Design and Construction of Corn Crusher Machine for Duck Farming

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Abstract. Duck farming as one of the pioneers in fulfilling animal protein needs requires good feed. A good feed, for one, meets the amount of carbohydrate needs. The carbohydrate needs of duck feed can be met by providing feed in the form of crushed corn, making it easier for ducks to swallow their food. For this purpose, the researchers designed a mechanical system for crushing corn kernels that is simple, easy to use, and portable. So with this research, in the end, it will be able to help the production process of duck farming.

Keywords: Corn Crusher · Design · Mechanical System · Corn Crusher Machine

1 Introduction

Topographically of Indonesia has brackish soil and swamps that can be planted with various kinds of food crops as a source of carbohydrates. Corn as a type of food plant, is needed because corn functions as a producer of carbohydrates. In the data, the national corn production in 2015 exceeded 19 million tons (BPS, 2021). Corn contains carbohydrates that are quite high, so it is often used as industrial raw material, such as the ethanol industry and other industries. Corn, in the process, mostly has to be ground into a finer grain. For this, we need a machine that can assist in the process. A machine whose function is to change the shape of corn kernels into smaller grains or even finer forms of flour.

In this regard, the flour machine is one of the tools commonly used in the process of increasing the economic value of the crops produced. The flour machine is used to change the shape of agricultural produce into flour. Coffee beans can be turned into coffee grounds, as can rice, corn, sweet potatoes and other ingredients. All produce produced can be converted into flour by using a flour machine. Coffee beans, rice, corn and other agricultural products will go through a series of processes starting from drying, to a series of mechanical processes to produce the desired product in the form of flour.

The challenge that arises is how to reduce production costs so as not to suffer losses when food and plantation prices decline. One way is to reduce production costs, when production costs fall, margins will increase. Using cheap and renewable energy sources

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and using multi-use production tools is one of the right solutions to help farmers. In this research, the flour machine will use alternative energy that is cheap and economical.

Duck breeders are one of the targets of flour machine users. The flour machine is used by duck breeders as a means of making quality duck feed. Duck food ingredients are converted into flour before being given to ducks. However, problems arise because fuel prices increase which eventually causes an increase in the cost of production of duck feed. In the end it will cause production prices to increase.

1.1 State of the Art

Most of the existing factory Flour Mill equipment has focused on the Flour/Flour tool partially, namely the Flour Mill focuses on only one material, for example only to process Coffee or rice. Even if there is a Flour Mill tool, the price of a Flour Mill tool becomes very expensive in the market and must be ordered custom. Moreover, the propulsion engine uses fuel which is expensive and difficult to obtain, especially in remote areas, therefore the existing machines on the market do not help reduce production costs which will have an impact on increasing the economy.

This research develops and implements multipurpose flour machine technology in duck farming activities so that it is expected to assist in the process of duck feed production activities which in turn will help reduce duck farming production costs.

The milling process is a pre-process in processing in order to obtain materials that are ready to be processed. Milling has a very important purpose, this is done to reduce the particle size of a material. Milling is said to be optimal if it is able to grind materials with low energy consumption.

1.2 Types of Flouring Machines

The types of flour milling machines are categorized based on their shape and working process. Judging from the force that will act on the material, the flour machine is divided into four types (Brennan et al., 1990), namely:

a. Hammer Mill type, the pulverizing machine works based on a punch, in the pulverizing chamber consisting of several hammers that rotate on their axis. Hammer mill is a pulverizing tool whose purpose is to break or crush raw materials into small pieces using repeated hammer blows. The material is reduced in size by a blow between the hammer and the wall, and pushing the material through the perforated plate to generate heat. This causes the product to be heated and lose its water content (Posner and Hibbs, 2005). It takes energy of one kilowatt (Kw) to grind one kilogram of material per minute in a medium mill (Sutanto, 2006). A hammer mill is basically a steel drum in which there is a shaft. The hammer is mounted on the shaft, and the shaft rotates vertically or horizontally in the drum. The hammer is free to swing and pound the raw material. The rotor rotates at high speed inside the drum while the material is fed into the feed hopper. Materials that have been crushed will be removed through a dispensing funnel according to the selected size.

b. Disc Mill type, the flouring machine works based on a combination of friction and disc pressure. Disc mill technology is a combination of hammer mill and roller mill that applies punch and pressure to the material to reduce the material to a smaller size. Disk Mill is one type of machine used for the manufacture of flour. This flour machine has an important role in the manufacture and production of flour. Food ingredients that can be applied or processed using this machine are rice, coffee, soybeans, pepper, corn, corn cobs, dry spices and many other ingredients. In order to produce good quality flour, it is best if all the ingredients to be made flour must go through the drying stage first.
c. Cylinder Mill type (Roll Mill), the flouring machine works based on rolling the material through the cylinder gap. Rolling is a deformation process in which the thickness of the workpiece is reduced using compressive force and using two or more rolls. Roll rotates to pull and press the workpiece that is in between. In the rolling process, the object is subjected to high compression stresses that come from the clamping motion of the rolls and surface shear stresses as a result of friction between the rolls. Roller mill is a grinding machine that is often used in commercial flour mills because of its ease of operation
d. Cutter Mill type, the flouring machine works based on the rotation of the blade which is driven by a motor. The Cutter Mill type is the most effective in the milling process

