MODELLING OF COAL COMBUSTION IN A COMBUSTOR

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This report is submitted
in fulfillment of the requirement for the degree of
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DECLARATION

I declare that this project report entitled “Modelling of Coal Combustion In A Combustor” is the result of my own work except as cited in the references

Signature	:	....
Name	:	....
Date	:	....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Plant & Maintenance).

Signature : ....

Name of Supervisor: ....

Date : ....

DEDICATION

To my beloved parents, Mohd Yusof Bin Abdullah and Kamariah Bt Ibrahim, most supporting supervisor, Dr.Fudhail bin Abdul Munir, not to forget my course mate and my entire friends in UTeM for their encouragement.

ABSTRACT

Coal has many important users worldwide. Usually, coal was burned in order to generate electricity. Today, there is lots of technology related to the coal combustion such as fluidized bed combustion. To develop these technologies, the fully understanding about the coal is needed. The types, rank and properties of the coal are important because it can affect the combustion process. After getting fully understanding about the coal, modelling process can be proceed. Modelling the coal combustion in the combustor is not too easy. There are many parameter that involved in this process. One of that is inlet velocity magnitude. The effect of this parameter must be known to avoid unwanted tragedy such as the explosion of the combustor. In order to analyze the reaction of coal combustion process in a combustor, numerical simulation which is ANSYS is used while to model the combustor, SolidWorks is used. During the coal combustion process in a combustor, the velocity magnitude, temperature and pressure were affected the combustor. This study will discuss detail related to the effect of the inlet velocity to the combustor during the coal combustion process.

ABSTRAK

Arang batu mempunyai banyak kegunaan penting di seluruh dunia. Selalunya, arang batu dibakar bagi menjana tenaga elektrik. Hari ini, terdapat banyak teknologi yang berkaitan dengan pembakaran arang batu seperti pembakaran katil fluidized. Untuk membangunkan teknologi ini, pemahaman sepenuhnya mengenai arang batu amat diperlukan. Jenis, pangkat dan sifat-sifat arang batu adalah penting kerana ia boleh mempengaruhi proses pembakaran. Selepas mendapat kefahaman sepenuhnya mengenai arang batu, proses pemodelan boleh diteruskan. Pemodelan pembakaran arang batu di dalam pembakar tidak terlalu mudah. Terdapat banyak parameter yang terlibat dalam proses ini. Salah satunya ialah halaju masuk. Kesan parameter ini perlu diketahui untuk mengelakkan tragedi yang tidak diingini seperti letupan pembakar. Dalam usaha untuk menganalisis reaksi proses pembakaran arang batu dalam pembakar, simulasi berangka iaitu ANSYS digunakan manakala untuk pemodelan pembakar, SolidWorks digunakan. Semasa proses pembakaran arang batu di pembakar berlaku, halaju magnitud, suhu dan tekanan akan memberi kesan kepada pembakar. Kajian ini akan membincangkan detail berkaitan dengan kesan halaju masuk ke kebuk pembakaran semasa proses pembakaran arang batu.

ACKNOWLEDGEMENT

Bismillahirahmanirahim,

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I would like to thank to my lovely parents for their never ending support and give me the chances to continue my study in degree without hesitation. They have helped me so much in not only my education but they also guide me on how to be the better person afterwards. Not to forget for my older sister that has always boost me for never give up in my study and also my life.

Last but not least, thank you to my fellow classmate and housemate for the unlimited time spending with me through all this 4 years' time. We have gone through a lot of pain, delight and hardness together especially to complete assignment and discussion. Thanks a lot with all your help and ideas that you have given me and motivation to finish my studies in UTeM.

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CFB	Circulating Fluidized Bed Combustion
RFG	Recycled Flue Gas

CHAPTER 1

INTRODUCTION

1.1 Background

Coal have many important uses worldwide. Today, coal were used in the industry such as in steel production, cement manufacturing, electricity generation and as a liquid fuel. Usually, coal will go through to the combustion process to allow us get benefits from it. So, modeling the coal combustion are needs before start the combustion process. In order to modeling the coal combustion, there are a few aspect that must be consider. For example, Fig.1 illustrate some aspects of a complex pulverized-coal flame at the industrial or utility coal boiler.

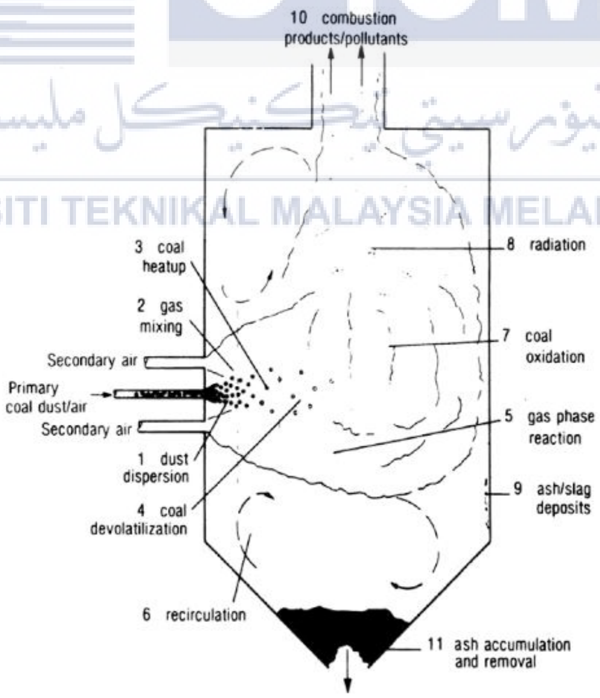

Figure 1.1: Aspect of pulverized-coal flames[1]

The main point of this study to establish a workable three dimensional (3D) model the coal combustion using the commercial software that is ANSYS with Fluent capability. In modelling the coal combustion, there are a few properties must be consider to get the best data for modelling the coal combustion. The typical properties need to be included are as follows [1]:

<u>Independent variables</u>

Physical coordinates(x, y, z)

Time(t)

<u>Dependent variables</u>

Composition of gas species	Pressure
Temperature of the gas	Mean turbulent kinetic energy
Velocity of the gas	Turbulent energy of dissipation

<u>Input data for inlet</u>

Velocity of the gas	Turbulent intensity of the gas
Composition of the gas	Mass flow rate of the gas
Temperature of the gas	Pressure

<u>Reactor Parameter</u>

Inlet location	Wall material
Dimension	Wall thickness

The results of the combustion process will be identified and discussed which is :

1. contours of temperature
2. contours of velocity magnitude
3. contours of pressure

ANSYS Fluent software contains the broad physical modelling capabilities needed to model flow, turbulence, heat transfer, and reactions[2]. By using this simulation software, the flow inside the combustor will be established of which represents the combustion occurs inside the combustor. By changing parameters such as the inlet and outlet size, the flow is also affected[4]. Figure 1.2 shows the example of the flow that can be generated using ANSYS-Fluent.

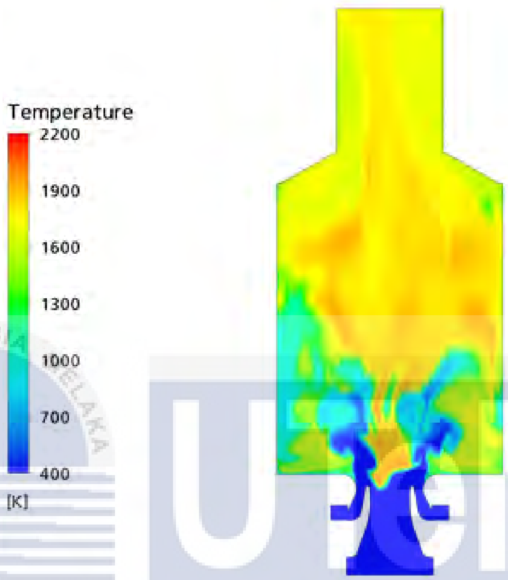

Figure 1.2 Simulation ANSYS-Fluent Flow[4]

1.2 Problem Statement

Modelling coal combustion generally difficult. There many parameters involved in the process of establishing a numerical model of coal combustion. Each parameter will affected by the process of the coal combustion. It is important to identify the effect of these parameter on the coal combustion to improve combustion efficiency and enhance safety.

1.3 OBJECTIVES

Objectives of this project are:

1. To establish a workable model of coal combustion using commercial software.

2. To identify the effect important parameter of the inlet velocity during the coal combustion process.

1.4 Project Scope

The scopes of this project are:

1. To create a workable three dimensional (3D) numerical model of coal combustion.
2. To perform simulation using ANSYS-Fluent software.
3. To investigate the effect of velocity inlet on the coal combustion.

1.5 General Methodology

The actions that need to be carried out to achieve the objectives in this project are listed below.

1. **Literature review**

   Journals, articles, or any materials regarding the project will be reviewed.

2. **Set up parameter**

   After literature review, the research take part on by set up the simulation geometry and parameter. These parameter act as manipulation in this research.

3. **Simulation by using (ANSYS-Fluent)**

   This part is where the result of the data is been collected. By running this simulation, each parameter is been set up into this software.

4. Analysis

Analysis will be do for each parameter in order to identify the effect of the parameter to the model.

5. Report writing

A report on this study will be written at the end of the project.

