OIL CONDITION PREDICTION IN DIESEL GENERATORS USING ACOUSTIC SIGNALS

W. A. Hiran Wijesuriya

208810B

Master of Science in Industrial Automation

Department of Electrical Engineering
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DECLARATION

I declare that this is my own work, and this thesis/dissertation does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other University or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. I retain the right to use this content in whole or part in future works (such as articles or books).

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The above candidate has carried out research for the Master's thesis/dissertation under my supervision. I confirm that the declaration made above by the student is true and correct.

Name of Supervisor: **Prof. Buddhika Jayasekara**

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W. A. Hiran Wijesuriya
208810B
University of Moratuwa.

ABSTRACT

This research proposes a novel method for predicting the oil condition in CAT diesel generators using acoustic signals, aiming to overcome the limitations of traditional Scheduled Oil Sampling (S·O·S^{SM}) testing methods. Conventional S·O·S^{SM} programs often face challenges such as delayed results, sampling errors, and high operational costs. To address these, the study develops a non-invasive acoustic monitoring technique that correlates generator sound patterns with oil health indicators.

Audio samples were collected using a Blue Yeti microphone under controlled conditions, and corresponding physical oil samples were subjected to standard S·O·S^{SM} laboratory analysis. Various time-domain and frequency-domain features, including MFCCs, Zero Crossing Rate, and Spectral Centroid, were extracted using the Librosa library. A neural network model was developed to classify oil condition states into "Action Required," "No Action Required," or "Monitor," based on these acoustic features.

Testing the system on a dataset of 75 samples showed encouraging results, with the second iteration achieving improved classification accuracy. Findings confirm that generator acoustic emissions change with oil degradation, validating the hypothesis that sound can predict oil condition. Conclusions highlight that this method enables timely, cost-effective oil monitoring without operational disruption.

Recommendations for future work include optimizing the neural network through learning rate adjustments, particularly expanding the sample dataset, exploring ensemble methods, and validating performance across different generator types to enhance system robustness and industrial applicability.

Keywords: Oil Condition Prediction, Diesel Generators, Time – domain, Frequency – domain, Machine Learning.

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LIST OF ABBREVIATIONS

Abbreviation	Description
S·O·S^{SM}	Scheduled Oil Sample
MFCCs	Mel Frequency Cepstral Coefficients
FT-IR	Fourier Transform Infrared
TBN	Total Base Number
OEM	Original Equipment Manufacturer
ISO	International Organization for Standardization
TUT	Tampere University of Technology
DCAMS	Detection and Classification of Anomalous Machine Sound
BSS	Blind Source Separation
MC-FIR	Multichannel Finite Impulse Response
LPF	Low Pass Filter
IIR	Infinite Impulse Response
GKF	General Kalman Filter
AE	Amplitude Envelope
RMSE	Root Mean Square Energy
ZCR	Zero Crossing Rate
BER	Band Energy Ratio
SC	Spectral Centroid
BW	Bandwidth
SS	Spectral Spread
ML	Machine Learning
MRMR	Minimum Redundancy Maximum Relevance
FDR	Fisher’s Discriminant Ratio

MLP	Multi-Layer Perceptron
ReLU	Rectified Linear Unit
NN	Neural Network
RBFNN	Radial Basis Function Neural Network
CNN	Convolutional Neural Network
ANN	Artificial Neural Network
BN	Bayesian Network
SVM	Support Vector Machine
FL	Fuzzy Logic
MF	Membership Function
FIS	Fuzzy Interference System
PdM	Predictive Maintenance
FCM	Fuzzy C – Means
OCSVM	One Class Support Vector Machine
RUL	Remaining Useful Life
RNN	Recurrent Neural Network
SVR	Support Vector Regression
FFT	Fast Fourier Transformation

LIST OF APPENDICES