1.3 Selection of Flour Machine

The selection of the type of machine is carried out after conducting a market survey. Hummer mill machines and disk mill machines are types of flour machines whose function is to break the feed material into flour. This flour machine is identical to the business of supplying flour, raw materials for the food and animal feed industries, to metering and wood processing.

The choice of disk mill is because disk mill machines tend to be more effective when used on dry materials such as feeder materials, wood, or coconut shells and so on. While the hummer mill machine can be used to assist in the refining process for feeder materials with a fairly high water content. The disc milling machine works by combining the forging function and the milling function. In the disk mill, there is a disk mill with a series of pens. This disc mill works forging as well as chopping materials into flour faster and smoother than a hummer mill.

1.4 Corn Crushing Efficiency

A test is unlikely to achieve 100% efficiency, as well as this study. For this test, a 1 kg feed sample was taken and the results obtained were less than 1 kg. The results obtained varied depending on the mesh, mc, and others. The reduction in final weight resulting from the flouring process is also due to the flour that is scattered and scattered during the machine's operation and due to a decrease in MC levels during the flouring process. The final result of the test is closely related to the engine efficiency value. The greater the efficiency value, it can be said that the machine is operating well.

2 Previous Research

Some of the research that has been done on the theme of flour machines are:

1. 2005, Ali Zamsuri et al. making a flour machine with a pounding mechanism that is used to pound the basic ingredients for making pancakes for the people of Pekalongan. The flour machine that is designed is able to provide the performance of shortening the processing time as much as 150 min faster. The designed machine is also able to show resistance by trying to start the engine continuously for 12 h at full load for one week. The production capacity of the machine designed by Zamsuri (2005) is 90 kg of rice per day with an operating time of 6 h, and a production cost of Rp. 2,250 for 6 h of operation. Which means an increase in efficiency of 83% for production capacity, and 85% for production costs.
2. 2008, Paramawati et al. designing a double jacket type flour machine for biopharmaceutical commodities that provides increased production capacity and essential oil content of biopharmaceutical raw materials.
3. 2012, Rangkuti et al. tested the performance of the disk mill machine in the juwawut milling process. The tests carried out showed that the optimal use of the engine was at a speed of 5,700 rpm using a filter size of 80 mesh which could produce a capacity of 20.43 kg/h, flour yield of 91.6% and scattered shrinkage of 1.77%. Based on power and efficiency requirements, the use of a flouring machine with a rotational speed of 5,700 rpm and a filter size of 80 mesh requires a power of 519 watts with an efficiency of 0.20%. With the use of the machine at 5,700 rpm and an 80 mesh sieve, the flour produced is of the most optimal quality with a flour particle size of about 0.015 in, a degree of fineness of about 43% with an initial moisture content of 14.23% of juwawut seeds, producing flour with a moisture content of approx. 6.80% after the flouring process which is very suitable as a food raw material.
4. 2015, Junaidi et al. designed a flouring device for the jellyfish flour process. Still in 2015, Qonita et al. also designed a flouring machine that is used to increase the efficiency of the herbal ingredients flouring process. The flour machine designed is used to help SMEs in the Jogjakarta and Central Java areas.
5. 2016, Saefudin et al. designed a disk mill type flouring machine that is used for the seaweed flouring process on a laboratory scale which produces seaweed flour in the size of 1 to d. 10mm.
6. 2018, a disk mill type flouring machine for the sorghum flour process was tested for its performance and developed by Arustiarso et al. The flour machine developed has the best performance at 600 rpm rotation with a capacity of 200 kg/h, and the resulting flour has a fineness of 96 mesh.
7. 2019, Sugandi et al. conducted a performance test on a corn seed flour machine in Cikawung village, Bandung Regency. The flour machine is used for the process of flouring broiler animal feed. The performance test carried out obtained the results that the corn kernels flour machine had a theoretical capacity of 54.53 kg/h, an actual capacity of 29.73 kg/h, an engine efficiency of 54.52%, an actual power requirement of a machine without load of 3.12 HP, the actual power requirement of the engine with a load of 4.37 HP, the fuel consumption of the engine without a load of 0.96 L/h, the fuel consumption of the engine with a load of 1.41 L/h, the thermal

efficiency of 21%–28%, the efficiency of the transmission system with a load of 98.29%, the shrinkage of scattered flour is 2.65%, the flour yield is 97.35%. The engine noise level is still in the safe category for the use of 6 h of work per day with a no-load engine noise level of 83 dB, a noise level with a load of 86.93 dB. The vibration value on the corn kernels flour machine exceeds the permissible threshold for machines with a power of less than 20 HP, which is more than 4.5 mm/s so that it is included in the dangerous category with machine vibrations in the frame of 4.72 mm/s when no load and of 4.99 mm/s when under load, and 3.86 mm/s at no-load and 6.44 mm/s when under load.

