

**STUDY ON THE IMPACT OF COMBUSTION
RELATED BOILER OPERATING PARAMETERS ON
“LOSS ON IGNITION” OF FLY ASH OF LAKVIJAYA
COAL POWER PLANT**

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Degree of Master of Engineering

Department of Mechanical Engineering

University of Moratuwa

Sri Lanka

August 2023

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COAL POWER PLANT**

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Thesis submitted in partial fulfilment of the requirements for the degree
Master of Engineering

Department of Mechanical Engineering

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Sri Lanka

August 2023

Declaration

I solemnly affirm that this thesis is solely the product of my own efforts and does not contain any material formerly presented for a degree or diploma at any other institution of higher learning, to the best of my understanding and belief.

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Prof. R A Attalage

Abstract

Fly ash, an inevitable by-product of coal combustion in power generation, possesses diverse potential applications, such as serving as a raw material for cement production. The quality of fly ash, however, depends on various factors, with Loss on Ignition (LOI) being the paramount parameter. LOI denotes the presence of combustible matter in fly ash which is attributed to the quality of coal and combustion conditions. This study was conducted for the Lakvijaya Power Plant (LVPP) (3x300MW), which is the sole coal-based power generation facility in Sri Lanka, providing 40% of the country's total electrical energy demand.

The aim of this study was to develop a model which could map the relationship between boiler operating parameters and LOI, using Artificial Neural Networks (ANNs) with the support of high-level programming language, MATLAB. The dataset consisted 1,615 observations, each with 25 input variables and a single output variable. The investigation utilized different combinations of ANN training algorithms and activation functions and the results were elaborated in each case. A preliminary analysis was conducted using the maximum available samples (1615). Further investigations were then carried out using classified datasets based on the Mill Configuration (656 samples) and Load Point (435 samples). To represent real time variations in coal quality, a separate index was introduced in the model incorporating “Load to Coal” ratio in the final analysis.

The analysis revealed that feedforward two hidden layer ANN with “Bayesian Regularization Backpropagation” being the training function and “Tanh” being the activation function performed well for the dataset. The Correlation Coefficient (R) of unclassified samples 0.71, could be improved to 0.80 by means of data classification. By introducing “Load to Coal” ratio as a separate input variable, R could be further improved to 0.86. The study culminated in the development of sensitivity analysis plots that depict the relationship between LOI and boiler operating parameters i.e., coal to total air ratio, coal to primary air ratio, burner tilt angle, wind box pressure, air flow proportions of individual burner (14 Nos) and coal flow proportions of individual mill (4 Nos). The sensitivity analysis revealed that the uppermost primary burner air flow proportion, the lowermost primary burner air flow proportion and the burner tilt angle have the highest impact on LOI.

Key Words: Fly Ash, Loss on Ignition, Artificial Neural Networks, MATLAB

Acknowledgement

I am delighted to convey my sincere appreciation to everyone who provided assistance in different ways during the course of my research project.

At the outset, I must respectfully acknowledge my supervisor, Prof. Rahula Attalage, who is the Pro Vice-Chancellor (Academic) of SLIIT, Malabe Campus (Former Deputy Vice Chancellor of the University of Moratuwa). His expertise, insight, and unwavering support were instrumental in ensuring the success of this study. His mentorship has helped me to refine my research skills, develop new insights and produce work of the highest quality.

Next, I must be thankful to Eng. H.A.J.M. Sameera, the chemical engineer of LVPP for making necessary arrangements to conduct additional ash and coal related tests at my request without delay. I also must express gratitude to Mr. A.W.W.C Jayalath, one of the technical officers attached to LVPP laboratory for conducting a comprehensive practical session for me on how ash and coal related tests are carried out.

Finally, my gratitude should be extended to Eng. K.G.T.D. Chathuranga, I&C Engineer, LVPP Unit 1 for helping me in extracting data from the computers of Distributed Control System (DCS) of LVPP Unit 1.

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LIST OF ABBREVIATIONS

| | |
|------|----------------------------------|
| APH | Air Pre Heater |
| ANN | Artificial Neural Network |
| BMCR | Boiler Maximum Continuous Rating |
| BR | Bayesian Regularization |
| CEB | Ceylon Electricity Board |
| CNN | Convolutional Neural Networks |
| DCS | Distributed Control System |
| ELU | Exponential Linear Unit |
| ESP | Electro Static Precipitator |
| FD | Forced Draft |
| GUI | Graphical User Interface |
| ID | Induced Draft |
| LM | Levenberg-Marquardt |
| LOI | Loss On Ignition |
| LVPP | Lakvijaya Power Plant |
| MSE | Mean Squared Error |
| OFA | Over Fire Air |
| PA | Primary Air |
| PCA | Principal Component Analysis |
| R | Correlation Coefficient |
| RNN | Recurrent Neural Network |
| SCG | Scaled Conjugate Gradient |