DEVELOPMENT OF ROUGH GRINDING EQUIPMENT FOR RAW BIOMASS RESOURCE

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Thesis submitted in fulfillment of the requirementsfor award of the degree of
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EXAMINERS APPROVAL DOCUMENT

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I certify that the thesis entitled 'Development of Rough Grinding Equipment for Raw Biomass Resource' is written by Muhammad Haikal B. Abdullah with matric number MH09044. I have examined the final copy of this report and in my opinion, it is fully adequate in terms of language standard, and report formatting requirement for the award of the degreeof Bachelor in Mechanical Engineering with Automotive Engineering. I herewith recommend that it be accepted in fulfillment of the requirements for the degree of Bachelor Engineering.

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I hereby declare that the work in this report is my own, except for quotations and summaries which have been duly acknowledged. The report has not been accepted for any other Degree and is not concurrently submitted for award of other degree.

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DEDICATION

Specially dedicated to

My beloved family and those who have

Encourage and always be with me during hard times

And inspired me throughout my journey of learning

ACKNOWLEDGEMENTS

Praise to god Allah S.W.T that I am so grateful in preparing this project report. This project had taught me in many ways, something I couldn’t get in classes. I was able to contact with many important people, researcher, lecturers, and engineers. They have contributed towards my understanding and thought in accomplishing this project. In particular, I am indebted and I want to express my sincere appreciation to my project supervisor Prof. Dato. Dr. Hj. Rosli Bin Abu Bakarfor encouragement, guidance, comments, and knowledge that he had taught to me. I am also very thankful to my co-supervisor Dr. Gan Leong Ming for his time, guidance, and knowledge towards this project.

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Last but not least, I am very grateful to all my family members for their support, advises and motivation for encouraging me not giving up whenever I feel down and hopeless. This project wouldn’t be succeedingwith one man alone. I do hope for whom that does help me with this project may achieve success in their future life. Thank you.

ABSTRACT

This researchdeals with the development of rough grinding equipment for raw biomass resource.Significant of this project is to provide equipment to grind the raw biomass materials and produce standard size of particle materials. The objective of this thesis is to develop grinding machine for raw biomass and to fabricate a grinding machine for raw biomass. The thesis describes finite element analysis techniques to predict the displacement magnitude and identify the worst stress locates in the structures. The structural of three-dimensional solid modeling of the machine grinding was developed using Solidworks software. The strategy of validation of finite element model was developed. The finite element analysis was then performed using SolidWorks Simulation. The machine grinding for biomass structure was analyzed using the static stress with linear material models approaches. The result of simulation show the minimum factor of safety is greater than 1 which means this frame and shaft machine grinding is in safe condition. In fabrication process,the machine grinding will be fabricated based on the design has been made. Fabrication process has involves mechanical processes such as grinding, drilling, cutting, milling and etc. Test run on the machine grinding will be done after all process had been completed to get the standard size of particles from output materials. As a conclusion, the development of rough grinding equipment for raw biomass resource was been developed and the result of the simulation and output materials from machine grinding show the positive result.

ABSTRAK

Kajian ini berkaitan dengan pembangunan peralatan pengisaran kasar bagi sumber biomas mentah. Penting projek ini adalah untuk menyediakan peralatan untuk mengisar bahan-bahan mentah biomas dan menghasilkan saiz standard bahan zarah. Objektif projek ini adalah untuk membangunkan mesin penggiling bagi biomas mentah dan untuk membangunkan mesin pengisaran untuk biojisim mentah. Tesis menerangkan terhingga teknik analisis unsur untuk meramalkan magnitud anjakan dan mengenal pasti menempatkan tekanan paling teruk dalam struktur. Struktur model tiga dimensi yang kukuh mesin pengisaran telah dibangunkan menggunakan perisian Solidworks. Strategi pengesahan model unsur terhingga telah dibangunkan. Analisis unsur terhingga kemudian dilakukan dengan menggunakan Solidworks Simulasi. Mesin pengisaran untuk struktur biomas telah dianalisis dengan menggunakan tekanan statik dengan model linear pendekatan material. Hasil simulasi menunjukkan faktor keselamatan minimum adalah lebih besar daripada 1, yang bermakna bingkai dan aci ini mesin pengisaran adalah dalam keadaan selamat. Dalam proses fabrikasi, mesin pengisar akan direka berdasarkan reka bentuk yang telah dibuat. Proses fabrikasi telah melibatkan proses mekanikal seperti mengisar, menggerudi, memotong, pengilangan dan lain-lain Ujian dijalankan pada mesin pengisar akan dilakukan selepas semua proses telah selesai untuk mendapatkan saiz yang standard zarah daripada bahan-bahan keluaran. Kesimpulannya, pembangunan peralatan pengisaran kasar bagi sumber biomas mentah telah dibangunkan dan hasil daripada bahan-bahan simulasi dan pengeluaran dari mesin penggiling menunjukkan hasil yang positif.

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LIST OF SYMBOLS

T	Torque
P_{hp}	Power
n	Revolution per minute
F	Force
r	Radius of sprocket

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Renewable energy is of growing importance in satisfying environmental concerns over fossil fuel usage. These can provide the only source of renewable liquid, gaseous and solid fuels. Biomass is considered the renewable energy source with the highest potential to contribute to the energy needs of modern society for both the developed and developing economies worldwide. Biomass resources include various natural and derived materials, such as woody and herbaceous species, wood wastes, bagasse, agricultural and industrial residues, waste paper, municipal solid waste, sawdust, bio solids, grass, waste from food processing, animal wastes, aquatic plants and algae etc. Recently, owing to environmental and economic considerations, interest in utilizing biomass for the production of energy and chemicals is increasing.

