Induction Motor Fault Identification using Support Vector Machine

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***Abstract* — Different induction motor applications have subjected this machine to different conditions that will affect its effective operation. Various types of faults are caused by the environment in which induction motors are installed, which eventually affect the entire operation of the industrial plant, these machines operate. This study aims to develop a more effective method for identifying and classifying faults in three-phase induction motors using Support Vector Machines. The method of Artificial Intelligence (AI), which incorporates the Support Vector Machines (SVM) algorithm, is used to classify nine conditions of fault in induction motors, namely the unbalanced supply voltages, over-voltage, under-voltage, blocked rotor, line-to-line short circuit, line-to-earth short circuit, single phasing, mechanical overload, and a healthy motor. A SIMULINK simulation of an induction motor will be created to simulate the faults independently, and the results will be trained to the SVM model. Using an Orange tool, the SVM method was used in conjunction with the one-versus-all multiclass approach and the Radial Basis Function (RBF) kernel.**

Keywords* — *Simulink, support vector machines, radial basis function (RBF) kernel, condition monitoring, induction motor

I. Introduction

Induction motors are required for most industrial applications. Advantages such as ease of handling, cheap cost, high dependability, high efficiency, robustness, and the availability of power converters make induction motors the best choice for industrial applications [1], [2], and [3]. Since installing several backup units is not cost-efficient, online monitoring for induction machines is essential for safe operation and product quality. Defect monitoring, detection, classification, and diagnosis have become crucial to keep equipment in good operational condition [4], [5], and [6]. To identify machine faults, there are both invasive and non-invasive techniques [7], [8], and [9]. Non-invasive techniques are recommended over intrusive methods because they diagnose machine faults without damaging the machine structure. Artificial intelligence (AI) systems have recently been proposed for non-invasive machine failure detection [7], [9], and [10].

As a result, if a fully developed and autonomous condition monitoring system is adopted in place of established planned maintenance, it will be able to save the replacement of unnecessary components while also drastically lowering unplanned failures. All common squirrel-cage induction motor faults are bearing-related, lack of stator windings, rotor bar broken, air gap eccentricity, and shaft imbalance [11].

TABLE I: Induction Motor Faults [2].

Major components	IEEE	EPRI	Allianz
Stator faults	26%	36%	66%
Rotor faults	8%	9%	13%
Bearing faults	44%	41%	13%
Other faults	22%	12%	8%

Table I compares several surveys by IEEE, EPRI, and Allianz. The survey conducted by IEEE and EPRI focuses on medium-sized induction machines. In contrast, the survey conducted by Allianz is more interested in the big, medium, to high-voltage induction machines [12] and [13]. According to relevant publications and various fault surveys for the most prevalent induction motors, the most common failures are due to the following: bearing (40%), stator winding breakdown (38%), broken rotor bar or end-rings (10%), and other induction motor defects (12%) [14], [15], and [16].

Because a defective motor consumes more energy than a healthy motor, detecting motor problems automatically and in real time is crucial. Modern methods for diagnosing induction motors include testing electromagnetic fields, temperature distribution, noise testing, chemical analysis, modal testing, vibration analysis, motor current signature analysis (MCSA), and artificial intelligence [17].

However, the performance of AI-based fault diagnostics remains heavily dependent on the machine learning algorithms used to evaluate the input data. Support Vector Machines (SVM) are supervised machine learning algorithms that can be used in classification and regression challenges. They are primarily used for classification problems. SVM algorithms help find a hyperplane in an N-dimensional space that distinctly classifies the data points and Artificial Neural Networks (ANN) [18] are the two most often used approaches for diagnosing induction motor faults [19], [20], and [21]. The main focus of the work, is the identification of induction motor faults, by the use of Support Vector Machine (SVM).

II. Classification

A. Support Vector Machines

According to several studies, Support Vector Machine (SVM) is a cutting-edge machine learning technique built on the structural risk minimization concept and statistical learning theory. SVM is an effective technique for dealing with issues including small samples, nonlinearities, and local minima and performs exceptionally well in classification. Some classifiers attempt to solve each specificity of the training set while simultaneously attempting to build a general model from the feature set. SVM is a classification and regression prediction method that automatically avoids overfitting the data while maximizing predictive accuracy.

