Jurnal Multidisiplin Sahombu
E-ISSN : 2809-8587

DESIGN AND CONSTRUCTION STUDY OF MOLLEN DRYER TYPE

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ARTICLE INFO

Keywords:
Threatening Crime,
ITE Law,
Judge's Decision

ABSTRACT

The aim of this research for mollen dryer project is to give application to small and middle industries in dry juice production. Benefit from this research was to give more choice for dryer utilize, with used dried air as heating media. The principal of this mollen dryer was based on hot air blows into mollen tube, rotation of mollen tube and move of agitator in mollen tube to material mixing was to spreading of heated air over to entire heating material and water evaporating to get good dried products criterion. The steps of this studied as followed : literature studied, basic designing, detail engineering design (DED), revision of DED, design simulation, prepared of construction material, construction of mollen dryer, and test of operational to dried products. The result from drying tested of mollen dryer which had desgned and constructed, with air flow between 1.1 m/s - 4.5 m/s during operating about 4 - 5 hours, we got pineapple powder equal to 550 g, water content equal to 2.71 %, and the content of vitamin C about 16.13 mg / 100 g, from pineapple fruit extracts with total dissolved solid equal to 16 °brix which have been enhanced by sugar equal to 1100 g with water content equal to 82.3 %. Totally operational of mollen dryer have been designed and construction was efficient, effective, and good.

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1. INTRODUCTION

Drying is the process of reducing the water content of a food, whether derived from agricultural or plantation materials, to a certain extent, so as to reduce the level of damage caused primarily by microorganism and biochemical activity.

The last few years have developed in Indonesia an alternative product diversification, as well as ways to extend shelf life by making product diversifications such as microcrystallization / microencapsulation. Microcrystallization is a process of drying food in liquid form into powder using hot air exhaled for a certain time so that the food material becomes dry in the form of crystals or powder with a low water content so that the shelf life of the product can be longer.

which are processed into powder form include drinks derived from fruit juices such as melon, orange, strawberry, tomato, and others. Processing of this type of instant drink is still difficult to maintain due to high nutrition (Vitamin C), relatively long drying time, relatively high temperature, and limited effective tools.

As a solution to this problem, it is necessary to study a tool that can dry the material without significantly reducing the nutritional content of the material. Currently, there are many kinds of drying equipment circulating, however, to dry materials in liquid form, special drying equipment is needed, such as a Mollen dryer or a spray dryer.

The main problem in the manufacture of fruit juice powder is the browning of the product. One of the efforts to control browning is by adjusting the drying temperature. Temperatures that are too high cause the loss of volatile compounds (aroma), vitamin C, and browning reactions

from sugars in foodstuffs. Meanwhile, low temperatures cause the drying process to be less efficient and will also encourage damage caused by active microorganisms during the drying process (Suryanto, 2002).

Another obstacle faced for drying liquid or paste-shaped materials lies in the drying time, drying temperature, the price of the dryer and how to retain the nutrients contained therein.

The effectiveness and efficiency of the spray dryer is high, it is able to maintain the nutritional content of the ingredients, the drying temperature can be adjusted, however, this tool has an expensive price, thus burdening small entrepreneurs or home industries in investing in these tools. In addition, the maintenance costs are also high, whereas if you use conventional drying it will be less effective and less efficient due to the long drying time, uncontrollable drying temperature, uneven drying of the material and the product will lose a lot of the nutrients it contains (Andrian, 2005).

Another alternative that can be used to reduce the problems that arise in the drying of liquid materials is to process them into powder form using a Mollen dryer. Drying using this tool when compared to conventional drying has advantages, where the temperature and flow rate of dry air can be controlled, with this control it is hoped that the dried material will not experience changes in nutrition.

The drying process is the first food process carried out to preserve food. In addition to preserving food ingredients that are easily damaged or spoiled in storage conditions prior to use, drying food also reduces costs and reduces difficulties in packaging, handling, transportation and storage, because by drying the materials become solid and dry, so that the volume of materials is greater in storage. , easy and space-saving in transportation, packaging and storage (Brennan et al, 1974).

