PERFORMANCE COFFEE BEAN ROTARY DRYER TO EFICIENCY AND SPESIFIC ENERGY

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Abstract. Drying foodstuff is one of the most important post-harvest handling. Currently, drying method is still widely used by farmers is conventionally by using sunlight. This method have difficulty control because it depends on the weather, requires a broad place and long time. Therefore, need to designed the mechanical dryers with a large capacity, that is rotary dryer. The dryer consists of a furnace (combustion chamber) and the rotary cylinder (drying chamber) by using the media hot air from the blower. Dryer making mechanism starting from design planning, preparation tools and materials, workmanship and performance test tools. The purpose of dryer design is to determine the performance of dryer in reviewed by efficiency and specific energy consumption. Based on the results of determination temperature effect on the efficiency and specific energy consumption at performance rotary dryer, for the drying with capacity 4 kg, air flow 6,5 m/s, amount rotation 10 rpm and drying time 1,5 hour, so obtain the optimum temperature at 60ºC with percentage final moisture content 13,57% that approaching the SNI standard quality of coffee beans in Indonesian that value 12%. Dryer performance proven in optimum condition, can be viewed from the drying efficiency between 71-85% and specific energy consumption between 717.406 to 879.811 kkal/kg H_2O

Keywords : , rotary dryer, Coffe, temperature, specific energy consumption

I. INTRODUCTION

Drying is a operation that includes heat and mass transfer rates and some processes, such as physical or chemical transformations, which in turn causes change in the quality of the results as well as the mechanism of heat and mass transfer. [1].

Most widely used for drying is conventional way which using sunlight. This method is very cheap and easy, but it is difficult to control, very depending on the weather, requires a wide place, long process, and less maintained clean [5]. Drying with mechanical dryers needs a shorter time than conventional drying.[3].

One of mechanical dryer which has a large capacity is rotary dryer. Rotary dryer is one of the continuous dryers type. According to [6], rotary dryer is a direct contact dryer that operates continuously and consists of a cylindrical shell that rotates slowly and usually tilted a few degrees from the horizontal to help the transfer of wet feed which inserted at the top end of the cylinder.

Previous researches [8] has made modifications to the anchovy dryer with rotary system, although it still has the disadvantage that the performance of the dryer is not quite optimal because the efficiency of drying still ranged from 35.02 % to 60.03 % with average temperature of drying at 66ºC and 3.5 hours of drying time. Besides, the number of rounds that are used also very large, which is 24 rpm that may cause dwell time of materials in the drying chamber become faster that makes lower drying efficiency. [7] in his research has determined the performance of rotary dryer for drying shredded sweet potato. Based on the performance, it obtained the lowest drying efficiency is 29.42% and the highest efficiency of 81.61%. This proves that the performance of the dryer is not in optimal conditions, since the lowest efficiency in the dryer is very small. Based on these references, further research is needed to obtain a more efficient drying process.

In this research, the author tries to make a prototype dryer with rotary type for drying coffee beans with the simple design and installation, which is the hot-air drying media without the use of heat exchangers, with the addition of insulation in the furnace in order to reduce heat lost to environment due to the heating process, so that the drying process becomes more efficient. The motor has a fewer number of rounds, which is 10 rpm, so that the dwell time of materials in drying chamber will be longer. This research is expected to reduce large enough of moisture content large enough in coffee beans, which is 40% to 60%, so that the final moisture content in coffee beans can meet SNI standards, which is 12% with determining the optimal drying temperature and the effects on the efficiency and specific energy consumption based on performance of rotary dryer.

PURPOSES

1. Determining the effects of drying temperature to the efficiency and specific energy consumed in the rotary dryer.
2. Determining the optimal drying temperature in the drying process of coffee beans based on the amounts moisture content in accordance with SNI standards of coffee beans quality in Indonesia, which is 12% (w/w).
3. Calculating the efficiency and energy consumption of the dryer, and the water content from the results of the coffee beans drying.
4. Determining the performance of the dryer based on the calculation results of the efficiency

BENEFITS

1. Contributing to the development of science and technology that can utilize appropriate technologies.
2. Helping people in the process of drying and obtain more efficient production.
3. Contributing as a practical work at the Laboratory of Energy Engineering and Chemical Engineering, Politeknik Negeri Sriwijaya

II. LITERATURE REVIEW

1. Rotary Dryer

Rotary dryer is a commonly used industrial dryer. Rotary dryer typically consists of a steel cylinder (trommel) which slightly tilted, and has a diameter of 0.3 - 5 m and a length of 5-9 m. Material is fed from the highest part of the cylinder and the material moves along the cylinder to the other end. Rotary dryer has two functions of the transport of materials and drying [4].