The methodology of this study is summarized in the flow chart as shown in Figure 1.3

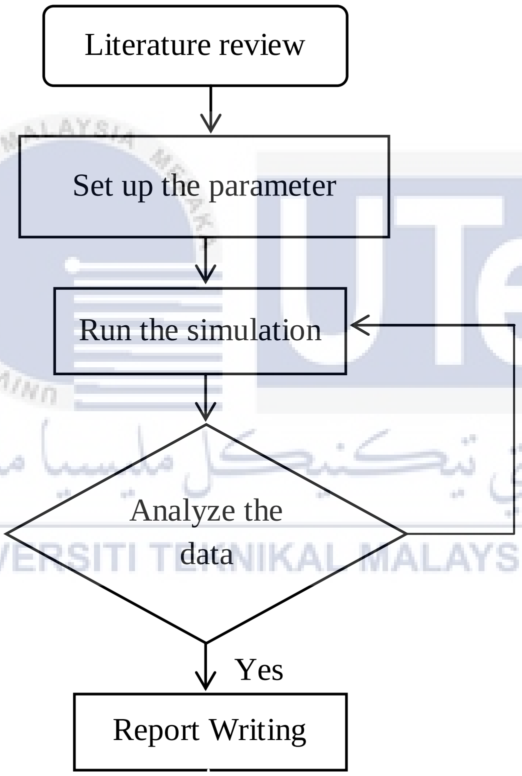

Figure 1.3: Flow chart of the methodology

CHAPTER 2

LITERATURE REVIEW

2.1 Basic Processes of Coal Combustion

Coal is one of the non renewable sources. It also know as an organic fuel. Today, the problem that industry face is to predict the behaviour of the organic and inorganic constituents of coal during combustion [36–42]. When the coal was heated, pyrolyzed occur to the organic matter that consist in the coal, then change as volatile. The factors such as pressure, temperature, biomass composition and heating rate can affect the pyrolysis conversion efficiency[5]. The combination of mineral matter and carbon is remaining solid, which is known as "char". The coal combustion of is mainly the combustion of carbon as well as the volatile matter. Based on the principal combustion process of coal, there are three basic stage involves which is :

i. Volatile matter will release from the heating of coal
ii. The burning of the release volatile matter
iii. The burning of the remaining char

Usually, by using non-designed coal in a blast furnace or in a pulverized coal boiler, it may cause the combustion problems. Moreover, the problem of burner damage must be considered, which occurs because of the ignition mechanisms involved in high-volatile low-rank coal. Therefore, to avoid burner damage, the ignition behavior as a function of coal rank should be investigated as fundamental data in order to take advantage of the new operating procedure of the burner[17].

2.2 Coal Volatile and Devolatilization Combustion

From heating process of the coal, volatile matter will release and it include in devolatilization stage. At this stage, the present of moisture in the coal evolves as the temperature of the coal rises. So, in characterizing ignition and flame stabilization, this stage is very important[6,7]. The gases and heavy tarry substances are release as the temperature increases. Depending on the coal types and heating conditions, the content of these matters can vary from a few percent up to 70-80 percent of the total weight of the coal. Size, temperature condition and the types of coal will result the time taken of devolatilization to complete. It usually takes a few minutes to complete the process. Tar, hydrocarbon gases and others products are produced during the this process. These products are flammable. It will react with oxygen around the coal particle and produced the bright diffusion flames. The reactions that occur in the volatile and devolatilization combustion process are so complex and it beyond the scope of this thesis.

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2.3 Types of Coal

As geological processes apply pressure to peat over time, it is transformed successively into different types of coal[8]. There are three major types of coal which is:

1) Lignite

Figure 2.1: Lignite coal[8]

Figure 2.1 show the example of lignite coal. It also known as brown coal. This soft brown coal consist high amount of water which is 70 percent. It has around 60-70 percent of carbon.

2) Bituminous

Figure 2.2: Bituminous coal[8]

Figure 2.2 show the example of bituminous coal. This coal form when the pressure applied to the lignite. When the pressure applied on it, more water that content in the coal will be expelled. So, the amount of pure carbon will be increase. It contains between 69% and 86% carbon by weight. The amount of pure carbon will affect the heat content in the coal.

3)Anthracite

Figure 2.3: Anthracite coal[8]

When the great pressure applied on the bituminous, it form the highest grade coal that call anthracite as shown in the figure 2.3. It is hard rock with a jet-black colour. Water content in this form of coal are lowest than other form of coal. As the result, it has high heat content. It contains between 86% and 98% carbon by weight and it burns slowly, with a pale blue flame & very little smoke.

2.4 Coal Component

Figure 2.4: Component of coal [8]

Figure 2.4 shows the component that consist inside the coal. From the figure, one of the component is the fixed carbon which is a component which is the quantity of carbon after the volatile matter being removed. the fixed carbon main function ia to estimate the quantity of coke that being yielded from a set of coal sample. Although, the fixed carbon is different from the ultimate carbon content since a few carbon contain will be diminished in hydrocarbon with volatiles.

Another component that consist in coal is volatile matter. It release at high temperature when appearance of air. This component can be determine under rigidly controlled standards. Volatile matter consists of a combination short and long chain of hydrocarbons, aromatic hydrocarbons and a few of sulfur.

After the coal have be burnt, it product some ash. Ash is the part where the coal is non-combustible. During combustion, sulfur, carbon, oxygen and water has been removed and bulk mineral matter will represent. The percentage of original weight can be expressed by the ash material. Ash properties also can affect the combustion behavior[35].

Usually coals are mined wet. So, important property of coal is moisture. Extraneous moisture and groundwater also known as adventitious moisture. It is easy to evaporated. Inherent moisture is the moisture within the coal and it is analyzed quantitatively. Surface moisture is refers the water on the surface of coal particle. Table 2.1 shows the weight in percent the composition in the various types of coal.

Table 2.1: Composition of various types of coal[8]

% weight	Anthracite	Bituminous	Sub-Bituminous	Lignite
Heat Content (Btu/lb)	13,000-15,000	11,000-15,000	8,500-13,000	4,000-8,300
Moisture	< 15%	2 - 15%	10 - 45%	30 - 60%
Fixed Carbon	85 - 98%	45 - 85%	35 - 45%	25 - 35%
Ash	10 - 20%	3 - 12%	≤ 10%	10 - 50%
Sulfur	0.6 - 0.8%	0.7 – 4.0%	< 2%	0.4 – 1.0%
Chlorine (ppm)	340 ± 40ppm	340 ± ppm	120 ± 20ppm	120 ± 20ppm

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2.5 Coal Rank

The degree of coalification that be going through by a coal, as it matures from lignite to anthracite, has an important parameter to shows its physical and chemical properties and it is referred as the 'rank' of the coal.

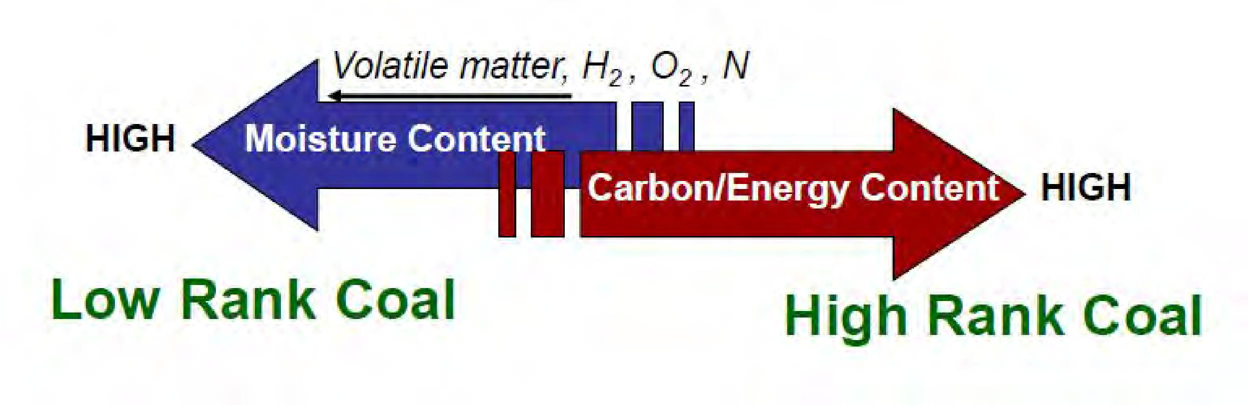

Figure 2.5: Factor that affects the coal rank

Figure 2.5 shows the factor that effect the rank of the coal. Coal that have high moisture content and volatile matter were classified as the low coal rank while the coal that have high carbon and energy content which is heat content were classified as high rank coal. Table 2.2 shows the rank for the 3 types of coal. It is rank based on its relatively lowest heat content.

Table 2.2: Heat content the various types of coal[9]

Coal Type	**Ignition Temperature/°C (Heat Content)**	**Volatile Initial Release Temperature/°C**
Lignite	250-450	130-170
Bituminous	400-500	200-300
Anthracite	700-800	380-400

2.6 Coal Combustion Technology

There are several aspect that affect the combustion of coal. It usually depends on the types of coal firing equipment, coal-feeding method and type of combustion devices such as fluidized-bed combustion, fixed-bed combustion and coal suspended-bed [9]. By using fluidized bed combustion, it give more benefit than the traditional firing system because it have higher combustion efficiency, simpler boiler design and reduced pollution problems[10,11]. The bed of particles will stay stationary at low velocity if air is move upward through a bed of solid particles. When the air velocity is increases, it will cause the particles suspended in the air stream. At certain condition of air velocity, the particles look likes a boiling fluid. This phenomena is called fluidized bed. If the air velocity continuously increased, the bubbling fluidized bed will occur. The particles will blown out of the bed at certain higher velocity. Circulating fluidized bed is the product of the recycled particles by mixing the particles with the air feed. Sand particles is used as the heating medium in this fluidized bed combustion. There are three types of the fluidized bed combustion which is:

i. Fluidized Bed Combustion
ii. Circulating Fluidized Bed Combustion
iii. Pressurised Fluidized Bed Combustion

There are a few features of fluidized bed-combustion. First, it have direct contact of the particles with heat exchange and intensive mass. Second, the wet, low quality and high content of ash is possible to burn by using fluidized bed combustion with high heat capacity. Lastly, the fuel supply, air and heat extraction are control the effectiveness of bed temperature. Figure 2.6 shows the fluidized bed combustion which is circulating fluidized bed combustion(CFB).

