Designing And Performance Testing Of Meatball Forming Machine

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Abstract— Indonesia is a country that is famous with variety of culinaries, one of them is meatballs. Meatballs are processed foods from beef with a mixture of tapioca flour in a round shape. Meatballs can be found easily as foodstreet or even restaurant's menu. In producing the meatballs, manual method is still adopted which is in forming the meatballs into a round ball shape by using hands which is not hygienic and also takes a long time. So this study adopted design and experiment method, which is started by designing the meatball forming machine which is good in strength, durability, and safety, and also approriate with the security standards and scientific principles of a product design, then followed by doing experiment to find the best parameters and then performance testing. The testing process was done by analyzing the calculations of the meatball forming machine in order to obtain test performance that meets the engine criteria, in accordance with the design results. So it will get a machine with a more satisfying production capacity. Meatball forming machine with performance testing can accommodate meatball dough with a larger capacity, and is able to produce a more perfect meatballs using 3 blades that can be replaced as desired with the results of cutting on a knife in length of 22 mm, the meatballs can produce 232 item / minute, and 2 meatballs with knife length of 27 mm which is able to produce 189 item/ minute, while 3 meatballs with 35 mm meatballs can produce 146 item / minute.

Keywords— ***Meatball forming machine, performance testing, production capacity***

I. INTRODUCTION

Indonesia is very famous for a variety of culinary and traditional foods, one of which is meatballs. Meatballs are processed foods from beef with a mixture of tapioca flour in a round shape. In Indonesia, this food is very popular with the community, because the meatballs are served with clear beef broth, mixed with vermicelli, celery, fried onions and chili sauce that fits the Indonesian tongue. This food can be found as foodstreet and also as restaurant's menu. The production process of meatballs is still manual, using hand to form the balls into a ball shaped round. It takes a long time with the results obtained are not perfectly round and also unhygienic, because of doubtful cleanliness, so many people are hesitant to eat it after knowing the process of making the meatballs.

As technology develops, the manual things are now slowly being abandoned and replaced with machines that can increase the efficiency of production.

A meatball production was once developed by Yusran Ahmad (2013), with the use of a meatball forming tool, the results of the meatballs are 195 grains / minute, from these results it is obtained that the meatballs are not round because the cutting knife only circulates the fall of the meatball dough so that it does not satisfy the meatball trader as an SME partner.

Similar research was also carried out by Juned (2018), the results of the study were obtained at a rotating speed of 933 rpm shaft results of meatballs 186 item/ minute, from these results the dough before being put into the machine must be given the addition water so that the product is soft and not spherical in shape.

In research conducted by Abram (2017), the use of a meatball forming machine was able to produce 71 item/ minute, and the results obtained were fewer than previous studies.

Based on research by Bandarta (2012), the machine used is in the form of an automatic forming machine that can produce meatballs of 70 item/ minute. In this case the resulting meatballs are not in accordance with the desired shape and the raw material for the formed meatballs still often gets stuck because the beef to be formed is still in the form of fibers so the motor gets stuck.

Based on research by Gusriady (2018), the design of the meatball forming machine used is capable to produce 250 meatballs/ minute. The machine only has one knife that cannot be replaced, so to vary the size of the existing meatballs cannot be done.

Based on the description above, this study conducted a research towards the use of the meatball forming machine by using 3 cutting blades with the testing of the performance of the meatball forming machine.

The benefit of this research is to develop the deficiencies that have been done by previous researchers so that an efficient meatball forming machine can be obtained.

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II. RESEARCH METHOD

The research method used in this study is design and experiment method which consists of three stages:

A. Concept Development

Preparation of design concepts is needed in a design to determine the model and mechanism in the specifications and components that will be used to build the product to be produced.

B. Product Design Process

At this stage the design is done by measuring or dimensioning and choosing the material to be used in each component by taking into account the strength, durability, and safety of the machine to be made. It aims to produce designs that meet the security standards and scientific principles of a product design.

