УДК 621.086
МРНТИ 44.37.29 DOI 10.55452/1998-6688-2021-18-2-67-72

FAULT DETECTION OF INDUCTION MOTORS

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Abstract. *In this work described method of fault detection of induction motors. Induction motors are broadly utilized in numerous mechanical applications. Subsequently, it is exceptionally imperative to monitor and detect any faults during their operation in arrange to alarm the administrators so that potential issues can be avoided before they happen. In common, a fault within the acceptance motor causes it to induce hot amid its operation. This paper presents a developed protection method algorithm that uses unbalanced power components and simulates the overall design based on the Matlab Simulink. Three-phase voltage and current data are observed first, followed by signs of unbalanced power, according to the digital relay safety algorithm. The relay then uses a negative sequence reactive power sign to decide if the fault is internal or external. A negative sign for negative sequence reactive power indicates a fault inside the motor, while a positive sign indicates a fault outside the motor.*

Key words: *stator windings, reactive power, squirrel rotor cage, motor backup, power oscillations.*

ОБНАРУЖЕНИЕ НЕИСПРАВНОСТЕЙ АСИНХРОННЫХ ДВИГАТЕЛЕЙ

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Аннотация. *В данной работе описан метод обнаружения неисправностей асинхронных двигателей. Асинхронные двигатели широко используются во многих механических приложениях. Следовательно, крайне важно отслеживать и обнаруживать любые сбои во время их работы, чтобы предупредить администрацию, чтобы можно было избежать потенциальных проблем до их возникновения. Обычно неисправность в приемном двигателе вызывает нагрев во время работы. Этот тезис обеспечивает разработанный алгоритм метода защиты, который использует несбалансированную составляющую мощности и моделирование всего проекта на основе Matlab Simulink. Согласно алгоритму цифровой релейной защиты, во-первых, наблюдаются данные трехфазного напряжения и тока, после чего обнаруживаются какие-либо признаки несбалансированной мощности. На следующем этапе реле определяет тип отказа, внутренний или внешний, используя знак реактивной мощности обратной последовательности. Отрицательный знак реактивной мощности обратной последовательности означает, что неисправность находится внутри двигателя, с другой стороны, положительный знак указывает на то, что неисправность произошла вне двигателя.*

Ключевые слова: *обмотки статора, реактивная мощность, короткозамкнутый ротор, резерв двигателя, колебания мощности.*

ИНДУКЦИЯЛЫҚ ҚОЗҒАЛТҚЫШТАРДЫҢ АҚАУЛАРЫН АНЫҚТАУ

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Аңдатпа. *Бұл жұмыста асинхронды қозғалтқыштардағы ақауларды анықтау әдісі сипатталған. Асинхронды қозғалтқыштар көптеген механикалық қосымшаларда кеңінен қолданылады. Демек, жұмысшыларды ескерту үшін олардың жұмысы кезінде орын алған бұзушылықтарды бақылау және* *анықтау өте маңызды, сондықтан олар пайда болғанға дейін алдын алу жағы қарастырылады. Әдетте, қабылдау қозғалтқышындағы ақаулық жұмыс кезінде қызуды тудырады. Бұл диссертация теңгерілмеген қуат компонентін қолданатын және Matlab Simulink имитациялық бағдарламасына негізделген бүкіл дизайнды имитациялайтын қорғаныс әдісінің дамыған алгоритмін ұсынады. Сандық релелік қорғаныс алгоритмі бойынша, біріншіден, үш фазалы кернеу мен ток деректері байқалады, содан кейін теңгерімсіз қуаттың кез келген белгілері анықталады. Келесі қадамда реле реактивті қуаттың теріс дәйектілігін пайдаланып, ішкі немесе сыртқы істен шығу түрін анықтайды. Теріс дәйектіліктің реактивті қуатының теріс белгісі ақаулықтың қозғалтқыш ішінде екенін білдіреді, екінші жағынан, оң белгі ақаулықтың қозғалтқыштан тыс екендігін көрсетеді.*

Түйінді сөздер: *статор орамдары, реактивті қуат, тиін-торлы ротор, қозғалтқыш қоры, қуаттың ауытқуы.*