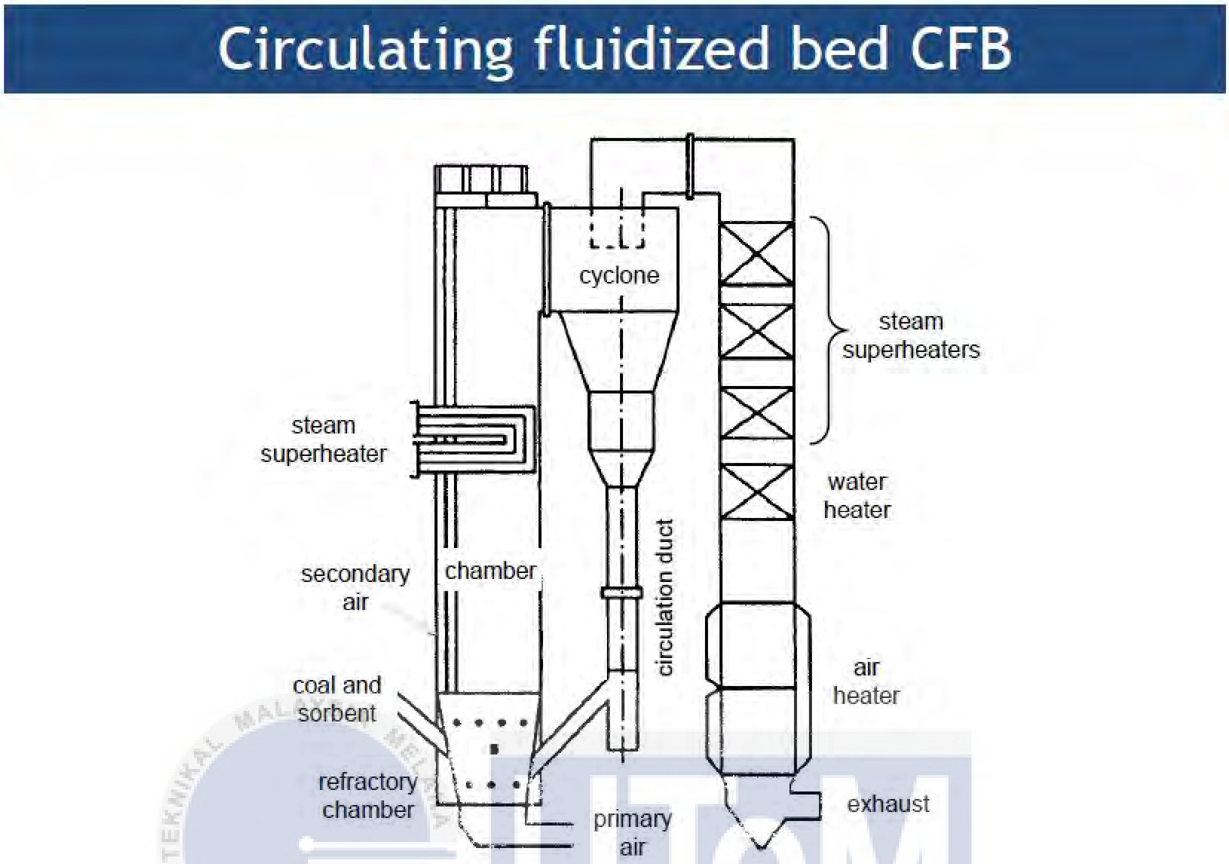

Figure 2.6: Circulating fluidized bed[8]

In fixed bed combustion, grate used in the combustor to supported the coal particles. The combustion air is flow in upward direction through the coal bed cause by the chimney draft or by a fan. There are two types of grate which is fixed and moveable. For overfeed technique, the fresh coal particles are put on the bed. In the different zone of combustion, different reactions may occur as shown in figure 5.

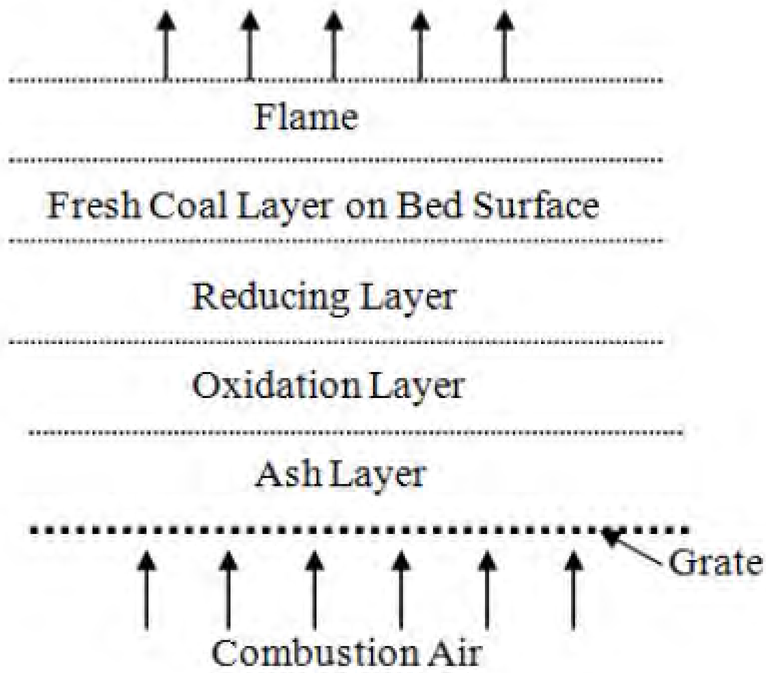

Figure 2.7: Fixed grate overfeed combustion[8]

The combustion air are move through the grate in upward direction. In the ash layer, combustion takes place and produce carbon dioxide. This reaction is highly exothermic and generates heat. The oxidation reaction occur in this zone as the bed temperature rises.

Oxy-fuel combustion is a combustion process that involve the pulverized coal and usually practiced in the coal-fired power plant. Smith and Smoot[12] have developed one-dimensional modal and was used by Suzuki et al[13] to predict the overall characteristics of pulverized coal combustion under a wide range of conditions in a test furnace similar to the blowpipe- tuyere-raceway system. To simulate the combustion that same as a blast furnace which is using pulverized coal at the high heating rates and temperature, a quasi-two-dimensional is one of the method that can be used [14]. In a power plant, pulverized coal used as a fuel and react with the oxygen that injected to start the fired process. Due to the differences in the volume flow rate and properties of the feed gas, the challenges to maintaining oxy-coal combustion stability have been reported in the open literature[15].

By using higher concentration of oxygen, the flame temperature in the boiler become very high. Sometimes, the recycled flue gas (RFG) with oxygen stream is used. This will result the decreasing of the flame temperature to the level same as the conventional air-fired boiler. After the combustion process, water, particulate, sulfur and others gases can be eliminated from the flue gas. Carbon dioxide (CO_2) mostly consist in the remaining gas and can be process for sequestration[16].

2.7 Coal Combustion with Flat Flame

Many investigators choose to studied coal combustion and its ignition behaviour using laminar flow conditions before further their investigation under turbulent condition[33]. It is compulsory in order to help the investigators to solve the chemical reaction in turbulent flow. In a laminar flow, the temperature, velocity and concentration profiles that measured is quite smooth compared to turbulent flow[19]. From previous studies related to ignition process of the pulverized coal particle[20], rank [21–26], particle size [27], coal-feeding rate [28], heating rate, and ambient gas conditions such as gas composition [29-32], oxygen concentration and temperature can cause the homogeneous ignition of the released volatile matter or heterogeneous ignition on the char surface.

One experiment were carried out in an entrained-type flat flame burner at Pusan Clean Coal Center, South Korea[18]. A schematic of the system is shown in figure 2.8.

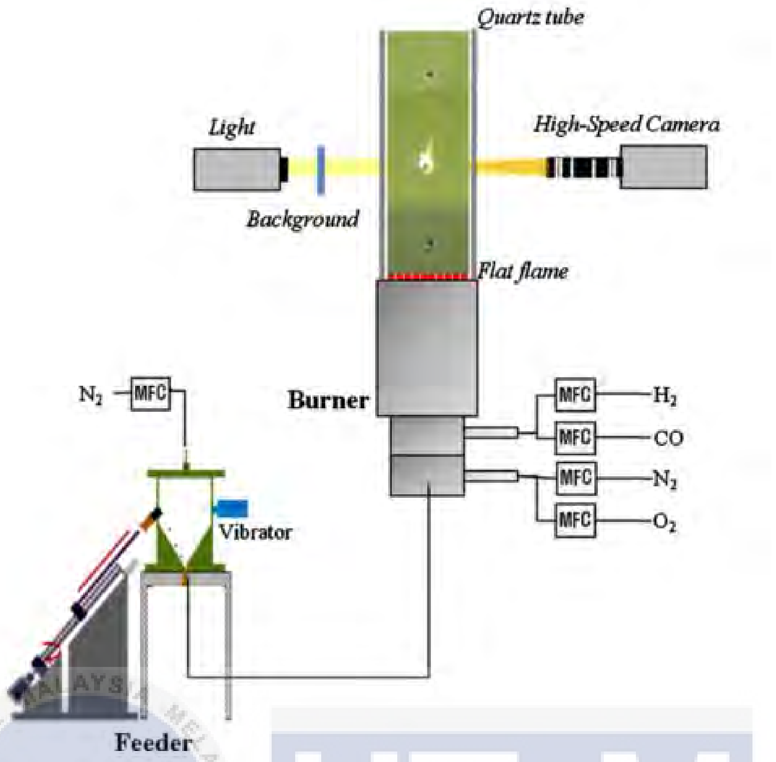

Figure 2.8: Schematic of flat flame burner and high-speed camera imagin system[18].

