Technical Paper

Performance Evaluation of Rotating Cylinder Type Coffee Bean Roaster

Evaluasi Kinerja Penyangrai Biji Kopi Tipe Silinder Berputar

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Abstract

One strategy attempts to reduce dependence on primary commodity markets are overseas market expansion and development of secondary products. In the secondary product processing coffee beans is required of supporting equipment to facilitate these efforts. Research Center for Indonesian Coffee and Cocoa has developed coffee bean roaster. However, there are still many people who do not know about the technical aspects of roaster machine type of rotating cylinder so that more people use traditional ways to roast coffee beans. In order for the benefits of this machine is better known society it is necessary to study on the technical aspects. The purpose of this research is to evaluate the technical performance of the coffee beans roaster machine type of rotating cylinder. These include the technical aspects of work capacity of the machine, roasting technical efficiency, fuel requirements, and power requirements of using roaster machine. Research methods are including data collection, calculation and analysis. The results showed that the roaster machine type of a rotating cylinder has capacity of 12.3 kg/hour. Roasting efficiency is 80%. Fuel consumption is 0.6 kg. The calculated amount of the used power of current measurement is the average of 0.616 kW.

Keywords: *coffee beans, roasting, performance*

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Introduction

Indonesia is become one of the largest coffee producers in the world after Costa Rica and Brazil. Current production reached 500 thousand tons and is expected to continue to increase significantly because the program is regular replanting and expansion of new plantations (Directorate General of Plantations, 1999). On the one hand, increasing the production has a positive contribution to the increasing in export earnings. But on the other hand, an anticipatory action needs to be done to deal with a drastic decline in prices that occurred from time to time due to excess supply of coffee beans in the world market (USDA, 2000).

One strategy attempts to reduce dependence on primary commodity markets are overseas market expansion and development of secondary products. Development of coffee valued secondary products will provide some economic incentives for countries including the increase value added greater agricultural products, employment opportunities in rural areas, development of related industries and increased per capita coffee consumption in the country which is currently relatively low (USDA, 2000).

The bean coffee is a product of secondary and one of the favorite beverage ingredients well by residents of rural or urban population. With a population in Indonesia, which reaches more than 200 million, the coffee bean market in the country is still basically wide enough (Lakshmi, 1987). Current domestic consumption of coffee is still very low at only 70000 tons / year or about 0.5 kg / person / year. This value is much lower than the level of consumption in other countries such as Finland, Norway, Danish, Austria, Germany and the Netherlands, which reached approximately 8 to 11 kg per person / year. Based on the economic aspects, the price of coffee beans in the last ten years has tended to decline, while the price of coffee powder increased (USDA, 2000).

The development of downstream industries should be developed coffee powder in the production centers so that the coffee production process cheaper and affordable communities, especially in the villages. In addition, the expansion of this industry will have a chain effect on the growth of industries and services associated with those products such

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as metal and machinery industry, plastics industry for packaging, advertising and distribution services (ICBS, 1998).

Development of secondary products that lead to downstream industry will provide added value and increase domestic consumption of coffee. Coffee consumption is currently estimated at approximately 0.50 kg / person / year and is expected to be increased to 1 kg in the next few years. Thus the domestic market opportunities and the negative effects of coffee price fluctuations on world markets can reduce farmers' income (Zaenuddin and Martadinata, 2000).

As a step anticipatory, Research Center for Indonesian Coffee and Cocoa in the last few years has developed a technology package processing secondary products (coffee powder) ready for the market. Base design and engineering process technology and machine tools and supporting equipment is selected on the economies of scale, i.e. 60 tons of rice beans (Robusta type) per year, equivalent to 45 tones of coffee powder (Mulato et al., 2000).

Based on previous research, the temperature roasted robusta coffee beans (without the steaming process) revolved around 190-205 ºC with a long 45 minutes to roast the capacity of 25 kg of coffee beans (Widyotomo and Mulato, 2000). In periodic, roasting degree are measured by the color of coffee beans, monitored by taking samples of coffee beans roasted in the cylinder through the hole. The sample included roasted coffee beans into a glass dish and compared with roasted coffee beans color are also standard in other petri glass. The level of the coffee bean color is a medium level according to the level of the Lovibond color.

The roasting process coffee beans for each group of product quality coffee bean is done separately, because the old roast and uniformity level depends on the size of coffee beans. (Widyotomo and Mulato, 2000).

