Utilization of Heat Loss by Flue Gas in Using Solid Fuel Furnace to Increase Heat Efficiency

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Abstract Commercial solid fuel furnace efficiency was too low, the biggest cause of heat loss was heat loss carrying out by the flue gas. The aim of this research was to increase heat efficiency by utilization the flue gas as a preheater the solid fuel.

This research was done with burning 100 grams of wood charcoal by different initial temperature and observed flue gas temperature change in the isolated chamber every 5 minutes. To know utilization of flue gas, put water in the kettle in the isolated chamber and flue gas would heating the water, observed water temperature change, and this experiment was repeated with uninsulated chamber. To know overall heat efficiency was done by burning simultaneously 200 grams wood charcoal that divided each 100 grams with variation of initial temperature, and water was heated in the isolated chamber.

The result show that the higher initial temperature cause faster burning rate until 6th minutes. Using insulation yielded increase heat efficiency amount of 20% with aluminum insulation and 44% with asbestos insulation. Utilization flue gas to heating fuel stock before burning increase heat efficiency amount of 27,8% with isolated furnace.

Keyword *: heat loss, flue gas, solid fuel, furnace, increase heat efficiency*

1. Introduction

The alternative fuels to replace petroleum fuel were biomass, natural gas, biogas and biofuel. The choice the kind of alternative fuel depend on the typically using. Biomass was an interest kind of fuel that used at the industry and at home, because biomass was rapidly renewable and easy to find its resources.

Using biomass as an alternative fuel usually change the biomass to be a charcoal. This transformation was to increase burning efficiency and to reduce the gas emissions. Charcoal can be made from many kind of biomass. One of the source of biomass is waste from wood industry. Developing biomass charcoal is a strategic step to reduce wood wastes and to supply energy demand.

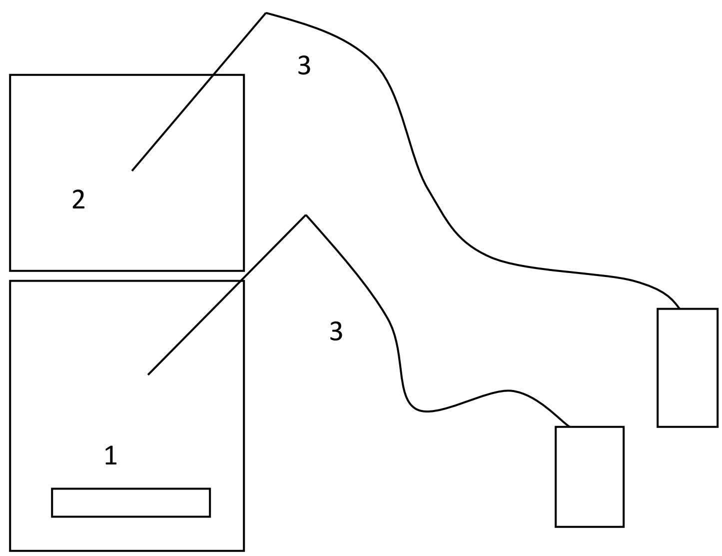
The problems using charcoal as a fuel at the home were difficult to initial burn, it hard to arrange velocity burning, it hard to stop the burning immediately, and low heat efficiency.

Issues investigated in this study is limited to the effect of temperature on the initial burning velocity, and utilization of heat lost by flue gas convection to increase temperature of the fuel stockpile and to increase the heat efficiency. Another influential variables such as the size of a solid fuel, speed of combustion air and the amount of fuel burning made constant.

The heat loss from the furnace is huge by any calculation of the Energy Efficiency Guide for Industry in Asia - www.energyefficiencyasia.org. Most heat is lost from the furnace flue gas of most dominant at 57, 29% of the heat produced by fuel. Heat efficiency will be increased by taking heat from flue gas to heating the fuel stockpile until near the combustion temperature.

