PERFORMANCE EVALUATION AND OPTIMISATION OF ADVANCED CYCLONE SYSTEM FOR PALM WASTE INDUCED FLUE GAS

By

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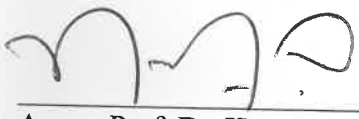

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Project Supervisor

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November 2017

DECLARATION

I, the undersigned, hereby declare that this report is my own independent work except as specified in the references and acknowledgements. I have not committed plagiarism in the accomplishment of this work, nor have I falsified and/or invented the data in my work. I am aware of the University regulations on Plagiarism. I accept the academic penalties that may be imposed for any violation.

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ABSTRACT

The design and performance of a cyclone is determined by three non-physical parameters of assessment which are inlet velocity, pressure drop and collection efficiency. In order to achieve optimal operating cost is it important to have accurate prediction of cyclones pressure drop and collection efficiency. This was achieved by understanding the effects of varying inlet velocity from 15m/s, 17.5m/s, 20m/s, 22.5m/s and 25m/s. Varying the inlet velocity in an increasing manner of the cyclone further increased the pressure drop and collection efficiency.

Hand calculation and simulation was done using a model of Stairmands High Efficiency cyclone. Data attained from the sample of ash collected at the boiler's output was used for the hand calculation. ANSYS FLUENT software was used to simulate a cyclone with similar parameters. Both the results were compared to attain the optimal inlet velocity. The optimal performance was attained by having 20m/s as the inlet velocity.

Twelve cyclones were configured in series with an inlet ducting and outlet ducting. The simulation was made with having all cyclones to attain 20m/s as their inlet velocity. However, due to improper dispersion of gas flow the required inlet velocity was not achieved. Modification by partitioning using baffle plates of the inlet ducting caused a better flow of gas but in turn resulted in the formation of vortex in both the inlet and outlet ducting. The vortex formation was fairly minimized using better angle of baffle plate then further reduced by reshaping the outlet duct to be rectangular in shape. The results of research achieved its objectives although it could be further improved without time constriction.

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Furthermore, I would like to also thank INTI International University to accommodate my needs to carry out the simulation process successfully. Mr. Paneer Selvam the lab assistant was very helpful and understanding throughout the project.

Finally, I would like to thank my parents for supporting me and giving encouragement throughout the completion of my project.

DEDICATION

This thesis is dedicated to my parents Mr. Uthama Kumaran Sinnathamby and Mrs. Selvy Ramasamy

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LIST OF ABBREVIATIONS

PM	Particulate Matter
FCC	Fluid Catalytic Cracking
EFB	Empty Fruit Bunch
FS	Fruit and Shell
ESP	Electro Static Precipitator
MPOB	Malaysian Palm Oil Board
RSM	Reynolds Stress Model
DPM	Discrete Phase Model

NOMENCLATURE

Symbol	*Definition*
µm	micrometer
mg/Nm^3	milligram per nominal meter cube
lb/hr	pound per hour
kg/m^3	kilogram per meter cube
m^3/hr	meter cube per hour
mNs/m^2	millinewton second per meter square
mm water	millimeter of water column
inch water	inches of water column
kg/s	kilogram per second
m/s	meters per second

CHAPTER 1
INTRODUCTION

1.1 General

Gas or liquid flow particle separation by utilizing the method of centrifugal force is best achieved by the usage of devices such as cyclones. This inertial separating device is used as a method of pollution control in industries. Cyclones are chosen amongst others due to their performance in producing high efficiency and they are most economical which makes them the most commonly used device for dust removal within industries.

Even after all these years of cyclone usage, there are many misunderstanding and conception on achieving its maximum capacity. Their flexibility and ability of particle separation is still misconstrued. A usually non-moving, firm structure with a simple design that has an ability to collect fine particulate makes a cyclone.