Introduction

Induction motor is the primary necessity motor used in mechanical applications. Three phase induction motors are the most growing and frequently encountered machines in enterprises. An electromechanical system, called electric motor, which converts electrical energy into a mechanical energy. The most sorts of issues experienced by these motors are single staging, over voltage, beneath voltage, over current, under current, speed varieties, over temperature and vibration. Acceptance motors are broadly utilized as mechanical drives since they are tough, dependable and prudent. Single-phase acceptance motors are utilized broadly for littler loads, such as family apparatuses like fans. When the three stage induction motor supply with higher voltage than rated at that point induction motor begins overheated and consequently over temperature blame happens. When supply voltage is lower than evaluated constrain at that point voltage drop over the resistance is higher and blame occurs. Even, as three-stage Induction motor operates continuously, it is important to ensure these weaknesses are addressed to the motor. Induction motor safety plays a critical role in its long service life benefit [1]. Until now, a definite number of protection methods have been developed for various internal and external motor faults, depending on the motor power, motor type, motor application, and service type. Therefore, motor safety in general is less uniform than the defenses of other sections of the control system [2]. Protection given to the motor is to allow the motor to operate up to its limits, but not to allow the motor to operate above its mechanical and thermal limits in overloading and to provide optimum flexibility in detecting faults, hence the safety mechanism should detach defective parts from other parts of the power system as soon as possible, without damaging other systems detrimental to the power network and control system. The machine shaft or rotor has been continuously associated with the primary common fault sorts of these turning devices. The components of induction motor's percentage failure are as shown in Fig 1.

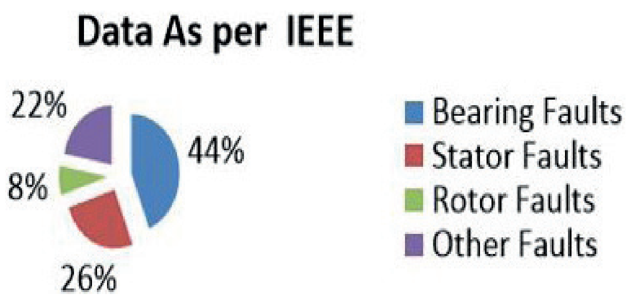

Fig. 1. Percentage Component of Induction Motor Failure

The survey was taken by Institution of Electrical and Electronics Engineers (IEEE) and Electric Power Research Institute [3].

Materials and methods

Three-phase induction motors, as is known, have simple construction of stator windings from where they are supplied, thus producing rotating magnetic field in the air gap. On the other hand, the rotor side depends on the required efficiency. This is a rotor with a phase winding, a cage with a squirrel-cage rotor. The rotor side of an induction motor has a high conductivity value, so the magnetic flux can change direction regularly due to the rotating magnetic field [4].

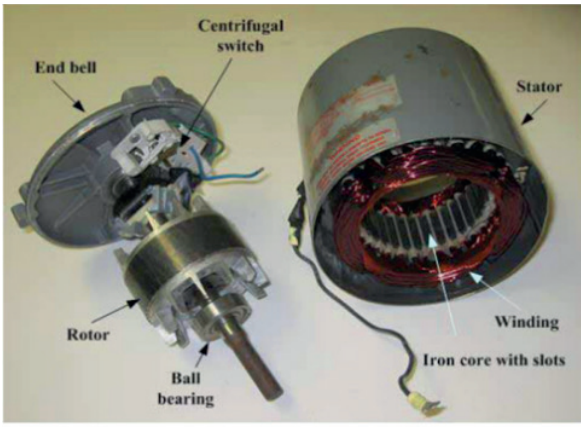

Fig. 2. Asynchronous machine components

In order to find a solution to faults in the work, it was necessary to analyze the causes of these faults. There are described in Figure below.