Fault Identification Of Induction Motors

Hong-Yue Zhang

Fault Identification Of Induction Motors:

Condition Monitoring and Faults Diagnosis of Induction Motors Nordin Saad,Muhammad Irfan,Rosdiazli Ibrahim,2018-07-11 The book covers various issues related to machinery condition monitoring signal processing and conditioning instrumentation and measurements faults for induction motors failures new trends in condition monitoring and the fault identification process using motor currents electrical signature analysis It aims to present a new non invasive and non intrusive condition monitoring system which has the capability to detect various defects in induction motor at incipient stages within an arbitrary noise conditions The performance of the developed system has been analyzed theoretically and experimentally under various loading conditions of the motor Covers current and new approaches applied to fault diagnosis and condition monitoring Integrates concepts and practical implementation of electrical signature analysis Utilizes LabVIEW tool for condition monitoring problems Incorporates real world case studies Paves way a technology potentially for prescriptive maintenance via IIoT **Fault Diagnosis of Induction Motors** Jawad Faiz,Vahid Ghorbanian,Gojko Joksimović,2017-08-29 This book is a comprehensive structural approach to fault diagnosis strategy The different fault types signal processing techniques and loss characterisation are addressed in the book This is essential reading for work with induction motors for transportation and energy Induction Motor Fault Diagnosis Subrata Karmakar,Surajit Chattopadhyay,Madhuchhanda Mitra,Samarjit Sengupta,2016-04-04 This book covers the diagnosis and assessment of the various faults which can occur in a three phase induction motor namely rotor broken bar faults rotor mass unbalance faults stator winding faults single phasing faults and crawling Following a brief introduction the second chapter describes the construction and operation of an induction motor then reviews the range of known motor faults some existing techniques for fault analysis and some useful signal processing techniques It includes an extensive literature survey to establish the research trends in induction motor fault analysis Chapters three to seven describe the assessment of each of the five primary fault types In the third chapter the rotor broken bar fault is discussed and then two methods of diagnosis are described i diagnosis of the fault through Radar analysis of stator current Concordia and ii diagnosis through envelope analysis of motor startup current using Hilbert and Wavelet Transforms In chapter four rotor mass unbalance faults are assessed and diagnosis of both transient and steady state stator current has been analyzed using different techniques If both rotor broken bar and rotor mass unbalance faults occur simultaneously then for identification an algorithm is provided in this chapter Chapter five considers stator winding faults and five different analysis techniques chapter six covers diagnosis of single phasing faults and chapter seven describes crawling and its diagnosis Finally chapter eight focuses on fault assessment and presents a summary of the book together with a discussion of prospects for future research on fault diagnosis **Induction Motors** Raúl Gregor,2015-11-18 AC motors play a major role in modern industrial applications Squirrel cage induction motors SCIMs are probably the most frequently used when compared to other AC motors because of their low cost ruggedness and low

maintenance The material presented in this book is organized into four sections covering the applications and structural properties of induction motors IMs fault detection and diagnostics control strategies and the more recently developed topology based on the multiphase more than three phases induction motors This material should be of specific interest to engineers and researchers who are engaged in the modeling design and implementation of control algorithms applied to induction motors and more generally to readers broadly interested in nonlinear control health condition monitoring and fault diagnosis **Incipient Detection of Faults in Three-Phase Induction Motors Using Stator Current Spatial Angular Vector Analysis** R.A Gupta,A. K. Wadhwani,S.R Kapoor,2009 The detection of motor faults at their incipient stage is gaining importance as it leads to increased reliability and reduced machine downtime The stator current analysis has caught the attention of researchers as a mature and simple technique for induction motor fault detection and identification In this paper angular space vector analysis of the induction motor stator current for fault identification has been investigated The tracking of spatial angular vector profile of stator current Parke s vector is used to identify the degrading health condition of induction motors Any significant deviation in the shape of spatial angular vector is an indicator of the inset of irregularities mechanical or electrical in the induction motor Three major types of induction motor faults bearing fault broken rotor bar fault and unbalanced supply faults have been experimentally investigated The experimentation has been performed on a 3 1 5 kW 4 poles 1440 RPM ABB squirrel cage motor The motor setup was mechanically loaded to operate at various loads The TMS 320F420 DSP based dSPACE DS 1104 control card has been used to carry out the experimentation The softwares used include MATLAB ver 2006 and dSPACE controldesk Fault diagnosis of induction motor fed by frequency converter. The signal signature analysis technique Hussain Mahdi,2016-08-12 Thesis M A from the year 2013 in the subject Electrotechnology Warsaw University of Technology Electrical Engineering language English abstract 3 Phase induction motors are widely used as a source of mechanical power for effective operation and low costs The abnormalities have to be detected in advance to avoid the motor breakdown and the cost associated restrain of plant production This work discusses current and flux leakage spectral analysis techniques for the diagnosis of broken rotor bars and shortcircuited turns in induction motor fed from different AC sources In spite of recent development of various types of models toward motor faults diagnosis and examining different problems associated with 3 phase induction motors the signal spectral analysis is considered as one of most important approaches Most of the models from simple equivalent circuit to more complex d q and a b c models and lastly developed hybrid models are provided for the integration of different forms of current and or voltage unbalance Generally techniques that relate to asymmetry identify asymmetrical motor faults Frequency converters in many applications feed induction motors Such applications which play a major role in industry are growing at a high rate allow to use 3 phase induction motor as variable speed applications This paper proposes application of spectral signature analysis for the detection and diagnosis of abnormal electrical and mechanical conditions which indicates chosen faults in induction