In the secondary product processing coffee beans is required of supporting equipment to facilitate these efforts. One example is the machine type of coffee beans roaster of rotating cylinder. But still there are many people who do not know about the technical aspect of roasting engine rotating the cylinder type. The results caused more people to use traditional ways to roast coffee beans.

In order for the benefits of this machine is better known roaster society it is necessary to study on the technical aspects.

Materials and Methods

Materials

Materials used in this study were dry Robusta coffee varieties, with the moisture content of ± 12% wet basis. Before roasting coffee beans is steaming, this process which will be minimal caffeine coffee products "komik".

Before data acquisition parameters are determined prior to observations, among others, as follows:

a. Variation materials (coffee beans) 10 kg, 8 kg, 6 kg, and 4 kg, each performed two repetitions.
b. Time roasting (according to level of maturity, ranging from 20-45 minutes).

Methods

1. Roaster engine rotating cylinder type, with a capacity of 10 kg/batch.
2. Balance, used for weighing coffee before/after roasted.
3. Roll meter, used to measure the dimensions of coffee beans roaster machine.
4. Digimost, used to measure the moisture content of coffee beans before/after roasted.
5. Thermocouple, used to measure the temperature of the roast, the temperature of the material, and the temperature of the chimney.
6. Stop Watch, is used to calculate the time required in roasting.
7. Ampere meter, used to measure the current flow (*I*) are used.

Target technical application is getting the maximum outcome per unit of input sources. There are several tests that need to be done in analyzing machine technically are as follows:

a. Capacity of roasting

Roasting capacity test aims to find out how many machines the actual capacity and level of fitness roaster listed in the user manual. The roasting capacity can be formulated as in Eq. (1).

$$Capacity\ (\mathrm{kg/h}) = \frac{Input\ Weight\ (\mathrm{kg})}{Roasted\ Time\ (\mathrm{h})} \quad (1)$$

b. Technical efficiency

Technical efficiency is used to determine whether the machine is roaster coffee beans economically feasible or not. The statement is an expression of physical efficiency can be expressed as in Eq. (2):

$$Roasting\ Efficiency = \frac{Last\ Weight\ (\mathrm{kg})}{Initial\ Weight\ (\mathrm{kg})} \quad (2)$$

c. Fuel consumption

Fuel consumption measurement is done by measuring the fuel before roasted reduced the amount of fuel after roasted. Measurements of LPG weight on a balance.

d. Power requirements
   The need for power is the power needed by the engine driver. Power is calculated based on observational data of the current flowing multiplied by the existing voltage in the driving engine, and can be formulated as in Eq. (3):

$$\textit{power}\ (\text{Watt}) = \textit{voltage}\ (\text{volt})\ \textit{x current}\ (\text{ampere}) \qquad (3)$$

Figure 1. Coffee beans with the moisture content of ± 12% wet basis

Results and Discussion

Identification of Raw Materials

Coffee processing is divided into two stages of processing of primary and secondary processing. Primary processing of the crop begins to produce coffee beans and when the process is continued up to produce the coffee bean is called secondary treatment. But today, many coffee marketed called roasting results roasted coffee. So coffee still is refined before they can be used as coffee drinks.

The raw material of roasted coffee is from Sumber Asin. Before roasting process, coffee beans sorted by color and size. Color sorting was done manually in order to separate the black coffee and a slightly yellowish green color because black coffee will spoil the taste of the coffee powder produced. Size sorting is done with the help of the type of sorting machine vibration table that can later be sorting through coffee beans by size. Coffee beans used in this study a diameter of 7.5 mm. Then the beans are steamed in order to reduce caffeine levels in coffee beans, this is the raw material of low caffeine coffee products “komik”. So after the steaming process, coffee beans are dried until the moisture content reaches ± 12%. Coffee bean moisture content was measured by using digimost (seeds moisture content gauges).