Based on the test results with the use of several rpm, it was found that the best rpm for the driving motor for the flouring process is 2325 rpm with an actual capacity of 27.98 kg/h, fuel consumption of 1.4 L/h, noise without load of 83, 68 dB and with a load of 85.1 dB, and a power requirement of 2.84 HP when no load and 3.77 HP when with a load. The corn flour machine will break even when the machine produces 48,657.83 kg of corn flour or will be achieved in 9 months. Based on the results of calculations and economic analysis, the corn kernels flour machine has met the criteria of economic feasibility with a large NPV of RP 2,197,755.94, IRR of 25.67%, B/C ratio of 1.012, and PBP of 2.75 years.

8. 2019, Ernawan et al. conducted a performance test and energy analysis for the MDP-10 type vertical mill dryer. The performance test was carried out to obtain an efficiency of 21.15%, the actual and theoretical capacity of 21.15 kg/h and 100 kg/h, the percentage of scattered flour was 0%, the percentage of mass loss was 78.82%, the flour yield was 21.18%, the total power requirement is 6.97 kW, lpg fuel consumption is 6.42 kg/h. The cassava flour produced has met the permitted category which has a wet basis moisture content value of 10.72% with a uniformity index value of 1:7,71:108,46, and the value of fineness modulus and average diameter of flour particles is 0.56. and 0.006 inches. The use of total energy in the process of making cassava flour is 83,881 MJ/kg with details, namely human biological energy of 0.759 MJ/kg, direct energy of electricity and fuel of 2,332 MJ/kg, and indirect energy of 80.79 MJ/kg.
9. 2020, Saefudin, et al. tried to modify the knife on the red seaweed flour machine to ATC (Alkali Treated Cottoni) with a cutting edge at an angle of 330o in the radial direction. The tests that have been carried out have concluded that the modified blade on the ATC flouring machine has succeeded in achieving a fineness of 100 mesh, although only 20% has managed to achieve a maximum fineness of 100mesh. The flouring capacity of the machine with this knife modification reaches 0.0036 kg/h for 20 g intake and 0.0074 kg/h for 50 g intake.
10. 2020, Subagio, et al. designed a cassava flour machine to be used for farming communities in Sapuran village, Wonosobo Regency. Tapioca flour making machine is designed using a rotating grater mechanism (cylindrical grater), which is combined with a squeezing and filtering mechanism using a rolling shaft placed on a perforated plate which also functions as a filter. The machine is designed to be able to grate, grind, and filter cassava as much as 50 kg/h with the time needed to do all activities for 10 to 10. 12 min for 2 kg of cassava per cycle.
11. 2021, Ningsih, et al. analyzed the performance of a vertical type of mangosteen peel pulverizing machine. The results of the analysis carried out get an average

capacity of 177.8 gr/second at 1400 rpm engine speed. The efficiency of the engine under study is 53.33%.

12. 2021, Sanyoto, et al. make a design of a disk mill type flour mill for sorghum seeds. This is done as an alternative to using wheat flour. They made modifications to the crushing pin which has a maximum force of 14.715 N.
13. 2021, Mulyono, et al. carry out community service by applying the technology of the flour machine used for wedang spice craftsmen in Pandean Lamper village, Semarang, Central Java

3 Research Methods

3.1 Place and Time of Research

The research was conducted at the Mechanical Engineering Workshop Department Building, Sriwijaya State Polytechnic. The research and design of the tool was carried out for 6 months starting from April 2022 to September 2022.

3.2 Tools and Materials

The tools used in this design research are:

1. Lathe machine
2. hand grinder
3. Welding machine
4. Hacksaw
5. Hand tools
6. Sieve
7. Digital scales
8. Tachometer
9. Occupational Health and safety equipment

The materials used are:

1. Corn Seeds
2. Hollow Iron
3. Steel pipe
4. Steel plate

3.3 Design Method

The design method is divided into several stages, namely:

1. Steps to collect the necessary data (observation and interview data).
2. The design step includes determining the type of chopping machine, material requirements analysis, tool design and tool production capacity as well as how much electrical energy consumption is needed.