motor fed by frequency converter Fault Detection in Three Phase Induction Motor Using Artificial Intelligence Unida Izwani Md Dun,2010 Artificial intelligence AI techniques have proved their ability in detection of incipient faults in electrical machines In this project the fault diagnosis of three phase induction motors is studied detailed in unbalance voltage and stator inter turn fault using simulation models and neural networks have been used to train the data using Radial Basis Function Neural Network RBFNN in MATLAB with Graphical User Interface Development Environment GUIDE structured Nowadays artificial intelligence is implemented to improve traditional techniques The results can be obtained instantaneously after it analyzes the input data of the motor The increased in demand has greatly improved the approach of fault detection in polyphase induction motor Data is taken from the experiment checking the induction motor fault and is simulated into MATLAB using RBFNN The first stage is to collect the data by experimental and simulating a Simulink model using MATLAB Three Simulink model will be created where each of the model represent the motor condition The result of the simulation will then be the data used to create an ANN The second stage creates and trains an ANN From the data obtained during the first section a target output will determine the motor condition whether the motor is in a healthy state or fault occurred In the third stage the development Graphical User Interface GUI is carried out this system The GUI is developed by using MATLAB for the purpose of evaluating and testing the ANN The purpose of this final year project the development of Fault Detection in Three Phase Induction Motor Using Artificial Intelligence is to satisfy the increased in demand to improve the approach of fault detection in polyphase induction motor Artificial intelligence is implemented to improve traditional techniques as the results can be obtained instantaneously after it analyzes the input data of the motor where it can be accomplished without an expert *Fault Detection* Wei Zhang,2010-03-01 In this book a number of innovative fault diagnosis algorithms in recently years are introduced These methods can detect failures of various types of system effectively and with a relatively high significance **Observer-based Fault Detection for Induction Motors** Guiying Yu,2006 Fault Detection in Three Phase Induction Motor Using Artificial Intelligence Ahmad Farid Abu Bakar,2009 Artificial intellegence AI techniques have proved their ability in detection of incipient faults in electrical machines in this project the fault diagnosis of three phase induction motors is studied detailed in unbalance voltage and stator inter turn fault using simulation models and neural networks have been used to train the data using Radial Basis Function Neural Network RBFNN in MATLAB with Graphical USer Interface Development Environment GUIDE structured Fault Detection, Supervision and Safety of Technical Processes 2006 Hong-Yue Zhang,2007-03-01 The safe and reliable operation of technical systems is of great significance for the protection of human life and health the environment and of the vested economic value The correct functioning of those systems has a profound impact also on production cost and product quality The early detection of faults is critical in avoiding performance degradation and damage to the machinery or human life Accurate diagnosis then helps to make the right decisions on emergency actions and repairs Fault detection and

diagnosis FDD has developed into a major area of research at the intersection of systems and control engineering artificial intelligence applied mathematics and statistics and such application fields as chemical electrical mechanical and aerospace engineering IFAC has recognized the significance of FDD by launching a triennial symposium series dedicated to the subject The SAFEPROCESS Symposium is organized every three years since the first symposium held in Baden Baden in 1991 SAFEPROCESS 2006 the 6th IFAC Symposium on Fault Detection Supervision and Safety of Technical Processes was held in Beijing PR China The program included three plenary papers two semi plenary papers two industrial talks by internationally recognized experts and 258 regular papers which have been selected out of a total of 387 regular and invited papers submitted Discusses the developments and future challenges in all aspects of fault diagnosis and fault tolerant control 8 invited and 36 contributed sessions included with a special session on the demonstration of process monitoring and diagnostic software tools Nondestructive Tests for Induction Machine Faults Diagnosis Paulo Cezar Monteiro,2016 A maintenance program must include several techniques of monitoring of the electric motor s conditions Among these techniques probably the two classic ones are related to megger and impulse test Unfortunately in both cases inherent drawbacks can expose the electrical motor at a high voltage that could deteriorate insulation condition making difficult its use on industrial environment As the electrical machines have several different components e g bearings rotor bars shaft and stator windings the fault frequencies can be excited by mechanical and or electrical faults making the identification of the real condition difficult This chapter describes several methods of the nondestructive tests for induction motors based on the motor current signature analysis MCSA magnetic flux and vibration analysis The method of analysis is a good alternative tool for destructive tests and fault detection in induction motors Numerical and experimental results demonstrate the effectiveness of the proposed technique This chapter also presents a model suitable for computer simulation of induction motor in a healthy state and with general asymmetries that can be analyzed simultaneously The model makes it possible to conduct research on different characteristics of engines and outstanding effects produced by the faults Early Detection of Faults in Induction Motors Daniel Morinigo-Sotelo,Rene Romero-Troncoso,Joan Pons-Llinares,2023-11-24 In modern industries induction motors are the backbone of numerous applications powering everything from manufacturing facilities to transportation systems While they are known for their reliability unexpected failures can still occur leading to increased operational costs facility damage or service interruptions Early Detection and Fault Diagnosis of Induction Motors is a comprehensive volume that compiles ten innovative journal articles focused on maintaining these machines The papers explore a variety of techniques that introduce new ideas to the field **Neural Network Based Incipient Fault Detection of Induction Motors** Mohd Rokonuzzaman,1995 Condition Monitoring, Fault Diagnosis and Applications of Induction Motors Lindy Ladner,2023-09-19 An induction motor refers to an alternate current electric motor for which the electric current is required to produce torque in the rotor through electromagnetic induction from the magnetic field of the stator