The purpose of that eperiment is to study ignition behavior for coal rank using a flat flame burner at a high heating rate. There are a few benefit that can be obtain when using the flat flame which is:

i. uniform heat radiation over a wide area
ii. no hot spot in front of the burner outlet
iii. Robust burner
iv. Fuel savings with hot air version

For this project, wire mesh will be locate between the unburned and burned region. The main purpose of this wire mesh is to act as a flame holder where a stable flame can be easily established[34].

2.8 Effect of Inlet Velocity In Coal Combustion

The coal combustion system is one of complex systems. This because there are many factor needs to be considered in order to complete this system. One of that is inlet velocity[42]. For circulating fluidized bed combustion system, the changing value of the inlet velocity will affect the pressure and velocity magnitude of the system. By changing the inlet velocity value, the result is shown as in figure 2.9 until figure 2.12.

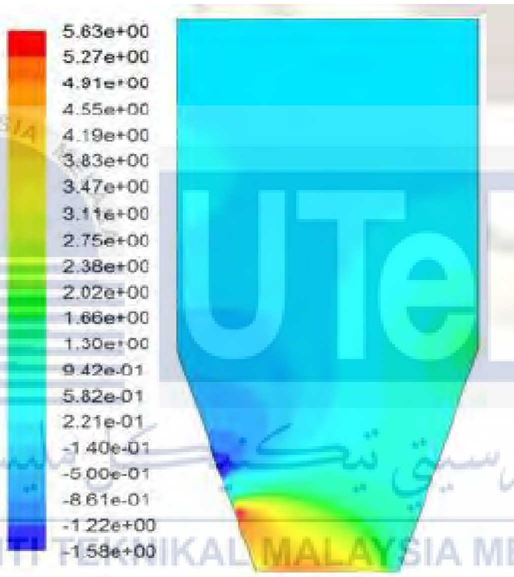

Figure 2.9: Contour of pressure at 4.5 m/s[42]

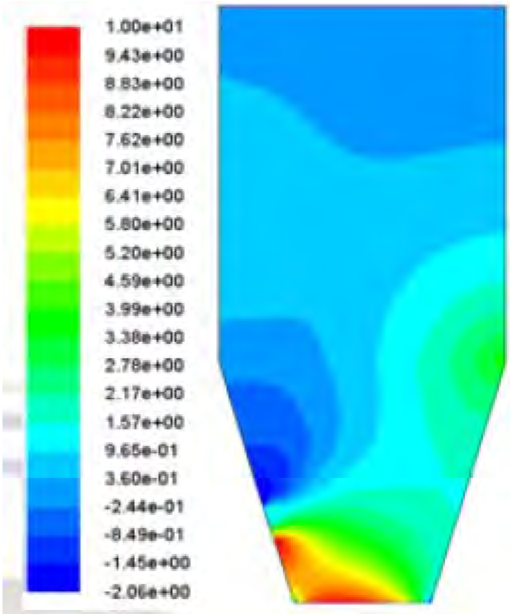

Figure 2.10: Contour of pressure at 6 m/s[42]

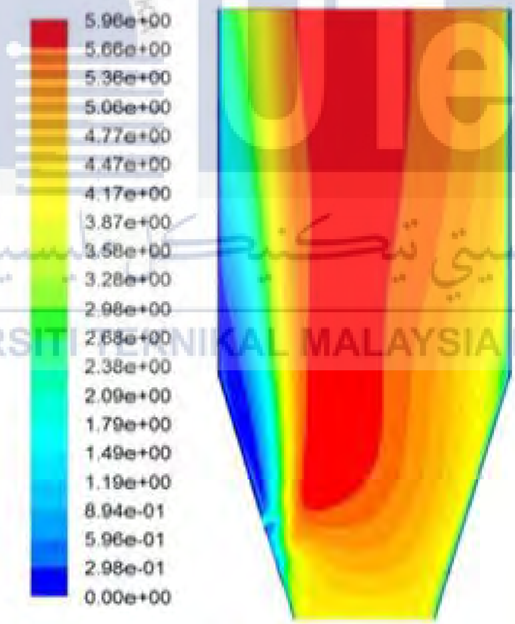

Figure 2.11: Contour of velocity magnitude at 4.5 m/s[42]

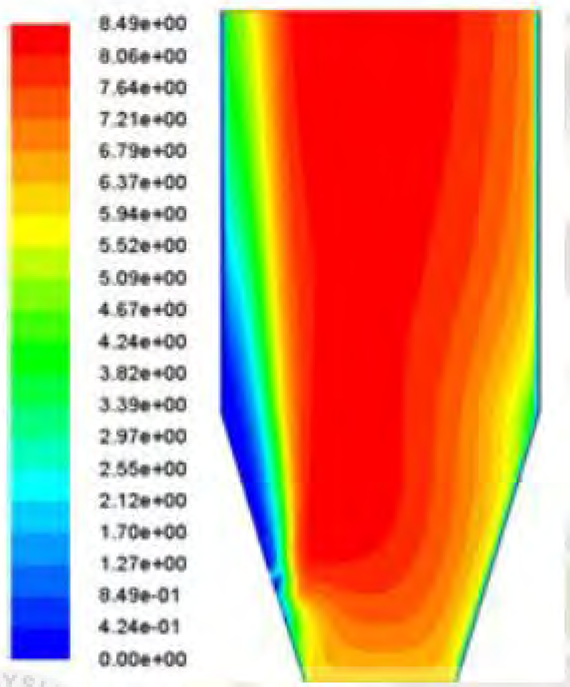

Figure 2.12: Contour of velocity magnitude at 6 m/s[42]

From the figure above, the value of pressure and velocity magnitude are increased when the value of inlet velocity is increased. The value of pressure in the combustor is 5.63 Pa for 4.5 m/s and 10.0 Pa for 6m/s while the value of velocity magnitude is 5.96 m/s and 8.4 9m/s for inlet velocity 4.5m/s and 6m/s respectively.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will explain the methodology that used in this project to get better understanding and flow of the project. This project starts by studying and get used with the software called ANSYS Fluent and Solidworks. The project only be simulate by using ANSYS Fluent and Solidworks will be used to modelling the combustor. Simulation have implement in this project because in order to build the prototype, it will be so costly. This software will help to solve coal combustion case using appropriate solver setting and postprocess the resulting data. The flow chart for the project is shown in Figure 3.1.

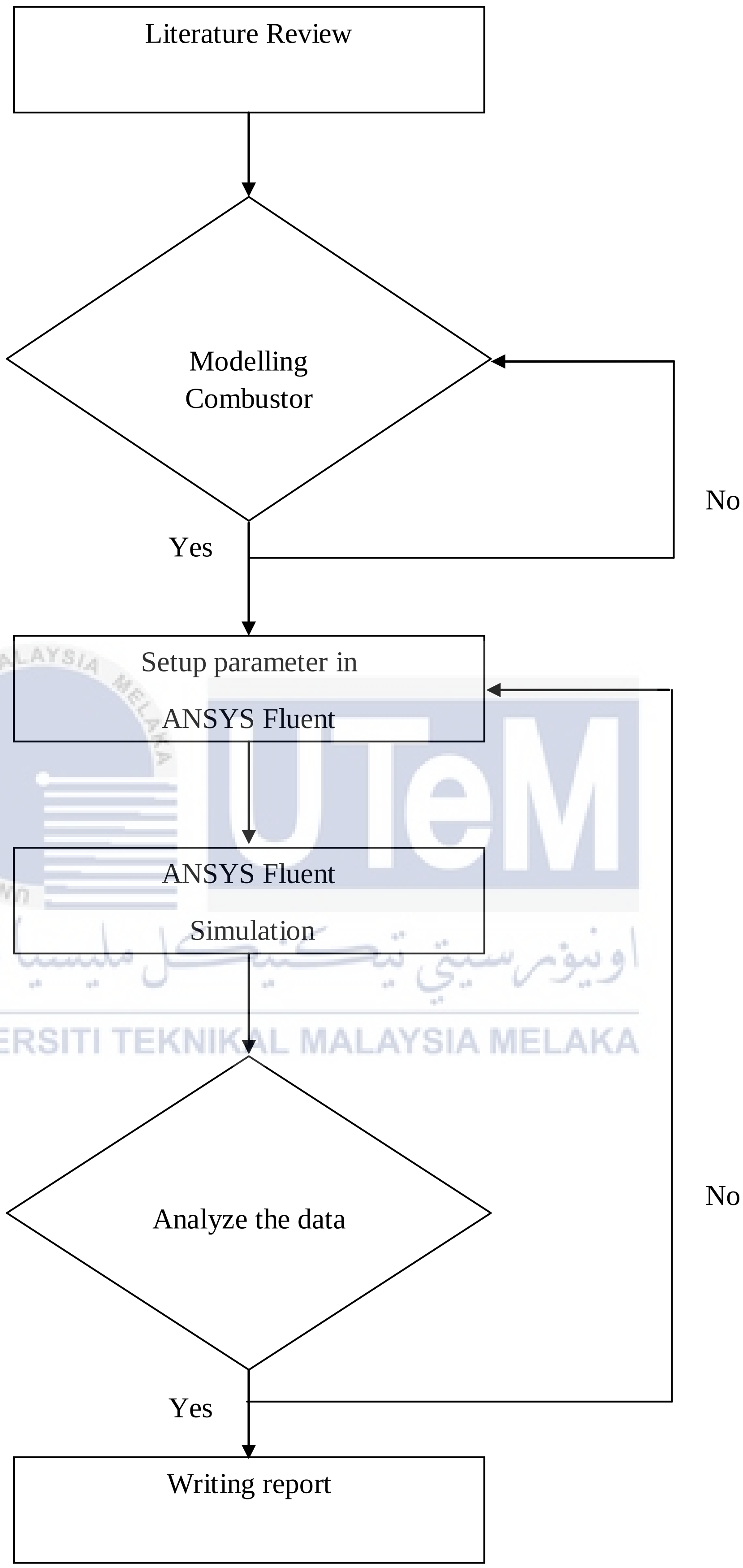

Figure 3.1: Flow chart of the project

3.2 Modelling the Combustor

Before start with the simulation, the combustor is need to be design. By using computer aided design software which is SolidWorks, the model was designed. Model of the combustor must be design or draw properly to avoid the problem occur and to proceed to next stages. Design properly means all line of the drawing need connected with each other or in other words no open edge. This because if the open edge occur, next stages cannot be proceed. The design for the combustor is shown as in figure 3.2 until figure 3.4 below while the detail about the design is shown in Appendix 1.

