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ENHANCING THE PRODUCTIVITY OF CEMENT GRINDING SYSTEM BY OBSERVING THE VIBRATION RESPONSE

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Degree of Master of Science in Industrial Automation

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DECLARATION

I declare that this is my own work, and this thesis 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).

Signature: Date: 23/12/2023

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

Name of Supervisor: Prof. A. G. B. P. Jayasekara

Signature of the Supervisor: Date:

DEDICATION

My thesis is dedicated to my loved ones and friends. A particular thank you to my devoted parents, Sampath and Priyanka Thennakoon, for their support and encouragement and for pushing me to be persistent. My wife Dilshani has never left my side and supported me throughout the research work. She has been my best cheerleader. I also dedicate this thesis to my many friends and colleagues at Siam City Cement Lanka Limited who have encouraged me all along the way. I will always be grateful for everything they did, especially Pramod Fernando for helping me to develop my technical skills and Harshana Gunasinghe for providing me process related information. I dedicate this work and give special thanks to my lovely two years old daughter Dithya for being there for me sacrificing her playing times with me.

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ABSTRACT

At a cement plant, the grinding process is the last phase of production. the process of turning kiln-ground cement clinker into final cement by mixing it with 4-5% gypsum, limestone, and potential additives. The grinding of cement must be fine enough to meet the strength properties requirements. For a particular cement type, the productivity of grinding process and the loading of ball mill has a proportional relationship, but it's important to note that the relationship is not always straightforward and can be influenced by various factors such as the characteristics of the raw material (mainly clinker), the design and condition of the mill, the speed of the mill, and the size and shape of the grinding media. As of now, there are no reliable ways for identifying the mill blockage condition of a cement ball mill, which occurs when the mill is suddenly overloaded with material to the point of obstruction and rapid drop in grinding productivity. Mill operators intentionally reduce the grinding output by feeding the mill with less material in order to prevent overloading and subsequent mill failure. This results in a less efficient and more power-intensive grinding process. There are very few external controls that can be used to create better conditions. Only the data extracted from sensors fixed at mill motor bearings do not provide accurate readings for mill fill level. Additional vibration responses and torque responses need to be considered for better fill level predictions. Time domain vibration signals are those that are obtained through the use of an accelerometer. Sensor array design and development has been done according to capture features of vibration signals of mill at various feed rates. Proper filtering has been used to remove noises of vibration signals. Fast Fourier Transform (FFT), with the use of DALOG BusyBee software has been used to extract features from time constrained vibration information. The features extracted were utilized as an ANN’s input parameters. The material feed rate to the ball mill is estimated using the ANN's output. Regression-based Deep Learning neural network fit for the cement mill operation automation and cement mill feed rate can be predicted without forcing mill blockages by analysis of vibration responses of mill motor and mill gearbox and torque response of mill shaft.

Keywords: cement mill, mill feed rate, mill blockage, accelerometer, torque sensor, vibration analysis, fast Fourier transform, artificial neural network

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LIST OF ABBREVIATIONS

Abbreviation	Description
AI	Artificial Intelligence
ANN	Artificial Neural Network
API	Application Programming Interface
CSV	Comma Separated Values
DAMASTA	DALOG Machine Status
DE	Drive End
DFT	Discrete Fourier Transform
DL	Deep Learning
DNN	Deep Neural Network
FFT	Fast Fourier Transform
HPGR	High Pressure Grinding Rolls
HSOP	Holcim Standard Operation Procedure
KNN	K Nearest Neighbors
MAE	Mean Absolute Error
ML	Machine Learning
MSE	Mean Squared Error
NDE	Non Drive End
PS	Position
RMS	Root Mean Squared
RMSE	Root Mean Squared Error
VRM	Vertical Roller Mill

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APPENDIX A: Python code of DNN Regressor 63