Malaysia as the largest producer of palm oil in the world generates a significant amount of oil palm wastes. This is true in the cases of some other Asean countries as well. According to a study by (Yatim 2003), Malaysia generates 7.7 million tonnes of empty fruit bunches (EFB) 6.0 million tonnes of fiber and 2.4 million tonnes of palm shell every year as wastes. EFB are not considered for fuel because of its high moisture content (65%). The fiber wastes are used to generate energy to run the palm oil mill by incinerating the waste for power and fertilizer purposes.

According to (Ngan and Ang, 2001), it must be emphasized that palm oil mills generally have excess fiber and shell which are not used and have to be disposed off separately. There are more than 270 palm oil mills operating in Malaysia that utilize mainly fiber and partly shell in their boilers as fuel to generate power and steam required by the industry. The fiber is fully required in the mill for this purpose. However, only about 30% of shell is utilized for this purpose (Shamsuddin, 2004). Besides, the present utilization of this palm waste as boiler fuel is creating a serious emission problem in the industry.

From a recent study conducted by (Rozaineel,2000), it appears that more than 80% of the boilers emit particles exceeding 0.4 g Nm-3, the permissible limit set by the Department Of Environment. The study showed that the range of emission varied from 0.25 to 3.73 gNm^{-3} From another study by (Yusofel, 2000), it was found that the boilers, using palm waste as fuel at palm oil mills, are producing very much higher levels of dust emission of up to 11.6 gNm^{-3} compared to the allowable limit of 0.4 g Nm-3 causing a serious environmental problem.

Thus, it is important to find some ways and means to use these wastes in a mannerthat does not pollute the environment and at the same time, provide improved materials and energy. It is currently widely acknowledged that the most ecologically sound way to treat a worn-out waste product is pyrolysis.

1.2 PROBLEM STATEMENTS

Generally, it is accepted worldwide that climate change is currently the most pressing global environmental problem facing humanity. Scientific data showed that hundreds of millions of people could lose their lives if the average global temperatures increase by more than2°C. In addition, up to one million species of animals and plants are currently at the threat of extinction. Use a palm oil as bio fuel and biomass energy.

The Fourth Assessment Report (AR4) which was released on 17 December 2007 of the United Nation Inter governmental Panel on Climate Change (IPCC) concluded that the observed warming over the last 50 years is likely due to the increase of green house gas emission such as carbon dioxide, methane and nitrous oxide (Hopwood et al, 2000). Nevertheless, carbon dioxide has been identified as the main culprit due to its huge emission and therefore, utilization of fossil fuel as a source of energy for heat, electricity and transportation fuel have been identified as the primary cause of global warming.

Besides that, from considering the current state of energy crisis with the price of crude petroleum hitting record high every other day. Apart from that, its utilization as a source of energy will bring other environmental benefit like reduction in CO_2 emissions. This problem can be overcome since oil palm biomass can be used as alternative fuel in the power generation meanwhile bio-ethanol and bio-methanol can be used as vehicles fuel.

The grinding is one of the methods for processing biomaterials, very little is known about optimizing the process based on the mechanical properties of the material to be ground.So to implement,grinding equipmentfor raw biomass material fuelis required tobedeveloped.

1.3 OBJECTIVES

The objective for this project is as following:

a. To develop grinding machine for raw biomass.
b. To fabricate a grinding machine for raw biomass.

1.4 SCOPES

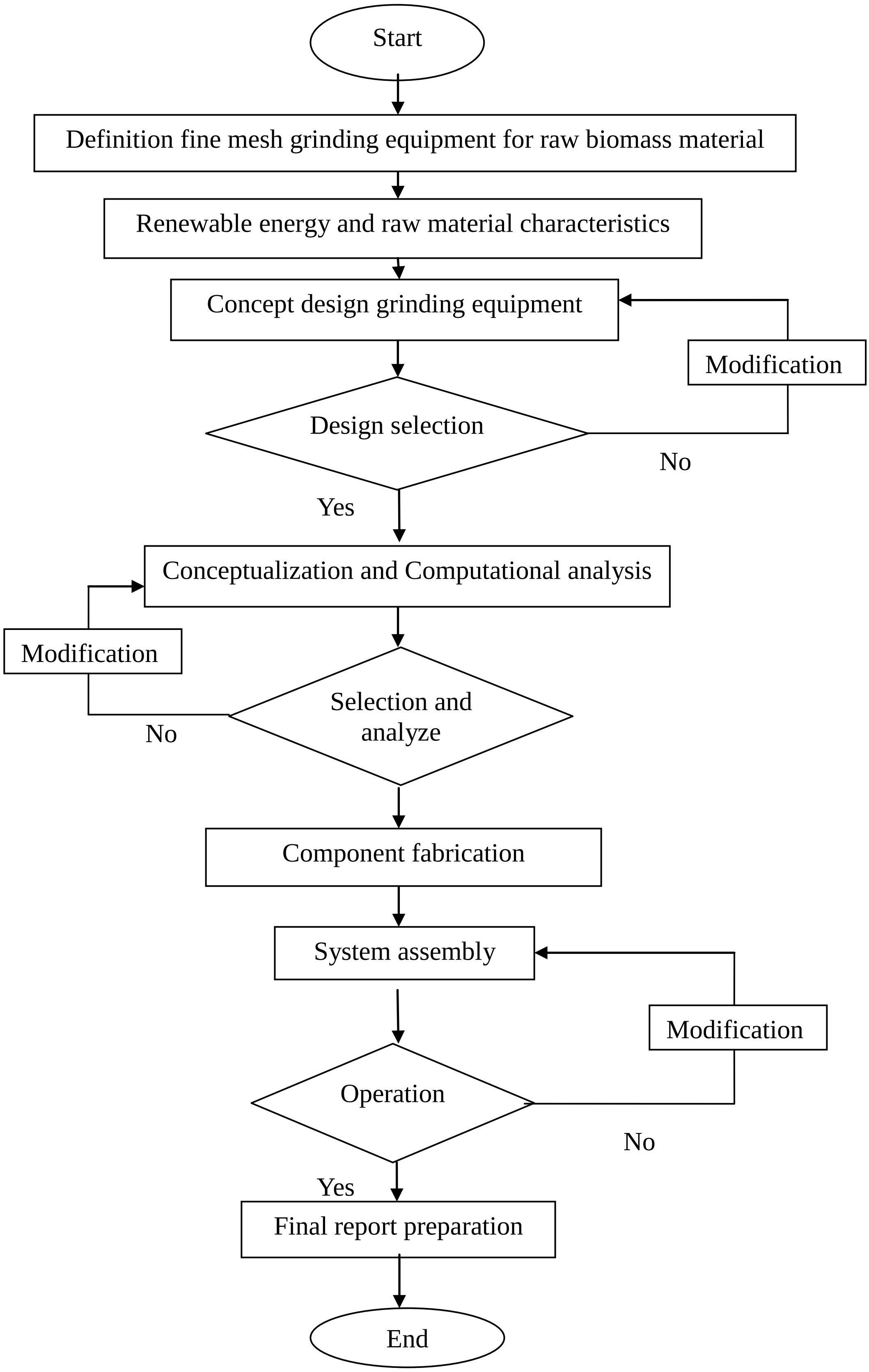
This scope for this project is as following:

a. Development of model grinding for raw material biomass using solid works.
b. Development and fabrication for grinding for raw material biomass.
c. Computational analysis on fabrication model.
d. Working model.
e. Final report preparation.

1.5 HYPOTHESES

Rough grinding equipment for raw biomass resourcecouldachieve allaspectsin design considerationwhichisfunctionalityandtheabilityof themachine grinding.Bytheend of thedevelopment,machine grinding will working and able to grind raw biomass resource.

1.6 FLOW CHART



1.7 GANTT CHART (ReferAppendix A)

CHAPTER 2

LITERATURE REVIEW

2.1 RENEWABLE ENERGY SOURCE (RES)

A renewable energy source (RES) can be defined as a simple sustainable resource available over the long term at a reasonable cost that can be used for any task without negative effects. Other authors consider RESs as clean sources of energy and that the optimal use of these resources minimizes environmental impacts produces minimum secondary wastes and is sustainable based on current and future economic and social needs (NL Panwar et al, 2011). Positive points in the use of RESs are the increased diversity in energy supply options, both for developed and developing countries (PD. Lund, 2009), less dependence on fossil fuels, the increase of net employment, the creation of export markets and a reduction in greenhouse gas emissions and climate change (R Sims, 2003)

Renewable energy takes on many forms, and usually describes using natural resources that won’t run out. There are several main renewable energy technologies in use, most of which are directly or indirectly due to the sun such as wind turbine, solar power and power generation from sea wave. But these kinds of renewable energy is not commercially used and based on geography of certain places for example, in sunny climates, it makes more sense to create renewable energy from solar panels, whereas in coastal areas, it may be more efficient and effective to use wave or tidal power.Three Gorges dam, the largest renewable electricity source in the world, having displaced 1.3 million people, (Lin Yang, 2007) and garnered environmental criticism.

To overcome these, biomass seems be more promising as a source of renewable energy as it is more reliable and sustainable source. Biomass can be found anywhere and can be replaced. As the need for alternative forms of energy become more important, biomass can play a bigger part for the production of fuel and electricity generations.

2.2 BIOMASS

Biomass refers to living and recently dead biological material that can be used as fuel or for industrial production. Most commonly, biomass refers to plant matter grown to generate electricity or produce bio fuel, but it also includes plant or animal matter used for production of fibers, chemicals or heat. Biomass may also include biodegradable wastes that can be burnt as fuel. Fossil fuels such as coal and oil are not considered to be biomass as they are not recently dead, nor were they produced especially to become biomass.

Biomass is carbon based and is composed of a mixture of organic molecules containing hydrogen, usually including atoms of oxygen, often nitrogen and also small quantities of other atoms, including alkali, alkaline earth and heavy metals. These metals are often found in functional molecules such as the porphyrins which include chlorophyll which contains magnesium. The carbon used to construct biomass is absorbed from the atmosphere as carbon dioxide CO_2 by plant life, using energy from the sun. Plants may subsequently be eaten by animals and thus converted into animal biomass. However the primary absorption is performed by plants. If plant material is not eaten it is generally either broken down by microorganisms or burned.

If broken down it releases the carbon back to the atmosphere, mainly as either carbon dioxide CO_2or methane CH_4, depending upon the conditions and processes involved. If burned the carbon is returned to the atmosphere as CO_2.These processes have happened for as long as there have been plants on Earth and is part of what is known as the carbon cycle.

2.3 SOURCES OF BIOMASS IN MALAYSIA

Malaysia is bestowed with significant of biomass resources. The agriculture and forestry sectors produce a large amount of residues from oil palm, wood, rubber tree and rice that has no other commercial values then potential energy generation. In addition, urban waste and some animal waste can be used to generate energy. The existence of the waste and residues has created some disposal problem to the country.

A large portion of renewable resource is contributed by biomass, namely oil palm waste, and wood waste, which are used to produce steam for processing activities and also for generating electricity. Biomass fuel contributed to about 16% of energy consumption in the country, out of which 51% come from palm oil biomass waste and 27%, wood wastes. Other biomass energy contributors are from plant cultivations, animal and urban waste. There are currently more than 300 palm oil mills in operation, which self generates electricity from oil palm waste not only for their internal consumption but also for surrounding remote areas.

