Temperature distribution simulation on Aluminum incineration furnace using Autodesk simulation mechanical CFD 2018

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Abstract. Used lubricating oil is one of the liquid wastes which is produced by an industrial machine or private vehicle machine. Lubricating oil is a waste that is produced by machines in both large industrial and private vehicle engines. This research aims to examine the process of manufacture and the system of oil-fueled crucible stoves, and simulated the temperature at aluminium melting furnace by doing some form of design testing; selection of furnace material using carbon steel, brick, plate; furnace modeling which has three parts of crucible, fireproof stone and lids where the three parts have different sizes and uses of each, then set the simulation as what we aim to such as the temperature distribution where the air temperature reached 40°C heat source from combustion 1200°C. From the combustion, the velocity value obtained is 0.5 in/s, distribution at crucible is 749°C. In conclusion, the used oil smelting furnace can melt used aluminium metal, so that the used metal oil melting furnace can be used in the home industry to recycle used aluminium metal.

Keywords: Temperature distribution, CFD, furnace, aluminium

1. Introduction

The development of the smelting and metal casting industry in Indonesia is currently very low. Even though Indonesia has the potential to become one of the largest markets in the world. Many small-scale metal casting industries are constrained by their development, this is due to the fact that metal smelting kitchens that are available on the market are very expensive and difficult to obtain because they have to be imported from abroad. The choice of the type of kitchen and the smelting process used must be in accordance with the type of metal chosen and also according to the desired product. The types and classifications of smelting kitchens that are currently developing include Crucible kitchens, cupola kitchens, electric arc kitchens, induction kitchens, converter kitchens, and the Thomas and Bessemer kitchens. The fuels used are also diverse including coal, fuel oil, electricity, charcoal, even gas-shaped fuels [1].

To solve the problems, it is necessary to design and manufacture metal smelting kitchens that are simple, easy to make, easy to move (portable) and the most important point, is that the machine has acceptable price so that they can be reached by household scale casting industries. The metal smelting
kitchen resulting from the design and manufacture will have several advantages including fuel efficiency because it uses used oil fuel and the combustion chamber temperature reaches 1000°C because kitchen construction uses heat insulation of refractory bricks. For this reason, it is necessary to obtain a relatively inexpensive aluminium smelting kitchen design using used oil fuel. Aluminium has a melting point of 660°C, so with a kitchen temperature of 1000°C it is very potential to be used to melt aluminium. Other types of metals that can be melted with melting points below 1000°C are copper (962°C), brass (940°C), tin (327°C), magnesium-lead (630°C), Sn-Bi (232°C), etc. [2,3].

In waiting for the smelting, the temperature produced must be greater than the melting point of aluminium, which is 660°C. In this research the temperature caused by heat loads on the furnace will be simulated using computation fluid dynamic (CFD) software.

Stoves or hearth are tools used to melt meals to smelting or heated materials to change the form (example: rolling) or the properties (heat treatment) [4].

Minimum-scale and Medium-scale aluminium melting and usually done by crucible furnace. A characteristic of crucible furnace is the usage of vessel to place the metals that are going to be melted. The vessel has a form of pot-like ceramic crucible with upper larger diameter which acknowledged by the name of kowi. This furnace is differentiated by the fuel-type that are being used, such as charcoal, oil, and gasses. Another differentiation is being done according to the furnace’s construction, which are divided into furnace with non-fixed kowi, and furnace with fixed-kowi and tungkik furnace [1].

In the melting furnace with the direct fire combustion, the fire flash is directly touching the aluminium scrape crucible. The study of the distribution of temperature in the melting furnace is very important in order to know the location of stresses and strain caused by increasing the temperature in the furnace.

2. Method

Furnaces are devices used for high temperature heating. Heat energy for furnace fuel can be supplied directly by burning fuel, by electricity such as electric arc furnaces, or by induction heating in an induction furnace.

Heat treatment furnaces are heating stoves used to heat the metal until it reaches its melting point so that it can be used for casting. Heat energy that is needed are including: heating energy to raise the temperature to the melting point and fusion heat to convert metals from solid to liquid.