Suryanto, (2001) stated in his research that a drying temperature of 50°C tends to produce soursop fruit juice powder which has a whiter, slightly yellow-reddish color, compared to a drying temperature of 60°C.

Furthermore, Labuza (1982) stated that temperature has a greater influence on non-enzymatic browning than other degradation processes, where for every 10°C increase in temperature the speed of the browning process increases between 4-8 times.

According to Desrosier (1988), Yeo and Shibamoto (1991) stated that high temperatures cause the browning reaction of sugars and amino acids to increase which affects the color and flavor which is not desirable in food ingredients.

Mollen dryer research conducted by Andrian, (2005) stated that the mollen dryer consists of a heating chamber which is round in shape and rotates on its axis with hot air flowing to dry materials in the form of slurry or liquid, so that the liquid materials can dry evenly.

The wet material that is rotated on the inside of the cylinder (mollen) serves to distribute the heat energy received by the material so that the heat is distributed evenly throughout the material. This dryer is also equipped with a temperature controller so that material damage that occurs due to drying both from temperature and drying time can be reduced (Anonimus, 2015).

The purpose of the research on the design of this mollen dryer device is to provide practicality and convenience in processing dried fruit juices or other ingredients for small industries engaged in the production of dried fruit juices or other products.

2. METHOD

Materials and tools

The materials used in the process of making this mollen dryer include materials, instruments, and components. The materials used are stainless steel plates, other metals, paint (duco or epoxy), sandpaper. The instruments used are the thermostat and timer. The components used are electric motors, heaters, blowers, gearboxes, bearings, electrical panels, buzzers, V-belts, gears. The energy used is electrical energy.

The tools used in the process of making this mollen dryer machine include: plate cutting machines, plate bending machines, grinders, press machines, electric drills, rivets, soldering iron, electric welding, plate scissors, metal saws, screwdrivers, welding wire, lathes , and so forth.

Research Stages and Treatment

The methods used in the design of this Mollen dryer include: Literature study, drawing basic designs, drawing detailed plans, revising detailed designs, preparing raw materials, carrying out construction, and testing processes.

The literature study was conducted to collect literature data on the types of dryers that are often used in drying fruits. The initial step of the machine design process is the initial description of the machine design. Drawing a detailed machine design, this is done by a more detailed machine design process, such as giving scale and giving measurements to the machine components that are made. Next, review the design that has been drawn to make it easier in the next step. Raw material preparation is carried out to prepare and design the components contained in this Mollen dryer, such as electric motors, blowers, heaters, and frames. The final step of the machine manufacturing process is to carry out the overall construction by assembling the existing components to become a Mollen Dryer tool. The testing process, this process is carried out with the aim of knowing the effectiveness and reliability of the designed Mollen dryer.

Mollen Dryer Design Calculation

- Calculation of Mollen Capacity

The Mollen chamber resembles the shape of a ball, but only 1/3 of the Mollen chamber is used for drying, so the basic formula is: 1/3. 4/3. π. r3

Determine the Pulley Diameter Calculation, Belt Type and rotation speed.

The basic formula for determining the pulley diameter and rotational speed is n1/n2 = D2/D1.

- Calculation of Gear Diameter on Gearbox and Shaft The basic formula for determining gears is n1/n2 = D2/D1 while for shafts it is

  $ds = (,1/\tau\ \alpha\ .\ Kt.\ Cb.\ T)^{1/3}$

  Information :

  ds : shaft diameter *(mm)*

  $\tau\ \alpha$: shear stress *(kg/mm^2)*

  Kt : load factor

  Cb : flexural loading factor

  T : moment of plan *(kg/mm)*

- Calculation of the required heating power:

  The basic formula for heating power is Q= h.A. (Δ T)

- Calculation of the Hot Air Flow Rate, The basic formula for calculating fluid velocity,

NRe = D.v. ρ_{aerial} / μ_{aerial}

G = v. ρ_{aerial}

h = 0,0204 $G^{0,8}$

q = h.A. ($T_w - T_b$)

- Calculation of Power Required :

The basic formula for calculating motor power (rotation), P = M. N / 9549

Information :

P : *power (watt)*

M : *torque (Nm)*

n : rotation speed *(rpm)*

- Speed calculation blower :

V = ω . r ; ω = 2 . π . n

- Calculation of pulley and gear diameters :

$N_2 = N_1 . D_1 / D_2$

Ratio gearbox with usable speed reduction 1 : 50.