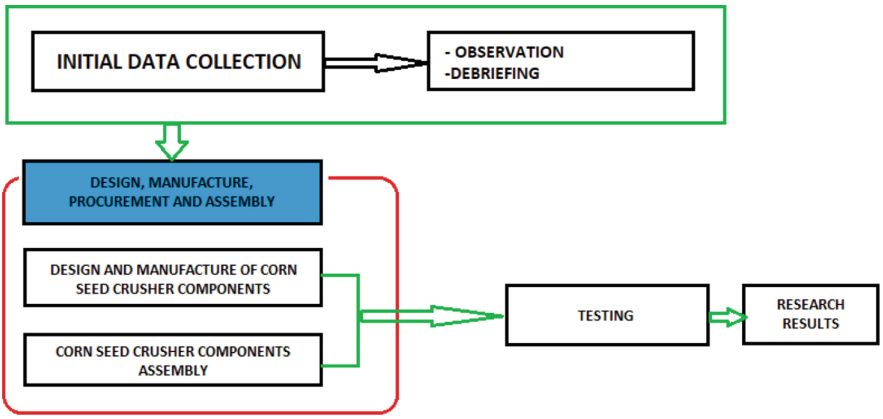

Fig. 1. The Research Stages

3. The manufacturing steps include, the manufacture of Components for the chopper machine, the manufacture of the frame, and the manufacture of the casing for the chopper machine.
4. Assembling step is the step of assembling components into a chopping machine tool according to the design results.
5. Testing Steps, if findings are obtained, they will be immediately corrected so that the results of the tool are close to perfect.
6. Reporting

3.4 Research Stages

See Fig. 1.

3.5 Research Methods

The activities are carried out in the following stages:

1. Literature review, the activity begins with conducting a literature study and reviewing the results of previous research related to postharvest technology and corn processing. At this stage, data related to the physical properties of corn kernels, quality requirements of corn flour, types and machines of corn flour will be obtained.
2. The next stage is to conduct a preliminary test of the machines that have been developed to evaluate the performance of the machine so that the existing weaknesses are known to be used as a reference in modifying or repairing the machine. From the preliminary test, the design parameters for the flour machine will be obtained.
3. The design parameters that have been set will be used as a reference in calculating the design, redesign, modification of the flour machine design. After the calculation and design process is complete, a detailed working drawing of the machine will be produced.

Fig. 2. The Corn Crushing Machine

4. Working drawings of each machine are then used for reference in the manufacture of machine components. After that the engine components are assembled into a prototype machine.
5. The finished machine prototype is then functionally tested to see if each component is functioning or not. After the functional test is considered good, then proceed with a performance test to determine the performance of the machine prototype.

4 The Results

The resulting flour machine is a machine that functions to grind dry corn kernels into shelled corn. This machine consists of 4 main components, namely the main frame, disk mill, cyclone, and the driving motor. The main frame is a hollow steel 2 mm thick. The disc mill is a dynamic blade that moves to grind dry corn. The cyclone is a tube made of steel pipe. The working mechanism of this machine is to grind dry corn kernels with a disk mill and then filter them through a sieve inside the disk mill and flow them through a cyclone to be accommodated. The capacity of the corn crusher machine reaches 76 kg/h, and an average of 41.6 kg/h with a softness level of 10 and 20 mesh. 125 W driving power requirements. The image of the designed corn crusher machine is shown in Fig. 2.

The designed machine was then tested by operating it to crush 1 kg of dry maize, the maize crushing time was recorded. The crushed corn was sieved with 10 and 20 mesh sieves, then weighed with a digital scale. The operating results are presented in Table 1.

Table 1. Corn crusher machine performance

Testing Number	Initial weight (gr)	Output (gr)	Process Time (minute)	Capacity (kg/h)
Mesh size: 10				
1	1000	782,7	1,12	39,04
2	1000	735,8	1,02	43,28
3	1000	711,1	0,58	73,56
4	1000	763,7	1,23	37,25
5	1000	773,9	1,15	40,38
Average		742,6	1,02	43,69
Mesh size: 20				
1	1000	790,8	1,57	30,22
2	1000	803,5	1,5	32,14
3	1000	803,9	1,48	32,59
4	1000	797,7	1,57	30,49
5	1000	794,9	1,7	28,06
Average		798,16	1,56	30,62

5 Conclusion

Based on the discussion, the following conclusions can be drawn:

1. Corn crusher machine is developed with main components: main frame, disk mill, cyclone and drive motor.
2. The maximum performance capacity for 10 mesh is 73.56 kg/h with an average of 43.69 kg/h. The maximum performance capacity for 20 mesh is 32.59 kg/h, with an average of 30.62 kg/h.
3. For a better design, this research needs to be continued again so that better efficiency is obtained, both for the results obtained, as well as the time used.

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