Chapter 20
Modeling, Analysis, of Induction Motor's Stator Turns Fault Using Neuro-Fuzzy

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ABSTRACT

This chapter discusses modeling and analysis methods for fault detection and diagnosis of stator inter-turn short circuit in three-phase induction machines. dq frame was used to model the induction motor for both health and fault cases to facilitate recognition of motor current and simulate motor environment. Fault diagnosis system was designed with adaptive neuro-fuzzy inference system (ANFIS) to provide an efficient online diagnostic tool. ANFIS diagnostic tool was trained with simulated data that generated by induction motor healthy and faulty models. Approached tool is verified online with a motor under different loading conditions. It determines the fault severity values using the motor current signature analysis (MCSA). Developed tool performance is investigated with a case study of two HP three-phase induction motor using Matlab/Simulink® software.

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1. INTRODUCTION

Induction machines are most common use machines in all industries. It is utilized with ninety percent over electrical motor industrial applications(Abdel, Hassan, & Bendary, 2018; Hussein, Ammar, & Hassan, 2017; Joshi & Talange, 2016). Induction machines are low price and reliability. Analysis of induction machines' faults is crucial to minimize downtime and cost of damages in additions to early detections (Abdel, El Samahy, Hassan, & El Bendary, 2016; Abdel et al., 2018; Milić, 2020). Machine faults can be divided into two categories, internal and external. The external faults can be determined as electrical (transient voltage, unbalanced voltage, voltage fluctuations…), mechanical (pulsating load, overloading, and poor mounting…) and environmental (Humidity, temperature, cleanliness…) as discussed in (Atig, Bouheraoua, & Fekik, 2018; Geethanjali & Ramadoss, 2019; He, Xie, & Luo, 2020). The induction machine internal faults contain two types of faults mechanical such as rotor strikes, bearing faults, and Eccentricity and electrical as Stator winding faults, Broken Rotor Bar, Broken End ring, and Rotor winding faults for the wound rotor machine.

Induction machine faults include winding faults, unbalanced stator and rotor, broken rotor bars, eccentricity and bearing faults. The failure due to the stator and bearing fault breakdown are considering the dominant fault incidents(Abdel et al., 2016; Joshi & Talange, 2016; Lázaro & Pinilla, 2020). The main goal of fault diagnosis is to determine the fault as early as possible and classify it correctly to facilitate localization. In order to ensure reliable diagnosis, advanced strategies must be used. Fault detection and diagnosis methods fall under three categories model-based fault detection and history-based method to build up an online signal based model (Enshaei, Hammad, & Naderkhani, 2020; Lázaro & Pinilla, 2020; Lei et al., 2020). The model-based technique requires a system modeling that is derived from the physics of the system to describe the motor in both quantitative and qualitative (Lei et al., 2020; Rahimi, Kumar, & Alighanbari, 2020).

Model-based fault diagnosis methods built on motor observer design, based on induction motor model (Han, Li, Dahhou, Cabassud, & He, 2020). Figure 1 shows schematic of model-based fault detection method. The observer estimates the system states in healthy operating conditions though the system state vector is measured. The error signal has a value when there is a difference between the measured and estimated system states. When the motor is working under healthy mode of operation the difference between actual and estimated states is almost zero given that the observer is well designed. However with inter-turn fault happen the real motor environment will be changed, but the observer keeps as it is. Hence the error signal will have a significant value that indicates an inter-turn fault. Model-based fault diagnosis method can detect the severity of the fault independently of loading condition and supply voltage quality. But it needs an exact mathematical model of the faulty motor with variable fault severity. Genetic algorithms were used in (Raie & Rashtchi, 2002) with classical model of the induction motor to estimate the severity of the stator inter-turn fault, where they used fitness function depends on the motor current and speed signals.

However model-based methods needless for a priori data. But it has a complexity of observer design. Besides the availability of a priori healthy and faulty operation data can support in the fine-tuning of the model-based observers.

The process history-based method requires enough history of measurements or system data. Parameter estimation is based on the input-output data where a mathematical equation could be realized using the measurements and decisions. Signal based models depend on online process system measurements. Online diagnosis use highly efficient sensors and Data Acquisition Card (DAC) to identify system fault

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