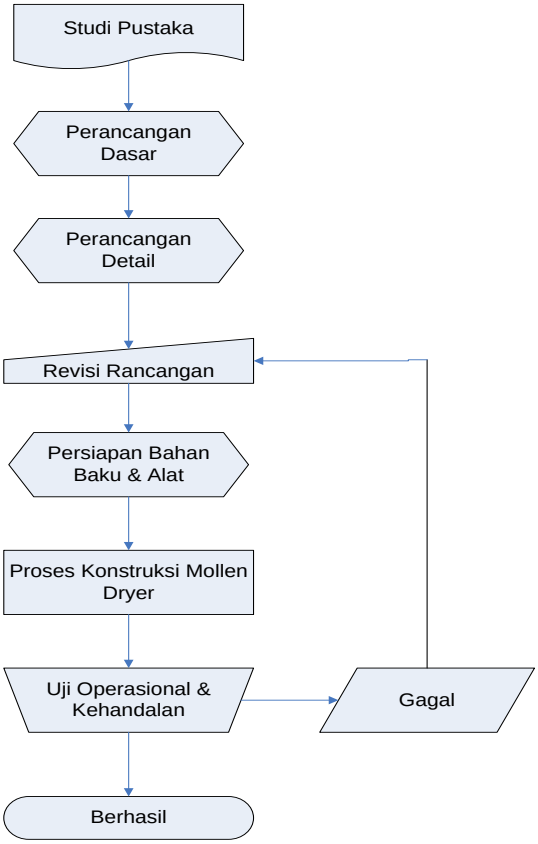

Figure 1. Flow chart for making a Mollen Dryer Tool

information :

The testing process for this mollen dryer is based on the results of the criteria for the dry product produced, the practicality of removing the product, the run test for four consecutive days with a time of ±4 - 5 hours, if one of these criteria does not match then the mollen dryer fails and it is necessary to revise the design, whereas if all of these criteria are met then the Mollen Dryer can be said to be successful.

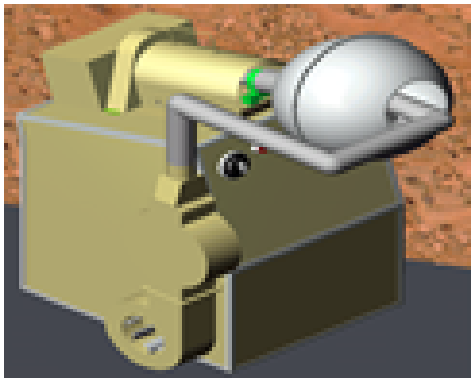

Figure 2. Mollen Dryer Design

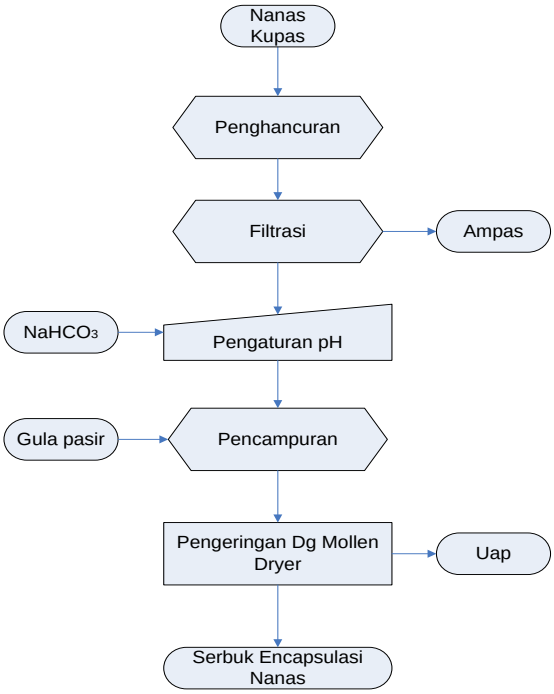

Figure 3. Drying Process Flowchart

information :

