APPROVAL

COMPUTATIONAL ANALYSES OF LABORATORY SCALE FIRE WHIRLS WITH A RING PAN

by

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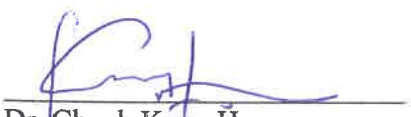

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ABSTRACT

Fire whirl is a phenomena that occurs with a burning fire to form an intensely rotating vertically fire flame with hazard consequences. Currently, there are still lack of researches and studies on fire whirls in terms of experimental and simulation on the characteristics of fire tornado to assist fire fighters to control the phenomenon. This paper will discuss on the study of fire whirl phenomenon and factors that affect the flame height, axial velocity and FFT frequency using Computational Fluid Dynamics (CFD) simulation and FORTRAN 95 to calculate the fluid flow equation and numerical analysis. The manipulative variable in this study is the size of the ring pan. The outcome of this study is to evaluate and discuss on the effect on flame height, axial velocity and FFT frequency with varies ring pan size (ratio of outer diameter to inner diameter) of 3.3:1.05, 3.3:0.75, 3.3:0.525, and 3.3:0.3.

Keywords: Fire whirl, FORTRAN 95, Computational Fluid Dynamics (CFD) simulation, FFT frequency, ring pan size

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DEDICATION

This thesis is dedicated to my parents, Madam Fong Yok Tau who have supported me all the way since the beginning of my studies.

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LIST OF ABBREVIATIONS

CFD	Computational Fluid Dynamics
FDM	Finite Difference Method
FDS	Fire Dynamic Simulator
TDMA	Tri-Diagonal Matrix Algorithm
SIMPLE	Semi Implicit Method Pressure Link Equation

NOMENCLATURE

Symbol	*Definition*
p^*	Guess pressure
u^*	Guess velocity
p'	Pressure correction
p	Pressure
F	Strength of the convection
D	Diffusion conductance
Cp	Specific Heat
Ru	Universal gas constant
T	Temperature
A	Pre-exponential factor
Ea	Activation energy
r	Radial
θ	Angular
z	Axial
Y_i	Mass fraction of fuel or air
u_i	Different direction velocity
T_o	Surface Temperature
v_s	Vertical velocity
$M_{W,F}$	Molecular weight of fuel
$M_{W,mix}$	Molecular weight of air and fuel
$X_{F,s}$	Mole fraction of the fuel
T_b	Boiling temperature of ethanol
V_R	Input angular velocity
$Y_{i,\infty}$	Ambient air mass fraction

CHAPTER 1

INTRODUCTION

1.1. Background

Fire whirl is a phenomena that occur a complex whirling fire flame with hazard consequences. Fire flame and whirlwind combine to form a whirling fire whirl like tornado. Besides that, fire whirl also make the fire flame increase its height, intensity and form a turbulent eddies of air. These eddies can be transformed into a tornado structure that burn combustible gas or waste.

Besides that, fire whirl is a dangerous catastrophe that it had destroyed many building or killed many peoples in many countries. Fire whirl also is an extraordinarily dangerous fire which represents the safety risk for fire fighters. Therefore, the understanding of characteristic of fire whirl is very important in order to prevent fire whirl disaster and help firefighter counter fire whirl with suitable plan.

The fire whirl disaster is very rarely occur in Malaysia. However, precautions of fire whirl is still important as there are a lot of unexpected things happen. As said, repair the house before it rains.

In this project, a computational fire whirl simulation with ring pan would be carried for better understanding on fire whirl. Besides that, air inlet boundary, temperature, velocity, mass of fuel which related to generated fire whirl was also studied in the project. To simulate and analyse the fire whirl, a Computational Fluid Dynamics (CFD) was used in the form of FORTRAN code. The programming language FORTRAN 95 and PARAVIEW 5.2.0-RC3 were used to evaluate and imitate in this project.

1.2. Problem Statements

1. There is insufficient of study on fire whirls.
2. There is lack of study on the relationship between injector and fire whirl.
3. There is inadequate in understanding the characteristics of fuel based fire whirls.
4. There is insufficient experience of Computer Fluid Dynamics simulation on fire whirl.

1.3. Objectives of the Research

All the overall objectives are shown as below:

- To study the effect of ring pan on fuel mass fraction, temperature, axial velocity, FFT frequency of ethanol fire whirl by using Computational Fluid Dynamics (CFD) simulation.

- To validate the Computational Fluid Dynamics (CFD) results using data for fire whirl experiment.

1.4. Scope of the Research

The scope this project cover include Computational Fluid Dynamics (CFD) simulation, FORTRAN 95 programming language, combustion reaction of fire whirls and the effect of ring pan to formation of fire whirl.

For Computational Fluid Dynamics (CFD) which is a numerical analysis to calculate and solve the equation of fluid flow. Furthermore, the discretization methods with Finite Different Method (FDM) was used to solve the approximate model. The fire whirl was discretized and mostly done by equating the domain into a same grid to make a sets of data numerical solution. Moreover, a boundary condition of system must be included to set exact control volume. Moreover, the Mach number of fire whirl in this project is low which means the speed of sound was faster than the speed of fire whirl.

On the other hand, the chemical reaction of fire whirl which involve one-step rate of reaction had been defined. The air flow of environment combine with the combustion to form a swirling flame tornado. Therefore, a complete combustion must stoichiometry

the chemical reaction of ethanol. Furthermore, the structure of ring pan affect the characteristic of fire whirl so, different dimension of ring pan had been defined in this project. The ratio of diameter inner block ring pan to diameter outer ring pan was discussed to form fire whirl with ethanol.

For the whole process was converted to programming language FORTRAN 95 codes for complete simulation. After that, the result from FORTRAN 95 was used by visualization software such as PARAVIEW to produce a mass fuel fraction, temperature, velocity simulation of fire whirl with ring pan.

1.5. Report Organization

Chapter 1: Introduce the title of project, background, problem statement, objective of project, and scope of research.

Chapter 2: Literature Review regarding the formation of fire whirl which involve SIMPLE Algorithm by using CFD simulation and characteristic of fire whirl with ring pan and ethanol.

Chapter 3: The methodology flow of this project, from start coding to obtain result and analysis.

Chapter 4: first test simulation result and simulation result with different ratio of diameter inner block to outer diameter of ring pan.

Chapter 5: To conclude result and discussion of fire whirl simulation. Also, understanding where the objectives reached.