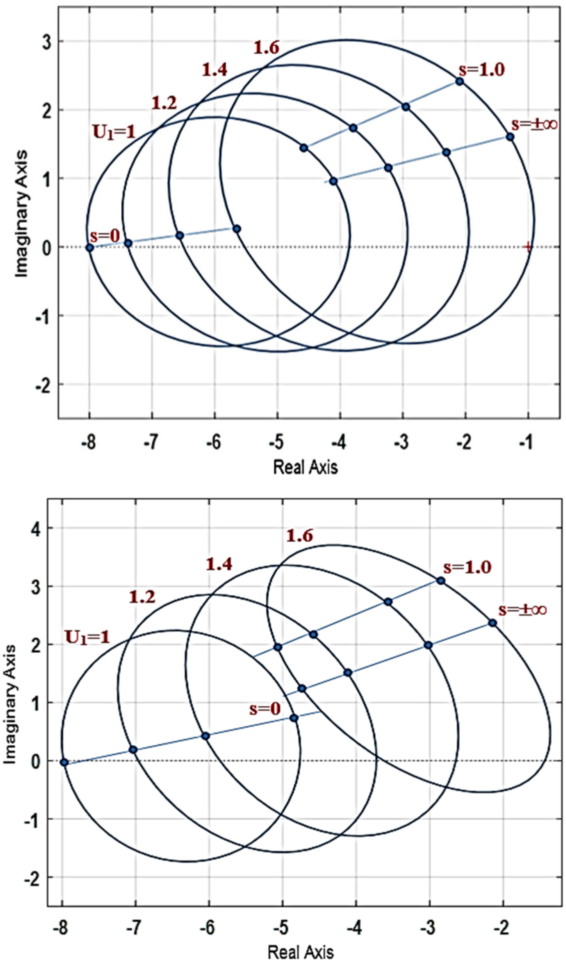


Figure 8. Hodographs of currents for various values of currents of coupling excitation

5. CONCLUSIONS

It is proposed to use an electromagnetic brake in a wind power plant as a damping and stabilizing element in case of sharp fluctuations in wind speed. A generalized mathematical model of an electromagnetic brake is defined in the form of equivalent circuits with a saturated magnetic circuit. A computational algorithm and a program have been developed to study various modes of clutch operation in order to select the main parameters that can provide the necessary characteristics under given conditions.

REFERENCES

[1] M.A. Bhuiyan, Q. Zhang, V. Khare, A. Mikhaylov, G. Pinter, X. Huang, "Renewable Energy Consumption and Economic Growth Nexus-A Systematic Literature Review", Systematic Review Article, Frontiers in Environmental Science, pp. 1-21, April 2022.

[2] D. Gielen, F. Boshell, D. Saygin, M.D. Bazilian, N. Wagner, R. Gorini, "The Role of Renewable Energy in the Global Energy Transformation", Energy Strategy Reviews, Vol. 24, pp. 38-50, April 2019.

[3] R.N. Mustafaev, L.G. Gasanova, "Comparative Evaluation of the Efficiency of the Functioning of Modern Wind Power Plants", Journal Electromechanics, Izv. Universities, No. 4, pp. 57-60, Novocherkassk, Russia, 208.

[4] A.I. Abdulkadyrov, N.A. Aliyev, "On the Use of an Electromagnetic Slip Coupling in a Wind Power Plant", International Scientific and Practical Conference on Development of Technical Sciences in the Modern World, pp. 76-96, Voronezh, Russia, 2016.

[5] M. Harun, R. Molla, N. Al Nahian Rahat, M. Alam, M.K. Uddin, "Construction and Experimental Analysis of an Electromagnetic Braking Clutch", The International Conference on Mechanical Engineering and Renewable Energy (ICMERE 2019), pp. 11-13, Chittagong, Bangladesh, December 2019.

[6] N. Fernando, "A Field Modulated Electromagnetic Clutch with Slip Control", IEEE 2nd Annual Southern Power Electronics Conference (SPEC), December 2016.

[7] D.M.M.S. Regis Prabha, "Development of Utilizing Magnetic Brake in Small Wind Turbine Speed Control using Fuzzy Logic Controller", Indian Journal of Science and Technology, No. 9, Vol. 13, pp. 1-13, Indian, April 2016.

[8] E.A. Sirotkin, A.S. Martyanov, E.V. Solomin, S.V. Kozlov, "Emergency Braking System for the Wind Turbine", The 2nd International Conference on Industrial Engineering, Applications and Manufacturing, May 2016.