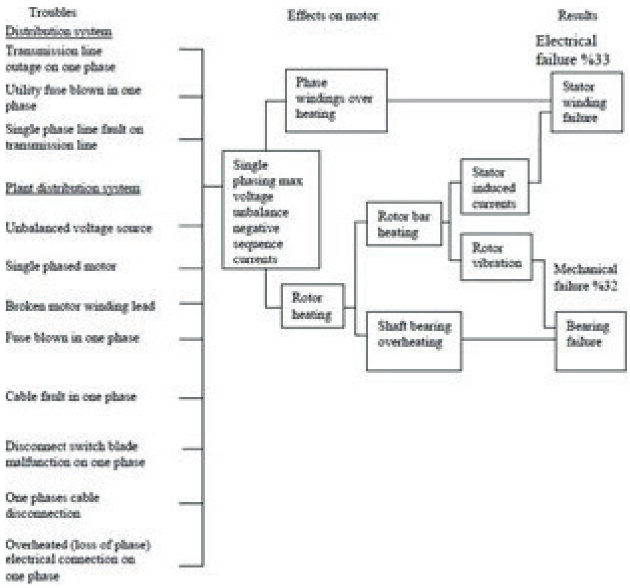

Fig. 3. Single phasing effects on induction motor operation [5]

First, the algorithm of the protection method for the protection of the induction motor is used to solve the problem of abnormal operation due to internal and external defects of the machine. This section briefly describes the security process. As it is written, the instantaneous power of the car.

When an error occurs, it vibrates twice its basic frequency. Thus, the data are taken from the first power system. These are the voltage and current values for each phase, and the other data needed to run the algorithms A, B, and C are the total power of the motor. The maximum limit sequence of unbalanced power and reverse current of a motor operating in an unbalanced state, constant capacity K, is equal to the number of tests for the period and time for this purpose. Thus, after obtaining the necessary information, the code determines whether an error has occurred based on the measured and compared values, whether the error is internal or external. A more detailed description of the mechanism is given in the next chapter of the study. It also gives a travel signal if it is likely to fail in the form of a failure.

Required values	Calculated values
V_a, V_b, V_c – 3 phase voltage values I_a, I_b, I_c – 3 phase current values S_n – Apparent power P_{unb} – Unbalanced power limit I_{ng} – Negative sequence current limit K – constant N – number of samples Δt – time for sampling	P_{2m} – Instantaneous power Q^- – Negative sequence reactive power A – integrator value for external fault

Fig. 4. Required and calculated value list

Solutions and results

This study provides a solution and description of the system of algorithms for the safety of an induction motor in unbalanced situations that can occur inside the motor or in defects that are considered external. The algorithm first looks for flaws in instantaneous power fluctuations caused by zero and negative sequence elements, then doubles the base frequency and investigates the negative reactive power circuit's source. This section delves into the algorithm's specifics.

The instantaneous power of induction motors is calculated at the terminals and can be reported as follows:

$$P(n) = v_R(n)*i_R(n) + v_S(n)*i_S(n) + v_T(n)*i_T(n). \quad (1)$$

Here n can be defined as an instantaneous example of the power p (n).aThis formula means of the above-managed state of the engine. However, when a short circuit occurs, the phase difference between the stator windings is 2pi / 3 asymmetric, and the following formulas are derived for the three-phase values of voltage and current.

The unbalanced power component generated by the negative sequence component can be converted into a shape by the Discrete Fourier Transform.

$$P_{2m} = \frac{2}{N} \sum P(n) * e^{-j4\pi n/N} \qquad (2)$$

In the event of a failure, the orientation of the negative reactive series calculated suggests that the failure is internal or external [6]. The negative sign of the Q-shows that the power transfer is from system to network, indicating that the fault is local. Vice versa of the sign indicates that there was a fault within the motor.

$$Q- = a3/N\sum v^{-}(n-\pi/2) * i^{-}(n) \qquad (3)$$

Here, v- and i- can be specified as follows:

$$v^{-}(n) = (v\,R(n) + v\,S(n - 2\pi/3) + v\,T(n + 2\pi/3))/3 \qquad (4)$$

$$i^{-}(n) = (i\,R(n) + i\,S(n - 2\pi/3) + i\,T(n + 2\pi/3))/3 \qquad (5)$$

Calculations:

Firstly, the value of P_{2m} is calculated, and if it is higher than the allowable value of P_{unb}, then the problem occurs, and then the algorithm begins to calculate the reactive power of the Q-negative sequence. If the measured value is negative, the fault appears to be internal and an immediate shutdown signal is given to isolate the faulty motor.