Palm oil is one of the world's most rapidly expanding equatorial crops. Indonesia and Malaysia are the two east oil palm producing countries and is rich with numerous endemic, forest-dwelling species. Malaysia has a tropical climate and is prosperous in natural resources. Oil palm currently occupies the largest acreage of farmed land in Malaysia (Tengku Mohd Ariff et al, 2001). The oil palm is grown for its oil and other part something valuable. Through certain process palm oil and palm kernel oil are extracting from monocarp and kernels respectively. In general, fresh fruit bunches contain 27 % palm oil by weight, 6-7% palm kernel, 14-15% fiber, 6-7% shell and 23% empty fruit bunch (EFB) material. The energy generating of oil palm comes from processing by-products, replanting residues and palm oil mil effluents (POME). The biomass from POM is burned in the boiler that produces process steam and electricity in a cogeneration system.

Malaysia is one of the major wood processing countries in the region. Wood are currently the largest renewable energy potential in the country. The greatest potential for developing wood as a source of energy is to use wood residues that have no other commercial values. Peninsular Malaysia is currently harvesting about 1.2 million tons per year of log. This amount is estimated to have 18 trillion joules of energy. However, this only represents 60 to 65 % of total harvested trees. The remaining percentage is left to rot or burn.

Malaysia is one of the biggest rubber producers in the world. Replanting and conversing of rubber land is the important source of rubber wood. Rubber wood has been used for fuelling various drying process such as smoking rubber sheet, drying cocoa beans and also drying and curing of wood as well as drying bricks. Since rubber wood becomes popular in furniture industries, the use as fuel has declined.

Waste generated rubber industry can be classified as coming from three sources. The first one is the biomass generated from fallen leaves, branches and twigs as well as rubber seeds. Most of this biomass is being left to root on the plantation ground, even though some branches and twigs are used for domestic fuel. The second source consists of effluents that are produce after processing of latex. The third sources of bio wastes, is rubber wood that become available in large quantities during replanting activities.

Paddy cultivation in Malaysia is concentrated in the state of Kedah and Selangor. The cultivation of paddy leave two type of residues: Paddy straw and rice husk. Even though the potential of biomass energy from paddy cultivation can be contributed quite a percentage of country demand, paddy waste is most difficult to handle. Furthermore, they only available during harvesting season that happen only 1 to 3 time a year.

Most of the sugarcane cultivation appears in the northern states of peninsular Malaysia where a dry season is distinct. Malaysia has to import about 600 000 tons of sugar every year to meet the demand.

In term of biomass energy, sugarcane cultivation produces granulated sugar, bagasse and dry leave and cane tops that can potentially be converted into useful energy.

Animal wastes in large amount can cause hazard to environment and health if not properly managed. Animal farming areas are places where high concentration of this waste accumulated. Some of these animals are concentrated over a small area such as poultry and goat.

The oil palm industry in Malaysia started 80 years ago in a modest way. Today it is the largest in agricultural plantation sector, exceeding rubber plantation by more than double in area planted. Based on the researched from the World Wildlife Fund (WWF), Malaysia is currently the world's largest producer of palm oil, contributing of 50.9% of total global production. In terms of hectare, the total area under oil palm cultivation is over 2.65 millionhectares, producing over 8 million tonnes of oil annually. The oil consists of only 10% of the total biomes produced in the plantation. The remainder consists of huge amount oflignocelluloses materials such as oil palm fronds, trunks and empty fruit bunches.

2.4 TYPE OF GRINDING MACHINE

2.4.1 Hammer Mill Machine

A hammer mill (Schuttle Buffalo) with a 230 mm diameter rotor powered with a gasoline engine rated at 18 kW was used for grinding. The hammer mill rotor had sixteen swinging hammers in four sets pinned to its periphery. Length and thickness of each hammer were 178 and 6.4 mm, respectively. The performance of dull versus sharp hammers of same hammer thickness was investigated to explore whether any advantage could be realized by knife shear action, or whether the relative high velocity of impact dominated in the failure of fibrous biomass.

Hammer thickness of dull and sharp hammers were same to no introduce the variable hammer thickness into experiments. Previously, thin hammers performed better than thick hammers. Hammers tested included 90° (dull) and 30° (sharp) leading edges. An interchangeable classifying screen of 3.2 mm was mounted around the rotor.

Hammer clearance with screen was 5 mm. An engine rated speed of 3600 rpm powered the hammer mill at the same speed by using a V-groove pulley and belt drive system. Various engine throttle settings operated the hammer mill at speeds ranging from 2000 to 3600 rpm (5 levels) to examine speed effects. Corresponding tip speeds were 48 to 87 m/s, respectively. These speeds were within the range of commercial milling of agricultural products using hammer mills. Hammer mill bottom was connected to a dust collector maintaining a negative suction pressure of 60 mm of water to overcome air-flow resistance of 3.2 mm screen and biomass, to reduce dust losses, and to improve flow of input feed.