Rotary dryer use sould be flight along the cylinder to and make the materials poured out to the dryer section. Flight design is important to increase the contact of gas and materials, it is necessary for rapid and steady drying [2]. According [6], the internal parts often required for materials that tend to form large clumps and should be resolved in order to avoid problems in the final stages of drying.. Heat and mass transfer processes mainly take place during the transport of particles from top to bottom by the work of gravity inside the drum. Thermal efficiency of rotary dryer ranges between 30-60%. For a better efficiency, the container material (10-15% volume) shouldbe lifter. Lifter should be well designed to get a good cascade action and prevent large lumps of material fell from lifter. Length to diameter between 4 to 10 is commonly used in the industry. [6]

Drying media (hot air, gases of combustion, flue gas, etc.) flows axially past the drum counter - clockwise to the flow of the product. Counter flow is preferred if dried material is not sensitive to heat and must be dried until lowest moisture content level. While the clockwise flow method is generally preferred for heat-sensitive materials for the high drying rate [6].

The fig .1 of rotary dryer can be seen below :

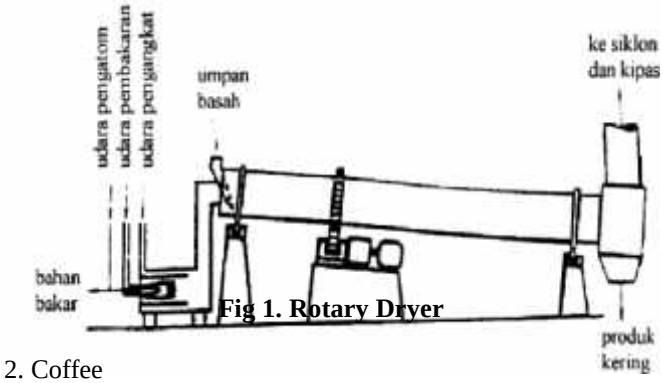

Fig 1. Rotary Dryer

2. Coffee

The coffee is a beverage from the processing and extraction of coffee beans. First, there is only coffee in Ethiopia, where the original grain grown by the Ethiopian highlands. At that time, many people in Africa, especially the Ethiopians, consuming coffee beans that mixed with animal fat and wine, to meet protein and energy needs of the body. Coffee then continues to grow, until today become one of the most popular beverage in the world that is consumed by various circle of society. Indonesia itself has been able to produce 400 thousand tons of coffee per year. Indonesia in the era of the 1990s had been the 3rd largest coffee exporting country in the world after Brazil and Columbia [3].

III. RESEARCH METHODOLOGY

The designed rotary dryer contains parts that have the function of each such as combustion chamber (furnace) to produce heat from fuel combustion. Rotary cylinder tube functions as the place for the drying process. Blower function as a carriers of hot air to the drying process. Motor / pump is used two to rotate the cylinder during the drying process. Furnace is made from iron plate coated with asbestos and glasswoll which function as insulation to reduce heat loss to the environment from combustion. While the cylindrical tube is made from iron plate equipped with a screw-thread spiral which function for insulating / supporting the process of drying the coffee beans so that the dwell time of materials in the drying chamber will be longer. Generally, the design of rotary dryer is divided into two parts, which is a cylindrical tube (drying chamber) and the furnace (the combustion chamber). Cylinder tube is designed with a length of 102 cm and a diameter of 40 cm. As for the furnace it is designed with 80 cm high and 60 cm long. Fig 2 and 3 is represent the prototype and design of the rotary dryer.

