LAB UNIVERSITY OF APPLIED SCIENCES LTD.
Technology, Lappeenranta
Mechanical Engineering and Production Technology
Bachelor's Thesis 2020

Lam Bui

Design system: Pulverising (Grinding) Powder Avocado Machine

Thesis 2020

Abstract

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Design system: Pulverising Powder Avocado Machine, 42 pages
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Finland is a Nordic country, which is proceeded the fast-paced industrialization after World War II, achieving the same GDP as Japan and the UK in the early 1970s. Initially, most of the developments were based on two groups of export industries are "metal industry" (metalliteollisuus) and the "forest industry" (metsäteollisuus). "Metal industries" include shipbuilding, metalworking, automotive industry, engineered products such as engines and electronics, and metal manufacturing (steel, copper, and chromium). The world's largest cruise ships are built at Finnish shipyards. The "forest industry" includes forestry, wood, pulp, and paper, and is a suitable development based on Finland's forest resources (around 75% of the area is covered by forests, most of which is renewable use). In the pulp and paper industry, many of the largest companies are based in Finland (Ahlstrom, Metsä Board, and UPM). However, the Finnish economy is gradually diversifying, which expanding into other areas such as electronics (such as Nokia), measurement (Vaisala), transport fuels (Neste), chemicals (Kemira), and technical (Pöyry) and information technology (Rovio Entertainment - Angry Birds, Small Giant Games – Empires and Puzzles); is no longer dominated by the metal and forest industries. Similarly, the structure has changed, with an increase in service industries, and with the fast-growing manufacturing industry; hence, agriculture is only a small part. (Wikipedia, 2020) To ensure the quality of products after long-term harvest and preservation, the support of machines is required.

Avocado is a fruit that is very familiar in daily lives, it has a very high nutritional value and is very beneficial to human health. Avocado is not only used as an ordinary fruit but also as a source of materials in many areas such as medicine and cosmetics. But this is a year-round fruitless crop, which requires a process of preserving avocado to enhance its value.

Recognizing the importance of this issue, the purpose of this thesis was to research about avocado value and technology in powder production, calculation, and design pulverising avocado powder system. Experiments and tests for this thesis were done in some university laboratories in Vietnam. Data and information for this study were gathered from practical experiments, study, books, internet sources, and training programs.

Due to the limitation of knowledge, experiences, the time of the project, and economics, the project failed to yield the practical product. Therefore, the mentioned issues could be performed.

Keywords: avocado, powder, design system, product design, manufacturing, pulverising, AC motor, centrifugal fan, cyclone.

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1 Introduction

1.1 Introduction material

The avocado (Persea Americana) is a tree native to Mexico and Central America, is classified as flowering plants, dicotyledonous, Lauraceae. This is a fruit of very high economic and nutritional value. Usually, people use avocado as a fruit to make a smoothie, salad... However, avocado has many other uses that medicine is applying. Avocado is both a source of materials for the food industry, cosmetics, and fruit with medicinal effects in medicine. One problem is that avocado trees cannot bear fruits all year round and thus processing and preserving the fruit so that it can use its nutritional value in the long term. (Tejero et al. 2018, pp. 322-324)

In recent years, the situation of the application of post-harvest technology has improved significantly. Many fruits and vegetables have a wide consumption market, not only in the country but also exported to many countries around the world. To preserve agricultural products, many methods such as fermentation, drying, extracting essential oils, ... are discovered. For avocado powder products, preparing and preserving could be done by measures such as: extracting essential oils, drying, and crushed then packed, ... However, in Finland, at present, there is quite a little research project applying this technology to avocado. The processing and storage must also ensure specific characteristics (nutritional indicators, sensory criteria, hygiene, and food safety criteria...).

1.2 Research content

The project is finding out the value of avocado and avocado powder, manufacturing the process, the standard system of avocado powder, and calculating and designing an avocado pulverizing system.

Methods of document analysis: references from books, textbooks, magazines, and the internet, etc.

Methods of synthesis: From the sources of information gathered from the pulverizing method, propose ideas and methods, processes, types of equipment, perform design and calculations of avocado powder pulverizing (grinding) systems.

1.3 Scientific and practical significance

Scientific significance

Proposing some technological grinding processes, calculating, and design a grinding machine for avocado powder production.

Practical significance

The project will be researched the method to solve the problem of using and preserving avocado to meet the requirements of avocado for food, cosmetic, and medicine industries, which improves the value of finished avocado powder. Therefore, new jobs for farmers are created, especially ethnic minorities in the highlands, areas where avocado can be grown with high yields.

2 Avocado and technology powder production

2.1 Overview of avocado

2.1.1 Avocado value

Among tropical and subtropical plants, avocado ranked higher in FAO statistics from 1994 to 2018. Total world production is over 6,400,000 tons, concentrated in the Americas in terms of consumption, developed countries have an increasing demand for these increasingly familiar items. (FAO, 2019)

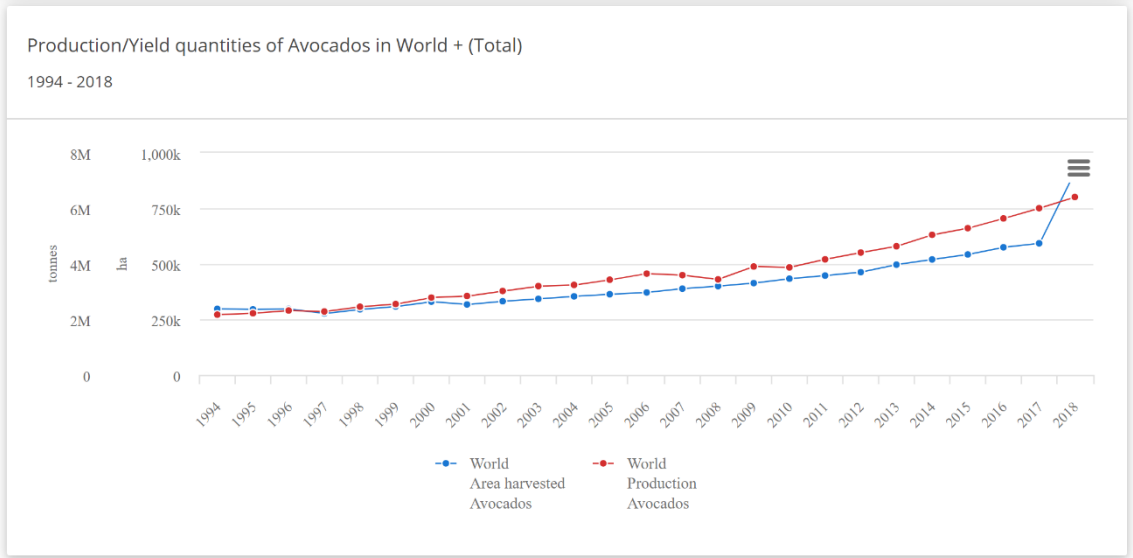

Figure 2-1. Chart of production/yield quantities of avocado in the world (FAO, 2019)

The nutritional content of avocado is higher than many other fruits, especially in terms of calories, protein, and mineral salts. Avocado is an ideal food for people with diabetes. The content of vegetable oils in avocado is very high (3 ~ 30%) and the human body can absorb up to 92.8%. (Tran, 2018)

Nutritional value:

In accordance with Essa et al. (2016) and Bunda (2011), avocado contains over 20 vitamins and minerals including calcium, iron, copper, magnesium, phosphorus, potassium, sodium, zinc manganese, and selenium.