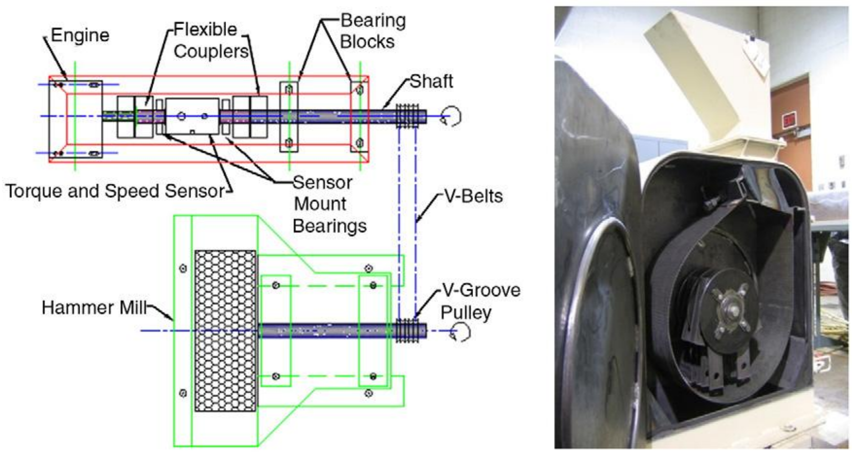


Figure 2.1: Overview of Hammer Mill Machine

Source: T. Yang el at(2007)

2.4.2 Knife Mill Machine

A commercial knife mill (H.C. Davis Sons Mfg.) with a 400 mm diameter rotor powered with a gasoline engine rated at 18 kW was used for chopping. The knife mill rotor had eight 75 mm-wide straight knife blades bolted to the rotor periphery. Length and thickness of single bevel edge blade were 600 and 12 mm, respectively. Knife blade lip angle was 45. Blades cleared two stationary shear bars indexed at about the 10 o’clock and 2 o’clock angular positions.

A uniform blade clearance of 3 mm was used. An interchangeable classifying screen was mounted in an arc of about 240 of angular rotation around the bottom side. Screen selections tested had opening diameters ranging from 12.7 to 50.8 mm (4 levels). An engine rated speed of 3600 rpm powered the knife mill at a speed of 507 rpm by using a V-groove pulley and belt drive system. Various engine throttle settings operated the knife mill at speeds ranging from 250 to 500 rpm (5 levels) to examine speed effects.

Figure2.2: Knife Mill Machine

Source: David R. Smith el al(2009)

2.4.3 Pin Mill Machine

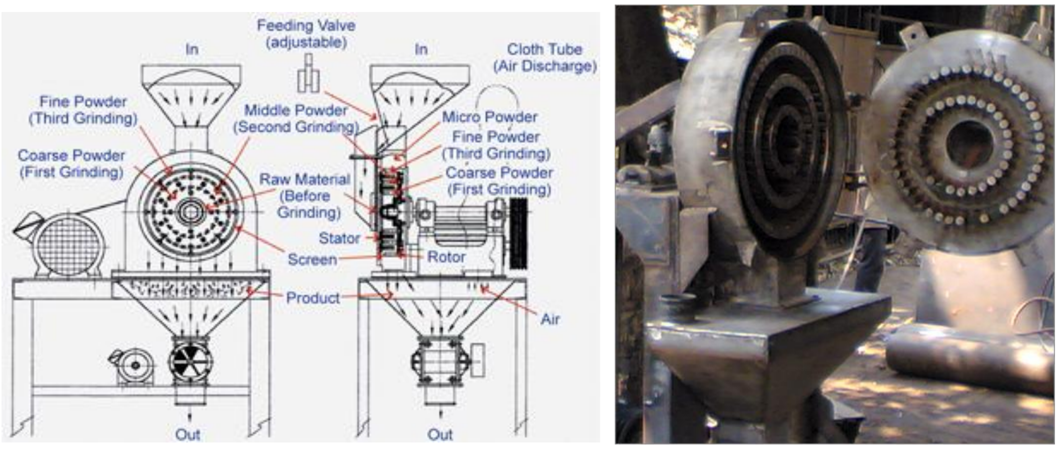


Figure2.3: Pin mill machine

Source: P. Bitrael et al (2007)

The grinding action within the Pin Mill is achieved by impacting the product particles with a series of hardened steel pins. Raw material is fed into the grinding chamber from the feeding hopper then passes through rows of pins rotating at high speed between stationary pins.

The first grinding is a shearing force created by the cutting impact of the inner rotor and stator. The product particles are shattered into fragments as they progress towards the outlet. This action creates a fan effect and a high volume of air is drawn through with the product, keeping it cool. After filtrating, any remaining coarser powder will be ground in the third grinding until it passes through the screen mesh. The finished product is discharged from the rotary valve. The machine's grinding action can be controlled by altering the feed rate to the machine and the speed of the rotor.

2.4.4 Disk Mill Machine

A disc mill is a piece of equipment used for crushing or grinding. The disc mill consists of a series of steel plates, or discs, that rotate within a machine to crush stones, metal, or other materials. Depending on the type of material being crushed or ground, the discs may have smooth or serrated edges. Some even have blades or spikes attached to the discs for cutting and shredding.

Vibrating disc mills use high-speed vibration to separate items after they have been crushed or ground. For example, a vibrating disc mill may be used to remove the shell from seeds or nuts, then to automatically dispose of the shells so the nuts can be easily collected. Single-wheeled models consist of one disc that runs along a steel base to grind items, while a double-wheeled disc mill crushes items by grinding them between two interconnected plates.

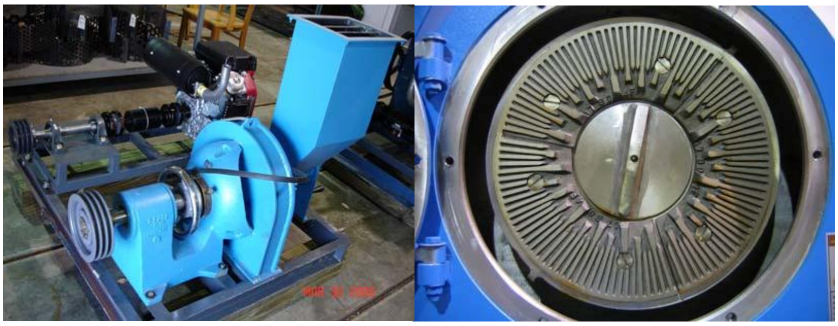


Figure 2.4: Disk mill machine

Source: T. Yang el al (2007)

2.5 GRINDING PROCESSES

(Austin, 1971) mathematically described grinding processes generally used for homogenous brittle materials. Topics included particle size distribution, differential equations describing particle breakage, and thee notion that grinding is a rate process dependent on some small period of time Δt. Continuous flow and batch grinding were considered.