The testing process for this mollen dryer is based on the results of the criteria for the dry product produced, practicality in removing the product, testing the run test for four consecutive days with a time of ±4 - 6 hours, if one of these criteria is not suitable then the mollen dryer can be declared is not successful and needs to be revised in the design, whereas if all of these criteria are met then the Mollen Dryer can be said to be successful.

One of the tests is using pineapple, the filtered pineapple is measured for pH, if the pH is less than 4 then baking soda is added until the pH reaches ± 5, then sugar is added in a 1:1 ratio with pineapple filtrate, this is intended to help the crystallization process in the material to be dried, then the material is dried for 4 - 6 hours at a temperature of around 50 oC – 60 oC until pineapple powder is formed.

3. RESULTS AND DISCUSSION

Design Results

the results of the designed mollen dryer can be seen in the following table:

Table 1 specifications for the design of the mollen dryer

Tool's name	: *Mollen dryer*
Function	: Drying fruit juice into powder
Principle	: Based on the flow rate of hot air blown into the molten, the mollen rotation and stirring so that the heat received is spread evenly throughout the material being dried.
Operation	: Batch
Tool Dimensions	
long	: 50 cm
wide	: 40 cm
Tall	: 50 cm
Mollen diameter	: 30 cm
capacity	: 3 liter
Maximum Temperature	: 80°C
Mollen rotation speed: 11 rpm	
Hot air speed: 1,1 m/s until 4,6 m/s	
utility	: electricity
Driving Force	: motor 0,25 HP
Heating	: 1000 watt
Blower	: 150 watt

The design of this mollen dryer model is intended to obtain good drying conditions with a spherical shape of the drying chamber, as well as to provide practicality in operation and removal of dry matter.

The process for making microcrystals was previously carried out by conventional methods, namely using a frying pan with a heating source from the stove and stirring using human power. This has many drawbacks because the heating temperature is difficult to adjust so it is very prone to browning of the dried material, but after designing a mollen dryer it is hoped that all the weaknesses of the conventional processing process can be overcome (Andrian, 2005).

The choice of stainless steel plate material, especially the SS 316 type on the Mollen Dryer tube which is in contact with the material to be dried is because stainless steel material apart from being resistant to corrosion and safe for foods containing acids because it does not react with acids, this material is also easy to obtain and easy to use. maintenance, the stainless steel material used must be classified as a food grade material, namely a material that does not react during the process, the selection of type 304 for stainless steel that is not in contact with the material is still within tolerance limits because types 304 and type 316 are still classified as Austentic stainless steel, which has nearly the same material characteristics, while steel and iron

are used for the construction and casing materials to reduce the price of the designed Mollen Dryer, so that it is affordable for small and medium industries.

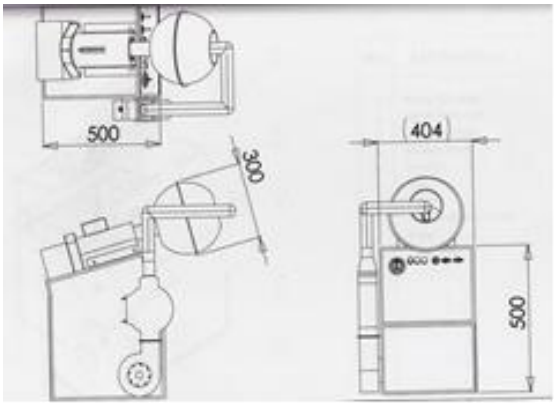

Figure 4. Projection of Mollen Dryer

The choice of a round shape on the mollen is due to the characteristics of the material to be dried which is in liquid form, so if it is in a shape other than round it will form an angle at the joint and if it is used then the liquid material can dry out at the corner of the joint and crust can occur at the angle so that the mixing and drying takes place ineffective because the heat is not distributed evenly.

