DESIGN OPTIMIZATION OF A BOILER FURNACE

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"I hereby verify that I have read this report and I find it sufficient in term of quality and scope to be awarded with the Bachelor Degree in Mechanical Engineering "

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Supervisor Name : ……

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This report is submitted to Faculty of Mechanical Engineering in partial fulfill of the requirement of the award of Bachelor's Degree of Mechanical Engineering (Thermal-fluid)

Faculty of Mechanical Engineering
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"I hereby to declare that the work is my own except for summaries and quotations which have been fully acknowledge"

Signature : …….

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Date : 7th April 2010

DEDICATION

To him who is our source of grace, our source of commitment, and our source of knowledge,
And,
To her, whose love is a source of joy.

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All praises to the Almighty Allah, for giving me the strength, patience and guidance throughout the process of completing this investigation. I am grateful to have the morally and physically support from many people throughout completing this study. For this opportunity, I would love to thank whose are either directly or indirectly involved during the process of this research is conducted.

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ABSTRACT

Air has most important function in biomass boiler system. Instead of supplying air required for combustion, it also functions to dissipate fuel in order to have wider heating surface. Turbulence created is necessarily to be controlled to avoid excessive or too lack of air being supplied into the system. Therefore, analysis on turbulence pattern and rate of air injected is needed in order to understand their relationship toward combustion performance. Using analysis performed, optimization can be predicted. Standard K-ε model of turbulence will be used in this analysis. The whole project will depend most of computer application which consist of Computational Fluid Dynamics (CFD) and Solidwork 2008 software. Parameters and systems definitions are provided by ENCO DANSTOKER (M) sdn bhd, a local company which run biomass steam boiler using empty fruit bunch as fuel. Several problems have been detected in their current design and operating system. Through this project, those flaws will be analyzed and overcome.

ABSTRAK

Udara memainkan peranan yang penting didalam sesebuah sistem dandang. Bukan sahaja membekalkan udara bagi tjuan pembakaran, udara juga berfungsi sebagai penghambur bagi bahan bakar mendapatkan lebih permukaan yang terdedah kepada pembakaran. Golakan yg terhasil perlu dikawal bagi memastikan jumlah udara yang dibekalkan tidak berlebihan dan tidak jega terlalu kurang. Oleh itu, analisa ke atas corak golakan angin dan kadar bekalan udara adalah perlu bagi memahami hubungan yang wujud daalam mencapai tahap pembakaran yang sempurna. Hasil analisa juga akan dijadikan asas dan rujukan bagi merancang proses penambahbaikan terhadap sistem. Bagi tujuan itu, model golakan k-ε akan digunakan sebgai asas. Projek ini akan bergantung keseluruhannya kepada penggunaan applikasi beasaskan computer yang terdiri daripada aplikasi pengiraan dinamik bendalir (CFD) dan juda Solidwork 2008. Parameter dan sifat-sifat asas sistem dibekalkan oleh syarikat ENCO DANSTOKER (M) sdn bhd, yang merupakan syarikat tempatan yang menjalankan dandang berasaskan sumber semulajadi sebagai bahan bakar. Beberapa kelemahan dan masalah telah dikenal pasti pada sistem yang sedia ada. Melalui projek ini, masalah-maslah tersebut akan cuba difahami dan diatasi.

TABLE OF CONTENTS

CHAPTER 3 METHODOLOGY

CHAPTER 4 RESULT

4.

LIST OF TABLE

LIST OF FIGURES

LIST OF SYMBOL

2D	=	2 Dimension
3D	=	3 Dimension
CFD	=	Computational Fluid Dynamics
CDM	=	Clean Development Mechanism
SGS	=	Sub-grid scale
LES	=	Large Eddy Simulation
SSTKW	=	Shear Stress Transport k-ω
SKW	=	Standard k-ω
ε	=	Epsilon
ω	=	Omega

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Boiler is a steam producing system that involve of heating raw water into a high energy of steam. The manipulation of steam properties produced are varies in wide range of application and industry. High in temperature, pressure and velocity has made steam as a main medium of energy transportation since decades ago. With modernization and continuous technology upgrading, the ability of boiler seems to move along and become more important.

High velocity of steam produced has many applications mostly in power generating system. Low power requirement and high of capacity produced making a steam boiler is an ideal way to generate power. Its high temperature property is also being widely manipulated especially in manufacturing industry. Paper maker industry as example uses the heat transferred by steam to dry their paper product.

The introduction of biomass fuel boiler from years ago seems to gain more acceptances in industry. This is due to the manipulation of solid waste which giving much more benefit in aspect of cost cutting. With continuous research and ability upgrading, little by little this type of boiler is replacing the use of oil based fuel boiler. Thanks to the current market price of oil that is high and sometimes undetermined. Moreover, the high efficiency of biomass steam boiler strengthens the reason for having a place in industry.

Since solid wastes are continuously produced and need proper management, the existence of biomass boiler seems to have solves or at least reduces responsibility carried by industries such as palm oil and wood manufacturing industry. Here the useable chain of solid waste were created where biomass steam boiler optimize the use of natural source until the maximum. Moreover, ashes produced from complete combustion in the boiler furnace recently rising in request especially from agriculture industries.

This project was inspired from my industrial training experience in biomass steam plant at ENCO DANSTOKER (M) SDN BHD. Empty fruit bunch is the main fuel used and at certain time being supported by palm kernel shell, wood chips and mesocarp fiber. The whole system applied in the plant is so interesting where water treatment, fuel processing, air cycle, combustion and steam transportation systems were combined using latest technology.