(Mohsenin et al, 1976) determined the minimum pressure and hold time required to compact unconsolidated wood particles and forage cuttings, including high moisture grasses. Compactions of these biomaterials required pressure as high as 48,265kPa for a piston velocity of 33 cm/s. Three different forage materials (alfalfa hay, fresh alfalfa and grass) were tested. The maximum hay particle size was 80 mm after thehammermillling action of the shredder. The initial moisture content for grass was 51%. The test showed that lower moisture content yielded higher final density for both unshredded hay and shredded hay. The moisture content 8% w.b. and 25% w.b. for both unshredded hay and shredded had around 641-801 kg/m^3 and 320 kg/m^3 final density. Moisture content in the material also affected the residual stress. With increasing moisture content, less energy was required to get a certain initial density. Also, the influence of the moisture content on the energy requirement is related to the final density.

(Finner et al, 1976) developed a mathematical model based on the energy requirements for shearing whole alfalfa and corn stalks less ears. Their objective of the optimization was to minimize the shearing energy. They concluded that the higher the moisture content, the lower the shearing energy. The corn stalks could be sheared efficiently by setting the knives at clearance distances greater than zero while alfalfa required a clearance distance as near zero for efficient shearing. Parameters included knife dullness, clearance distance, moisture content, cutting force, normal force, shearing energy, and rotational speed.

(Nelson et al, 1982) emphasized the densification of cubing versus typical pellet milling. The pellet mill required 35-70 kwh/ton on a given raw material, whereas the cuber will require only 10-20 kwh/ton. Pellet mills are limited in the size of biomass particles that can be ground. The particles processed by pellet mills are generally restricted to 80% of the die-opening diameter or less. A cuber by contrast can more easily process particles. 75% of these particles are smaller than 3.2 cm.

(Heimann, 1983) used indicted that roller mills were 16% more energy effective than hammermills in reducing grain to a small particle size (approximately 400 microns). Roller mills were up to 86% more energy efficient than hammermills for processed grain particle sizes approaching 2000 microns. Less heat buildup in the roller mill appeared as an advantage. It should be pointed out that the grain was perhaps more brittle than many biomass feedstocks.

Related to require particle sizes, (Shen, 1987) developed a new method to produce a water resistant pellet from mill residue with a conventional pelletizing process plus a simple pretreatment of high-pressure steam for a short period of time. He suggested the following standard: coarse particles are those that cannot pass through a 5 mm mesh. Medium particles can pass through a 5 mm mesh, but cannot penetrate a 1.7 mm mesh. Fine particles can penetrate a 1.7 mm mesh. In animal feed, medium and fine size is desirable because of its moisture-absorbing properties.

(Vigneault et al, 1992) investigated hammer thickness effects on the hammermill grinding rate and energy consumption for grains and forage pellets. They examined 3.18 and 6.35 mm thick hammers for grinding corn, alfalfa pellets, and wheat grain. Results indicated that thin hammers saved 13.6% in energy consumption and increased the grinding rate by 11.1% for a similar quality of grain grind. The results also showed the specific energies ranged from 5.5 to 9.5 kWh/ton for hammer thickness ranging from 1.59 to 8.00 mm, respectively.(Guritno et al, 1994) observed that energy per unit mass of milled product and energy per unit surface area of milled product also decreased when the fast roll speed increased. These increased as the roller gap setting was reduced and as the differential speed decreased. When the rolls were set on the dull-to-dull configuration, the energy per unit mass increased, but the energy per unit surface area decreased.

(Iwaasa et al, 1995) studied the stem shearing force for three alfalfa cultivars grown under dry land and irrigated conditions. Shearing forces were higher for alfalfa stems grown under irrigation than under drying condition. Shearing force and stem diameter had a significant positive correlation. Also, shearing force at the bottom of the alfalfa stem was greater than at the stem middle and top.

(O'Dogherty et al, 1995) studied the physical properties of tensile and shear strength of cutting stems between wheat straw nodes. Tensile strength was in the range 21.2 to 31.2 MPa and shear strength in the range 4.91 to 7.26 MPa for the four stages, and Young's modulus was between 4.76 and 6.58 GPa. Measurements were done on physical properties, strength and elastic model; they found that plant maturity had some significant effects on shear strength.

(Pasikatan et al, 2001) studied the effect of roller mill gap and single-kernel properties on energy requirements for wheat grinding. They found that roll gap had an effect on specific energy, new specific surface area, energy per unit mass, and also did single kernel hardness. Also, they showed that roll differential, roll diameter, roll speed, and roll corrugation affected grinding energy. Energy consumption increased with the capacity of grinders. Net specific energy consumption increased as roll gap was reduced, but decreased as fast roll speed increased. Wheat class had a significant effect on the energy per unit mass, new specific surface area created and specific energy.

(Pasikatan et al, 2001) investigated the single kernel properties of wheat and the milling data based on roller mill's roll gap and the size properties of first-breaking ground wheat. The experimental first-break roller mill used in this study was 52.3 rad/s fast roll speed; 20.9 rad/s slow speed (2.5:1 roll speed differential); 1.34 kg/m-s feed rate. Former studies showed any variation below 50% of the theoretical feed rate would not affect ground wheat properties. They concluded that roll gap had an inverse effect on break release and a direct effect on geometric mean diameter. Single kernel hardness had a direct effect on geometric mean diameter and an inverse effect on break release. Single kernel mass had direct effects on geometric mean diameter and inverse effects on break release. Wheat class had a significant effect on break release and geometric mean diameter.