Figure 3.2: Design of the combustor

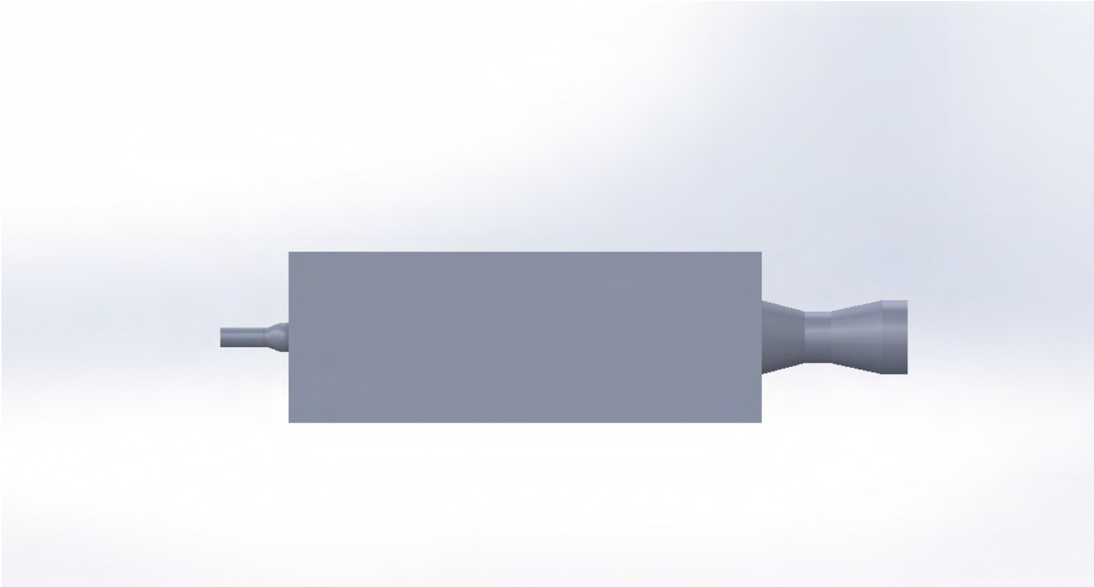

Figure 3.3: The side view of the combustor

Figure 3.4: Cross-sectional view of the combustor

The combustor have two annular inlets and a circular outlet have been simulate in the ANSYS-Fluent. Due to symmetry, only one quarter of the combustor used into simulation. Figure 3.5 shows the 3D cutaway of the combustor.

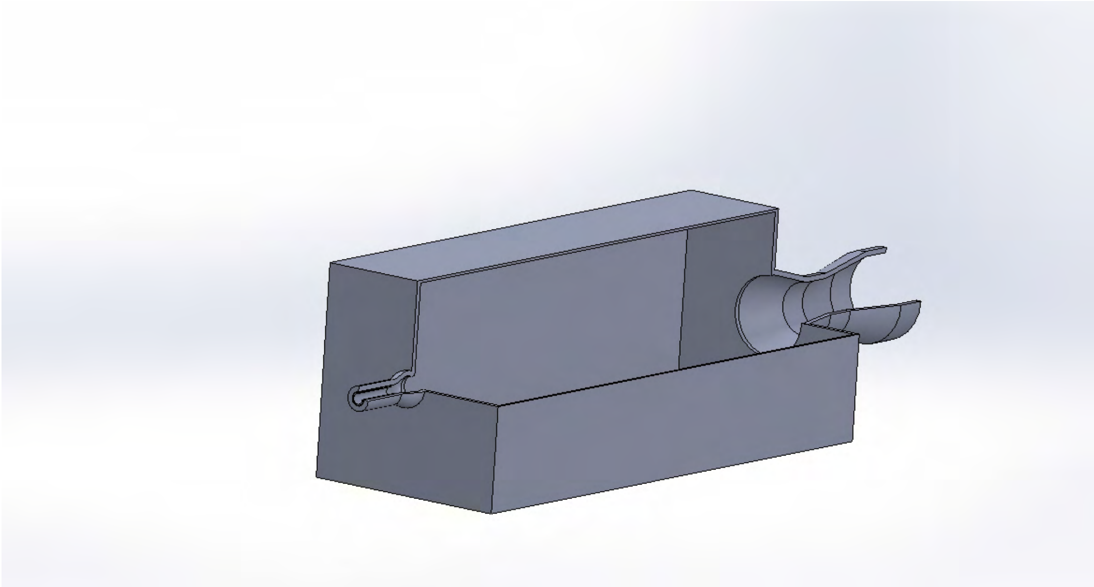

Figure 3.5: Three dimensional (3D) cutaway of the combustor

This combustor have been simulated by setup some condition.

3.3 Experiment Set up

When no problem occur with the design, next stages can be proceed which is setup the parameter. This stages are the main stages of the project. In this stages, there are four major item(in red box) that need to be setup as shown in figure 3.6.

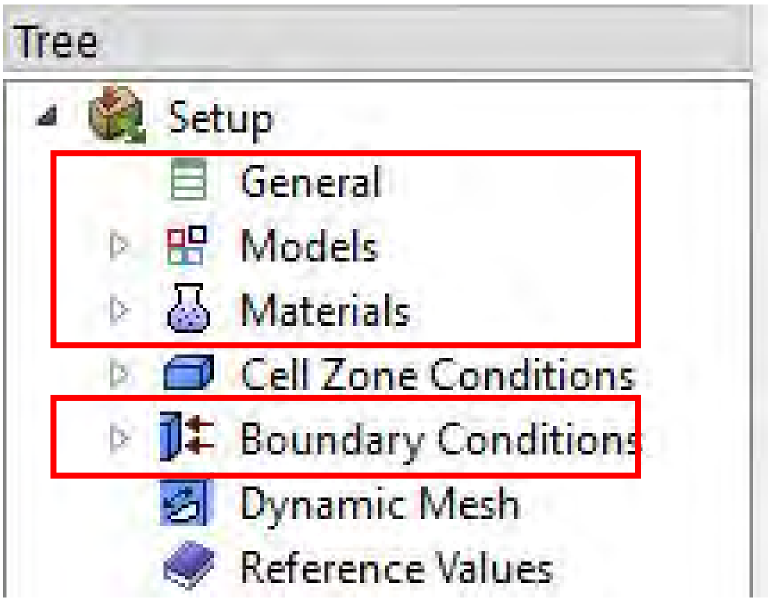

Figure 3.6: Four major item that need to be setup

After done with all of the setup, solution method will be choose before start the calculation. Result that come out from the calculation will shown in form of graphic as shown in figure 3.7.

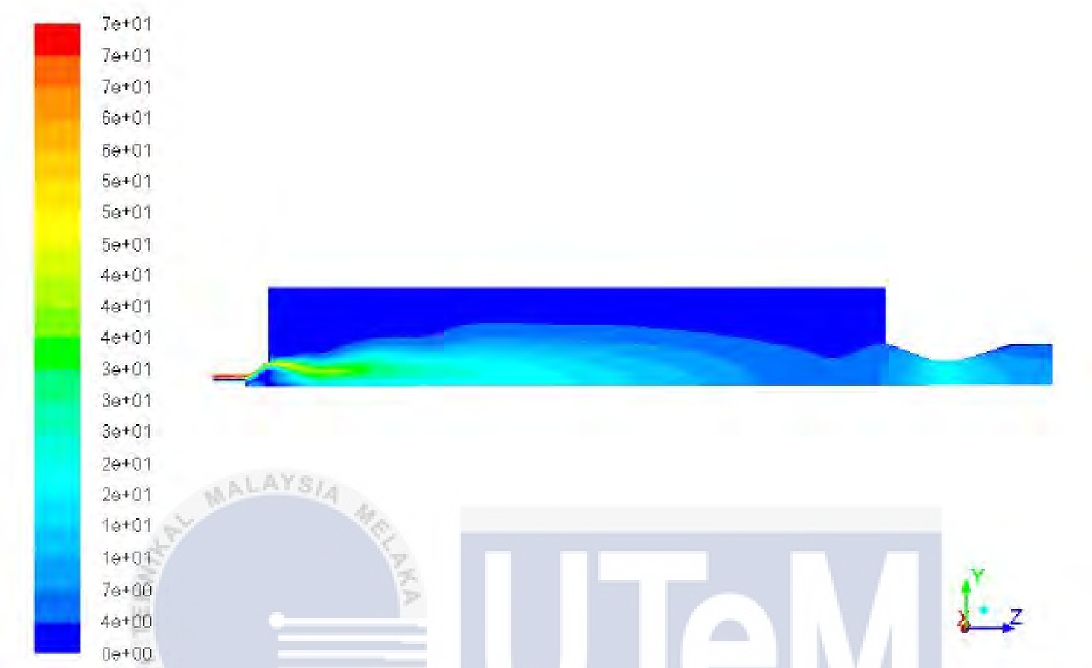

Figure 3.7: Example of the results obtained from the calculation

For the simulation, four condition will be used to get the data which is:

i. non-reacting flow

ii. reacting flow

iii. reacting flow including radiation

iv. reacting flow including particle-radiation interaction

Data that obtain from the calculation will be analyze and discuss detail in chapter 4.