2. Methods

Materials were used in this research were wood charcoal and paraffin, Wood charcoal was purchased randomly from the market. The main equipment was a commercial furnace that bought on the market. To compare it's efficiency, One of these furnace run at the genuine and the one modified by put the isolation, these isolation was functioned as stockpile fuel inventory, these equipment was placed above the furnace and flown the flue gas through this equipment to take the heat into the stockpile fuel and . These equipment shown below



1. Solid Furnace
2. Stockpile place
3. Thermocouple

Fig 1. Furnace with stockpile place

3. Procedures

This experiment was start by measured burning temperature of wood charcoal. 100 grams of wood charcoal were burned at the furnace with fire from 5 grams paraffin as a fuel starter. The furnace temperature was observed, note the temperature that wood charcoal begin burned.

To calculate increasing heat efficiency with heat isolation, first 100 grams of wood charcoal were burned at the furnace without isolation, put a kettle with 1000 grams of water above the furnace to take heat, measured initial water temperature and increasing water temperature each five minutes until the top temperature curve reached. Repeat this procedure with two kind of isolation, first aluminum and the second with asbestos isolation.

To compare heat efficiency between combustion without initial heating of charcoal and with initial heating by using flue gas, first 200 grams of wood charcoal were burned at the 2 sections simultaneously, each section 100 gram without initial heating of charcoal. Put 100 grams wood charcoal into the furnace, burn it with 5 grams paraffin, put the kettle with 1000 grams water, measure initial water temperature and measured increasing water temperature each 5 minutes, if the top of water temperature was reached, put 100 grams charcoal remain into the furnace and measured increasing water temperature until the top temperature reached. Repeat procedure above with initial heating.

4. Result and Discussion

4.1. Influence initial temperature Burning

Initial temperature of charcoal was give effect to the velocity burning, as shown at the figure below

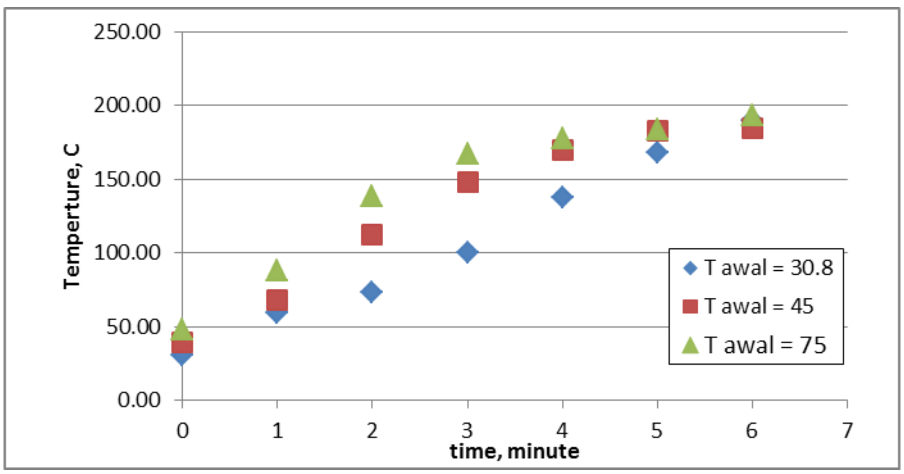


Fig 2. Burning Velocity as function of initial temperature

Figure 2 shows that the higher initial temperature make burning velocity faster at the first six minutes, after this time burning velocity became equal because the temperature was equal.

4.2 Increasing Efficiency by Heat Isolation

Comparison data temperature furnace function time burning between non isolation furnace, isolation by aluminum and asbestos isolation, shown in the graphic below