(Zhang et al, 2001) constructed a novel shredding/crushing machine (a forest harvester) and evaluated power requirements as a function of particle size as affected by roll speeds, speed difference, and minimum roll clearance. Increased clearance required increased specific energy. Minimum roll clearances of 10 mm (front rolls) and 1 mm (rear roll), along with unit roll forces of 15 N/mm (front) and 45 N/mm (rear) produced more processed material with thinner stalks and shorter pieces than the minimum roll clearance of pair 10 mm (front) and 2 mm (rear) or unit roll forces of 30 N/mm (front) and 30 N/mm (rear). Energy requirement was similar for roll speed differences of either 17% or 50%. There are very small differences in specific energy requirements among different speed treatment.

(Lopo, 2002) comparing three kinds of equipment (hammermill, roll mill, and vertical hammermill) that could produce a generally acceptable grind in the range of 600 to 800 μm. Hammer tip speed was a critical factor for good grinding. Typical tip speeds ranged from 81 to 117 m/s. He also concluded that the grind size depended on the roll gap. In order to improve size reduction, one of the rolls should rotate faster than the other, with the typical speed differentials ranging from 1.2:1 to 2.0:1 (fast to slow). Typical roll speeds range from 6.6 m/s for a 23-cm roll and 16 m/s for a 30-cm roll. The hammermill used energy less efficiently than a roller or vertical hammer mill. Comparing the vertical hammers and horizontal hammers, vertical hammer had lower energy consumption, less moisture loss, reduced grinding shrink, narrower particle size, and fewer fines.

2.6 EFFECT SIZE WITH ROTARY EQUIPMENT

Biomass utilization for bio-energy, bio-fuels or bio-products requires reduction of material size within specific ranges, depending on the feedstock species, handling and further material processing or conversion.

Biomass size reduction refers to mechanical treatment processes that significantly change the particle size, shape and bulk density of the material. These processes may involve one or a combination of the following types of actions.

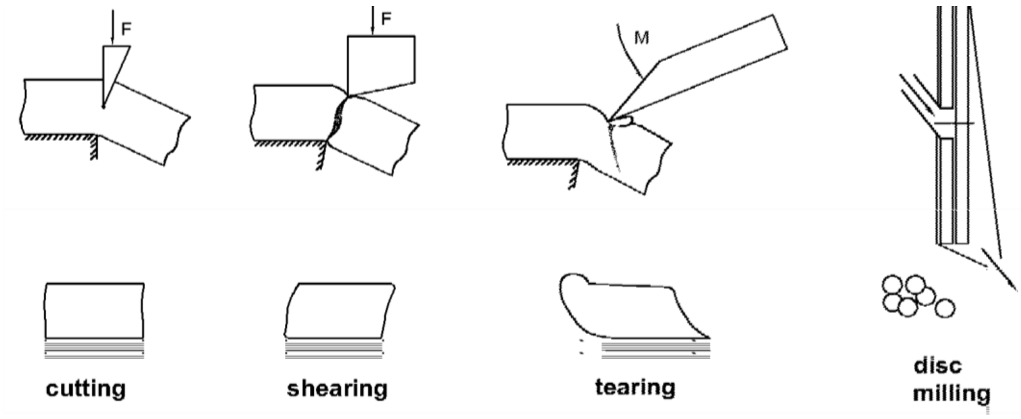


Figure 2.5: Cutting, shearing, tearing, impact stress, compression and friction, Types of actions and corresponding particle shapes

Source: T. Yang el al (2007)

The difference between cutting and shearing is defined by the way of deformation that occurs into the cross-section of material. Sharp knives are used for cutting while working tools with a wedge angle of 75° to 90° do the shearing. During cutting process the fracture of material is the result of splitting effect of the knife, while the shearing is the result of shear and tensile stress (Woldt et al, 2004).

During cutting process the deformation of material occurs locally and progressively, close to the tool tip, while during shearing the deformation zone extends before fracture between wedges of cutterhead and stationary knife. As a consequence, the cross-section of cut material is smooth, whereas for a sheared material the cross-section has a specific roughness.The combination of tensile stress with bending and torsion of the material is called tearing. (Woldt et al, 2004).

Impact loading occurs when a moving tool, such as a hammer, strikes the material. Then the material is usually fired against a fixed rigid target such as perforated surface of a sieve (Austin,2002).

The difference between cutting and shearing is defined by the way of deformation that occurs into the cross-section of material. Sharp knives are used for cutting while working tools with a wedge angle of 75° to 90° do the shearing. During cutting process the fracture of material is the result of splitting effect of the knife, while the shearing is the result of shear and tensile stress (Woldt et al, 2004).

Commination process of biomass can be described as a combination of shearing, torsion, compression and friction of the material with the active elements of equipment. There are three distinguished results of commination:

a. Particle sizing, shaping and classifying (coarse and intermediate size reduction)

b. Breaking connections between different material components (e.g. cell components).

Therefore, new reactive surfaces for subsequent bio-chemical treatments are created

Biomass particles have different shapes as a consequence of the stress loadings combination and magnitude applied to a certain material. Mohsenin, (1978) and Sitkei, (1986) presented a general and theoretical study of particle shapes as well as mathematical relationships to quantify an equivalent dimension such as equivalent diameter.(Paulrud et al, 2002) systematically researched wood particle shapes.

