Potential Increasing of Rubber Sheet Production with Fungus Displacement by Solar Tunnel Dryer by Integrating a Biomass Gasifier as an Assisting Heat Source

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Abstract. In this study, Potential increasing of rubber sheet production with fungus displacement by solar tunnel dryer. By integrating a biomass gasifier as an assisting heat source for drying Rubber Sheet produce and its performance analysis has been investigated. An experimental study has been carried out with the stand-alone solar tunnel dryer and the dryer with the assisted biomass gasifier. For thermal performance analysis, for wind speed 1.0 m/s, the dryer with assisted gasifier gave an average efficiency of 32.86% higher and the drying period was 31.45% shorter than those of the unit without the gasifier. For wind speed 1.5 m/s, and for wind speed 2.0 m/s, the values are 21.49%, 28.68% and 33.17%, 24.54%, respectively. From the economic analysis, drying of wind speed 1.5 m/s is the most appropriated. The payback and the IRR were 1.8 years and 55.48%, respectively. While those for wind speed 1.0 m/s were 2.74 years and 36%, respectively.

Keyword: Tunnel Dryer, Solar Dryer

1. Introduction

In dealing rubber sheets, the price is dependent on the quality of the rubber sheet. By which the quality will be tested for various values which are the amount of dirt within the rubber sheet, the amount of mold, the Inflatable point, thickness, weight, strength and flexibility, Contamination, Sand gravel and other flaws of a rubber sheet. Taken and adjusted from standards of “The Green Book” [1], one of the problems of rubber sheets found is that fungus around the sheet by which is the result from humidification non-standard drying of rubber sheets. Also, including drying rubber sheets during the raining season at a random pattern, which causes damp mildew, by which molds are created from rubber not being dry enough. If left out for humidity to be absorbed, even if not up to 1%, this can result in molding. Rubber with excessive molding will have a decrease in weight by 2% within a month, which affects the general price of the rubber. Therefore, the research team has the idea to increase the production capacity of rubber sheets by using solar energy in the drying process, to prevent molding around the rubber. This in a way increases the value of the rubber sheet.

Figure 1. Fungus (white mold and rust mold) within the rubber sheet

Figure 2. Drying at constant and reducing drying rate
2. Theory
   2.1 drying
In the process which heat is extruded with a certain method, to remove moisture by evaporation by relying on heat as a latent heat of evaporation, it is important in the process of drying to release heat into the drying material efficiently [5]. By which drying often uses hot air an intermediary in the drying process. Heat will be transplanted into the surface of the material by which most is used for evaporation. Steam will move from the surface of the material to the air flow. If the surface of the material has a large amount of liquid, the temperature and the concentration of the surface vapor will be fixed. This results in a heat transfer rate as well as a constant drying rate. If the temperature, moisture, and speed of the air flow are constant, then when the surface of the material has a decreased amount of liquid the temperature and the concentration of the steam on the surface of the material inevitably changes. By which the temperature of the material will rise and the concentration of the steam will decrease causing a decrease in the drying rate. Therefore, during the range of the drying rate the moisture between fixed drying rate range and the lower drying rate range is called “humidity”, which is shown in figure 2. The majority of materials that are to be baked have an interior structure of a porous. The drying ranges can be divided into two ranges which are a fixed drying rate and a decreasing drying rate [6]. Moisture is the indicator of the amount of water contained in the material by comparing with the mass of the material that is damp or dry as the following equation [7-9].

   Wet standard humidity
   \[ M_w = \frac{(w - d)}{w} \]  
   (1)

   And dry moisture standard found from
   \[ M_d = \frac{(w - d)}{d} \]  
   (2)

   When w is the mass of damp material (kg)
   D is dry mass of material (kg)
   M_w is the dry moisture standard (standard dry fraction)
   M_w is the wet humidity standard (standard wet fraction)