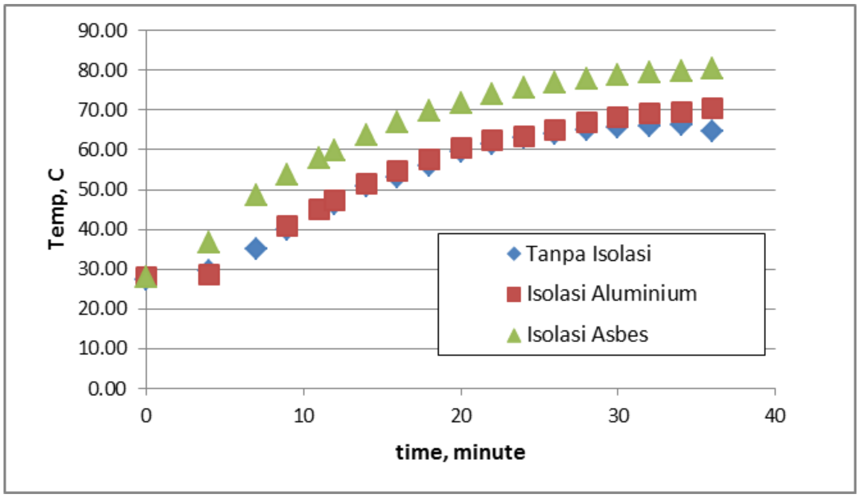


Fig 3. Comparison temperature water

Figure 3 shows that using isolation can make higher temperature of water in the same time burning, it is mean using isolation can increase the heat efficiency. Asbestos isolation was the better isolation than aluminum isolation.

Velocity of heat release from burned fuel can be calculated from this data by formula

$q = U.A(T \quad - T_{water})$ = m.cp (T1-T2)

The result of calculation can be shown as graphic below

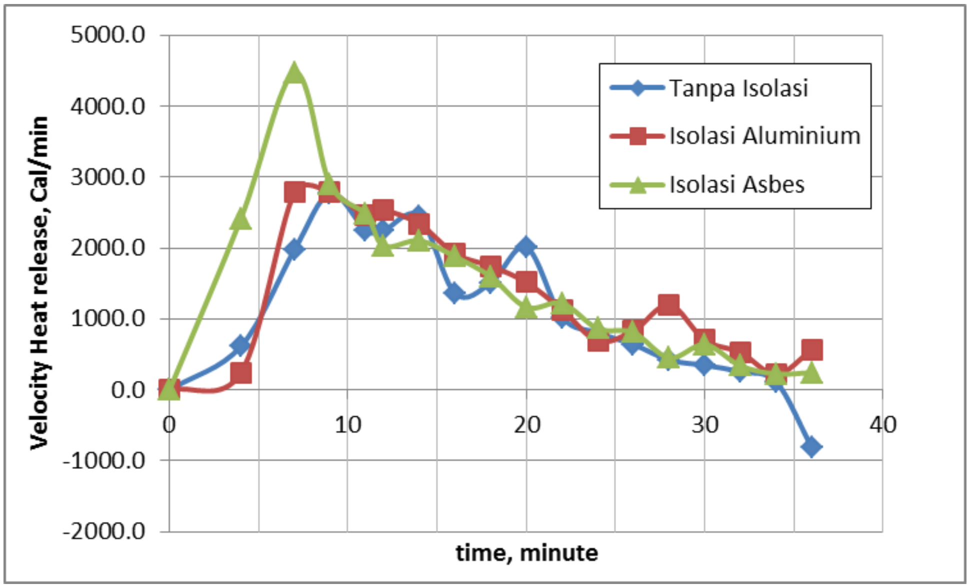


Fig.4. Velocity heat release function of time burning

Figure 4 shows that using asbestos isolation increase absorption of heat by water. It is mean that using isolation can increase heat efficiency. If total heat was calculated as long as 36 minutes, it can be compared as the table below

Table 1. Comparison of heat absorbed

	Heat absorbed in 36 minutes, calorie		
	No Isolation	Aluminum Isolation	Asbestos Isolation
Heat	40887.51	49066.67	58887.29
Percentage	100%	120%	144%

4.3 Utilization of flue gas

Flue gas was resulting by fuel combustion after used to heat the water, it can be used to heat the stockpile fuel, to increase its initial temperature

Comparison data temperature of water function time burning between burning without initial heating and with initial heating in two section burning, shown in the graphic below

