Automated system for processing diagnostic parameters of asynchronous motors for poultry house ventilation systems

A Yu Prudnikov, V V Bonnet and A Yu Loginov

Irkutsk State Agrarian University named after A.A. Ezhevsky, Molodezhny settlement, Irkutsk distrikt, Irkutsk region, 664038, Russia

E-mail: a.prudnicov@mail.ru

Abstract. The most common electric motor to drive working machines is an asynchronous one with a short-circuited rotor. It has a fairly large resource, provided proper operation. When analysing faults, it was found that the most common cause of failure is increased wear of bearings. The diagnostic parameter of this fault is an increase in the eccentricity of the rotor, to identify which we have developed a diagnostic method that allows us to evaluate the technical condition of the engine using an indirect indicator, the rotor speed. To make a diagnosis, it is necessary to process the data on the dynamics of change in the rotor speed of the engine and predict its operation for the forthcoming period. To simplify data processing, a program has been developed that is an automated system for analysing diagnostic parameters and can significantly reduce the laboriousness and time of diagnosis, eliminating the influence of the human factor. The developed programme was used to analyse the operation of asynchronous engines in poultry house ventilation systems, to predict their failure, as well as to plan maintenance and repair.

1. Introduction
The widespread use of asynchronous electric motors with a squirrel-cage rotor both in industry and in agriculture is due to their low cost and reliability of use. The effective use of these engines in agriculture is hindered by the aggressive environment and their irrational exploitation, as it is evidenced by the research results given in the works of the authors [1-3].

After analysing the methods and means for diagnosing faults of asynchronous motors in various sectors of their use, we can say that there is a large number of different stationary, built-in and portable diagnostic instruments and tools for diagnosing electric motors and their individual elements [4-13]. In addition, intelligent assessment systems have also been developed [14–18].

A promising area of research is engine diagnostics in transient modes of operation, since this process takes a short time, but is highly informative. Despite the fact that the study of transients in asynchronous electric motors has been the subject of many studies, the start-up mode is a poorly studied process [19-21]. This is due to the complexity of the mathematical expressions describing this process.

2. Materials and methods of research
We have developed a method for diagnosing eccentricity of the rotor of an induction motor during operation. Its essence lies in the fact that with an increase in the eccentricity of the rotor increases the amplitude of the rotational frequency when the engine is running in a steady state (figure 1). The
equations that describe the process of starting and operating an asynchronous motor with an eccentricity of the rotor and obtain the dependence of the rotor speed as a function of time are given in [20-21].

**Figure 1.** The dependence of the amplitude of the change in rotational speed when the rotor eccentricity of the induction motor.

Figure 1 clearly shows that the amplitude of change in the rotor speed of an engine with an eccentricity of 60% \( (A_2) \) is significantly greater than the amplitude of a technically sound engine \( (A_1) \), therefore, this indicator can be used as a diagnostic indicator characterizing the eccentricity of the rotor [22].

For an experimental verification of the theoretical background, we carried out a number of production tests of asynchronous motors that drive the exhaust fans in rotation [23]. To do this, an LED speed sensor was installed on the motor shaft; and the signal was read by ZET 210 analogue-digital converter. The data obtained were processed on a personal computer, where the pulsating signal was converted using the least squares method to the dependence of the rotor speed on time. As a result of exploratory experiments, the optimal sampling rate of 320 kHz of the analogue-digital converter was established, which allows to obtain the optimal amount of diagnostic data.

3. **Research results and their discussion**

The data obtained as a result of production tests for constructing functional dependencies in their original form represent a large body of data; and for their processing it was necessary to analyse the resulting graph for a long time to identify characteristic points and calculate the relative eccentricity of the rotor (figure 2) from them. This process is quite labour-intensive and requires high accuracy, therefore, for its automation, the authors developed a program [24] that allows determining the presence of asynchronous rotor eccentricity and its size. The interface of this program is shown in figure 3.

**Figure 2.** Rotor speed versus time.
3

Figure 3. The programme interface for the diagnosis of eccentricity induction motor rotor.

The programme includes algorithms for calculating the eccentricity of the rotor of an induction motor in idle mode and under load. To determine the eccentricity in this programme, it is necessary to load the data file obtained experimentally by clicking the "To open the data file" button and selecting the path to the required file; in the "Averaging window size" and "Increment" fields it is necessary to set such numerical values for which special the points will be located on the graph in the order which is shown in figure 3. Then, after pressing the “Report generation” button, the program will independently calculate the difference in the amplitudes of the rotor speed of the tested asynchronous motor and the technically sound (reference) one.

The tab «Report» will present the values of the relative eccentricity of the rotor of the induction motor both for idling mode and under load. Using the described program to diagnose the eccentricity of the rotor of the induction motor will significantly reduce the time of diagnosis, as well as eliminate the inaccuracies of diagnosis due to the human factor.

4. Conclusion
The process of diagnosing asynchronous motors installed on exhaust ventilation drives of poultry houses is complicated by the fact that access to the engine itself and its power supply wires is impossible, since access to electrical equipment is limited to the existing poultry house. If one of these engines fails, the group of fans is usually disconnected, which can lead to a massive death of the bird in the summer. The developed method of diagnostics allows to obtain diagnostic information without access to the engine, it is enough to get the fan acceleration curve, to which there is access outside the house. The developed automated diagnostic system for the eccentricity of the rotor asynchronous allows you to perform a number of functions, such as: visualization of the dependence of the rotor speed of the induction motor on the time; calculation and construction of characteristic singular points; calculation of the relative eccentricity of the rotor of an induction motor in idle mode and under load.