CHAPTER 4

DATA AND RESULT

4.1 Data of the Coal Combustion Simulation

As mentioned before, there are few factors that affect the coal combustion and one of them is coal properties itself. In order to achieve the objective of this study, the properties of the coal were fixed. Table 4.1 shows the fixed properties of the coal that used in the simulation.

Table 4.1: Fixed properties of the coal

Parameter	**Value(%)**
Volatile	51
Fixed carbon	34
Ash	8
Moisture	7

Combustion process also will be affected by a few types of gases. In this simulation, there are four types of gases that involved. One of the type of gas that usually related to the combustion is oxygen. Others gas that involves are carbon, hydrogen and nitrogen. To get the consistent result during changing the inlet velocity values, the composition of the gases also fixed. Table 4.2 shows the fixed composition of the gases.

Table 4.2: Fixed composition of the gases

Gas	**Composition(%)**
Carbon	80
Hydrogen	5
Oxygen	13
Nitrogen	2

The manipulated variable in this study is inlet velocity. The values of this variable were changed starting from 20 am/s until reached at the 35 m/s. By changing the value of inlet velocity, the contour of pressure, temperature and velocity magnitude for each value were analyzed to identify its effect with the coal combustion process in a combustor. Table 4.3 shows the value of the inlet velocity that were used in this study in order to identify its effect in the combustion process.

Table 4.3: Value of the inlet velocity

No.	**Value (m/s)**
1	20
2	23
3	26
4	29
5	32
6	35

4.2 Result and Discussion

The result of the simulation have shown as in figure 4.1 until figure 4.3.

a) Contour of velocity magnitude

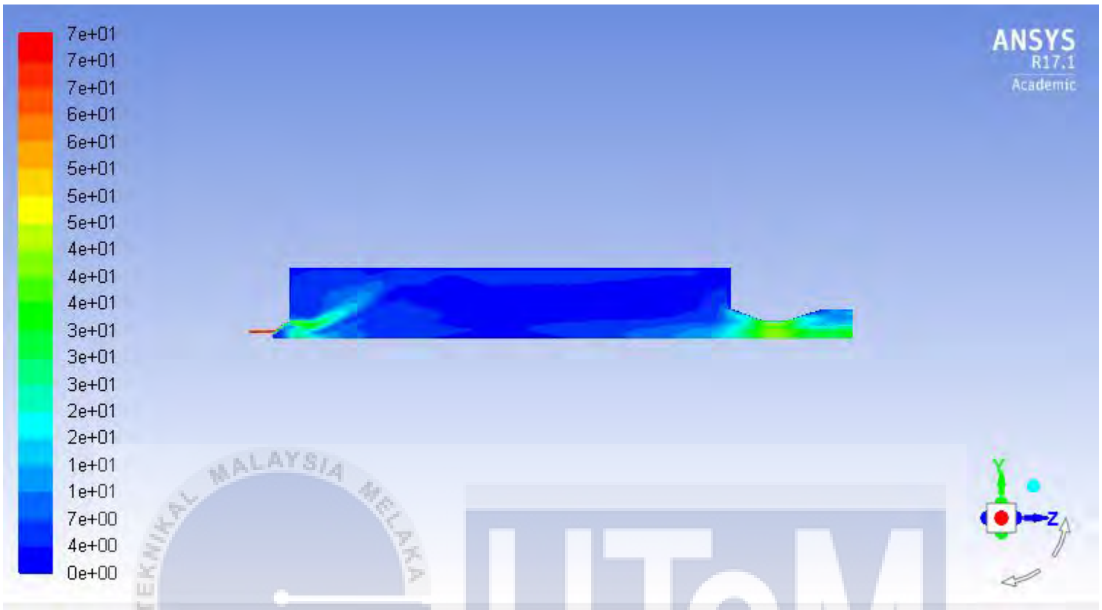

Figure 4.1(a): Contour for inlet velocity 20 m/s

Figure 4.1(b): Contour for inlet velocity 23 m/s

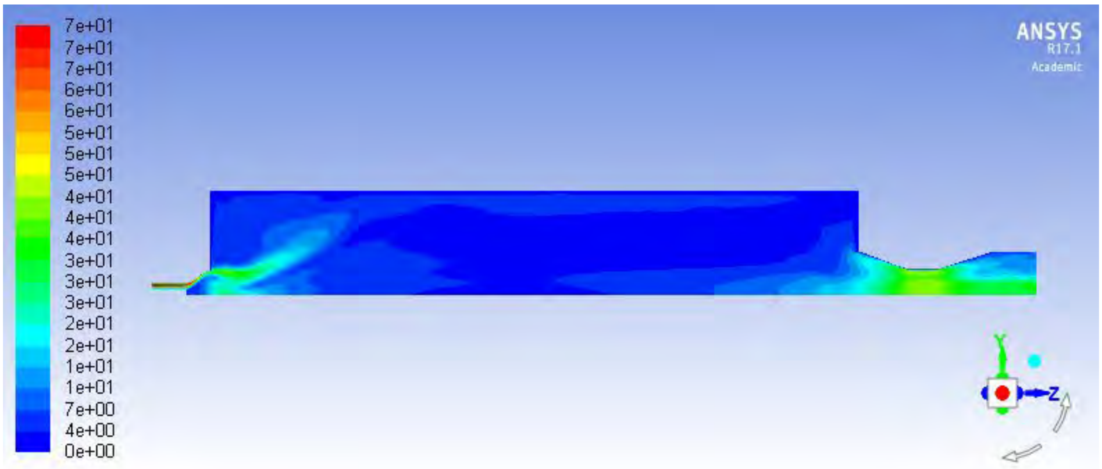

Figure 4.1(c): Contour for inlet velocity 26 m/s

Figure 4.1(d): Contour for inlet velocity 29 m/s

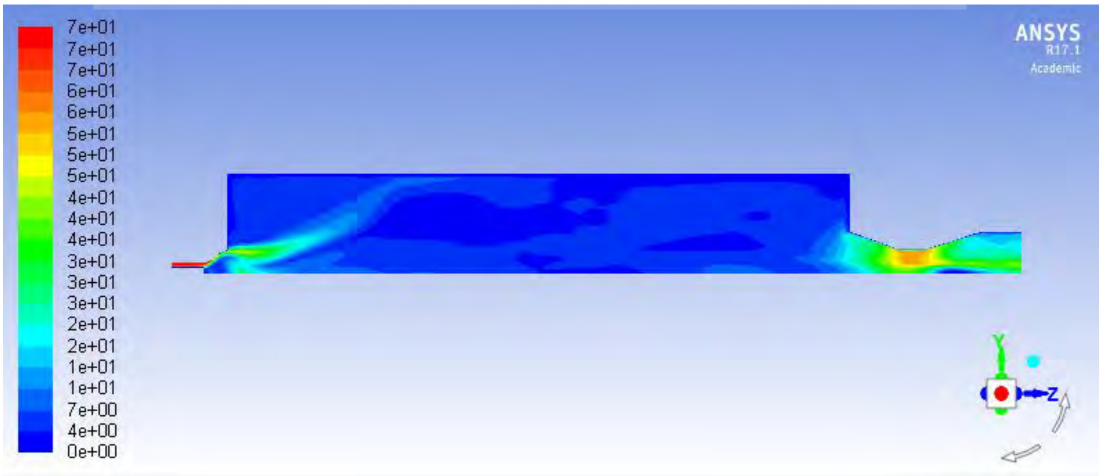

Figure 4.1(e): Contour for inlet velocity 32 m/s

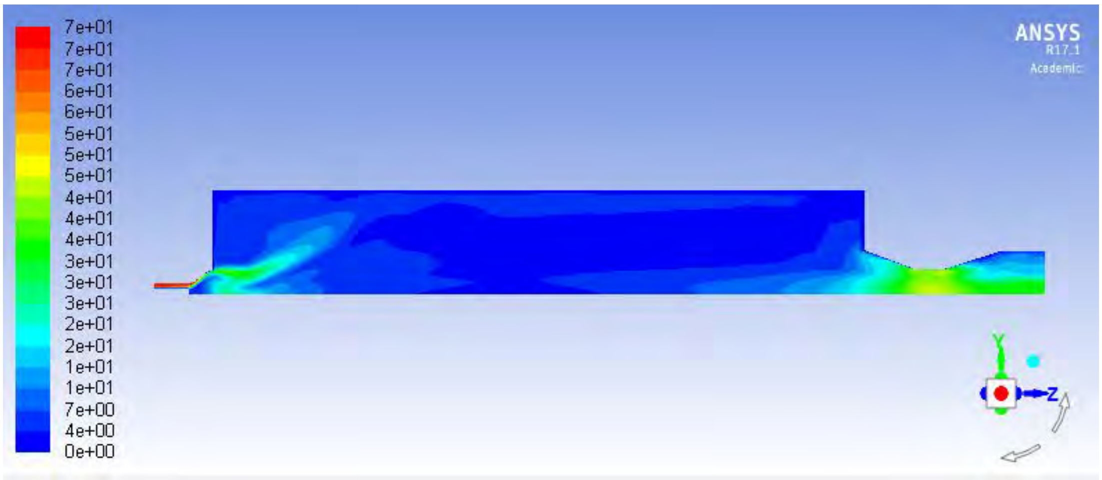

Figure 4.1(f): Contour for inlet velocity 35 m/s

From the above figures, it can be seen the velocity at the inlet area is higher compared to the centre area. It means the flow becomes stable when it's near to the centre area of the combustor. The velocity becomes a high back when it flow to the outlet area. By referring to Bernoulli's principle, the velocity is inversely proportional to the area. So, when the area is decreased, the velocity will increase. This condition can be related to the flow from the centre of the combustor to the outlet area. Based on the Fig.4, can be concluded that the changes values of the inlet velocity significantly affected the inlet and outlet area.