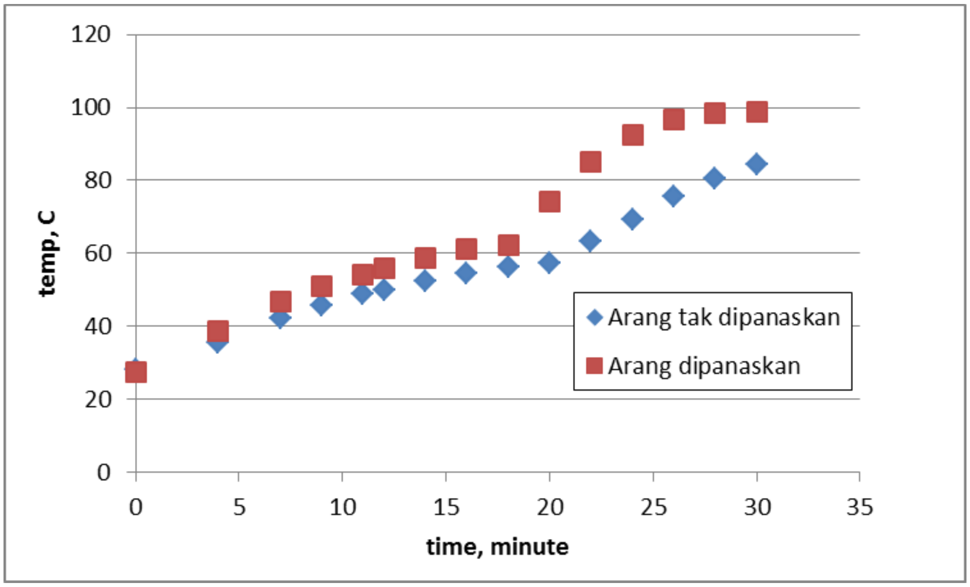


Fig 5. Comparison temperature water in the two sections burning

Figure 3 shows that using isolation can make higher temperature of water in the same time burning, it is mean using isolation can increase the heat efficiency. Asbestos isolation was the better isolation than aluminum isolation.

Velocity of heat release from burned fuel can be calculated from this data by formula

$q = U.A(T \quad - T_{water})$ = m.cp (T1-T2)

The result of calculation can be shown as graphic below

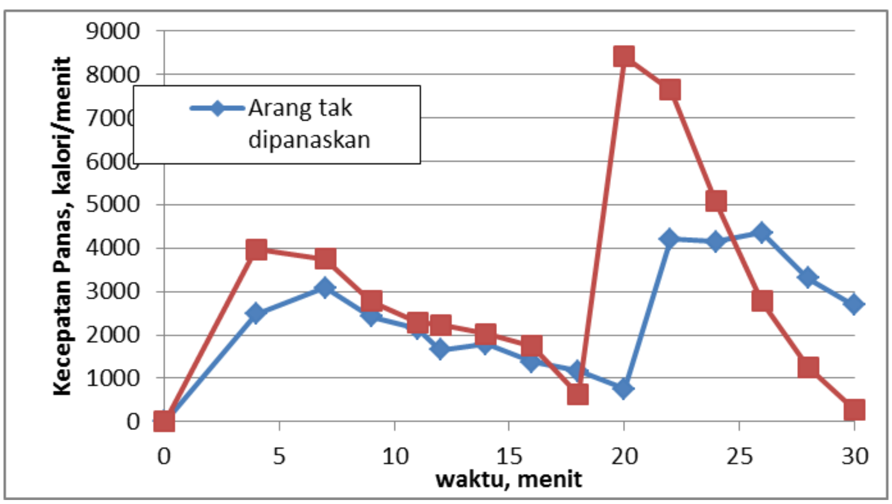


Fig.6. Velocity heat release function of time burning

Figure 4 shows that using heat loss to heating the stockpile of charcoal before burning at the simultaneously burning will increase the heat absorbing, and the heat efficiency will increase 27,8 %

more than unheated stockpile as shown at the table 2 below.

Table 2. Heat absorbed at the simultaneously burning

	Heat absorbed in 30 minutes, calorie	
	Unheated stockpile	Heated stockpile
heat	77556	99107
percentage	100%	127,8%

5. Conclusion

1. Temperature of charcoal had influence to its burning velocity, Increased temperature will increasing burning velocity at the first six minutes burning.
2. Increasing Utilization of heat burning can be done by flowing the flue gas around the kettle and prevent heat loss by insulation. Aluminum insulation can improve 20% and asbestos insulation can improve 44% of heat absorption.
3. using heat loss to heating the stockpile of charcoal before burning at the simultaneously burning will increase the heat absorbing, and the heat efficiency will increase 27,8 % more than unheated stockpile

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