References
[1] Kozhuhov V A and Strizhnev S A 2006 Overview of technological failures of induction motors in agricultural production Bulletin of Krasnoyarsk State Agrarian University 11 199-202
[2] Vorobyev A E and Fatyanov S O 2017 Analysis of the causes of failures in the operation of asynchronous electric motors in agriculture and industrial production Bulletin of the Council of Young Scientists of the Ryazan State Agrotechnological University named after P.A.
Kostychev 2(5) 169-74

[3] Khomutov S O 2015 System for maintaining the reliability of electric motors based on comprehensive diagnostics and efficient insulation restoration technology (Barnaul: Interregional Center for Electronic Educational Resources LLC)

[4] Kurakin A D, Voronov L V, Mekhonoshin G V, Semenov S V and Nykhamkin M Sh 2016 Laboratory complex for conducting experiments on rotor dynamics Modern high technologies 12-2 258-62

[5] Vasiliev D A, Dresvyannikova E V, Panteleeva L A and Noskov V A 2018 Development of a mathematical model of an asynchronous machine using an M-shaped equivalent circuit in the Simulink package Vestnik of NGIEI 4(83) 38-54

[6] Baturina N Yu, Kalienko I.V and Vorzhev V B 2015 Determination of parameters of a three-phase asynchronous engine by statistical processing of measurement pairs Modern trends in the development of science and technology 9-3 30-3

[7] Safin N P, Praht V A and Dmitrievsky V A 2017 Study of the influence of bearing failures on the efficiency of an induction motor Electrical engineering 10 87-91

[8] Volnikov M I 2018 On the issue of timely non-stop diagnosis of electric motors The role of university science in solving problems of the agro-industrial complex (All-Russian (national) scientific-practical conference dedicated to the 90th anniversary of the birth of Professor G B Galdin) ed O N Kukharevi et al. Penza: Publishing House of the Penza State Agrarian University vol 2 pp 14-7

[9] Magdanova K P 2017 Influence of rotor eccentricity on the energy characteristics of an asynchronous motor Nauka-Rastudent.ru 6 007

[10] Kryukov O V and Stepanov S E 2018 Method and new device for on-line diagnostics of the technical state of asynchronous electric motors at compressor stations Instruments and systems Management, monitoring, diagnostics 4 47-54

[11] Voronin V A 2017 Modeling bearing current in a variable frequency asynchronous electric drive Energy and energy saving: theory and practice Proceedings of the III All-Russian Scientific and Practical Conference December 13-15, 2017, Kemerovo ed I A Loburi and V G Kashirskikh Kemerovo: Publishing House of Kuzbass State Technical University named after T.F. Gorbachev p 406

[12] Sidelnikov L G and Afanasyev D O 2013 Review of methods for monitoring the technical condition of asynchronous motors in operation Bulletin of Perm National Research Polytechnic University. Geology. Oil and gas and mining 12-7 127-37

[13] Ivanov P Yu, Dulsky E Yu and Khudonogov A M 2016 Modern directions for the development of systems for monitoring the insulation status of asynchronous electric motors Bulletin of Irkutsk State Technical University 20-12 (119) 146-54

[14] Eltyshev D K, Gnutova K A and Litvinenko D A 2018 Automated estimation of the parameters of models for the diagnosis of electrical equipment using fuzzy clustering Bulletin of Perm National Research Polytechnic University. Electrical engineering, information technology, control systems 28 122-40

[15] Eltyshev D K 2018 Multi-criteria analysis of solutions in intelligent systems for assessing and managing the state of power equipment Informatics and control systems 2 (56) 96-107

[16] Panov A N, Bodrov E E, Bodrova S I, Mikheeva V O and Lysenko A A 2018 Possibility of using an intelligent sensor to diagnose the state of an electric motor Automated technologies and production 1 (17) 14-7

[17] Khoroshev N I и Kazantsev V P 2015 Management Support of Electroengineering Equipment Servicing Based on the Actual Technical Condition Automation and Remote Control 76-6 1058-69

[18] Eltyshev D and Gnutova K 2018 Influence of fuzzy clustering on the accuracy of electrical equipment diagnostic models Proc. the 6th Int. Conf. on Applied Innovations in IT (March 2018 Koethenvol 6) ed E Siemens et al (Koethen: Hochschule Anhalt) pp 23-8
[19] Mugalimov R G, Mugalimova A R, Kalugin Yu A and Odintsov K E 2018 Diagnostics and fault identification methods for asynchronous motor windings in its operation mode *Electrotechnical systems and complexes* **3 (40)** 70-8

[20] Prudnikov A Yu, Bonnet V B and Loginov A Yu 2015 Mathematical model of an asynchronous motor with an eccentricity of a rotor *Vestnik of KrasGAU* **6 (105)** 94-7

[21] Prudnikov A Yu, Bonnet V V, Gerasimova M N, Loginov A Yu and Rakotsa A 2016 The amplitude of oscillations of the rotor speed as a parameter for estimating the eccentricity of the rotor of an induction motor *Angar State Technical University Bulletin* **10** 70-3

[22] Bonnet B V and Prudnikov A Yu 2017 Statistical estimation of parameters for changing the rotor speed of an induction motor *Vestnik of IrGSKHA* **80** 125-30

[23] Prudnikov A Yu, Bonnet V V, Loginov A Yu and Potapov V V 2015 Experimental verification of the method for diagnosing the rotor eccentricity of an induction motor *Vestnik of KrasGAU* **11 (110)** 73-7

[24] Prudnikov A Yu, Bonnet V V and Kuznetsov B F 2016 *Automated system for diagnosing eccentricity of the rotor of an induction motor* (certificate of state registration of the computer program No. 2016618129)