- Vitamin: vitamin A - 338 iu, vitamin C - 20.2 mg, vitamin B1 (thiamine) - 0.2 mg, vitamin B2 (riboflavin) - 0.3 mg, niacin - 3.9 mg, folate - 205 mg , pantothenic acid - 3.3 mg, vitamin B6 - 0.6 mg and some other vitamins in small amounts.
- Minerals: potassium - 1,166 mg, phosphorus - 124 mg, magnesium - 67 mg, calcium - 30 mg, sodium - 18 mg, iron - 1.4 mg. Avocados also contain small amounts of selenium, manganese, copper, and zinc.

The researches on the effects of avocado conducted by Mexican experts shows that avocado contains a lot of nutrients, very beneficial to human health. Especially for obese people or people who are during the diet.

Avocados are an important source of folate (vitamin B9) for women of pregnancy and especially important in the first weeks because 75% of babies with spina bifida are caused by a lack of folate from the womb.

Avocado is one of the very few fruits that do not have cholesterol but contain monounsaturated fat, which is good for the body and helps reduce cholesterol. Avocados contain the highest protein content of any other fruit, almost as high as milk.

Besides, avocados are low in salt, high in fiber, high in lutein, and have natural carotenoids that help brighten the eyes and maintain beautiful skin. Avocados are also a source of nutrition for children. Avocado is very beneficial for the health of children because the avocado contains protein, vitamins A, E, C high. Protein is an important nutritional ingredient for the development of children and especially infants. In addition to the antioxidants that protect brain cells, the B-complex vitamin in avocados enhances memory. Hence, avocado is a perfect source of nutrition for the brain development of children.

Avocado value with aesthetic technology

According to K.T. Tran (2018), avocado is also used for beauty and health thanks to its rich vitamin A, E, D along with the mineral potassium, phosphorus, sulfur, and chlorine, in which:

- Vitamin E protects the fatty acids against oxidation, thus slowing down the aging process of cells to help skin youthful and firm.
- Vitamin A works to remove the dead skin layer, promote the production of collagen.
- Vitamin D helps maintain the content of calcium in the blood so that strong bones and teeth.
- Potassium and phosphorus work to beautify skin, hair, and help develop the body.
- Avocado oil has a lot of value in regenerating and moisturizing the skin. Avocado oil protects the skin from drying out and increases the skin's elasticity.

Table 2-1. Comparison of some fruits in terms of quality in 100g (Tran, 2018)

Fruits	Calories	Water (g)	Protein (g)	Lipid (g)	Sugar (g)	Vitb1 (mg)	Vitc (mg)	Phosphor (mg)	Calci (mg)
Avocado	102	79	1,1	6,1	13,2	0,05	8	38	12
Mango	70	79,9	0,9	0,1	18,5	0,01	13	-	4
Papaya	45	87,1	0,5	0,1	11,8	0,03	73	-	24
Orange	40	88,6	0,8	0,2	9,9	0,07	43	23	21

Environmental value

Growing avocado brings many benefits to the environment:

- Avocado trees not only help shade but also help reduce air temperature due to the evaporation of leaves.
- Avocado trees are also a significant source of oxygen and help keep the air fresh and fresh. Because studies show that 1 avocado tree produces nearly 118kg of oxygen per year and 1 ha of the avocado orchard in a year can help to eliminate 6.4 tons of CO_2. (Filippone, 2019)

Avocado orchards can also reduce runoff and filter rainwater thereby reducing flood risks, improving water quality and quantity. Avocado roots also help combat soil erosion.

2.1.2 The situation of planting and distribution of avocado varieties

Avocado consists of many varieties of the Lauraceae family. Most commercial varieties belong to three strains: Mexican, Guatemalan, and the Antilles or West Indian. The Guatemalan and West Indian strains (Antilles) are classified as Persea Americana Mill. The Mexican strain is classified as Persea Drymyfolia. (Goddard, 2018)

Characteristics of three important categories of avocado:

Figure 2-2. Mexican avocado (Kahn, 2018)

- Mexican strains: Many leaves in a different size, leaves are green, the lower surface is lighter than the upper one, especially when the leaves are crumpled up, it has a unique smell (anique smell). The fruit is usually long which is the same as the form of pears and papaya. Very good quality due to very high-fat content: 15 ~ 30%. Pods are thin, often smooth, when riping are green, yellowish-green, or purple-red, dark red depending on the variety. Seeds are slightly larger, seed pods are thin, having a smooth outer surface. When riping, seeds are loose from the middle but shake without sound. The time from flowering to maturity is usually 8 ~ 9 months. This is the highest quality avocado strain and has the best freezing properties. (Karimov et al. 2016)

Figure 2-3. Guatemalan avocado
(University of Buffalo, 2019)

- Guatemalan strains: have darker green leaves than Mexico and Antilles strains, when crumpled up without smell. The time from flowering to maturity is usually from 9 ~ 12 months. The avocado has many long stalks, slightly thick skin, and wood grain. The skin is usually rough like crocodile skin. Seeds are small and close to the middle. The fruit is thick, has 10 ~ 15% fat content. The outer surface is smooth. This strain is very resistant to cold. (Karimov et al. 2016)

Figure 2-4. West Indian avocado
(Shutterstock, 2020)

- Antilles or West Indian strains: have large leaves, often colored leaves are almost uniform on both sides of the leaves; When crumpled up leaves, it does not smell anything. The time from flowering to maturity is usually from 6-9 months. The fruit is usually large, some are very large. The pedicel is short. The skin is quite short and tough, on average 0.8 ~ 1.5 mm thick. The skin is green and when riping then changes to yellowish-green. The

fruit has a 3 ~ 10% oil content. The seeds are quite large and loosely located in the middle of the fruit; when riping, it has a sound from the middle by shaking. The outer surface of the grain is grainy, the shell surrounding the seed is not attached to the seed. The Antilles strain is weak with cold but it is good at heat resistant and high salinity (3% in irrigation water) environment (halophyte). (Karimov et al. 2016)

Differences of avocado strains

In general, table 2-2 is set up to compare the characteristics of different avocado varieties which created according to the criteria of their appearance (smell, size, skin, seed, the gap of seed) as well as their special characteristics (cold-resistant and advantages)

Table 2-2. Differences of avocado strains

Strains	The smell of crumpled leaves	Size	Skin	Oil	Seed	Gap of seed	Cold-resistant	Advantage
Mexico	unique smell (anique)	small	thin (0,8mm)	high	slightly large	loose from the middle	very good	freezing properties, highest quality
Guatemala	no	small or large	thick (1,5 ~ 1,8mm)	average	small	close to the middle	good	cold-resistant
Antilles	no	large or very large	average (0,8 ~ 1,5mm)	low	quite large	loose from the middle, has a sound when shaking	weak	heat resistant, halophyte

2.1.3 Research manufacturing system for avocado powder

Currently, according to market research, avocado powder has not been packaged and sold in supermarkets in the country. The production of avocado powder

has not been researched. Therefore, there are no specific standards as well as processes and equipment to produce this product. However, based on the actual nutritional value of avocado and standards for drying and preserving agricultural products as well as systems of milk powder, food powder (passion fruit powder, nutritious powder ...) to a quality system for avocado powder could be built.

2.1.4 The main criteria of avocado powder

Setting the targets for avocado powder is based on the criteria of nutritious powder, baking flour, and passion fruit powder. The following are specific targets

Sensory and physicochemical criteria:

To determine the sensory and physicochemical criteria of the finished product, the table 2-3 is created based on the sensory and physicochemical criteria of some finished powder (nutritious, baking flour, passion fruits). Hence, the general conclusion requirements of the finished avocado product are confirmed.