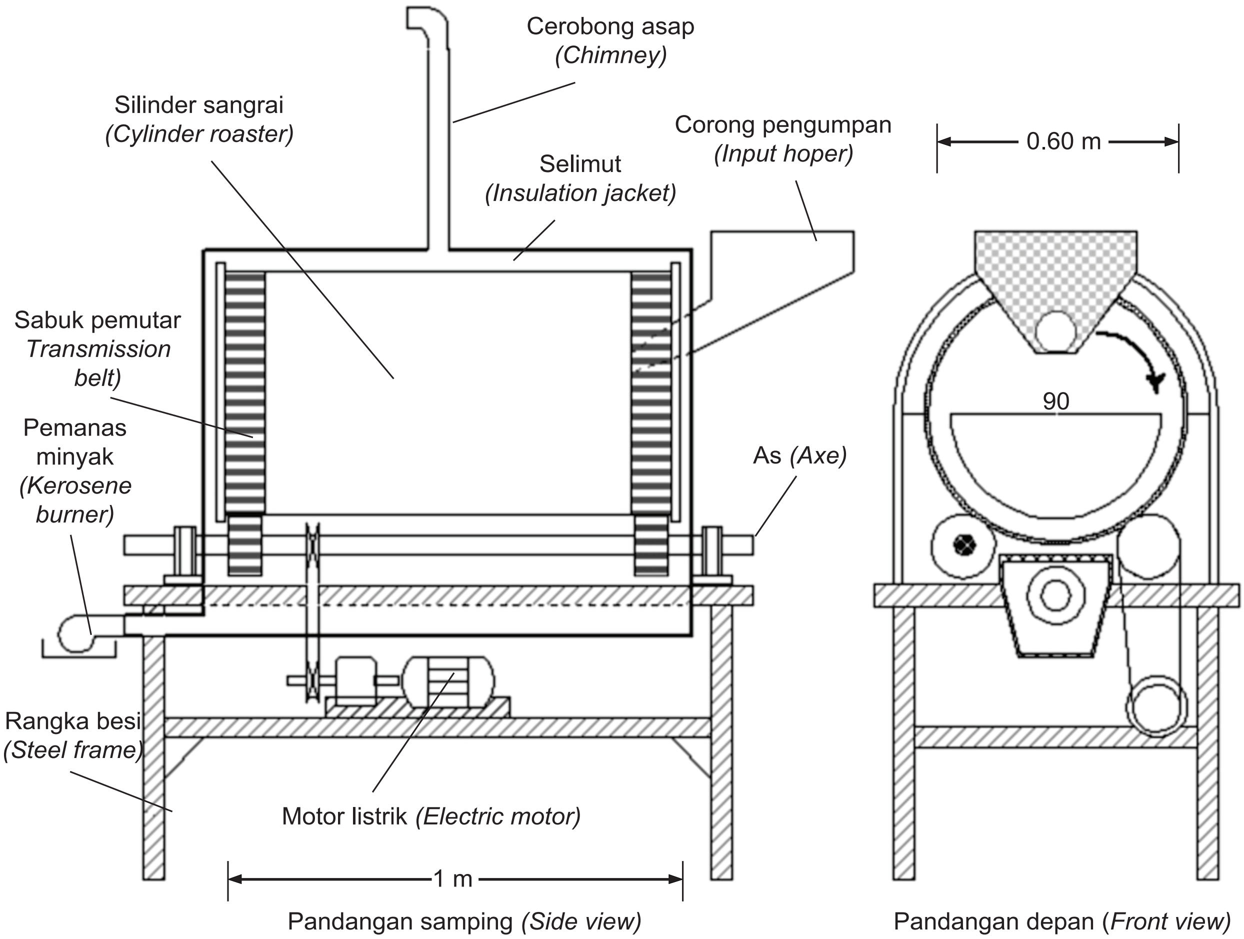

Figure 2. Roast machine sketch, side and front view (*source*: Mulato et al., 2000)

Description Roasted Machine (Roaster)

Roast machine consists of three important parts of the cylinder roasted, motor, and the source of heat.

The cylinder has a diameter of 0.60 m and 1 m long, serves to make roasting mechanism. The cylinder is made from stainless steel. The cylinder has a door to enter coffee beans. There are spiral fins inside cylinder as a coffee stirrer during roasting process. Roaster cylinder driven by an electric motor that serves as a source of power of 0.75 kW, 220 V, 1 phase and 1450 rpm. Before roasting process, lit the heater until the temperature reaches 150ºC. Then beans are inserted through the hole feeder (hopper). During the roasting process, the temperature inside the cylinder must be kept stable. After roasting process is complete, the roasted beans are inserted into a cylindrical tub equipped with a cooling fan.

This process is called tempering to cool the coffee beans roasted. During cooling, stir the coffee beans manually to roast smoothly and does not continue (over-roasted). In addition to cooling, this process is to separate the husk of coffee beans roasted.

