Induction Motor Fault Detection Using MCSA & Machine Learning

Sami Haider Mirza
BEE-15C, SEECS
NUST, H-12, Islamabad, Pakistan
smirza.bee23seecs@seecs.edu.pk

Muhammad Jahan Zaib
BEE-15C, SEECS
NUST, H-12, Islamabad, Pakistan
mzaib.bee23seecs@seecs.edu.pk

Muhammad Hussain
BEE-15C, SEECS
NUST, H-12, Islamabad, Pakistan
mhussain.bee23seecs@seecs.edu.pk

Rana Muhammad Bilal
BEE-15C, SEECS
NUST, H-12, Islamabad, Pakistan
rbilal.bee23seecs@seecs.edu.pk

***Abstract*—This project presents the detection and classification of faults in an induction motor using Motor Current Signature Analysis (MCSA) and machine learning techniques. Stator current signals are acquired and processed to extract fault-related features in the frequency domain. These features are used to train a machine learning model capable of distinguishing healthy and faulty operating conditions. Experimental results show that the proposed approach provides accurate, non-invasive, and reliable fault detection suitable for condition monitoring of induction motors.**

***Keywords*—induction motor, fault detection, motor current signature analysis, machine learning, condition monitoring.**

I. Introduction

Induction motors are extensively used in industrial applications due to their robustness and low cost, making their reliable operation critically important. Undetected faults can lead to efficiency loss, unexpected downtime, and severe equipment damage. This project focuses on induction motor fault detection using Motor Current Signature Analysis (MCSA), a non-invasive diagnostic technique. By combining MCSA with machine learning algorithms, the system enables early, accurate, and automated identification of motor faults for effective condition monitoring.

II. PROBLEM STATEMENT

Traditional induction motor fault detection methods are often invasive, costly, and unable to provide early diagnosis. There is a need for a reliable, non-invasive, and automated technique that can accurately detect and classify motor faults using readily available electrical signals.

III. Components and Materials

The key components used in the implementation include:

- Induction Motor: The test motor used to generate current signals under healthy and faulty operating conditions for analysis.
- Current Sensor (CT / Hall-Effect Sensor): Measures the stator current of the induction motor non-invasively for signal acquisition.
- Data Acquisition System (DAQ): Converts the analog current signal into digital form for further processing and analysis.
- Signal Processing Software (MATLAB): Used to perform filtering, FFT, and feature extraction required for MCSA.
- Machine Learning Algorithm: Classifies motor conditions by learning patterns from extracted current signal features.
- Laptop: Executes signal processing and machine learning tasks and stores experimental data.
- Power Supply: Provides the required electrical input to operate the induction motor safely during experiments.

IV. WORKING MECHANISM

The proposed system monitors the induction motor by analysing its stator current to detect faults using Motor Current Signature Analysis (MCSA) and machine learning. It detects the following faults: broken rotor bar, bearing inner race fault and bearing outer race fault. Our sampling rate was 10000 Hz. The motor current is continuously measured, processed in the frequency domain, and evaluated by a trained model to determine the motor’s condition.

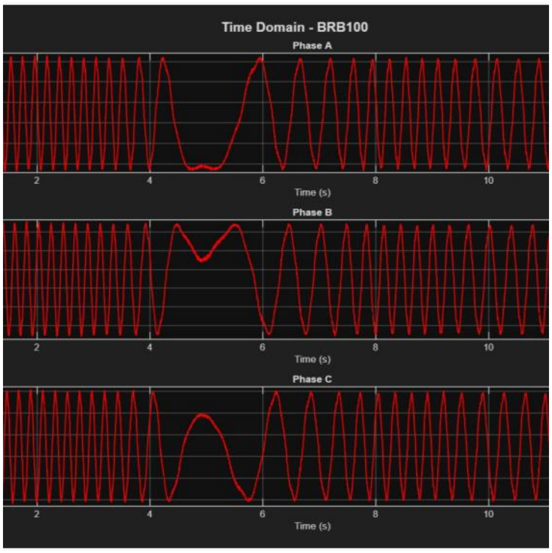

Fig.1. Time domain analysis.