Table 2-3. Sensory and physicochemical criteria of some powder/flour (Ogunjobi et al. 2016, Ahmed et al. 2019, Garcia et al. 2019)

Powder / *Criteria*	**Nutritious Powder**	**Baking Flour**	**Passion fruits powder**
Moisture	6 ~ 10 %	≤ 15,5%	6 %
Colour	Uniform, no strange color	Ivory-white to ivory-yellow	Bright yellow
Smell	Flavorsome, pleasant smells, no smack	Good smell, no smack	Flavorsome
Taste	Sweet-scented, no smack (bitter, burnt,…)	Normal, no smack (bitter, sour,…)	Sour, sweet, no harsh

Smoothness	The proportion of sieve 0.630 mm is at least 95%	The proportion of sieve 0.230 mm is at least 95%	Smooth
Purity	No ectoplasmic	No ectoplasmic	Ectoplasmic not exceeding 0.3%
Shape	Uniform, lump-free, smooth, soluble in water into a uniform emulsion system or a sediments-less liquid system	Smooth, uniform	High solubility, dissolving without sediment, uniform, no separated layer
Ash level	-	≤ 1%	≤ 6,5%
Acidity	**-**	The amount of KOH needed to neutralize 100g powder ≤ 50mg	**-**

Requirements for micro-organisms and hygiene

The requirements for micro organisms and hygiene of nutrious powder can be used to apply in avocado product.

Table 2-4. Requirements micro-organisms and hygiene of nutritious powder (Ahmed et al. 2019)

Criteria	**Requirements**
Total number of impurities in 1g of powder	≤ 5000
Escherichia coli bacteria	Not allow
Staphylococcus aureus	Not allow

Clostridium perfringens	Not allow
Fungus, moldy in 1g of powder	≤ 100
Aspergillus flavus	Not allow

Proposing the system of production target

Based on the comparison table of some powder products (tables 2-3 and 2-4), the following criteria for avocado powder is proposed:

- Sensory and physicochemical criteria:

Table 2-5. Sensory and physicochemical criteria of avocado powder.

Criteria	**Requirements**
Moisture	≤ 10 %
Colour	Uniform, based on natural avocado's colour, no strange
Smell	Flavorsome, pleasant smells, no smack (burnt, musty smell,…)
Taste	Retaining sufficient fat of avocado
Smoothness	Smooth, lump-free, the proportion of sieve 0.6mm is at least 95%
Purity	No ectoplasmic
Shape	Uniform, smooth, lump-free, soluble in water

- Requirements for micro-organisms and hygiene of avocado powder: Do not have pathogenic bacteria, no mold, preserving time is long, no strange creatures during storage.

2.2 Production process

2.2.1 The avocado powder production process

According to reference, observation, research, the production process of avocado powder is proposed below

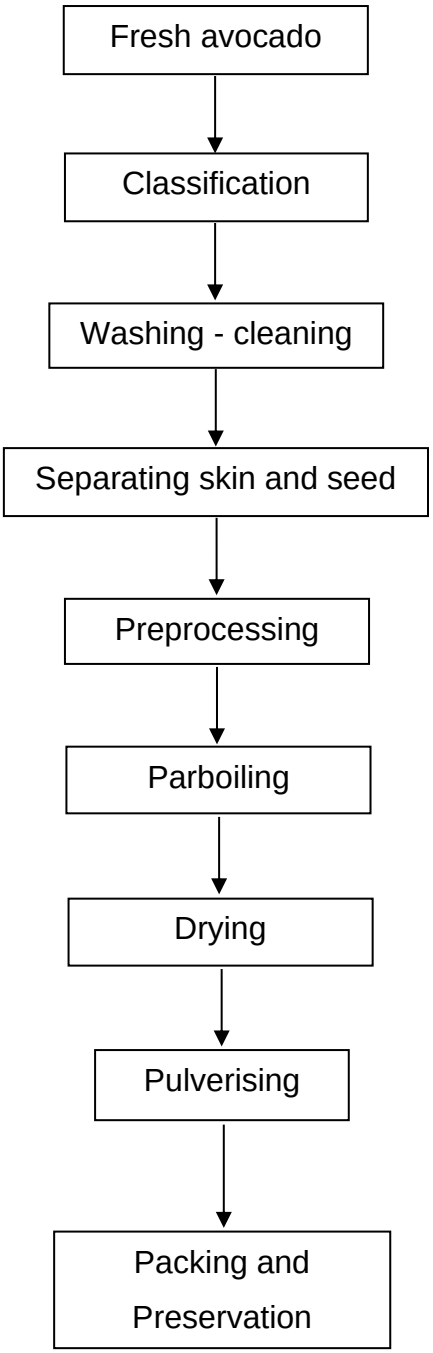

Figure 2-3. Production process of avocado powder

Demonstration process:

- Procurement of raw materials:

In Finland, K Group is one of the best markets, from 2018, they determine no avocado purchasing from the highly problematic Chine (Petorca region) due to water risks. The avocados are purchased increasingly in areas with the lowest water risk such as Peru and South Africa in summer and Spain, or Chile in winter. (K Group, 2018) The avocado varieties are also good quality, high in nutrients and fatty. Avocados can be purchased from farmers or farms in these areas.

- Selection - classification:

Material quality is the first-factor determining product quality. So first of all, quality fruits that are high nutritional value are chosen. In which, the selection helps the material eliminate unqualified materials, pests, molds, rot. Besides, classification could uniformly distribute materials in size, shape, color, ripeness.

- Implementation:

Manual or on a conveyor belt. The avocado is put into the raw material container, then put on the conveyor belt, the two sides of the conveyor belt are the workers to sort the fruits. Here is to remove the suspect fruit damaged (stamping, crushed, rot, ...). This conveyor belt also removes the fruits that are not suitable size for the production process.

Avocado is picked through a conveyor belt and workers will inspect and select rotten, worms, insects damaged fruit, remove needless objects such as leaves, rubbish, and other objects. And also cleaning dirty fruits before sorting.

Insufficient ripe fruits may be stored until they reach maturity. The over-ripe fruit can also be used if there are no signs of damage.

It is necessary to eliminate rotten fruits because rotten is the gateway for micro-organisms to invade and develop, affecting the quality of finished products.

- Washing - Cleaning:

Purpose: After being purchased, the material is still mixed with many impurities such as dust, sand, pesticides ... sticking on the surface of the fruit. Raw materials

need to wash to avoid these impurities that can mix into the intestines which adversely affect the product properties, and reducing the number of microorganisms outside the skin.

Implementation method: the washing process consists of two stages: soaking and flushing. The fruit will first be put into the soaking basin and then conveyed into the flushing system of the washing machine.

Soaking makes water soaked in the material, making impurities soft, stains, and facilitating easy washing. The soaking solution can be plain water, hot water, or lye. It can be static or immersion soaking, time is shortened to reduce nutrient loss.

Flushing is using the flowing effect of water to pull the remaining dirt on the surface of the material after soaking. Spraying water (p = 2 ~ 3 atm) and shower are often used for flushing. The washing water must be clean again, the amount of Cl_2 left in coated water is 3 ~ 5 mg / L. (Salvato et al. 2003, p. 431)

Depending on the material and the degree of contamination of the material, one or more times can be washed with many corresponding washing methods.

Equipment: Using a conveyor washing machine, with bubbling system stirring and pressure about 2 ~ 3 atm.

- Preprocessing (shelling, seeding and cutting):

Method: Shelling and seeding to obtain avocado before drying. This phase can be carried out manually and by machine. After that, cutting the avocado into slices with a thickness of about 3 to 5 mm, which will allow the avocado to be evenly spread over the drying system (the exposed surface of the avocado of the large area) for the best drying product.

