別紙様式８

研　究　主　論　文　抄　録

論文題目　TEMPORARY SHORT CIRCUIT ANALYSIS IN STATOR WINDING OF INDUCTION MOTOR（誘導電動機電機子巻線における突発的短絡事故の解析）

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主論文要旨

Induction motors are one of the most used equipment in industrial sector for electrical to mechanical energy conversion due to the flexibility control of motor system. About 70% of the industrial applications utilize induction machines and because of this trend they consume more than 50% of an industrialized power generating capability. Although this equipment is known as robust design, occasionally its failure during operations. Induction motor failure in industrial plants can produce huge losses. For instance, in offshore oil plants, downtime losses due to motor failures can reach 25.000 per hour. Considering industrial survey, stator winding contributes up to 66% of motor faults. Moreover, stator insulation is one of the weakest parts and causes approximately 80% stator failures. Early fault detection system is one of alternative solution to avoid huge losses due to motor failure. When the fault is detected in early stage, the maintenance program can be scheduled to fix the fault and sudden stop can be avoided.

The aim of the thesis is to investigate the behavior of incipient short circuit fault in stator winding and proposes a method to detect this fault. In this thesis, the short circuit fault is defined as low current magnitude and temporary occurrence representing the initial stage of insulation failure and also a very short time of fault which is defined as a spike short circuit. Mathematical model and simulation are developed to investigate the current transient behavior affected by the fault. The detection focuses on the starting and ending points of fault. The fault is selected as the point detection because it results in a higher transient current than other normal operating condition such as load change. Wavelet transform (WT) is used as a feature extraction of the current signal. For optimal

selection of a wavelet filter, linear discriminant analysis (LDA) is used as a wavelet filter evaluator, while neural network is selected to be the detection system to avoid the complexity of determining a detection threshold.

Based on literature study, simulation and experimental analysis, we got some importance finding in this thesis. The combination some stress, imperfect fabrication and ageing are the most importance factor to lead induction motor failure. Most cases, the motor failure is occur gradually until the motor stop rotating. In certain stage of deterioration, the symptom of fault can be identifying physically as cracking, partial discharge and surface tracking. Recently, the online fault detection and monitoring is widely developed but still encounter the noise signal and data interpretation problems. Moreover, most of winding fault is initiated by inter-turn fault. Although inter-turn fault exist in stator winding, motor is seems operating normally. Motor speed and mechanical torque are oscillated near the operating point during low current inter-turn. Simulation analysis shows that inter-turn short circuit can be detected using negative sequence current. The negative sequence current is providing sensitive detection that can detect clearly 1% of shorted turn. But, this method is only effective in the balance operation. Unbalance stator winding and unbalance voltage causes the increase in the magnitude of negative sequence current.

The characteristic of transient short circuit is quite different with sudden load changes. Motor current is increase or decrease rapidly during transient short circuit. The incensement is much faster than sudden load change. Based on these transient phenomena, detection using wavelet transform is proposed. The energy of high frequency signal from wavelet transform is used as input of detection system. Statistical analysis named linear discriminant analysis is used to selecting the most appropriate wavelet filter. This analysis result shows that the Haar wavelet third level transformation is the most effective wavelet filter with 22.1% classification error. Moreover, neural-network detection system is designed to recognizing the trending and classification threshold. In this work there are three type of neural network are evaluated to obtain the most suitable system for detecting temporary fault that are Feed Forward Network, Elman neural network and Radial basis function neural network. Evaluation analysis result are shows that the detection efficiency each network are 97%, 100% and 68% for FFNN, ELNN and RBFNN, respectively. Based on this result, it can be concluded that ELNN is the most appropriate system for detecting temporary short circuit occurrence.