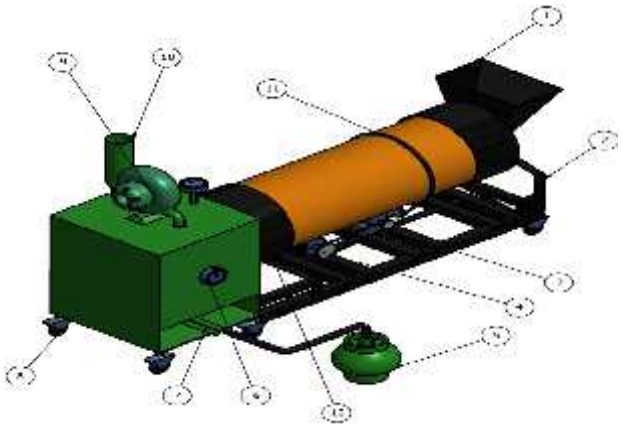

Fig 2. *Prototype* Rotary Dryer

Information:

1. Feed In	7. Gas Stove
2. Iron Stand	8. Wheels
3. Rubber Belt	9. Blower
4. Motor	10. Stack Gas
5. LPG Gas	11. Rims
6. Analog Thermometer	12. Feed Out

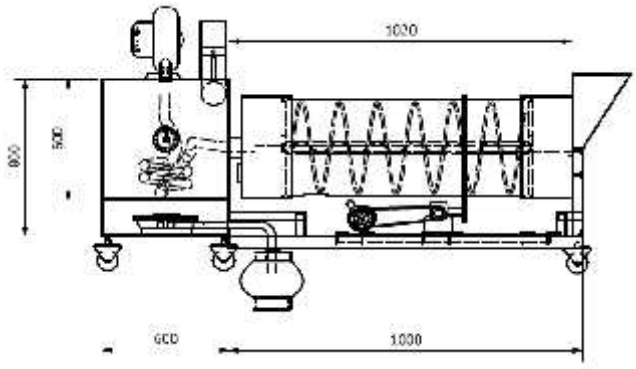

Fig 3. Design of Rotary Dryer

IV. RESULTS AND DISCUSSION

1. Description (*Rotary Dryer*)

Furnace

Furnace is the place of the combustion process to generate heat, generated heat is used to heat the air from the environment which is exhaled through pipes inside the furnace. Furnace is made in a rectangular shape with width 60 cm and height 80 cm. Section of walls were made of iron plate coated with asbestos and glass wool with the aim of reducing the heat lost from the combustion process. Inside the furnace is installed 2.5-inch iron pipe as a place of exhaled air circulation from blower. The iron pipe was made circular, pipe shape greatly affects the process of heating the air, because the straight pipes will create faster airflow than the elbow pipe. Stack gas is installed at the top of furnace which is made of 2.5-inch iron pipe with a length of 20 cm. Stack gas is used to remove residual gases of combustion which is not used and can interfere the combustion process.

Drying Chamber (*Rotary Cylinder*)

Drying chamber is the place of the drying process which is the contact between the air that has been heated in a furnace with the wet material that will be dried. The drying chamber is made of 2 mm cylindrical steel plate, with a length of 102 cm and 50 cm circle diameter. Rotary dryer is installed with a slope angle of 10% and a round of 10 rpm. Flights were installed inside the screw thread-spiral shaped made of iron. Flights lift material inside the drying chamber and circulating it based on form of installed flights. The size and form of the flights greatly affect the distribution and movement of material that will be dried.

The rotary dryer was equipped with a motor / electric motor that works to drive the gearbox pulley which is paired with rubber belt, then the gearbox pulley will drive gear in the gearbox and at the same time, gear on the wheels that has been installed on the cylinder rotates too. The used electric motor has the specification of 1 phase, 125 watt, 220 volt, 2850 rpm and a frequency of 50 Hz. The used pulley on the electric motor and the gearbox has the same size, which is the diameter of 5 cm with 2 cm thick pulley.

Blower

Blower is used to supply air that will be absorbed from the environment and then blown through the air pipe that will be heated inside the furnace and headed to the drying chamber. The specifications of used blower are 3 inch, 1 phase, 350 watt, 220 volt 1100 rpm. Blower performance test is done by measuring the speed of blown air from blower, using Anemometer. Measurements were performed on a scale of ½ and full blower openings.

2. Graphs

From the data that has been obtained based on the variation of the drying temperature at 40ºC, 50ºC, 60ºC, 70ºC and independent variables, which are air velocity of 6.5 m/s, the round number of 10 rpm and cylinder drying time of 1.5 hours, and the calculations, the obtained graph can be seen in Fig 4-6 below:

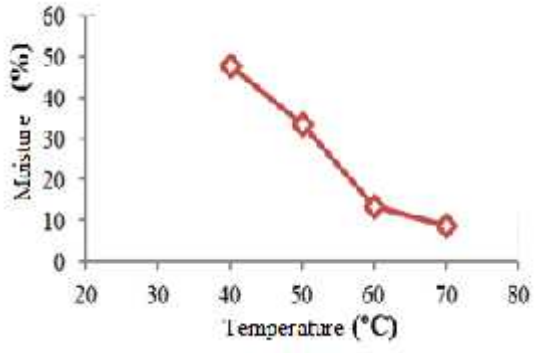

Fig 4. The Effects of Drying Temperature To Moisture

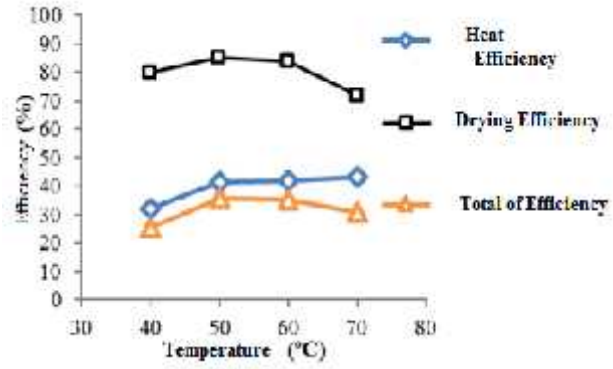

Fig 5. The Effects of Drying Temperature To Efficiency

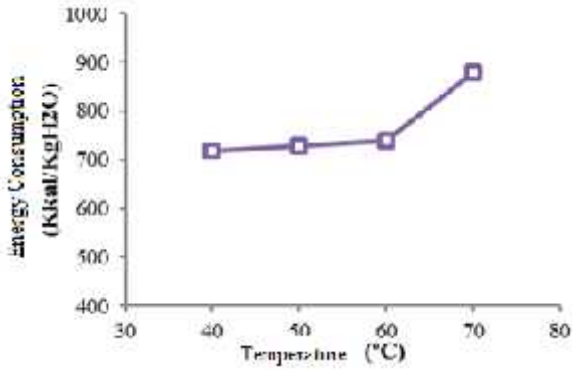

Fig 6. The Effects of Drying Temperature To Specific Energy Consumption

According to the standard of quality for coffee beans in Indonesia (SNI 01-2907-2008), the requirements of maximum moisture content (w / w) contained in dried coffee beans is 12%. Based on data in tables and graphs known that the moisture content (w / w) which is closest to the requirements of SNI was 13.51% at drying temperature of 60ºC. For the use of heat efficiency in the drying air is relatively high at 71-85%, because almost entirely utilized hot air evaporate the moisture content of the material and the rest is lost to the environment through the air and the walls of the drying chamber. The total efficiency of the dryer as depicted on the graph is the lowest at 25-35%, because only a few from the large amount of heat energy generated by fuel that can be used to evaporate the moisture content of the material The highest energy consumption is obtained at a temperature of 70ºC in the amount of 879.811 Kcal / KgH_2O, while the lowest energy consumption obtained at a temperature of 40°C in the amount of 717.406 Kcal / KgH_2O. It is strongly related to the amount of utilized air heating energy to evaporate water on the material (evaporation energy). Evaporation energy is influenced by several factors, which are the rate of evaporation of water, the mass of water evaporated, and the latent heat of vaporization. The higher specific energy consumption was caused by the drying is done with small capacity of the material. The drying process is said to be efficient if value of specific energy consumption is low[7].

V. CONCLUSIONS

1. Temperature affect the specific energy consumption of drying. The higher the temperature, the higher its energy consumption.
2. Optimum drying temperature was obtained at 60 ° C with moisture content at 13.51%, which is close to the quality requirements of dried coffee beans at 12% according to SNI 01-2907-2008.
3. The drying efficiency that obtained from the calculation is 71-85%. Specific energy consumption ranged from 717.406 to 879.811 Kcal / KgH_2O. And the amount of final moisture content obtained at the lowest drying the highest temperature at 70ºC, is 8.57%.
4. Performance of the dryer if reviewed from the furnace is not effective enough, because the value of efficiency is still low, between 31-43%.

VI. SUGGESTION

1. Needs to do a review of the design of is uncover furnace part of the dryer and the type of used insulation, so that performance of furnace can be optimal.
2. To obtain an accurate temperature measurement, it needs thermocouple as temperature control can be set automatically.
3. In order for the dwell time of material in the drying chamber can be much longer, it is recommended to replace 2 phase automatic driving motor type with the fewer number of rounds, as well as reducing the angle of the cylinder

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