Produces 35 tons steam capacity per hour, this type of boiler has been classified as the most efficient boiler currently. Therefore, optimization and analysis of current operating system is highly important in order to get maximum performance while reducing its disadvantages and minimizing source required.

1.2 OBJECTIVES

1. To optimize the current boiler design by modifying the flue duct design and secondary air inlet positions.

1.3 WORK SCOPES

1. To run a simulation of flow in biomass boiler furnace using computational fluid dynamics (CFD) software.
2. To study the effects of current design towards air flow pattern.
3. To make comparison and optimization of fuel scattering by modifying flue duct design.
4. To make comparison and optimization of turbulence and fuel trajectories relative with time by modifying secondary air inlet positions.
5. To make comparison and optimization of turbulence and fuel scattering by trying new sets of primary and secondary air velocity.

1.4 PROBLEMS STATEMENT

During normal operation, Enco Danstoker (M) sdn bhd's biomass boiler facing several problems related to its system. Flow distribution at the outlet of the furnace (inlet of fire tubes) is not evenly distributed. This will result in right side of the fire tubes inlet clogging faster than the other side. Too much ash particulate emission is obtained released from the system which indicates a problem in flow pattern inside the furnace and combustion level.

1.5 SIGNIFICANT OF STUDY

Simulation using CFD in the boiler furnace can be used to analyze the effect of system's design towards flow pattern or turbulence. Simulation of flow will track and prove the path of the flue gas and fuel particle during operation. Thus, by monitoring the simulation, modification can be done to change the flow pattern. Results of this study can be use to predict the best design to reduce ash emission and increase blending time of oxygen in the furnace.

CHAPTER 2

LITERATURE REVIEW

2.1 COMPUTATIONAL FLUID DYNAMICS (CFD) IN FLOW ANALYSIS

The equations for fluids thermal are quite complex and can be difficult to solve, especially if the geometry of a problem is complex. By making use of computers as a computational tool, we can solve these equations in nearly any arbitrary situation. The computational method allows us to get results quickly (a matter of minutes to hours depending on the complexity) and visually close to reality. These results can be used to guide experiments and even as a substitute for preliminary testing in situations where building prototypes might be prohibitively expensive.

Using CFD application, analysis of flow pattern inside a furnace, combustion performance, particulate's velocity profile and design modification can be done. Using data and simulation obtained from the analysis, any defect in the current operating design system can be predicted, thus, with smallest cost and shortest time of methods, modification can be made.

Current CFD software compatibility allows integrated with other software such as Solidwork. This will be taken as advantages where degree of similarity of the analysis's system can be achieved as close as possible with the true system. The use of Soliwork software will make drawing process of control volume easier, faster and more accurate.

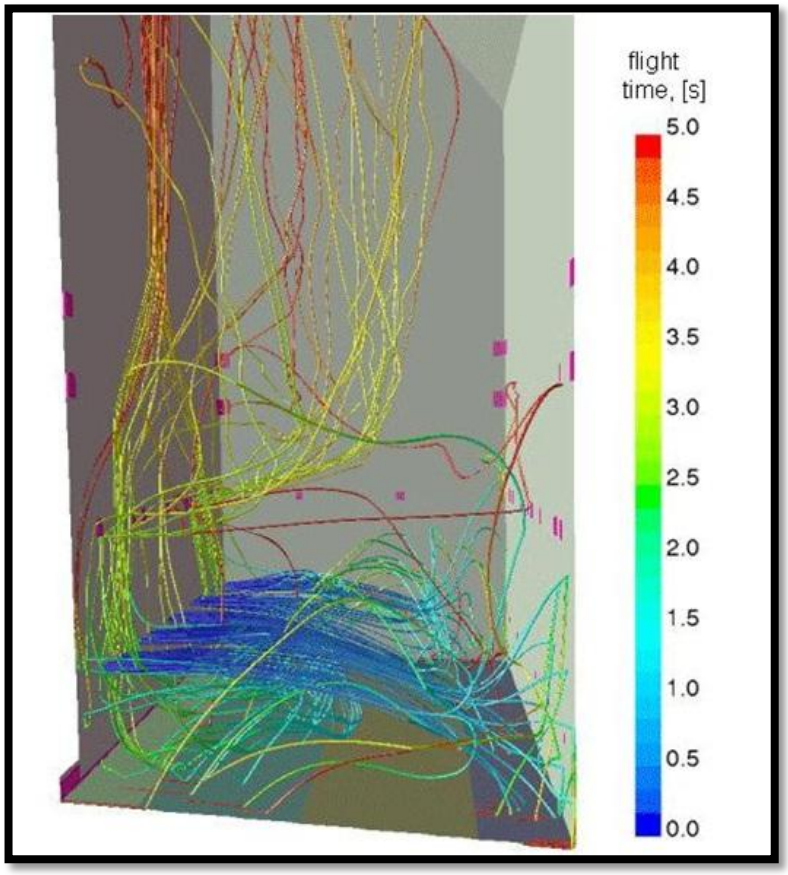

Figure 2.1.1: Light time of particles trajectories
(Source: FLUENT.com)

As shows in figure 2.1.1 above, particulate trajectories can be simulated using CFD. Example above shows a trajectory relative to flight time. Thus, this is very useful in order to track the flow path of the ash particle. From current condition, the particulate emission rate out of the system is quite high and need to be reduced. By making the flight time longer at the bottom of the furnace, even fuel with high moisture content will have enough time to be complete combusted. In another terms, simulation of particle velocity respect with time is also useful to the analysis.