2.2 Gasifier system
Principles of biodegradable gasification furnace. The first step is to use charcoal as fuel. Because it can produce gas. Stable than firewood. Charcoal, used as a fuel, weighs about 1 kg, is put into a gasifier. At the same time, the charcoal is used as fuel to ignite outside the furnace. When the charcoal ignited, it poured into the charcoal before. Turn on the exhaust fan from the outside into the burner. Using a low flow rate first. Then add the charcoal into the oven for about 3 kilograms. Climb the top of the furnace to produce gas. Over time, about 20 minutes can accelerate the flow of air into the gasification furnace. By checking the air entering the gasifier furnace to see if it needs to be changed. By firing at the cyclone exit. To burn a Gas Producer that ignited it? In ignition of the cyclone. It depends on the rate of air flow into the gasification furnace is important. This would require techniques to control the flow of air. And other factors include airiness or burning pattern inside a gas stove, siphon etc. And when the Producer Gas burns well, it can be used to blow the hot gas into the tunnel solar drying system. At the same time, the testers always have to constantly check the amount of charcoal burned in the combustion chamber. And come to the car to refill charcoal into the oven as needed and in the test will be used firewood for comparison.
3. Procedure
Researchers have designed a solar tunnel dryer, which has a higher tunnel. This allows people access which has a height of 2.10 meter and the base has a width of 3.20 meters as shown in figure 3. This enables the drying of rubber sheet conveniently. At the end of the tunnel, there will be a chimney to help in the drainage of moisture from the rubber sheets. The work will control the temperature by which there is a biodegradable gas stove which biomass will come from agricultural residues such as husks, branches, leaves that are gas producers. Hot air is supplied to the drying chamber at the bottom of the conveyor belt making the rubber sheet dry faster. All of this, the reason for designing the tunnel to have a biased bridge to help in moving rubber sheets from the front of the tunnel to the back with an electric motor. The speed of the biased bridge and the distance must be studied to be suitable with the size of the rubber sheets and the amount that needs to be dried.

4. Results
The effect of the reduction of moisture ratio of the drying process is under the frequency of belting the bridge (Hz). 3 levels of frequency include 1.5, 2.5 and 3.5 Hz and use 3 example groups of rubber sheets and compared them to 2 drying patterns which are Drying System that uses only sunlight, and a drying system that uses sunlight together with gasifier that is used to give additional heat. You will see that the temperature has an effect towards these two drying patterns by which the drying system chases out moisture that uses only sunlight. The average temperature within the drying tunnel is at about 50-55 degrees Celsius. As for the drying system that chases out moisture that uses sunlight together with gasifier which uses additional heat will have an average temperature of about 65-70 degrees Celsius. The high drying temperature will make the ratio of moisture have a fast decrease which is a result that causes the drying rate to be high. Also, it takes less time in the drying process when considering the humidity ratio of each temperature. It is found that each drying temperature, in the starting period, the moisture ratio will decrease speedily and also relatively slow down until once time passes by, in the drying process it is found that the moisture ratio tends to decrease steadily. Since in the beginning of drying all three groups of the rubber sheets, there is still high moisture which the heat in the drying tunnel has the ability to make the amount of liquid evaporate out of the production well. Then makes the moisture ratio, in the beginning, decrease fast and when able to dry up to a certain stage, the amount of liquid in the production starts to decrease in amount. This makes the moisture ratio start to slowly decrease when a time of the drying process passes by, making the moisture ratio almost fixed. From the analysis of the both drying systems, it is also found that the drying process that chases out moisture with sunlight together with gasifier that uses additional heat has a high-speed drying ratio, more than the drying system that chases out moisture by using sunlight alone.
5. Conclusion

5.1 Studying the drying system of rubber sheets of example group 1
The system using sunlight along with gasifier that gives additional heat in efficient drying has
efficiency of drying higher than average of about 32.86 % and dries in a time below the average of
about 31.45 % (if the system that uses sunlight in drying in 100 hours, the system using sunlight with
gasifier will take about 68.67 hours).

5.2 Studying the drying system of rubber sheets of example group 2
The system using sunlight with gasifier that gives additional heat in drying has the efficiency of drying
higher than the average of about 21.49 % and takes time in drying lower than the average of about
28.68 % (if the system that uses sunlight takes 100 hours, the system that uses sunlight along with
gasifier will take about 71.31 hours).

5.3 Studying the drying system of rubber sheets of example group 3
The system using sunlight with gasifier that gives additional heat in drying has the efficiency of drying
higher than the average of about 33.17 % and takes time in drying lower than the average of about
24.54 % (if the system that uses sunlight takes 100 hours, the system that uses sunlight along with
gasifier will take about 75.45 hours).

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