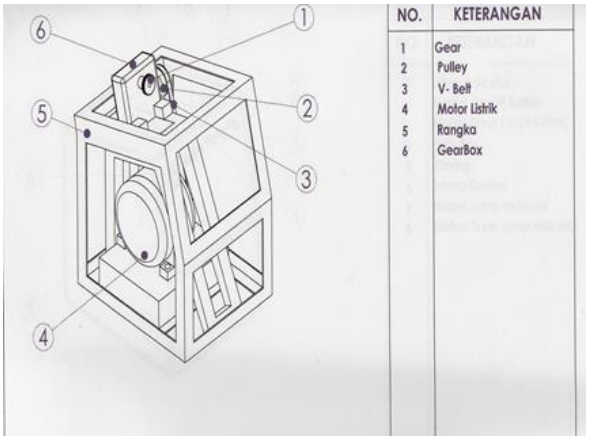

Figure 5. Mollen Dryer Mount Frame

The difference between the designed Mollen Dryer and other types of Mollen Dryers is that the electrical energy used is much more efficient where the Mollen Dryer designed uses a blower with a power of 150 watts while the other types of Mollen Dryers use a blower with a power of 540 Watts, and other electrical energy is also smaller when compared to with other types of mollen dryers.

The mechanism of air blowing from the blower enters the heating chamber and then hot air exits through a pipe that functions as a hot air path that leads directly to the surface of the material to be dried in the mollen, as long as this air channel is as much as possible the resistance must be reduced so that the air velocity can be maintained, i.e. by reducing the number of turns on the track and reducing the diameter of the airways.

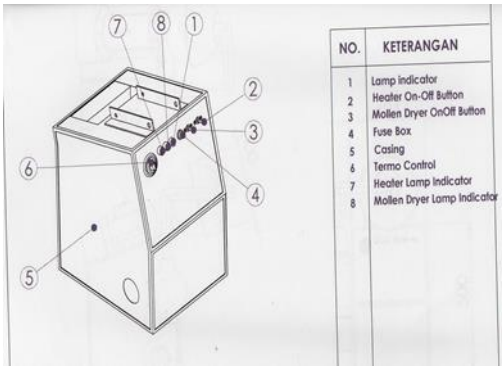

Figure6. Mollen Dryer Motorhome Design

This Mollen dryer belongs to the adiabatic dryer, namely drying where heat is brought into the dryer by a hot gas / air. Gas / hot air provides heat to the water in the food and carries out the resulting water vapor. Gas / hot air can be the result of combustion or air heating (Desrosier, 1988).

Vitamin C which is still contained in the dried honey pineapple powder product which is dried using a mollen dryer, obtained vitamin C of 16.13 mg/100g from the test results using the iodometric method, whereas according to the literature the vitamin C content of fresh pineapple is 24 mg. /100g, means that there is a depreciation of vitamin C by 74.45%, this results in the need for the addition of vitamin C from outside to restore the vitamin C content which is reduced during drying. Factors that affect the shrinkage of vitamin C during drying apart from dry air temperature are also affected by oxidation. (Sibuea, 2003).

The position of the stirrer which hits the inner mollen is intended so that the material which has started to dry can be rotated from the bottom up and the right direction of hot air blowing on the surface of the material aims to make the stirring and heating process run more effectively because in such a position the liquid or material which has started to dry is will be mixed evenly, resulting in heat circulation from the surface of the material into the material.

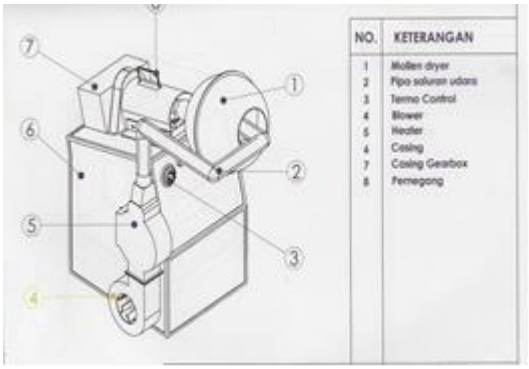

Figure 7. Mollen Dryer Design

For the Mollen rotation speed, the faster the Mollen rotation, the faster the material is mixed because the Mollen rotation affects the mixing speed, but if the Mollen rotation is too fast, the material that has started to crystallize will easily come out of the Mollen because the lowest air speed given can still be exhale the finished crystal particles flying inside the mollen, so that a lot of material is wasted.