Secondly, the algorithm calculates the reaction of the negative sequence in the case of the following possible situation, resulting in a positive sign. Therefore, the fault is an external style fault, and the initial equation of the algorithm is used to measure the departure time to back up the engine.

$$P_{2m}\,(pu) = (V\,I-)/V\,I = I-/I = I-(pu) \qquad (6)$$

$$[P_{2m}\,(pu)a]^2 * t = K \qquad (7)$$

Typically, the equilibrium protection time using Equation [7] is defined differently for different types of motors. The constant K, which is the resistance to unbalanced activity under the influence of the heat of the motor winding of an induction machine, varies depending on the type of motor associated with its characteristics. There is a difference in the value of K according to IEC standards from 1 to 40 [7, 8]. For modeling in the thesis, the value of K is assumed to be equal to 11.

The complete diagram of the induction protection system is shown in the figure below. [7].

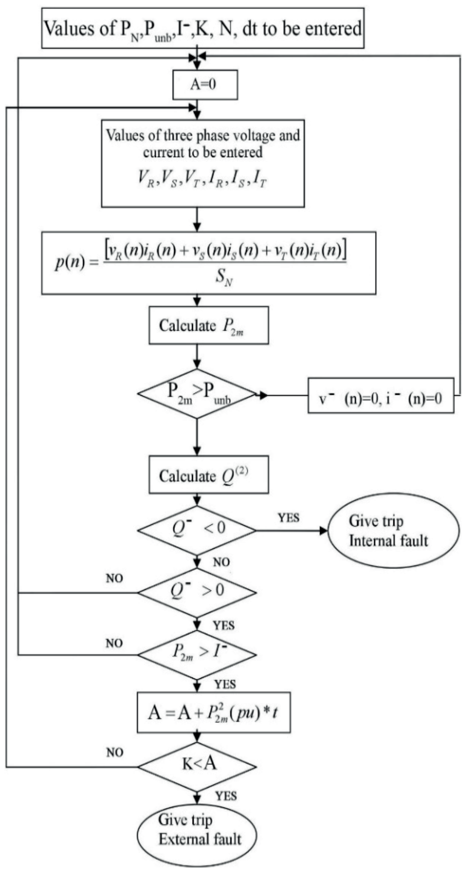

Fig. 5. Motor protection flow diagram

Simulation

The dissertation was submitted by MATLAB / Simulink system software, which measures the performance of the simulation defects. For one fault type situation, two phases to the ground were provided with this simulation of the single phase to the ground. External problems were interpreted as problems with the motor's cables. The diagram below depicts the virtual machine scheme.

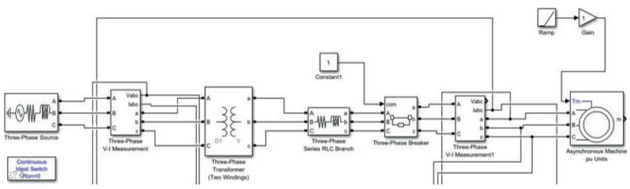

Fig. 6. Simulated model

The motor in this case was a 10 HP squirrel cage asynchronous system operating at full load. The power transformer used in the simulation was a delta-star coupled transformer with a primary voltage of 13.8 kV and a secondary voltage of 0.22 kV. It's also worth remembering that the machine's frequency was 60 Hz. The fault was thought to have started in the second and lasted two seconds during the simulation period of five seconds. For the simulation unit, the short circuit resistance was set to 0.01 ohms.

Cases for external faults

External faults on the asynchronous machine's power supply cables are identified, and the system was tested in three scenarios, yielding graphs of instantaneous power, unbalanced power, and negative sequence intensity. For simulation, the K constant was set to 11.

Two phases to ground fault

The two processes are short-circuited to the ground in this case, and the fault occurs as described in the second. When an imbalance occurs, the chart shows that power oscillations have begun. As the unbalanced power begins to remain constant after 20 ms, the algorithm begins to measure negative sequencing power.

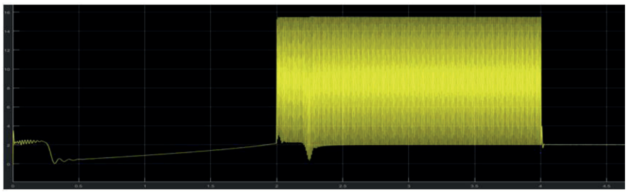

Fig. 7. Instantaneous power

Figure 8 shows that negative sequence reactive power has a positive symbol, indicating that the fault is located externally.