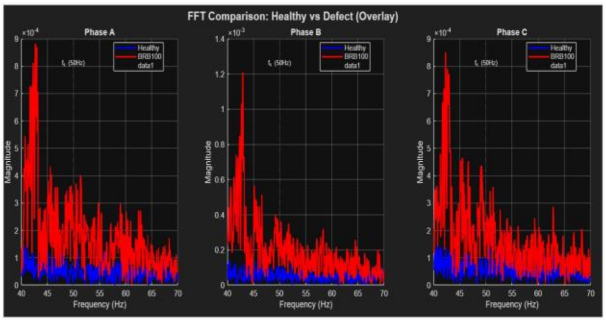

Fig.2. FFT analysis

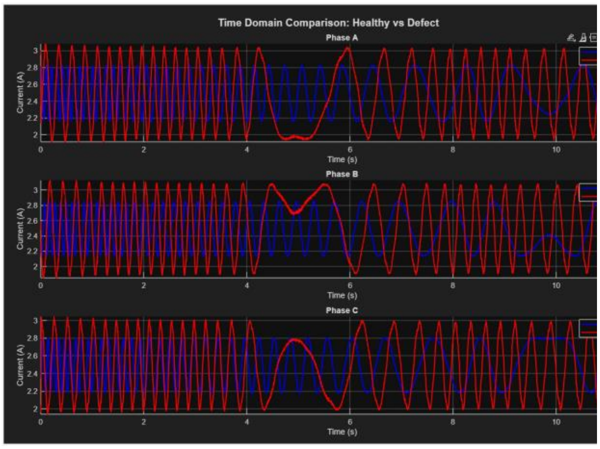

Fig.3. Time domain analysis: healthy vs defective

A. *Current Signal Acquisition*

The stator current of the induction motor is measured using a current sensor, providing a non-invasive and real-time representation of motor behaviour under different operating conditions. The acquired current reflects variations caused by electrical and mechanical faults without requiring physical access to internal motor components.

B. *Signal Conditioning and Processing*

The acquired current signal is filtered and converted into the frequency domain using FFT, where fault-related frequency components and harmonics are extracted as features. Noise reduction and normalization are applied to improve signal quality and enhance fault-related information.

C. *Feature Extraction and Selection*

Key spectral features such as sideband frequencies and amplitude variations are identified, as these features indicate specific faults in the induction motor. Relevant features are selected to reduce computational complexity and improve classification performance.

D. *Machine Learning–Based Fault Classification*

The extracted features are fed into a machine learning model, which classifies the motor as healthy or faulty by recognizing learned patterns. Multiple classifiers are trained and tested to compare performance under identical feature sets.

E. *Fault Detection and Decision Output*

The final classification result is displayed or logged, enabling early fault detection and supporting condition monitoring and maintenance decisions. This helps reduce unplanned downtime and improves motor reliability.

V. RESULTS AND DISCUSSION

The proposed induction motor fault detection system was evaluated using seven machine learning classifiers. Among them, Random Forest and KNN achieved the highest classification accuracy, indicating their strong capability in handling nonlinear patterns in MCSA features. Naive Bayes, Decision Tree, Linear Discriminant, AdaBoost, and Quadratic Discriminant showed comparatively lower performance. The results demonstrate that ensemble and instance-based learning methods are more effective for accurate induction motor fault diagnosis using current signature analysis.

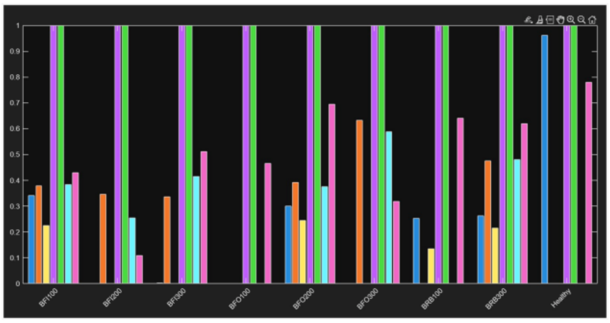

Fig.4. Different models with accuracy

TRAINING MODEL	ACCURACY
Naive Bayes	0.2951
Decision Tree	0.3359
Linear Discriminant	0.1515
KNN	0.9995
Random Forest	0.9995
AdaBoost	0.3324
Quadratic Discriminant	0.5390

Table.1. Accuracy comparison of different machine learning models

Fig.5. Confusion matrix analysis

REFERENCES

[1] Analysis of multiple faults in induction motor using machine learning techniques

[2] Fault detection in induction motors based on motor current signature analysis and accelerometer

[3] Current Signature Dataset of Three-Phase Induction Motor under Varying Load Conditions

[4] Dataset from Mehran University of Engineering and Technology