Processing: Preprocessing could be done by manual and machine with conveyor. The clean avocado is put into the conveyor belt, the two sides of the conveyor belt are the workers to shelling, seeding. And then, the avocado moves to the cutting machine to cut into slices (cutting phase is separated from other phases to confirm quality assurance).

- Parboiling:

Purpose: reduce bitterness, taste, and retain color after drying.

Method: Using a solution of salt, sugar, and special chemical ($Na_2S_2O_3$), parboiling in two minutes. (Garg et al. 2013)

- Drying

Purpose: To reduce the moisture in avocado, the avocado becomes crunchy and dry to prepare for grinding later.

Equipment: Using specialized drying equipment. There are many drying methods such as sublimation and convection drying. The suitable drying method could be chosen based on drying material specification and their purpose. The tunnel drying (convection drying method) which is using a conveyor to transport drying materials is applied for this project.

- Pulverizing (grinding):

Purpose: Making avocado in the form of a powder, convenient for packaging, preservation, and use.

Equipment: Using a ball mill or hammer mill. The analysis and selection of pulverizing machines will be elaborated in the following chapter.

- Packaging and preserving:

Packaging and preserving to keep the product long-lasting, easy to transport, and distribute the product. At this stage, complying with the requirements of food hygiene and safety. Packaging must be properly packed, not toxic to the product.

2.2.2 Pulversing (grinding) equipment

As well as drying equipment, there are many different types of grinders on the market. These machines are widely used in many areas of life, industry, and home. Some universities also research and produce cassava grinding machines with high productivity (7 tons/hour). It is also an advantage for the process of

researching and manufacturing avocado pulversing machine because the avocado after drying has mechanical properties and a similar shape to cassava. (Karimov et al. 2016)

2.3 Conclude

The overview shows that there is currently no specialized pulverising avocado that meets the requirements. Therefore, the research and calculation of this device design are necessary.

3 Proposal of pulverising (grinding) machine

3.1 Overal of pulverising (grinding) methods

Claimed by Malkin et al. (2008, pp. 1-3), there are four basic methods to change the particle size of materials.

Impact: it is the result of the instantaneous impact of materials. In this method, the moving materials collide with each other into smaller particles or materials lying on one surface and then being damaged by another object causing it to break.

Grinding (Attrition): it smashed material between two moving surfaces (usually in the opposite direction), the grinding force is friction force.

Shear: there are two forms: cutting (trimming) and cleaving, the material is broken by the wedge-shaped objects acting on it.

Compression: the material is sandwiched between two planes and increasing pushing forces until it breaks, applied in a jaw crusher.

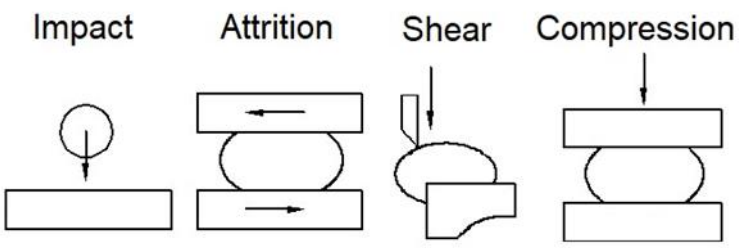

Figure 3-1. Basic pulverising (grinding) methods.

In industry, there are many types of grinding machines to grind the original materials into fine or smooth powders of certain sizes. For example, in the field of construction, there are stone and cement crushers; in the animal feed industry, there are hay-grinding machines, grinding agricultural products into powder to mix with nutrients to make animal food, …

Depending on the properties of the original material, characteristics of technological processes, and requirements for the grain of the product, the appropriate grinding machines are applied.

Grain grinding and various kinds of dried agricultural products are divided into three main types:

Table 3-1. Characteristics of grinding machines. (Rowe, 2014, pp. 6-8)

Grinding machine characteristics	**Types of grinding machine**		
	Attrition	**Vertical Shaft Impact**	**Hammer**
Principle of the effect for the working parts on the crushed material	Repeatedly destroying original material with compression and shearing	One or more destruction of original materials by compression and shearing as well as change their shape and structure.	Repeatedly destroying original material by impact or impact combined with rubbing
Velocity (m/s)	7 ~ 68	0.5 ~ 14	40 ~ 200 and bigger
Grinding properties	Medium and smooth	Coarse, medium, smooth, even pressed	Medium, smooth and very smooth

3.1.1 Attrition mill

Principle of operation: the basic parts are two grinding discs (one fixed and one rotating disc). Original materials from the feed chute go through several sieving stages and then they are pushed into the grinding chamber of the grinding disc pair. After that, the crushed powder is pushed into the discharge chute.

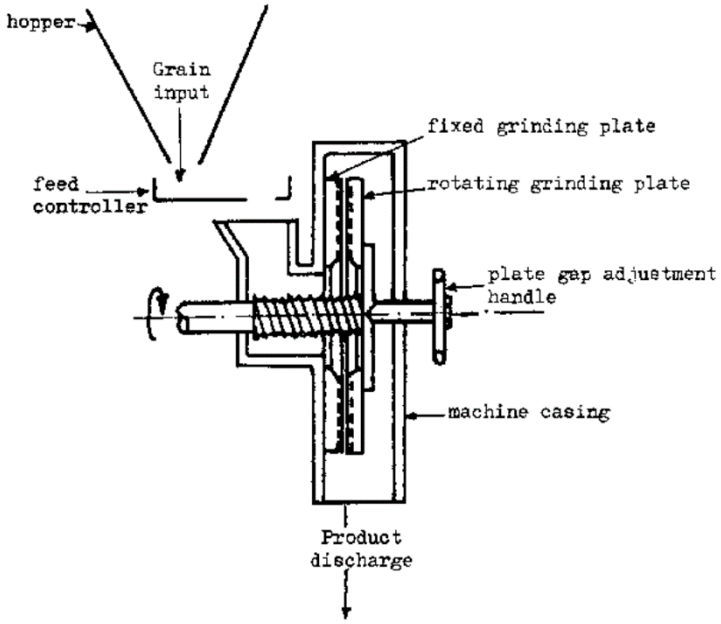

Figure 3-2. Principle of attrition mill. (ILO, 1984)

Advantages

- Can adjust the grinding slot can adjust the fineness.
- In addition to the ability to grind not only dry materials but also wet materials. It is a suitable production for flour, cell of beans in processing peanuts, fish sauce.

Disadvantages: low productivity, rarely used.

Application: mainly for grinding seeds such as coffee and pepper.

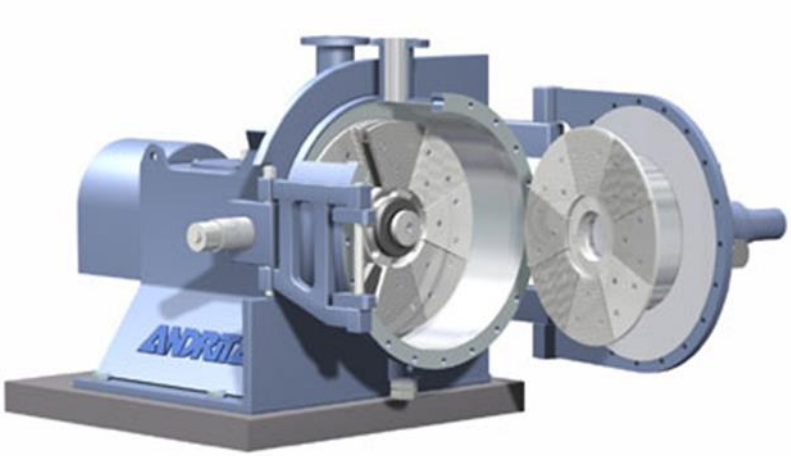

Figure 3-3. Attrition mill – TwinFlo Refiner (Andritz, 2009)

3.1.2 Vertical shaft impact crusher

Principle of operation: Crushing and rolling thin original materials as it passes through the narrow gap of two grinding rollers.