Technical Analysis

1. Roasting capacity
   Roasting capacity is the ability of roaster engine to produce roasted coffee, usually expressed in units of kg / hour. In this study the treatment is given based on the observation parameters set before doing research. The weight variation was performed 10 kg, 8 kg, 6 kg, and 4 kg.
   Theoretically roaster engine type rotating cylinder has capacity of 10 kg/hour, but the capacity obtained from this study is 12.3 kg/hour. Based on calculations roaster engine capacity is greater than the capacity that has been listed in this guide use roaster engine rotating cylinder type. The proves that the machine is still able to roast beans above 10 kg / hour, but keep in mind that for roasting should not exceed 10 kg, because it also can maintain stability so that the machine did not break down due to excess charges.
   Weight of material proportional roasting capacity or rather linear, because of roasting capacity is strongly influenced by the time roasting.

2. Roasting efficiency
   Roasting efficiency is the ratio between weight roasted coffee beans after (output) with weight coffee beans before (input). Roasting efficiency on roaster machine shows the machine's ability to produce roasted coffee after roasting process. Yield is to become the reference for calculating the roasted coffee product which will be produced. Usually the value of this yield is as a percentage. So that the raw material (input) to be roasted will know how much the value of output (output) that can be produced, simply by multiplying the yield value to the weight of raw material inputs.
   From Figure 5, average efficiency calculations for roasting is 80%, this means that each input of raw materials will be roasted to produce ± 80% of the weight of input (input). Losing weight by 20% is because of a changing in water content and coffee beans husk.

3. Fuel consumption
   Fuel consumption at each time doing roasting coffee beans depends on how long roasting. The

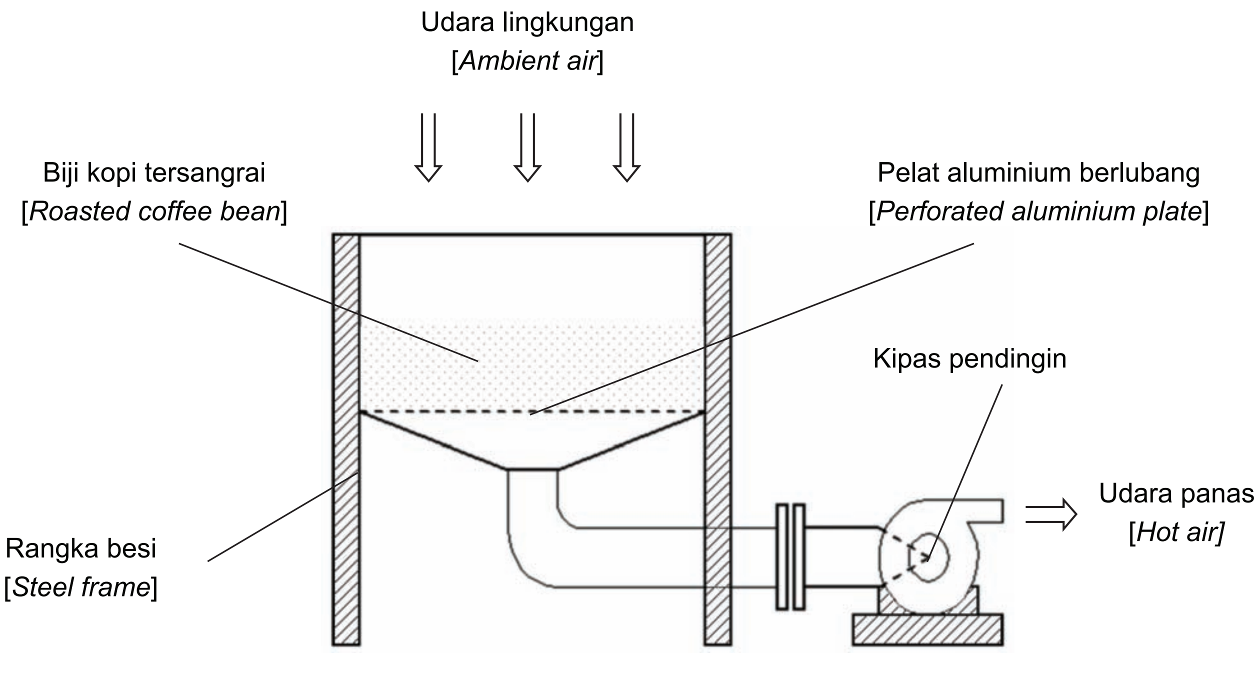

Figure 3. Sketch tool cooling roasted coffee beans results (*source*: Mulato et al., 2000)

longer the time it takes the necessary fuel will be more and more, and vice versa. Fuel used in roaster engine cylinder rotating type is LPG. Measurement of fuel consumption in this study is to weight method, so the fuel consumption before and after weighted. Fuel required in each roasting be known based on the fuel weight reduction before and after roasting process. Fuel costs depend on the amount of fuel use every time roasting process.