b) Contour of pressure

Figure 4.2(a): Contour for inlet velocity 20 m/s

Figure 4.2(b): Contour for inlet velocity 23 m/s

Figure 4.2(c): Contour for inlet velocity 26 m/s

Figure 4.2(d): Contour for inlet velocity 29 m/s

Figure 4.2(e): Contour for inlet velocity 32 m/s

Figure 4.2(f): Contour for in inlet velocity 35 m/s

Roughly, from the figure contour of pressure, the changes of the inlet velocity give the effect to the centre area of the combustor. As the temperature increases, the molecules in the gas move faster, impacting the gas's container more frequently and exerting a greater force. This cause the increases of the pressure.

It is known that the inlet velocity is directly proportional to the pressure inlet. This means that by increasing the value of velocity magnitude, the value of pressure inlet is also increase. The pressure in the combustor need to be control and monitor carefully. This because if the pressure gets out of control, a loss of draft in the combustor reduces the air flow. It will cause some fuel will go unburned and affect the firing rate become lower. So, the combustible gases will produce which are toxic and fire hazard[42].

c) Contour of temperature

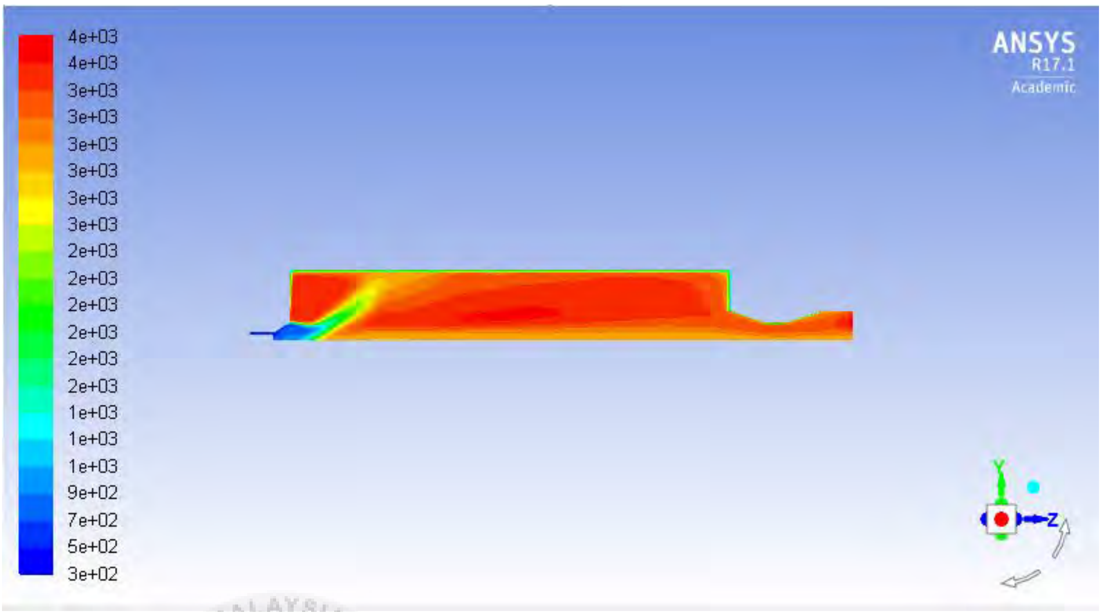

Figure 4.3(a): Contour for inlet velocity 20 m/s

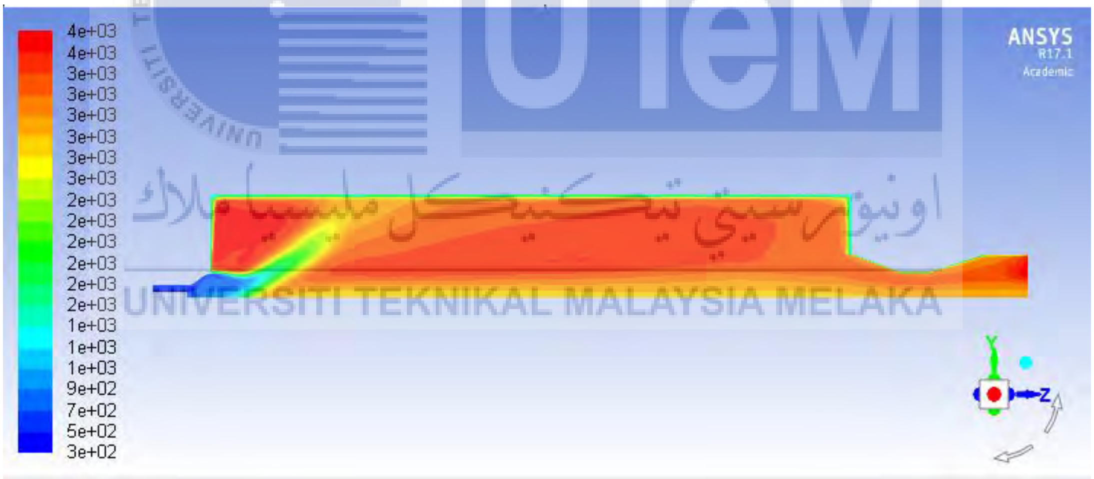

Figure 4.3(b): Contour for inlet velocity 23 m/s

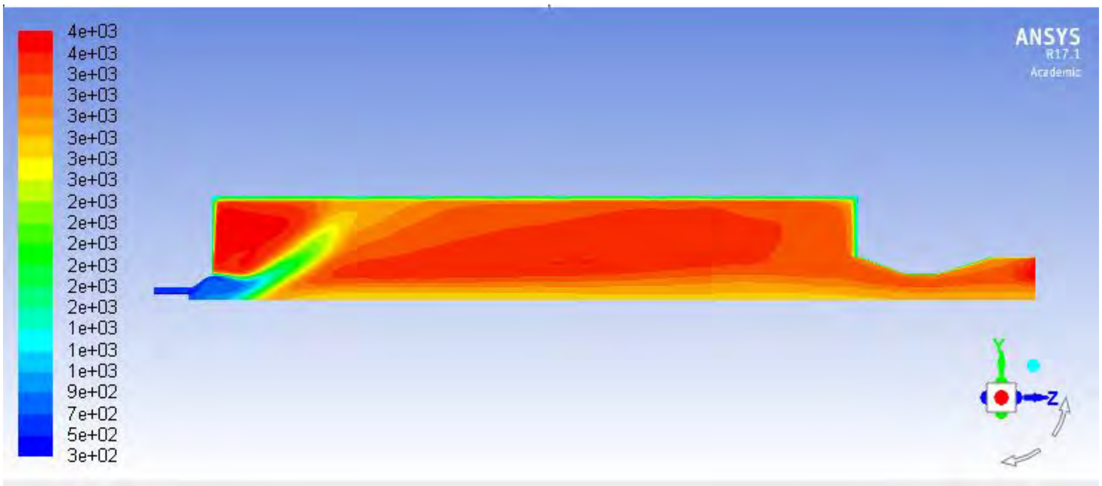

Figure 4.3(c): Contour for inlet velocity 26 m/s

Figure 4.2(d): Contour for inlet velocity 29 m/s

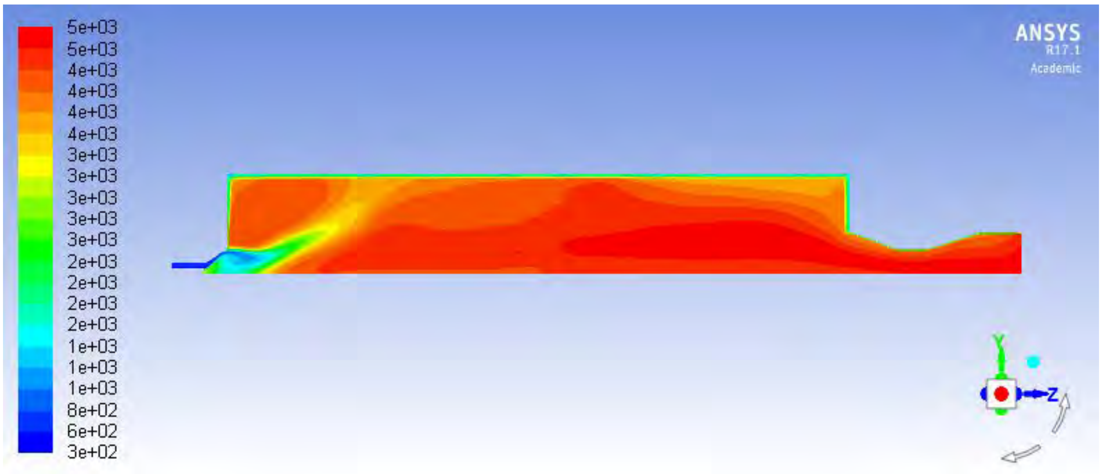

Figure 4.3(e): Contour for inlet velocity 32 m/s

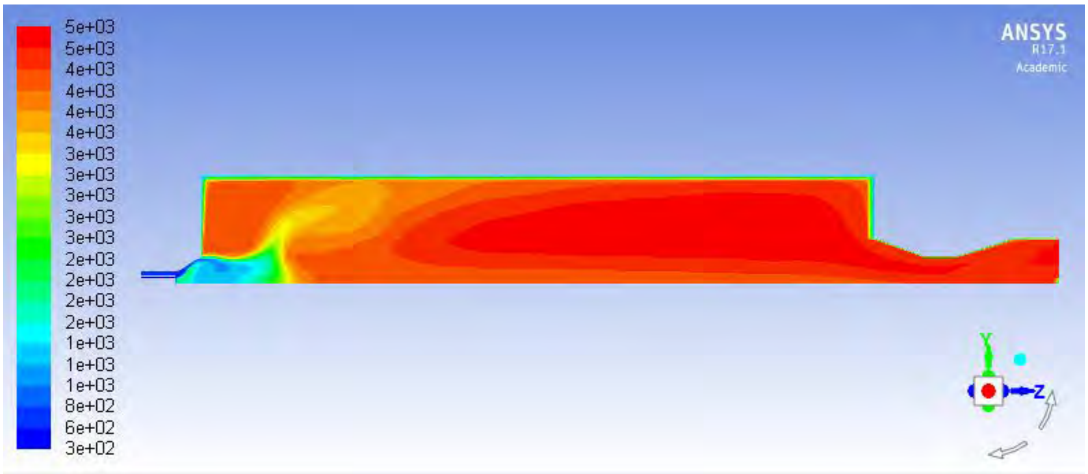

Figure 4.3(f): Contour for inlet velocity 35 m/s

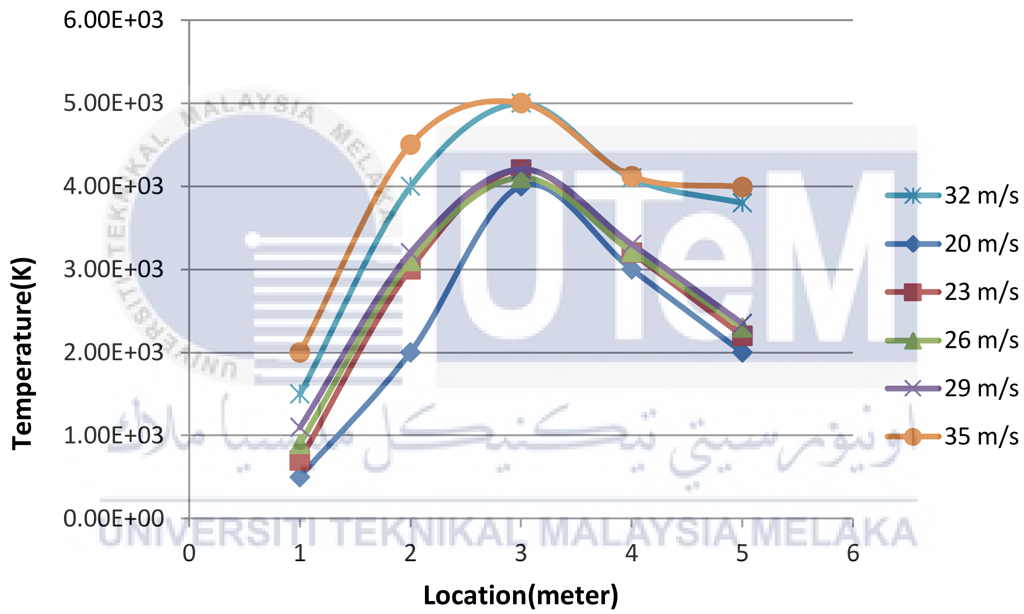

Figure 4.3(g): The graph of location against temperature

As previously mentioned, the inlet velocity is directly proportional to the pressure inlet. This means that by increasing the value of velocity magnitude, the value of pressure inlet is also increases. Therefore, the relationship between pressure and temperature is directly proportional to each other.

