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Fault diagnosis of single-phase induction motor based on acoustic signals

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ABSTRACT

The paper presents description of bearing, stator and rotor fault diagnostic methods of a single-phase induction motor. The presented methods use acoustic signals. Five states of the single-phase induction motor were analysed: healthy motor, motor with shorted coils of auxiliary winding and main winding, motor with shorted coils of auxiliary winding, motor with broken rotor bar and faulty ring of squirrel-cage, motor with faulty bearing. A method of feature extraction of acoustic signals – SMOFS-22-MULTIEXPANDED (Shortened Method of Frequencies Selection Multiexpanded) was developed and implemented. The SMOFS-22-MULTIEXPANDED was implemented as feature extraction method of acoustic signals. Classification step was performed using the NN (the Nearest Neighbour) classifier. The proposed methods had good results for diagnosis of bearing, stator and rotor faults of the single-phase induction motor. The developed approach can find applications for fault diagnosis of other types of rotating machines.

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1. Introduction

The number of electric rotating motor is increased every year, so it is essential to diagnose them properly. A single-phase induction motor (Fig. 1) is simple in construction, inexpensive and reliable. It finds its application in both industrial and domestic electric motors such as: drill, blowers, elevators, cordless drill, vacuum cleaner, conveyors, fans, machine tools, pumps. Many parts of the motor (rotor shaft, bearings, insulation, stator and rotor circuits) wear out depending on operating stress and operation time (Figs. 2–5). Degraded parts of electric rotating motor can cause accidents and downtimes during the operation of machine. Repair or replacement of a damaged motor costs time and money. Often it is better to repair the motor than replace it (if we have expensive machine).

Technical improvement, cost reductions and high reliability are essential for mining and fuel industries. Mining and refinery use many electric rotating motors. Stator and rotor electrical faults often appear in electric rotating motors. Such faults can damage windings of the motor permanently. There are many different approaches for detecting faults of the electric motor.

In the literature diagnostic techniques based on the analysis of defect signatures in electric currents were developed [1–6]. These techniques had high recognition efficiency. An electric signal is easy to process, because it is not so mixed together (comparing with acoustic signals).

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Fig. 1. Low-cost capacity microphone and single phase induction motors.

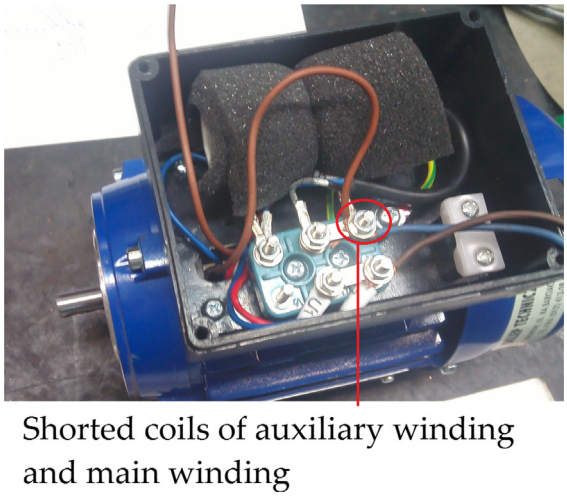

Fig. 2. Motor with shorted coils of auxiliary winding and main winding.

Unfortunately current signal can be used only for limited faulty states such as: shorted windings, broken bars, faulty ring of squirrel-cage [7–11]. Moreover access to the electric signal is not so easy (comparing with acoustic signals). Many articles described techniques based on vibration signals [12–16]. Techniques based on the analysis of vibration are very common used. Similarly to the analysis of electric currents, techniques based on the analysis of vibration have high recognition efficiency.

Advantages of vibration based fault diagnostic techniques are: inexpensive accelerometer, immediate measurement of the vibration signal, it is possible to analyse electrical (shorted windings, broken bars, faulty ring of squirrel-cage) and mechanical faults (bearings, rotor shaft etc.) [17–20], easy access to vibration signal. Disadvantages of vibration based fault

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