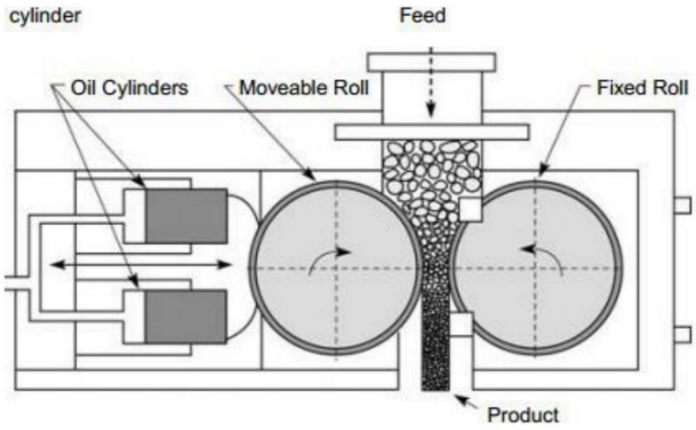

Figure 3-4. Diagram of vertical shaft impact grinding (Grunditz, 2015)

Advantages

- Can adjust the grinding slot by adjusting the distance between the two grinding axes.
- Compression spring between the drive cylinder and a fixed base to help prevent overloading.

Disadvantages: low productivity due to small grinding velocity. For a multi-shaft crusher, the structure is complex (so less used).

Application: grinding plastic, pasty, and oily materials such as peanuts.

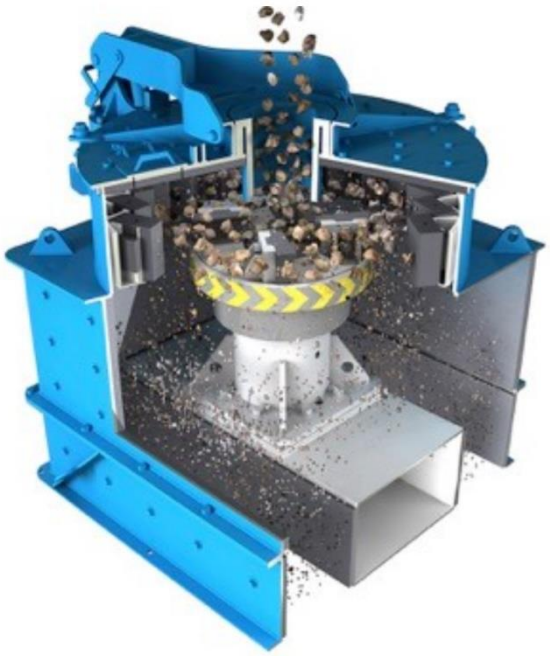

Figure 3-5. Vertical shaft impact crusher (Marcotte, 2020)

Hammer mill

Principle of operation: the process of grinding in a hammer mill is due to the impact of the hammer on the material, the impact between the materials on the chamber, and by the rubbing of the material with the hammer or with the inner surface of the chamber. When the material is feed into the crusher from the top of the machine, thanks to gravity, it falls or slips into the impact area of the hammer which is rotating at high speed. After impacting, the material breaks into pieces and flies with a reflective angle of about 90˚, forming a crushing zone. When flying, the debris hit the pads (attached to the reacting plates) on the inner surface of the chamber, it goes back to the hammerhead for further grinding, continuing until the material was small enough to pass through the screen.

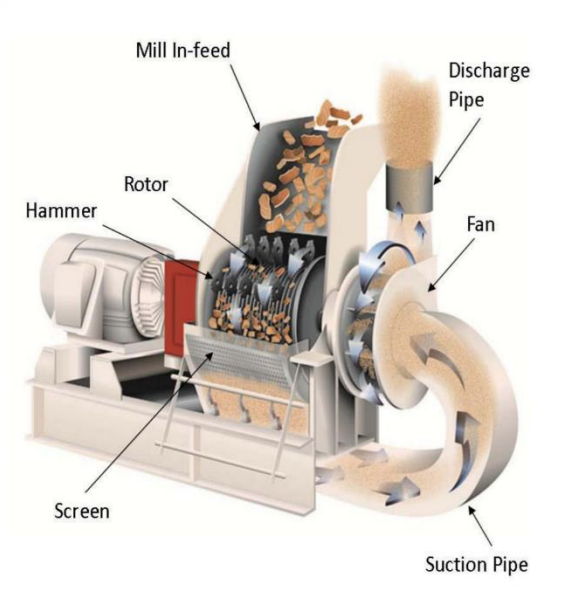

Figure 3-6. Diagram of hammer mill (Schutte Buffalo, 2019)

Advantages:

- Large hammerhead (up to 50 mm).
- The rotation speed of the hammer is very high.
- High productivity.
- Simple structure, convenient for mechanizing.

Disadvantages:

- Quickly abrasive hammer
- When the material moisture is more than 15%, the hammer is sticky. However, the moisture content of avocado is less than 10%; hence, this disadvantage does not affect the grinding process.
- When the original material is too hard, the grinding efficiency is not high.
- Because the machine has a high speed, it produces a lot of noise and dust

Application: It is not suitable for flexible, sticky, high moisture materials.

Figure 3-7. Corn hammer mill (Farthest, 2013)

3.2 Gerenal concept

In the mentioned options, the hammer mill is optimal because of its high productivity, the avocado powder reaches the required smoothness. Additionally, the avocado after drying is not shaped like nuts, usually in the form of slices, it is not suitable for attrition mill.

According to project research, the general pulverising machines are designed in two concepts: using container or cyclone to discharge finished products.

3.2.1 Using a container to discharge finished product

In general, the basic pulverising machine is using container to discharge the finished material which shows in figure 3-8.