winding Three phase induction motors play an important role in various industries because of their benefits over other electrical motors As a result there is a high demand for their dependable and secure operation Any breakdowns or faults in the motor might result in longer downtime and can cause significant maintenance and revenue losses requiring early fault detection for motor protection Condition monitoring of induction motor is a new technology for detecting potential faults online It entails taking measurements on a machine while it is in operating condition for detecting faults The goal of online condition monitoring is to lower maintenance costs and unexpected failure This book outlines the applications of induction motors as well as their condition monitoring and fault diagnosis It will serve as a valuable source of reference for graduate and post graduate students *Fault Detection and Protection of Three Phase Induction Motor* Maruti R. Jadhav,2013 Induction motors are widely used in industries some electric faults may cause malfunctioning of it so protection of it against these incipient faults is very necessary This monograph refers to an approach of protection of motor using micro controller It emphasizes on PIC 18F4431 family controller to detect the faults and protect them some simulink modelling and simulations are done to find the tolerable limit values *Influence of Adjustable Speed Drive on Induction Motor Fault Detection Using Stator Current Monitoring* Ali S. Al-Shahrani,2005 The detection of motor faults at their incipient stage is of prime importance to any industrial plant The introduction of adjustable speed drives has improved the control and the efficiency of induction motors however this has changed the nature of motor faults and how they can be detected Current signature analysis has caught the attention of researchers as a mature and simple technique for motor fault diagnosis In this research three main ways of analyzing the current signature for fault detection have been investigated These are the power spectral density analysis the current negative and positive sequence components and the Park s vector approach Three major induction motor faults have been experimentally tested for the above diagnosis techniques the bearing fault the broken rotor bar and the air gap dynamic eccentricity Using an adjustable speed drive for controlling the motor while applying these fault detection techniques has been compared to the supply of the motor directly from the mains source and to a pure sinusoidal supply through a programmable source This research has proved that using the power spectral density analysis is a good tool for induction motor fault detection regardless of the source of supply This technique can be easily implemented in standard commercial adjustable speed drives with no additional hardware requirements *Identification of Induction Machine Winding Faults Using Stochastic Optimization Techniques* Salah Eddine Ethni,University of Newcastle upon Tyne. School of Electrical, Electronic and Computer Engineering,2011 **Online Condition Monitoring and Fault Detection in Induction Motor Bearings** Turker Sengoz,2018 Induction motors IMs are commonly used in industry Online IM health condition monitoring aims to recognize motor defect at its early stage to prevent motor performance degradation and reduce maintenance costs The most common fault in IMs is related to bearing defects Although many signal processing techniques have been proposed in literature for bearing fault detection using vibration and stator current signals reliable bearing fault

diagnosis still remains a challenging task One of the reasons is that a rolling element bearing is not a simple component but a system its related features could be time varying and nonlinear in nature The objective of this study is to investigate an online condition monitoring system for IM bearing fault detection The monitoring system consists of two main modules smart data acquisition DAQ and bearing fault detection In this work a smart current sensor system is developed for data acquisition wirelessly The DAQ system is tested for wireless data transmission consistent data sampling and low power consumption The data acquisition operation is controlled by using an adaptive interface In bearing fault detection a generalized Teager Kaiser energy GTKE technique is proposed for nonlinear bearing feature extraction and fault detection using both vibration and current signals The proposed GTKE technique will demodulate the signal by tracking the instantaneous signal energy An optimization method is proposed to enhance the fault related features and improve signal to noise ratio The effectiveness of the proposed technique is verified experimentally using a series of IM tests The robustness is examined under different operating conditions **Fault Detection of Induction Motors Using Neuro-fuzzy Modelling** Hong Huo,2002

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