In the current market, according to research, it has been witnesses that a high efficiency cyclone for industry for particles with diameter of 2m is capable to have collection efficiency of 90 percentage and higher. The cyclone could generate greater force than the force of gravity and inertia of particle due to centrifugal force. It is known that; the centrifugal force is several hundred times greater than the gravitational accelerator making them the most efficient device for particle separation.

Cyclones are well known for their readiness to produce results in most severe conditions and due to the simplicity of their design cyclones need very less maintenance or none at most cases. All these factor makes the cyclone the primary particle separation device.

1.2 Problem Statement

According to the Malaysian regulatory by Department of Environment, the emission rate for a biomass boiler was reduced from 400mg/Nm^3 to 150mg/Nm^3. The current model is only capable of reducing the particulate emission from 4000mg/Nm^3 to 350mg/Nm^3. The new standards have increased the demand for a more efficient and

affordable flue gas purification system. Due to this condition, a secondary stage dust collector system must be added to reduce the particulate emissions to 150 mg/Nm^3.

Boilermech Sdn.Bhd a boiler manufacturing company has been faced with the need to build a Secondary Stage Dust Collecting system in order to meet the requirement of the government standards.

1.3 Objective

The objectives of the research are as follows:

1. Particle study and gas flow interaction in a cyclone by Computational Fluid Dynamics.
2. To optimize the design of a cyclone for maximum efficiency
3. To study the gas flow characteristics of series configured cyclones.

1.4 Project Scope

The experimental result of the Secondary Stage Dust Collector is not obtainable as it is not constructed. Therefore, the simulation results are to be verified and fine-tuned with the theoretical results obtained from hand calculations.

The general idea for the ideal Secondary Stage Dust Collector would be a combination of an array of cyclones within a system. After studying a single cyclone, the next step would be the simulation of a series of cyclones. However, the project is limited to study of only a series cyclone due to the computational limitation. The characteristics were analyzed and taken into consideration with regards to its performance. Finally, with this study, the method of optimizing the dust collector system at maximum efficiency would be attained.

1.5 Project Flow

The process flow chart shows the flow of the project.

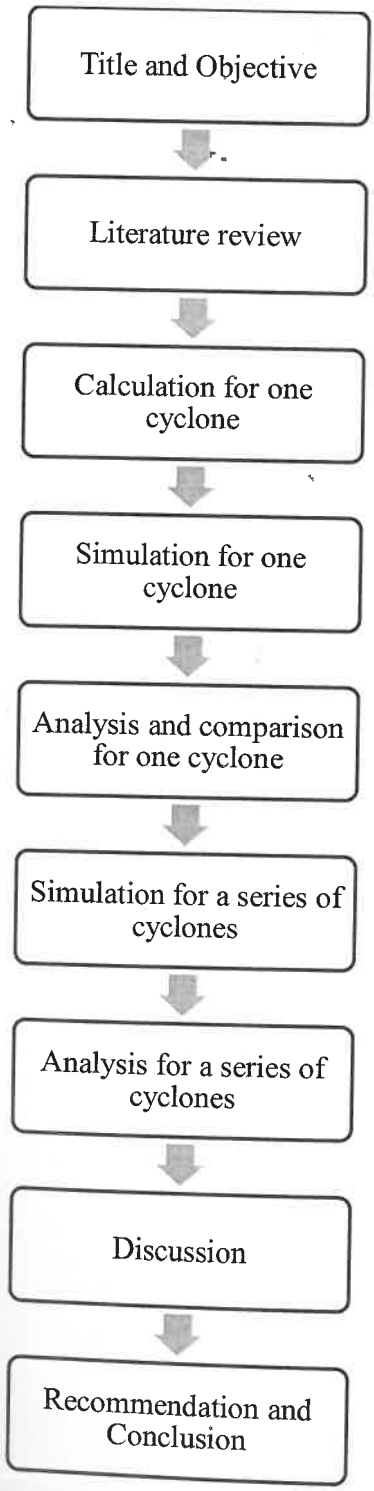

Figure 1: Flow Chart