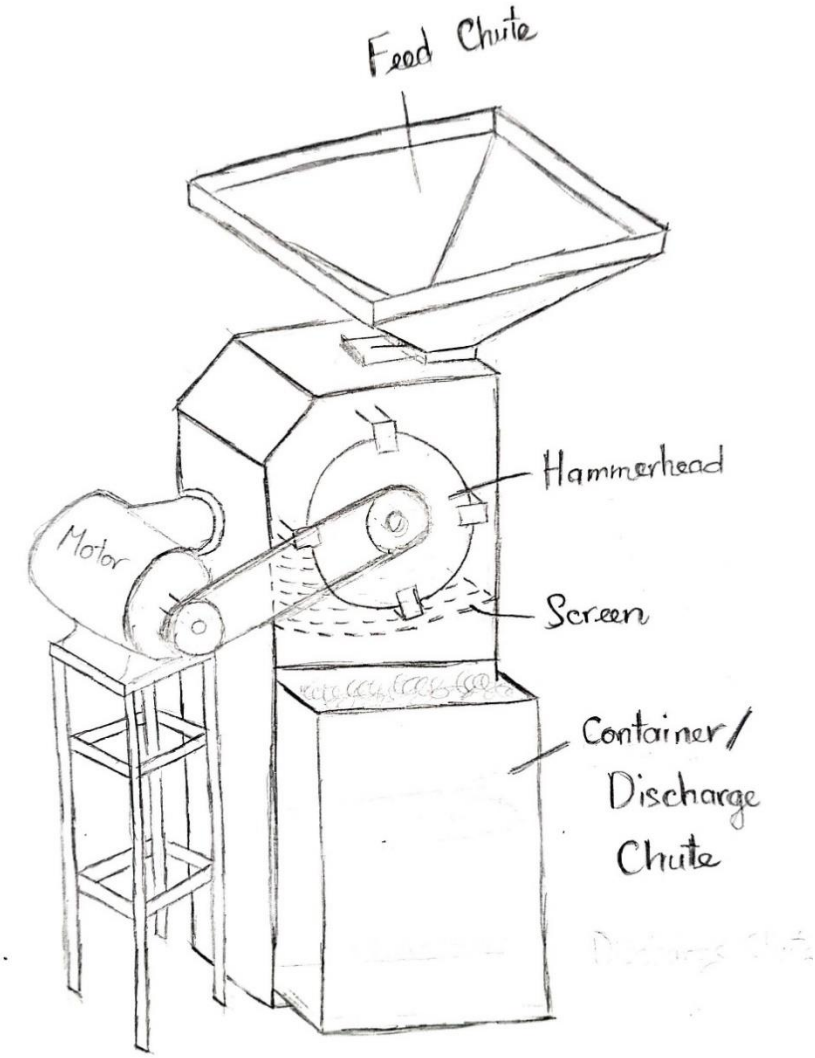

Figure 3-8. General diagram of pulverising machine using container

Principle of operation: Dried material which goes into pulverizing machine through the feed chute, is smashed into powder in the grinding chamber. The pulverized powder is brought to the container. The finished powder is stable in the container and waiting to package.

General specification: Based on the research of some grinding machine in Schutte Hammermill (2019), table 3-2 is shown some general specification of pulverising machine using the container to discharge finished product.

Table 3-2. General specifications of pulverising machine using container

Parameters	Value	Unit
Chamber size	550 x 400 x 1000	mm
Speed	3000	rpm
Motor power	4 – 6	kW
Voltage	320 – 400	V
Load current	10.2	A
Shaft diameter	30 – 60	mm
Rotor diameter	30 – 60	mm
Feed chute capacity	0.05	m^3
Container	0.2	m^3
Frame	1300 x 700 x 1200	mm
Weight	100 – 1000	kg

3.2.2 Using cyclone to discharge finished product

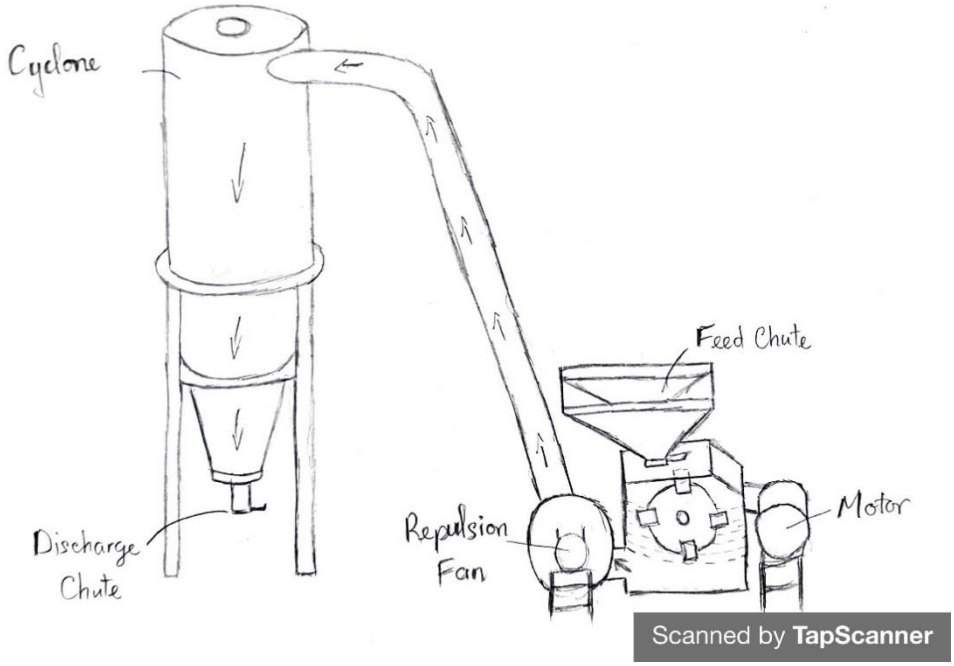

Figure 3-9. General diagram of pulverising machine using cyclone

The foundation of pulverising machine is using cyclone to discharge the finished material which shows in figure 3-9

Principle of operation: Dried material which goes into pulverizing machine through the feed chute, is smashed into powder in the pulverising chamber. The pulverized powder is brought to the cyclone by the attraction and repulsion fan through the pipeline. The finished powder is stable in the cyclone and waiting to package.

General specification: Based on the research of some grinding machine in Schutte Hammermill (2019), the table 3-3 is shown some general specification of pulverising machine using a cyclone to discharge finished product.

Table 3-3. General specifications of pulverising machine using cyclone

Parameters	Value	Unit
Chamber size	550 x 400 x 550	mm
Speed	3000	rpm

Motor power	4 – 6	kW
Horsepower range	2 – 100	HP
Voltage	320 – 400	V
Load current	10.2	A
Shaft diameter	30 – 60	mm
Rotor diameter	30 – 60	mm
Feed chute capacity	0.05	m^3
Cyclone	0.71	m^3
Frame	3200 x 1200 x 2800	mm
Weight	100 – 1000	kg

3.3 Evaluate concept

Conforming to the study, the selected concept is applied to the matrix method. Some criteria (such as hygiene, mechanical, area space, etc.) of two pulverising machines should be compared with its value

Table 3-4. Matrix method for pulverising machine selection

		Container		**Cyclone**	
Criteria	**Value (1 – 10)**	**Points**	**Score**	**Points**	**Score**
Hygiene	10	6	60	9	90
Mechanical	7	8	56	7	49
Consuming energy	9	9	81	7	63
Investment cost	8	7	56	6	48
Area space	7	9	63	6	42
Maintenance cost	8	8	64	7	56
Productivity	9	7	63	9	81

Sensory	8	8	64	8	64
Product quality	10	8	80	10	100
Extra time	6	6	36	9	54
Sum of points		76	623	78	647

By matrix method above, pulverising machine which is using a cyclone to discharge the finished product is chosen because of its advantages. On the other hand, the cyclone is usually used in industry, high productivity, semi-continuous, or continuous and easily mechanized.

4 Manufacturing specification

In general, the target specification of pulverising machine is set in table 4-1 below

Table 4-1. Target specification of pulverising machine

	Value	***Unit***
Production capacity	800 – 1000	kg/hour
Time to refill feed chute	1 – 2	minute(s)
RPM range	29 – 4060	rpm
Frame	3200 x 1200 x 2800	mm
Torque transmitted to the shaft	10000 – 20000	Nmm
Grinding ratio	25 – 30	
Safety factor	1.5	
Practical ratio transmission	1.1	
Total frame weight	250 – 300	kg

The manufacturing specifications are created based on the detailed calculation,

simulation test, practical experiments, and the production specification of pulverising equipment. The detailed calculation is performed with simulation test document and 2D-drawing which are made in Solidwork software in the attached documents. The table 4-2 shows some foundation resuft of process.

