Chapter 11
Progressive Bearing Fault Detection in a Three-Phase Induction Motor Using S-Transform via Pre-Fault Frequency Cancellation

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ABSTRACT

Detection of bearing faults have become crucial in electrical machines, particularly in induction motors. Conventional monitoring procedures using vibration sensors, temperature sensors, etc. are costly and need more tests to estimate the nature of fault. Hence, the current monitoring attracts the concentration of many industries for continuous monitoring. Spectral analysis of stator current to estimate motor faults, FFT analysis, is commonly preferred. But the problems associated with normal FFT analysis will mislead the fault diagnosis. Therefore, advanced spectral methods like wavelet transforms, matrix pencil method, MUSIC algorithm, s-transforms have been proposed. But each technique requires special attention to get good results. On the other hand, faults experienced by the induction motor can be categorized into bearing-related, rotor- and stator-related, and eccentricity. Among these faults, bearing damage accounts for 40-90% and requires additional concentration to estimate.

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INTRODUCTION

Induction motors are extensively used electrical machines in industries for various applications. These motors frequently suffer from faults due to electrical, mechanical, and thermal stresses and cause calamitous damage to industries' production and financial aspects. To prevent unnecessary maintenance costs and burdens, continuous assessment for these faults at the nascent stage is essential. In induction motors, most common bearing faults, broken rotor faults, stator inter turn faults, and eccentricity faults (PEOCO,2014). Several reports like IEEE and PES have mentioned the percentage involvement of these faults like 42, 37, 10 and 12 for 200HP and above (Zhang,2011). Hence, the contribution of bearing faults is more for high rating machines and further increases to 90% in small and medium ratings (El Houssin,2013). These faults can be primarily classified into localized faults and distributed faults. Localized faults are categorized into the inner race, outer race, cage, ball defects (Nath,2020) and distributed faults into corrosion, misalignment, and generalized roughness (Zhou,2008). Localized faults (Single point defect) will produce a perceivable impact on the machine parameters and take place due to the usage of the motor for a long duration without any maintenance (Frosini,2010). On the other hand, distributed faults of bearing like generalized roughness are difficult to trace through the indicators as they are obscure. These faults are progressive and become calamitous if non detected at a premature stage. Fault detection using popular methods using vibration sensors, temperature sensors, chemical procedures etc., are costly and needs more tests to estimate the nature of the fault.

For instance, vibration monitoring is most popularly used but needs a lot of manpower, costly equipment, and difficult to direct motor access in hazardous situations (Zhou,2008). Because of this, there is a requirement of cost-effective, suitable for all environments and non-intrusive methods to detect faults in an induction motor. Motor current spectral analysis will meet all these requirements and require less manpower (Dalvand,2017). This attracts the attention of many recent researchers for fault diagnosis in 3 phase induction motor. Many recent works provide (Sun, 2019) motor current signature analysis based fault detection and suffer from major complications like not being suitable for nonstationary nature, resolution problems. Fast Fourier transform (FFT) based spectral analysis has issues like inaccurate resolution, computational time, and inefficacious to provide time-frequency resolution (Kim, 2007).

The resolution issues under stationary condition are overcome using MUSIC and ESPRIT algorithms in (Garcia,2011) (Kia, 2005) (Bracale, 2007) and have computational issues (Liu,2017), whereas for nonstationary condition time-frequency spectral analysis using short-time Fourier transform (STFT) (Henao,2011). This gives inappropriate magnitudes for the signals due to fixed window size. As the fault

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