C. Machine Testing Process

The testing process is done by analyzing the calculations of the meatball forming machine in order to obtain test performance that meets the engine criteria in accordance with the design results.

III. RESULTS AND DISCUSSION

From the analysis of the data that has been done, it is obtained the design and performance test of the meatball forming machine as described in Figure 1 which is explained in Table 1.

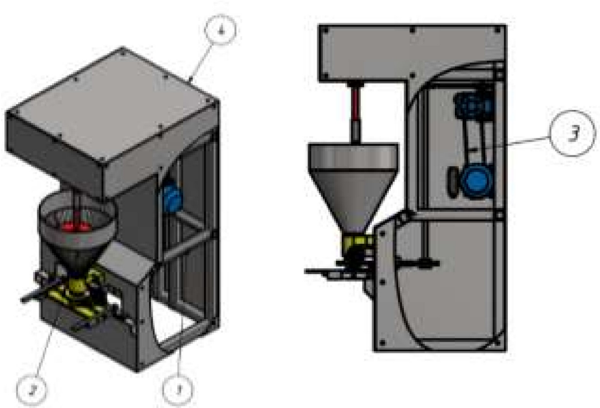

Figure 1. Meatball Forming Machine

Table 1. Description of Figure 1

Part List	
Item	Part Name
1	Framework
2	Processing Unit
3	Transmision and Movement Unit
4	Cover Plat Machine

A.Performance Analysis of Meatballs Forming Machine

1. Calculation of Container Funnel

a) Analysis of Push Screw Calculations

The diameter of the filled funnel is known to be 88 mm. And 0.97 as the provisions of conveyor leaves. The equation to determine it can be explained as follows:

$p = 0{,}97 \; x \; \mathrm{D}$

$p = 0{,}97 \; x \; 88$

$p = 85{,}36$ mm

b) Analysis of Capacity Collection of Funnel Funnels

The equation used to determine capacity using unit weight is as follows:

$$Q \; = \frac{\pi \; x \; D^2}{4} \; x \; s \; x \; \mathrm{i} \; x \; 60$$

Note:

Q = Capacity (Kg)

D = Diameter of conveyor screw (dm)

S = Pitch (dm)

i = Degree of through filling (0,9)

$$Q = \frac{3{,}14 \; x \; 0{,}85^2}{4} \; x \; 0{,}88 \; x \; 0{,}9 \; x \; 60$$

$Q = 0{,}77 \; x \; 0{,}88 \; x \; 0{,}9 \; x \; 60$

$Q = 36{,}59$ kg

1. Calculation of Electric Motor Usage

a) Determine the value of the force if the data m = 3.659 kg is assumed to hold the capacity of the funnel with a value of g = 10 m/s^2.

F = m x g

Note:

F = Force (N)

m = Mass (kg)

g = Earth's gravity acceleration (m/s^2)

Then it can be obtained :

F = 3,659 kg x 10 m/s^2

= 36,5 N

b) Determining torque can be calculated by finding the required torque value in the following way:

T = F x r

Note:

T = Torque (N.m)

F = Force (N)

r = Distance to the point of loading (m)

Known data :

F = 36,5 N

r = 0,95 m

Then it can be obtained :

T = F x r

= 36,5 N x 0,95 m

= 34,6 N.m

From the calculation of torque of 34.6 Nm, an electric motor which has a greater torque in the market will be found, namely a 1 phase electric motor with torque 37 Nm, 2800 rpm, 1 Hp, 220V.

3. Use of the Transmission System

a) Rotating Speed

Based on the data obtained for the drive motor pulley Ø 144 mm, pulley reducer (Input gearbox) ø 96 mm, pulley reducer (output gearbox) ø 74 mm, pulley spinner ø 84 mm, pulley screw booster ø 112 mm. The equation for finding the pulley rotational speed is as follows:

n1.d1 = n2.d2

Note:

n1 = Motor rotation (rpm)

n2 = Shaft rotation (rpm)

d1 = Motor pulley diameter (mm)

d2 = Shaft pulley diameter (mm)

Then:

1) Round the reducer pulley n1.d1 = n2.d2

$$n2 = \frac{2800 \ x \ 74}{96} = 2158 \text{ rpm}$$

1) Pulley spinner

n1.d1 = n2.d2

$$n2 = \frac{2158 \ x \ 74}{84} = 1901 \text{ rpm}$$

2) Pulley screw

n1.d1 = n2.d2

$$n2 = \frac{1901 \ x \ 74}{112} = 1256 \text{ rpm}$$

b) Around Pulley

The Ø 144 mm motor pulley rotation is 2800 rpm and the Ø 74 mm reducer pulley rotation (output gear) is 2158 rpm. The equation for finding the pulley rotational speed is as follows:

$$V = \frac{\pi \ x \ d \ x \ n}{60 \ x \ 1000}$$

Note:

d = Pulley diameter (mm)

n = Shaft rotation (rpm)

So that:

1) The speed of the driving motor pulley

$$V = \frac{\pi \ x \ d \ x \ n}{60 \ x \ 1000}$$

$$V = \frac{3{,}14 \ x \ 144 \ x \ 2800}{60 \ x \ 1000} = 2110 \text{ m/s}^2$$

2) Speed of the pulley reducer (input)

$$V = \frac{\pi \ x \ d \ x \ n}{60 \ x \ 1000}$$

$$V = \frac{3{,}14 \ x \ 96 \ x \ 2800}{60 \ x \ 1000} = 1406 \text{ m/s}^2$$

3) Speed of the pulley reducer (*output*)

$$V = \frac{\pi \ x \ d \ x \ n}{60 \ x \ 1000}$$

$$V = \frac{3{,}14 \ x \ 74 \ x \ 2800}{60 \ x \ 1000} = 10{,}84 \text{ m/s}^2$$

4) Speed of the pulley reducer (*output*)

$$V = \frac{\pi \ x \ d \ x \ n}{60 \ x \ 1000}$$

$$V = \frac{3{,}14 \ x \ 74 \ x \ 2800}{60 \ x \ 1000} = 10{,}84 \text{ m/s}^2$$

c) Belt Length (L)

Based on the data obtained to determine the circumference of the belt, the axis distance between shafts is as follows:

1. The distance of the driving motor shaft to the reducer (input) shaft is 346 mm.
2. The distance of the reducer (output) shaft to the pulley shaft (C1) is 262 mm.
3. The distance of the pulley shaft (C1) to the screw shaft axis (C2) is 156 mm.

The axis of the axis of the screw shaft (C2) with the stirrer spinner (C3) is 320 mm.

Furthermore, the length of the circumference of the belt can be determined by the following equation:

$$L = 2c + \frac{\pi}{2}(dp + Dp) + \frac{1}{4c}(Dp - dp)^2$$

Note:

C = Shaft axis distance (mm)

Dp = Diameter of driven pulley (mm)

dp = Diameter of drive pulley (mm)

Then:

a) The length of the circumference of the belt that connects the drive motor to the reducer (input)

$$L = 2c + \frac{\pi}{2}(dp + Dp) + \frac{1}{4c}(Dp - dp)^2$$

$$L = 2 \ x \ 346 + \frac{3{,}14}{2}(144 + 96) + \frac{1}{4 \ x \ 346}(144 - 96)^2$$

$$L = 692 + 294{,}7 + 1{,}66 = 988{,}36 \text{ mm}$$

b) The length of the circumference of the belt connecting the reducer (input) to the stirring screw and spinner.