Table 4-2. Manufacturing specification of pulverising machine

	Parameters	Symbol	Value	Unit
Main	Production capacity		875	kg/hour
	Time to refill feed chute		1.5	minute(s)
	Frame	L x W x H	3200 x 1200 x 2800	mm
	Speed		3000	rpm
	Torque transmitted to the shaft	M_x	18099	Nmm
	Power transmitted to the shaft	N	5.28	kW
	Grinding ratio	i	27	
	Safety factor	k_{sf}	1.5	
	Practical ratio transmission	i	1.1	
	Total weight		280	kg
Hammer-head	Hammer velocity	v_{hammer}	70	m/s
Rotor	Rotor length	L	320	mm
	Rotational speed of the rotor	n	2786	rpm

	The outside diameter of rotor	D_{rotor}	40	mm
Chamber	Material of chamber	S355 J2		
	Chamber size	L x W x H	536 x 376 x 548	mm
	Chamber volume	$V_{chamber}$	0.12	m^3
Screen (Sieve)	Screen thickness	t_s	1	mm
	Screen hole diameter	d_s	2	mm
Motor	Motor type	5.523TECCB3-IE3 (TEC Motor, 2020)		
	Engine power	N_{motor}	5.5	kW
	Output speed	n_{motor}	300	rpm
	Torque of motor	T_{motor}	17.52	Nm
	Voltage	U_{motor}	400	V
	Load current	I_{motor}	10.2	A
Feed chute	Feed chute diameter	l x w x h	700 x 700 x 250	mm
	Volume of feed chute	V	0.063	m^3
Cyclone	Working volume of cyclone	V_w	0.71	m^3
	Height of cyclone	$H_{cyclone}$	2.18	m

5 3D Modeling of pulverising (grinding) machine

There are some views of pulverising (grinding) equipment in the machine.

