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Abstract

In today's modern industrial environment, ensuring the reliable functioning of electrical assets is essential for sustaining uninterrupted operations in various industrial sectors. Induction motors (IMs), permanent magnet synchronous motors (PMSMs), generators, and transformers play crucial roles in the transmission and conversion of electrical energy. A fault in these assets, if left unnoticed, can lead to catastrophic failure of the machinery, and thus a cyber-physical system (CPS) framework is implemented that can diagnose the faults in a real-time environment followed by fault prognosis.

The thesis commences with a comprehensive literature review, delving into the dynamical models and prominent flaws that impact three-phase induction motors, permanent magnet synchronous motors, three-phase AC (alternating current) generators, and three-phase transformers. Following that, the thesis provides comprehensive examinations of fault diagnosis procedures specifically designed for the electrical assets. Motor current signature analysis and vibration analysis are employed to detect faults in both IMs and PMSMs. In the case of generators and transformers, electrical signature analysis is utilised to detect operational status and deviations from normal performance.

The thesis makes a noteworthy contribution by creating a fault diagnostic framework based on CPS. This framework successfully integrates current sensor data with motor current signature analysis to enable automatic and real-time fault defect identification. In addition, a methodology is presented for predicting the remaining useful life (*RUL*) of equipment using statistical based methods. The proposed methodology takes into account the equipment-specific baseline hazard function that defines the instantaneous rate of failure depending on the service time.

The fault diagnosis and prognosis techniques developed were experimentally validated. This validation demonstrated the effectiveness and practicality of the proposed methodologies in improving the reliability and performance of electrical assets. To summarise, this thesis provides useful knowledge and techniques that advance the present knowledge and application of fault diagnosis and prognosis for electrical assets.

Keywords: Induction motors; motor current signature analysis (MCSA); predictive maintenance; remaining useful life (*RUL*); vibration analysis,