[9] B.T. Polyak, O.N. Kuznetsov, V.V. Chumachenko, "Investigation of the Stability of a Power System with a Unipolar Electromagnetic Brake", Automation and Telemechanics, No. 9, Vol. 77, pp. 1557-1566, Moscow, Russia, 2016.

[10] N. Goudarzi, W.D. Zhu. "Studying the Potential of a Novel Multiple Generator Drivetrain in Wind Energy Conversion Systems", IMECO, pp. 15-21, San Diego, California, USA, November 2013.

[11] F.G. Huseynov, N.A. Aliyev, "Optimization of Geometry, Parameters and Characteristics of Electromagnetic Sliding Clutches and Brakes with a Massive Magnetic Core", Izv. Universities, Electromechanics, No. 10, pp. 75-78, Novocherkassk, Russia, 1983.

[12] V.M. Kutsevalov, "Analysis of Equivalent Circuits of Alternating Current Electric Machines", Journal Energy and Transport, No. 5, pp.98-103, Moskow, Russia, 1985.

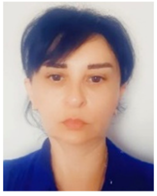
[13] N.A. Aliyev, E.N. Ahmadov, S.A Khanahmedova, "Some Issues of Use and Simulation of Electromagnetic Brake in Wind Power Plant", The 18th International Conference on Technical and Physical Problems of Engineering (ICTPE), No. 21, pp. 104-110, 30 October 2022.

BIOGRAPHIES

Name: **Nadir**
Middle Name: **Abdulrakhman**
Surname: **Aliyev**
Birthday: 19.06.1952
Birth Place: Gakh, Azerbaijan
Bachelor: Electrical Engineering, Department of Electrical Machines and

Apparatuses, Energy Faculty, Azerbaijan State University of Petroleum and Chemistry, Baku, Azerbaijan, 1976
Master: Electrical Engineering, Department of Electric Machines, Azerbaijan State University of Oil and Industry, Baku, Azerbaijan, 1979
Doctorate: Candidate of Technical Sciences, Department of Electric Machines, Azerbaijan State University of Oil and Industry, Baku, Azerbaijan, Since 1979
The Last Scientific Position: Assist. Prof., Department of Electromechanics, Azerbaijan State Oil and Industry University, Baku, Azerbaijan, Since 2016
Research Interests: Electric Machines with a Massive Magnetic Conductor and Wind Power, Modeling and Research of Special Types of Electromechanical Converters
Scientific Publications: 65 Papers, 6 Books, 2 Textbooks, 1 Monograph

Name: **Elbrus**
Middle Name: **Nasi**
Surname: **Ahmadov**
Birthday: 20.06.1964
Birth Place: Shikhly Agdash, Azerbaijan
Bachelor: Electrical Engineering, Department of Electromechanics, Energy Faculty, Azerbaijan Institute of Petroleum and Chemistry (State University of Petroleum and Industry), Baku, Azerbaijan, 1994
Master: Electrical Engineering, Department of Electromechanics, Energy Faculty, Azerbaijan Institute of Petroleum and Chemistry (State University of Petroleum and Industry), Baku, Azerbaijan, 1996
Doctorate: Candidate of Physical and Mathematical Sciences, Department of Electromechanics, Azerbaijan State Oil and Industry University, Baku, Azerbaijan, 2003
The Last Scientific Position: Assist. Prof., Department of Electromechanics, Azerbaijan State Oil and Industry University, Baku, Azerbaijan, Since 2016
Research Interests: Electrophysics, Effect of Electric Fields on Substances, and Protection of High-Voltage Electrical Equipment from Overvoltage
Scientific Publications: 62 Papers, 14 Books, 22 Theses



Name: **Samira**
Middle Name: **Alkhadi**
Surname: **Khanahmedova**
Birthday: 09.10.1967
Birth Place: Baku, Azerbaijan
Bachelor: Electrical Engineering, Department of Electrical Signal and Automation of Industrial Installations, Energy Faculty, Azerbaijan State University of Oil and Industry, Baku, Azerbaijan, 1988
Master: Electrical Engineering, Department of Electric Machines, Azerbaijan State University of Oil and Industry, Baku, Azerbaijan, 1990
Doctorate: Doctor of Technical Sciences in Philosophy, Department of Electromechanics, Azerbaijan State University of Oil and Industry, Baku, Azerbaijan, Since 2014
The Last Scientific Position: Assist. Prof., Department of Electromechanics, Azerbaijan State Oil and Industry University, Baku, Azerbaijan, Since 2016
Research Interests: Control of Asynchronous Electric Drives, Alternative Energy Sources, Management of Various Technological Processes Using Programmable Logic Controllers
Scientific Publications: 60 Papers, 14 Books, 22 Theses