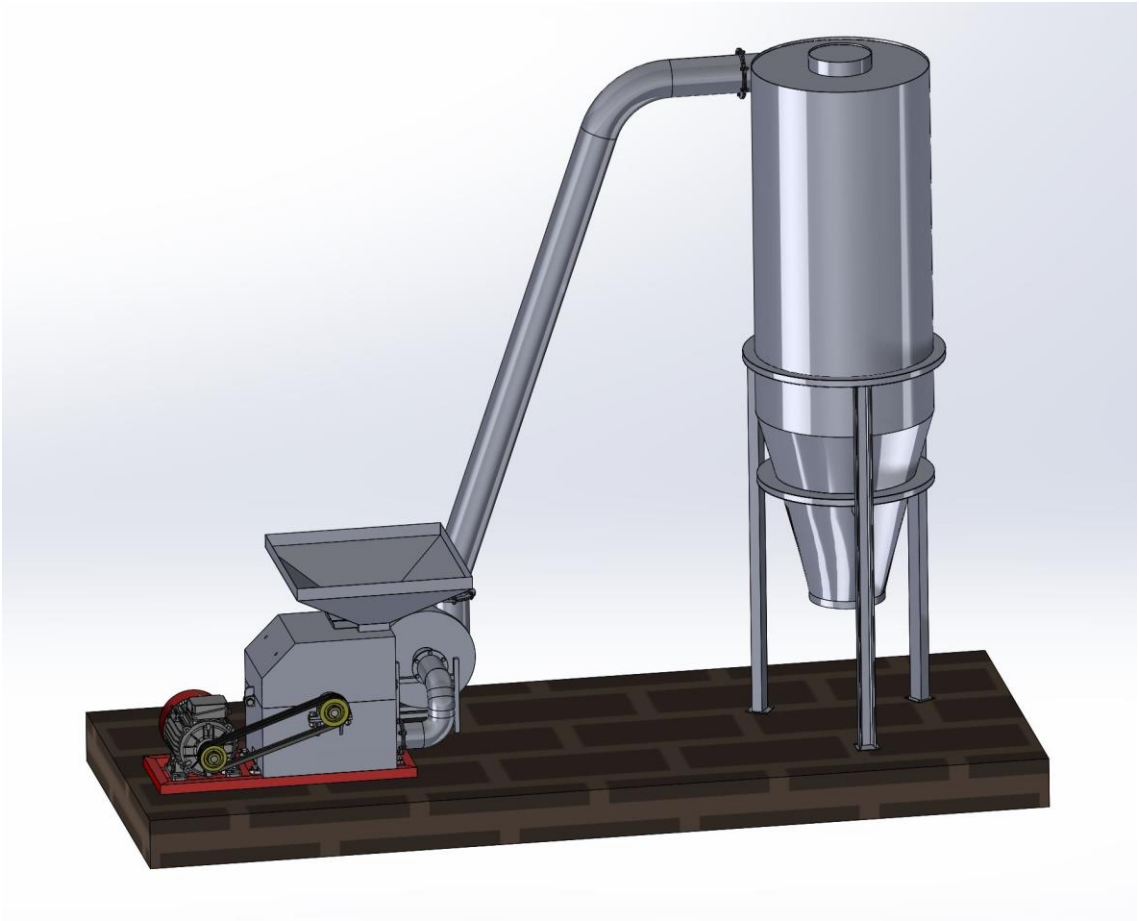

Figure 5-1. Front view of grinding machine

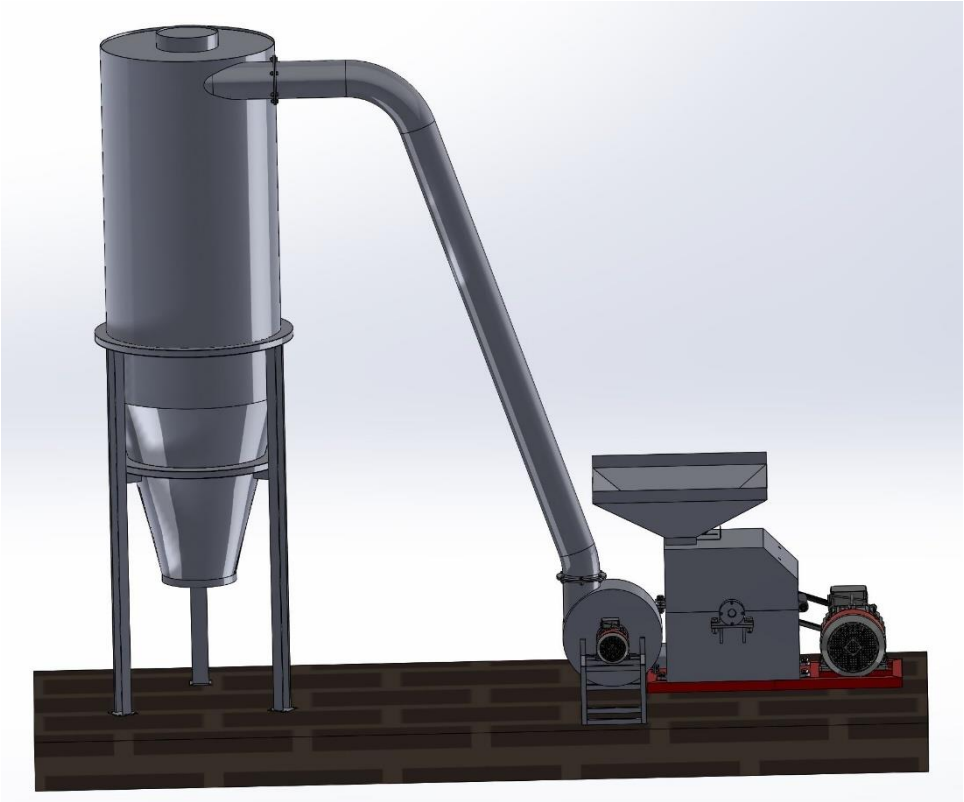

Figure 5-2. Back view of grinding machine

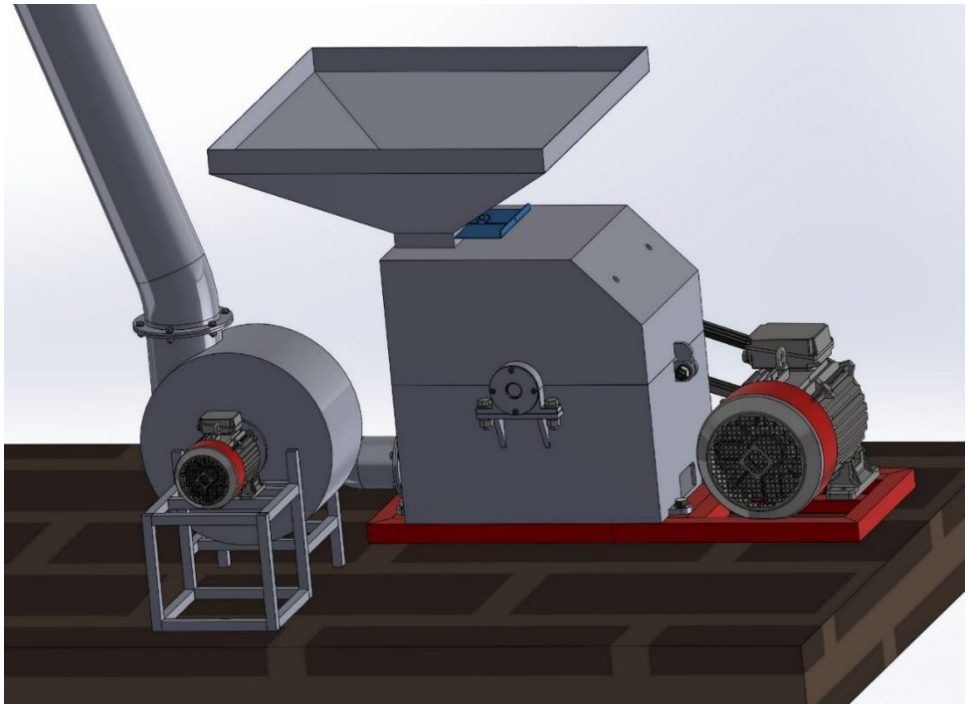

Figure 5-3. Backside of motor and hammerhead part

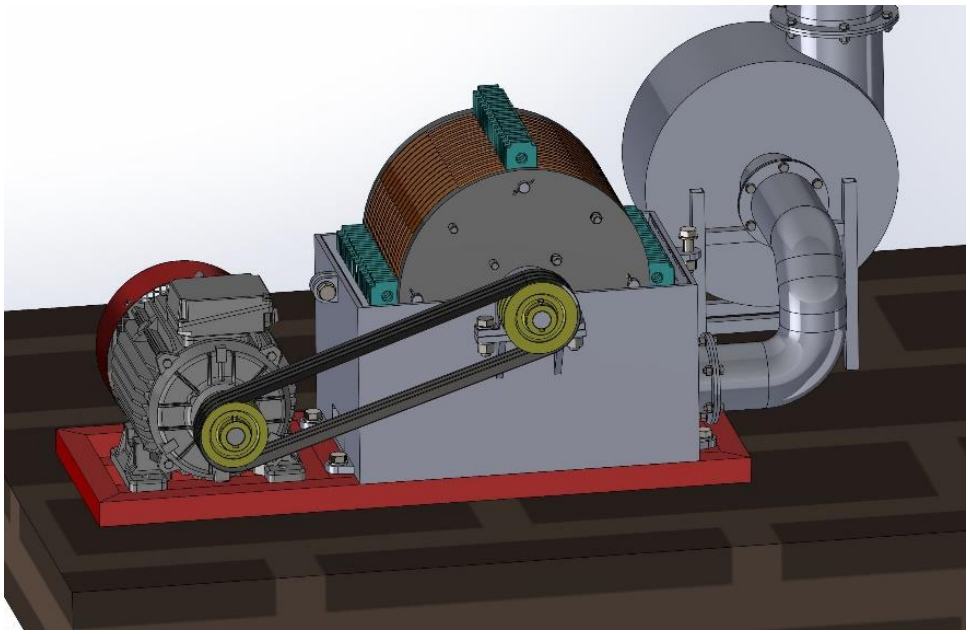

Figure 5-4. Hammerhead system inside the grinding machine with motor

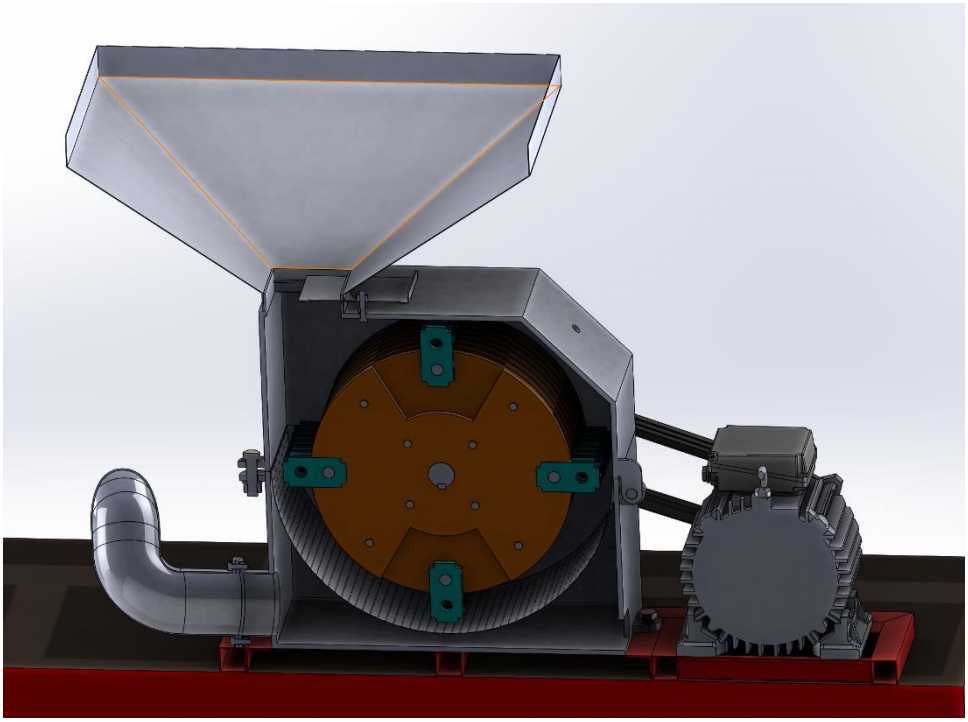

Figure 5-5. The section view of pulverising system

6 Conclusion

The thesis is divided into some parts that are linked together so that readers can easily take ideas and knowledge. During the process of studying and calculating, due to the experimental conditions as well as limited knowledge, many resources on the internet confused, the project is completed later than scheduled.

The project is implemented in Vietnam, so there are many technical limitations such as design products are not applied exactly according to the structure of LAB university of applied sciences Ltd. However, the opportunity when implementing this thesis is visiting and conduct experiments in factories, or labs of Vietnam universities (private university).

During the process, with the dedication of the instructors, even though there are many obstacles in the design equipment, the thesis can still be completed. There were errors during the test such as data redundancy, inaccurate information with the source, errors during project inspection, incomplete design drawings, etc. It is improved through teacher feedback with the elimination of redundant data, re-checking information references, using supportive software for computational checking (such as Solidwork ...), editing drawings according to EU standards for manufacturing ...

Through the topic, knowledge of pulverising (grinding) methods and equipment in the food industry, standards on food safety and hygiene, and the durability of equipment are expanded. Due to the limitation of economics, the project could not be implemented despite being highly practical.

The specifications in the project need experimentation to verify and change further. The project can be improved in the future by developing on the design of automatic material feeding and retrieval system, sensor system design, temperature adjustment, and implemented as a practical model.

List of tables

List of figures

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