Based on the usefulness of the heat treatment furnace divided into four (4) namely, annealing furnace, hardening furnace, tempering furnace, and carburizing furnace. The difference from the four heat treatment stoves this is the capacity to achieve its temperature. According to heat sources, the heat treatment furnace can be divided into two: fuel burning furnaces fuel-fired furnaces (see Fig. 1 and 2) and electric heating furnace electrical heated furnaces. Fuel combustion stoves can be further classified depending on the type of fuel, solid fuel (figure 3), liquid fuel, and gas fuel. Liquid fuel commonly used is fuel oil. As it concerns on efficiency and economy, gas combustion stoves are lower than on electric heating stoves [5].

Electric furnaces have advantages such as uniformity of temperature in the chamber, free of pollution, neat and clean working conditions, efficient use of heat energy (minimizing lost energy), and easy start and closing down. Electric furnaces can be grouped into resistance furnaces, arc furnaces, Induction furnaces, plasma arc furnaces, and electron beam furnaces [6].

Heat is a form of energy that can be transferred from one system to another due to temperature differences. Heat Transfer always from media with higher temperatures to lower temperatures, and heat transfer stops when the two media reach the same temperature. Problems with heat transfer those encountered in practice can be considered in two groups: (1) assessment and (2) size problems. The assessment problem is related to determining the heat transfer rate for a system that is at a certain temperature difference. The problem of size relates to determining the size of the system to transfer heat at a level determined for a certain temperature difference.
Conduction heat transfer on a flat plate only at the X-coordinate is shown in Figure 6. Based on Fourier's law equation about conduction is as follows [4,6].

\[ q_x = -K_{xx} \frac{dT}{dx} \]

In which:
- \( Q_x \) = X-axis transfer heat
- \( K_{xx} \) = Thermal conductivity on the X-axis W/(m.°C) atau Btu/(h-ft-°F)
- \( \frac{dT}{dx} \) = temperature gradient°C/m

The process of heat transfer in the furnace will begin at the heat transfer from the fire which is sprayed directly through the furnace lid hole to aluminum on the base of the crucible which is the transfer of heat by convection. Conduction heat transfer occurs between krusibel used aluminum, also in the crucible with 0.3 m thick conduction heat transfer occurs.

3. Result and Discussion
After the run simulation process is complete, the temperature to time graph will be obtained from two simulated crucible materials. The CFD simulation on the furnace was successfully carried out using Autodesk CFD software. The speed vector in the dimensional field view is shown in figure 4. In the figure it can be observed that the maximum velocity distribution of high fluid.
from thermal conductivity the Graphite material has a value high. The maximum speed is shown in the flow of flame when entering the combustion chamber, after the combustion energy is released then the speed increases and continues to decrease towards the outlet.

![Figure 4. Rate at graphite kowi material](image1)

![Figure 5. Temperature distribution](image2)

Figure 5 shown the results of the simulation of the temperature distribution in each material. Visible range minimum and maximum temperature ranging between 0°C-1200°C.

In figure 6, the following shows the temperature distribution from the inlet to the outlet in the kowi material Graphite maximum temperature is found in the inlet furnace, the temperature decreases more drastically when heading to the outlet, which is close to the value of 748°C.

![Figure 6. Temperature distribution graphic from inlet to outlet at graphite kowi material](image3)

![Figure 7. Combustion on steel material](image4)

The results of the temperature distribution that has been simulated indicate an increase in temperature during the combustion time (figure 7). Furnace is the increase in the maximum value and minimum value with increasing time, as highlighted by others [6,7].

Based on the simulation results it can be seen that the crucible material affects the graph of temperature distribution in the aluminum melting furnace. In the results of simulations that have been done, it is found that crucible with steel material carbon can increase the temperature with a maximum value of 1200°C and a minimum value of 40°C.

4. Conclusion
Based on the conclusions obtained from the research and discussion on the Simulation of Temperature Distribution in Aluminum Melting Furnaces by Using Autodesk Software CFD 2018, are as follows:
Based on the results the combustion temperature of used oil is quite high (the highest temperature measured is 1200°C. With kowi construction using used oil carbon steel material can be used as fuel to melt aluminum in aluminum melting furnaces. Based on the simulation results, it is found that crucible with steel material carbon undergoes a change in temperature distribution from transient to reach steady state quickly in aluminum melting furnaces.

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