Based on calculation, it is found that the average fuel consumption per hour is 0.6 kg. The relationship between the weight of material inputs can be said linear or proportional to the fuel consumption of LPG, it can be seen in Figure 6. So it can be concluded that the weight of coffee beans will be roasted the more fuel will be needed.

4. Power requirements

The need for power is the amount of power used for each time process. The needs for this power calculation derived from the current flowing in the machine multiplied by the amount of driving voltage on the machine. The tool for measuring of the amount of current flowing in this study is Ampere meter. An electrical current measurement made every 5 minutes or so until the roasting process is complete. Based on the measurement results are obtained the same results, because the amount of flow is not affected by the length of time used for roasting. The amount of current will be influenced by the weight of the roasted inputs. The more weight the roasted input then the greater the current flows. Observations show an average current of 2.8 Ampere. As for the voltage in the drive machine is used roaster type cylinder engine is spinning 220 Volt. The needs for power has been calculated will be used as a reference in the calculation of the cost of electricity consumption. The calculated amount of the unused power of current measurement is the average of 0.616 kW.

Conclusion

1. The roasting capacity result is 12.3 kg / hour and for each times the process requires 0.616 kW of power.
2. Minimum weight for all the process is 3.97 kg, with a yield value of 80%.
3. Fuel consumption is 0.6 kg.
4. The calculated amount of the used power of current measurement is the average of 0.616 kW.

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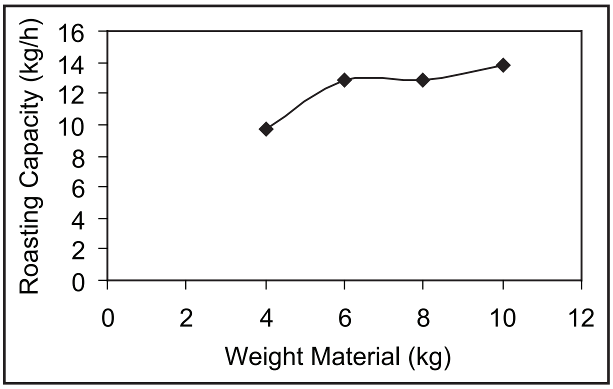

Figure 4. The weight of material relationship with the capacity roasting

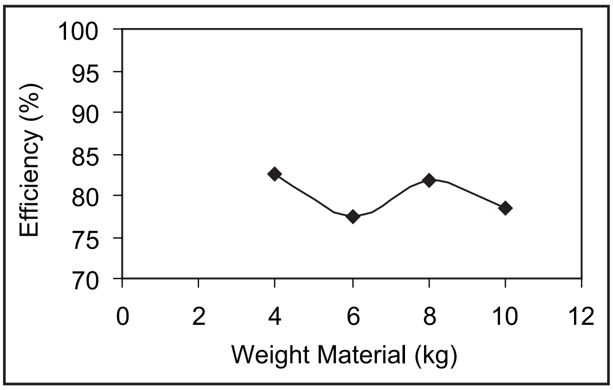

Figure 5. The weight of material relationship with the roasting efficiency

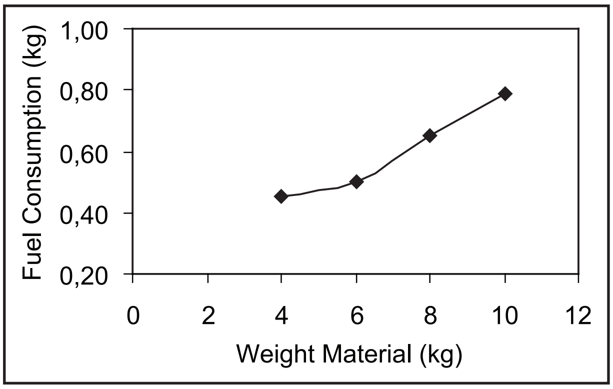

Figure 6. The weight of material relationship with the use of LPG

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