Data from the test results obtained better results when compared to data for other types of mollen dryers, both the amount of capacity and maximum air velocity that comes out of the airways are also very much different (other types of mollen dryers maximum speed = 2.2m/s, mollen dryer which is designed to have a maximum speed = 4.6 m/s), as well as the total amount of energy required is also more efficient when compared to other types of millen dryers, this affects the initial drying speed because the hot air discharge given each second is greater, so with greater air velocity, the drying speed is also faster.

The drying medium used is air, because air is the best drying medium apart from being seen from its unlimited amount, easy to use and controllable. When hot air is blown into food that is still wet, heat will be transferred to the surface and the latent heat of evaporation will evaporate the water.

Figure 8. Mollen Dryer Construction Results

Test result

The process of testing the drying of this material uses samples of pineapple fruit to make microcrystals. The steps taken are as follows:

The pineapple that will be made into microcrystals is first cleaned of the skin and cob so that the weight of the pineapple is only 0.764 kg, and from the pineapple a filtrate of 600 ml is obtained with a total dissolved solid of 16 obrix, with a water content of 82.3%, the pH of the pineapple is measured by using a pH-meter, because the pH of the filtrate is less than 4, sodium bicarbonate or better known as baking soda is added until the filtrate reaches a pH of ±5. After the filtrate reaches the pH, it is then put into the Mollen. The Mollen dryer was set at 60 oC and dried for approximately 4 - 5 hours, during the drying process 500 g of granulated sugar was added little by little until evenly distributed, and a yield of 550 g of microcrystals was obtained with a moisture content of 2.71%.

In the process of testing the flow and air and temperature it is known: when the air intake valve on the blower is closed the air flow rate on the mixer is 1.1 m/s with a temperature of 27 oC and when the air intake valve on the blower is opened, the air flow velocity on the molen is obtained as 4.6 m/s at 27 0C. when the heater is turned on with the temperature set at 60 0C, the temperature that comes out to the Mollen ranges from 56oC to 64oC.

The process of testing the mollen dryer machine was carried out using raw pineapple, to find out the length of the drying process that occurred, this experiment was carried out using 764 g of pineapple and 500 g of sugar. Setting the pH to pH 5 of the solution to be dried is intended

to speed up the drying process, because if the pH is too acidic it will be difficult for microcrystals to form, because the sugar present in the solution/mixture will hydrolyze at a pH below 5, while the total solids dissolved in the fruit filtrate pineapple of 16 obrix, intended to determine the amount of sugar content in the filtrate, so that the amount of added sugar can be determined from outside.

4. CONCLUSION

After the drying process was carried out using the planned mollen dryer, it can be concluded that to dry the material with air flow rates ranging from 1.1 m/s to 4.6 m/s, the pineapple fruit filtrate that has been added with a coating of 1100 g with a moisture content of 82.3%, a total dissolved solids content of 15.77o brix yielded 550 g of pineapple microcrystals with a water content of 2.71% and a vitamin C content of 16.13 mg/100g in a drying time of ±4.5 hours. The advantages of processing with this machine compared to conventional processing are that it is more practical, efficient, easy to maintain, and more economical, when compared to other mixer dryers, the energy required is more efficient. The ability to adjust the temperature and speed of hot air minimizes the loss of nutrients as well as losses due to material coming out of the molten, so that good microcrystals can be obtained. So thus the mollen dryer as a result of this design can function properly according to the expected product.

The author would like to thank: Head of the FT-Unpas Food Technology Study Program, Affan Nurachman, etc.

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