From the graph in Fig. 4.3(g), the general trend of obtained data shown the rapid increase in the temperature within the reaction zone which is at the centre of the combustor. Moving away from the reaction zone reaction, the temperature is slightly dropped. This situation occurs because the temperature depends on the pressure within the combustor and the inlet velocity of the combustible mixture. In other words, the changes of the inlet velocity were affect the temperature inside the combustor during the combustion process.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATION

Modelling the coal combustion in the combustor can be classified as a critical part because any mistake will cause serious damage to the combustor and consequently affect the whole process of coal combustion. There are a lot of factors that need to be considered in order to complete the modelling stages. Each factor must be analyzed in details to know the impact on the coal combustion. One of the factors that effect the coal combustion process is inlet velocity.

By using commercial software of numerical simulations which is ANSYS, the simulation had been done to identify the effect of the inlet velocity to the coal combustion process. In order to identify the effect, the value of inlet velocity had been changed. The contour of velocity magnitude, pressure and temperature from the simulation were used to study the effect. After completing the simulation with six different values of inlet velocity, the effect were identified which is the inlet velocity are directly proportional to the pressure and temperature. So, the objective of this study were successfully achieved.

Based on this study, the inlet velocity is affected by the temperature and pressure in the combustor. In practical, it is recommended that if the inlet velocity were to be changed, the reading of the current pressure and temperature need to be considered. For further enhancement of the current study, it is recommended to thoroughly investigate more parameters that considerably affect the combustion process

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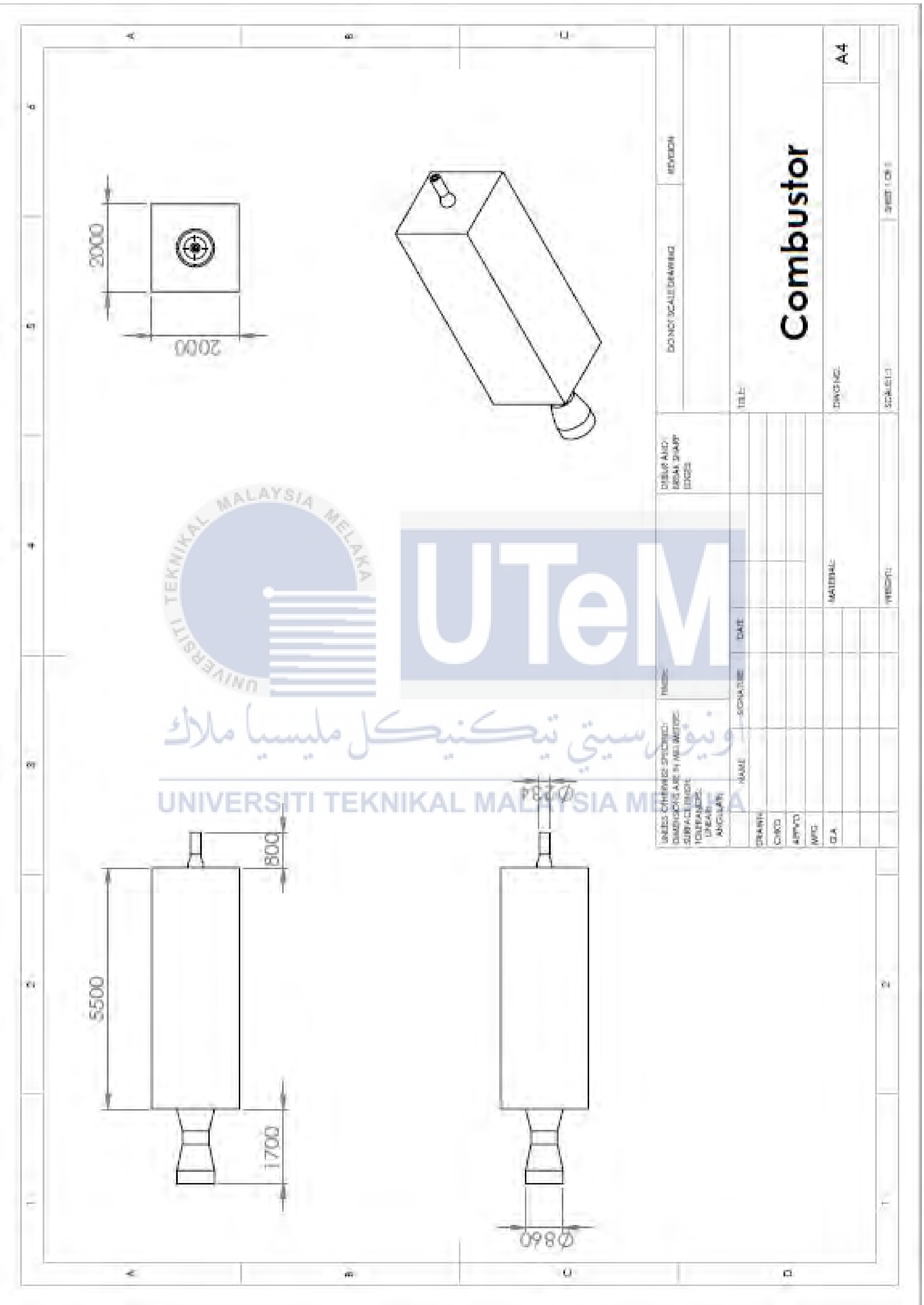
LIST OF APPENDIX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