C_1 = 262 mm

$$L = 2c + \frac{\pi}{2}(dp + Dp) + \frac{1}{4c}(Dp - dp)^2$$

$$L = 2 \ x \ 262 + \frac{3{,}14}{2}(144 + 74) + \frac{1}{4 \ x \ 262}(144 - 74)^2$$

$$L = 524 + 342{,}2 + 4{,}67 = 870{,}87 \text{ mm}$$

C_2 = 156 mm

$$L = 2c + \frac{\pi}{2}(dp + Dp) + \frac{1}{4c}(Dp - dp)^2$$

$$L = 2 \ x \ 156 + \frac{3{,}14}{2}(144 + 84) + \frac{1}{4 \ x \ 156}(144 - 84)^2$$

L = 312 + 203,8 + 5,7 = 521,5 mm

C3 = 320 mm

L = $2c + \frac{\pi}{2}(dp + Dp) + \frac{1}{4c}(Dp - dp)^2$

L = $2 \, x \, 320 + \frac{3{,}14}{2}(112 + 74) + \frac{1}{4 \, x \, 320}(112 - 74)^2$

L = 640 + 292 + 1,12 = 933,12 mm

Then obtained the length of the circumference of the belt that connects the reducer (input) with the stirring screw and spinner:

L = L1 + L2 + L3

= 870,8 + 521,5 + 933,1

= 2325,4 mm

d) Belt Linear Speed

After knowing the length of the circumference of the belt, then determine the linear velocity of the belt. To determine the linear velocity of the belt one can use the following equation:

V = $\frac{dp \, x \, n1}{60 \, x \, 1000}$

Note:

dp = Diameter of motor pulley (mm)

n1 = Motor pulley (rpm)

Then:

V = $\frac{dp \, x \, n1}{60 \, x \, 1000}$

V = $\frac{144 \, x \, 2800}{60 \, x \, 1000} = 6{,}72$ m/s

4. Calculation of Gears (Rack and Pinion)

In planning the existing rack and pinion using a large 1.25 module and wants the number of gears in the gears is 60 pieces. The gear calculation formula is as follows:

Pitch diameter = z x m

Addendum = 1 x m

Outside diameter = (z + 2) m

Cutting depth = 2.25 x m

Determination of dividing head = 40 / z

Shifting the milling table to pinion = m x

Note:

z = Number of teeth

m = Module size

π = Mathematical constant (3.14)

Data known:

z = 60 pieces

m = 1.25

π= 3.14

Then obtained:

Pitch diameter = 60 x 1.25 = 75 mm

Addendum = 1 x 1.25 = 1.25 mm

Outside diameter = (60 + 2) 1.25 = 77.5 mm

Cutting depth = 2.25 x 1.25 = 2.8125 mm

Determination of the dividing head = $\frac{40}{60} = \frac{2}{3}$

So it is obtained that the comparison of gear is 2:3 with the same amount of gear which is 60.

1. Calculation of Production Capacity

a) Calculating of Power Planning

Based on existing data, the power plan on axis (Pd) can adopt this formula:

Pd = fc.P

Note:

fc = Correction Factor

P = Normal Power (kw)

Then:

Pd = fc.P

Pd = 1,6 x 0,22 kw

Pd = 0,35 kw

b) Twisting Moments

After knowing the planned power on the shaft then further determine the amount of the moment of the punter on the shaft. The equation to calculate it is as follows:

T = $9{,}74 \, x \, 10^5 \frac{dp}{n}$

Note:

Pd = Plan power (watts)

n = Shaft rotation (rpm)

then:

1) Twisting moment on the spinner T = $9{,}74 \, x \, 10^5 \frac{dp}{n1}$

T = $9{,}74 \, x \, 10^5 \frac{0{,}35}{1901 \, rpm}$

T = 179,32 kg.mm

1) Twisting moment on the stirring screw T = $9{,}74 \, x \, 10^5 \frac{dp}{n2}$

T = $9{,}74 \, x \, 10^5 \frac{0{,}35}{1256 \, rpm}$

T = 271,41 kg.mm

c) Load Shaft Rotation

In the calculation of the rotation of the shaft loaded with torque moment must be times with the force of gravity. If the gravitational force is 9.8 m / s2, the amount of torque at the spinner is 179.32 kg.mm x 9.8 m / s2 = 1.757 Nm while the magnitude of the stirring screw torque is 271.42 kg.mm x 9.8 m / s2 = 2.659 Nm. After knowing the amount of torque on the rotating shaft, then look for the rotation acting on the shaft. The equation for calculating the load shaft turns as follows:

$$P = \frac{2\,x\,\pi\,x\,n\,x\,T}{60}$$

Note:

P = Power (watts)

n = Shaft Rotation (rpm)

T = Rotating shaft torque (Nm)

Then:

1) On a spinner

$$P = \frac{2\,x\,\pi\,x\,n\,x\,T}{60} = n = \frac{P\,x\,60}{2\,x\,\pi\,x\,T}$$

$$n = \frac{220\,x\,60}{2\,x\,3{,}14\,x\,1757}$$

n = 1196 rpm

2) On screw mixer

$$P = \frac{2\,x\,\pi\,x\,n\,x\,T}{60} = n = \frac{P\,x\,60}{2\,x\,\pi\,x\,T}$$

$$n = \frac{220\,x\,60}{2\,x\,3{,}14\,x\,2659}$$

n = 790 rpm

d) Production Capacity

The amount of production capacity is the amount of spin on the spinner that moves the cutting knife which is influenced by the amount of torque on the rotating shaft moving the cutting blade on the meatball forming machine. The equation for calculating the amount of production capacity is as follows:

$$Kp = \frac{n1}{n2}\,x\,Ks$$

Note:

Kp = Production capacity

Ks = Round peeler screw

n1 = Load rotation

n2 = No load rotation

then:

$$Kp = \frac{n1}{n2}\,x\,Ks$$

$$Kp = \frac{1196}{2800}\,x\,1901$$

Kp = 811 rpm

Meatball forming machine has 3 blades for forming meatball with size of 22, 27, 35 mm can produce:

1) By using a 22 mm meatball size

Kp = 811 rpm

$$Kp = \frac{5095\text{ minute}}{22\text{ mm}}$$

Kp = 232 items / minute

2) By using 27 mm meatball size

Kp = 811 rpm

$$Kp = \frac{5095\text{ minute}}{27\text{ mm}}$$

Kp = 189 items/minute

3) By using 35 mm meatball size

Kp = 811 rpm

$$Kp = \frac{5095\text{ minute}}{35\text{ mm}}$$

Kp = 146 items / minute

So, a knife with a meatballs with 22 mm diameter can produce 232 items / minute, and a knife with 2 meatballs with a diameter of 27 mm can produce 189 items / minute, while a knife with 3 mm meatballs with a diameter of 35 mm can produce 146 items / minute. This result has better performance than previous research conducted by Rebet (2018) which is only able to produce 17 item/ minute.

IV. Conclusion

Based on the results of the design and analysis of the performance testing machine meatballs forming can be concluded as follows:

1. Meatballs Forming Machine Specifications

   a. The frame structure uses hollow iron with dimensions of 30 mm x 30 mm x 2 mm.

   b. The dimensions of the machine are made length 600 mm x width 700 mm x height 1500 mm.

   c. Using 3 cutting blades with 1 knife with 22 mm diameter, 2 blade with 27 mm diameter, 3 blade with 35 mm diameter.

   d. Dough blades and funnel holders use stainless steel so it is more hygienic and food grade.

2. Analysis of the performance testing of the meatball forming machine found that:

   a. Electric motors are used with 34.6 Nm of torque so that greater torque is obtained in the market, namely a 1 phase electric motor with torque of 37 Nm, 2800 rpm, 1 Hp, 220 V.

   b. Pulley reducer rotation speed obtained at 2158 rpm.

   c. The turning speed of the drive shaft on the cutting blade is 811 rpm.

   d. The rotation speed of the machine within 3-5 hours of use with variations in the small load of the belt or belt of 1.6.

3. Production capacity obtained by the meatball forming machine with performance testing can accommodate the meatball dough with a large capacity, and is able to produce more perfect meatballs using 3 blades that can be replaced as desired with the results of cutting on a knife 1 meatballs 22 mm in diameter can 232 item/ minute were produced, and 27 mm meatballs with 2 mm meatballs could produce 189 item / minute, while 35 mm meatballs with 3 mm meatballs could produce 146 item / minute.

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