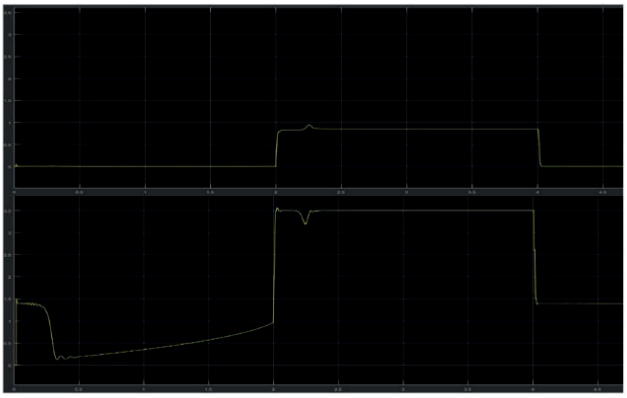

Fig. 8. Negative sequence and Unbalanced power

Single phase to ground

Decrease in average power happens as one of the processes is short-circuited to grounded and fault happens at this point. It can be seen from the figure that the negative sequencing power is positive, so the fault is external as expected.

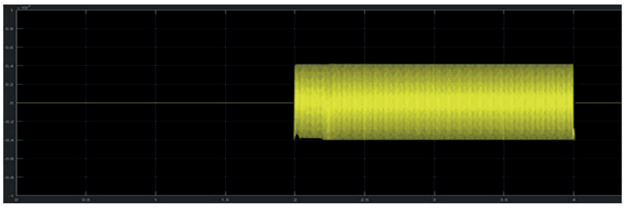

Fig. 9 Instantaneous power

120 Hz oscillations occur, causing an unfavorable state for the induction motor during unbalanced activity.

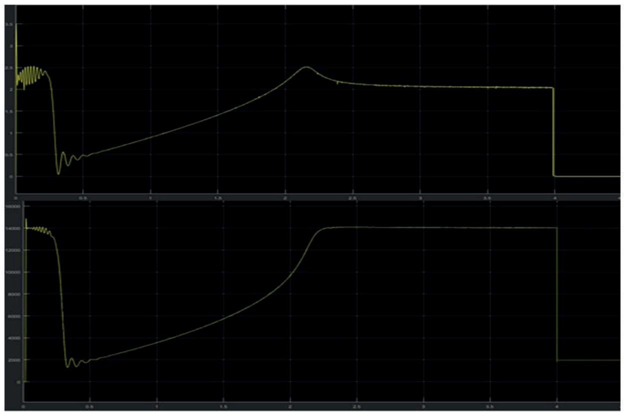

Fig. 10. Negative sequence and Unbalanced power

The trip time to protect the motor is estimated to be 4.5 seconds, preventing damage to an induction motor. As it's shown on figures, external fault detected and system shut down to protect motor and other equipment. It means that system works correctly, faster and corresponds all requirements.

Conclusion

In addition, the protection system is vital for any unit or component of the electrical power network because it is affected by potential irregular conditions. The induction motor, which is one of the most commonly used electrical machines, is often susceptible to failure, which means that the safe operation of an accurate protection method is required. In the simulation of the fault conditions for the induction motor, as a consequence, the safety device first detected a defective state from power oscillations at a two-fold base frequency before determining the type of fault based on the indication of a negative reactive power series. In a balanced network, instantaneous power is equal to the average power value, therefore, when an unbalanced condition occurs, the fault is detected, and when the internal form of fault relay is specified, the instant trip command is given. Today, it is important to provide reliable protection for every aspect of the electrical system because it is effective in many ways, including continuous regular operation of the network, efficiency and health of the equipment. Moreover, the devitalized age of technology allows society to develop all of the security mechanisms that have been developed, so that they can be quicker or better, more effective and perfect for prejudice, helping to plug the gaps produced by unreliable circumstances or irregular cases. Future simulation of an internal faults is planned. For the simulation internal faults will be assume to take place in stator windings.

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