Different rotary equipment performs differently the commination processes as one or more phenomena become dominant in the grinding / milling space. Ideal equipment is the one that, through an innovative combination of stress loadings, it will efficiently disintegrate the material to a certain biomass fineness that corresponds to optimal working or reacting circumstances with microorganisms or chemical substances.

2.7 EQUIPMENT CLASSIFICATION, DESIGN, AND SELECTION

In the previous section, we have mentioned different types of stress loadings during size reduction processes. Different equipment design involves applying different combinations of stress loadings. (Scubertet al, 2004) and (Woldt et al, 2004) have done a systematic classification of such machines. In the following, the Table 3 and Figure 4 present an extended layout of this classification to better illustrate global experience in material comminution and to suggest further different pathways of biomass processing equipment design and research. Following this classification, we suggest that the knife mill, hammer mill and disc mill are proper equipment for biomass comminution. There are couples of rationales in support of this selection, as follows:

- Knife mills work successfully for shredding forages under various crops and machine conditions (Ige and Finner, 1976; Zhang et al., 2003)
- Hammer mills are widely used for materials comminution because of their high size reduction ratio, easy adjustment of particles size range as well as a relative good ‘cubic’ shape of particles (Nikolov, 2004, Mani, 2005). Many researches (Rypma, 1983; Hill and Pulkinen, 1988; Paulrud et al., 2002; Djordjevic et al., 2003; Austin, 2002/2004) have used hammer mills in studies of grinding of different materials.

Disc mills produces very small particles and study of their biomass milling process is therefore very important especially in connection to the size of input material (that might be provided by knife mills or hammer mills) and required specific processing energy.

CHAPTER 3

METHODOLOGY

3.1 CONCEPTUAL MACHINE GRINDING DESIGN

The first step of the project is to get idea to design the project. This is important to create the design going to made. A design is proposed based on the research, information gathering and the objective. This is like a preliminary design which includes design concepts and sketches. Theexact dimension and geometry of the machine going to be crated is determinedin this part. In this part, all the general idea inthis phase, a 3D drawing will be made and the design will be more detailed and the entire thing involved in the design will be taking in to consideration.

The literature review involved studies and collecting information, particularly from previous research. Researcher then reviewed the current issue or development grinding equipment for raw biomass, and made comparison among the researches to identify the flaw of existing systems. Problems or shortcomings were identified and remedies were proposed in hardware and software development stage.

Starting with information gathered on the machine structure followed by design concept or sketching the prototype of grinding equipment for raw material biomass will be evaluated in order to select the best design and drawn using Solid work or AutoCAD software’s. After designing process is completed, comes an analysis process on the frame machine which is to make sure whether the design can be used or not or maybe the design has to be modified.

In detail design phase, the dimension, tolerance and details are finalized. This design has to be analyzing to ensure it can work perfectly. These include stress distribution, deflection and, etc. after that a decision will be make whether to proceed with the design or make a modification on the design before proceed to next phase. Continuing the process is fabrication process which the frame will be fabricated based on the design has been made. Test run on the frame will be done after all process had been completed and if there are any problems occur, the process should rollback to designing process.

This process will follow by fabrication process in order to develop the design. Fabrication process involves all basic mechanical processes such as grinding, drilling, cutting and etc. Once the fabrication process finished the blade for grinding, frame grinder and the motor will be attached. The test run will be conducted if all the component valid and functional well.

3.2 DRAWING CONCEPT

There isthree of designwith different type of concept mechanism can be applied in the machine system that has been done in order to find one of the best. Between this three proposed designs, only one design will be chose and modified to be applied in the machine system.

3.2.1 First concept design

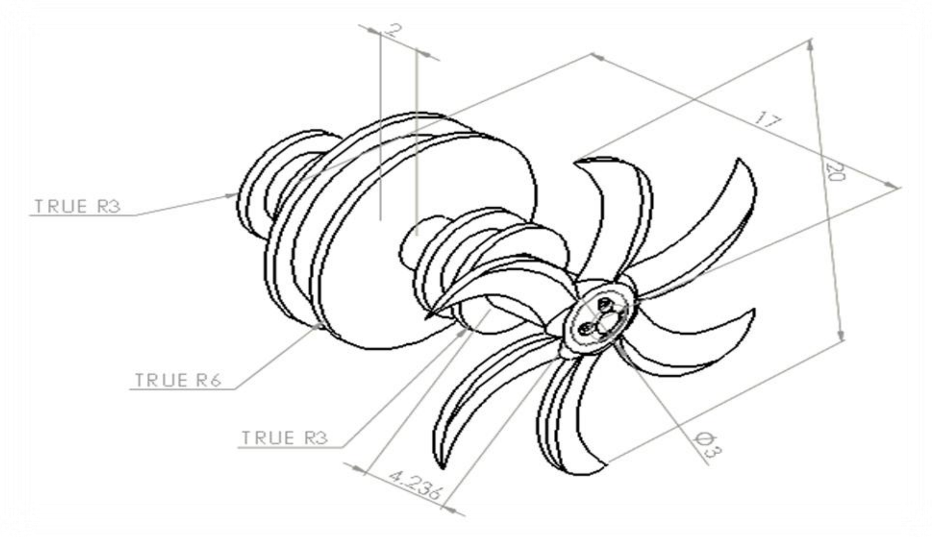


Figure 3.1: 1st blade design for raw biomass material.

TheFigure 3.1 design of blade for grinding the oil palm leave, rotation in motion with six blades. This idea concept gets from the grass cutter and also researcher from the journal and also some technical report. This blade concept has a two pulley to support the rotational when it functions. This design have it some advantage because easy to fabricate and the blade can easily find. However, these blades design it not suitable with the grinding for oil palm frond because the characteristic of oil palm frond is different with the grass. The oil palm frond it very loamy.

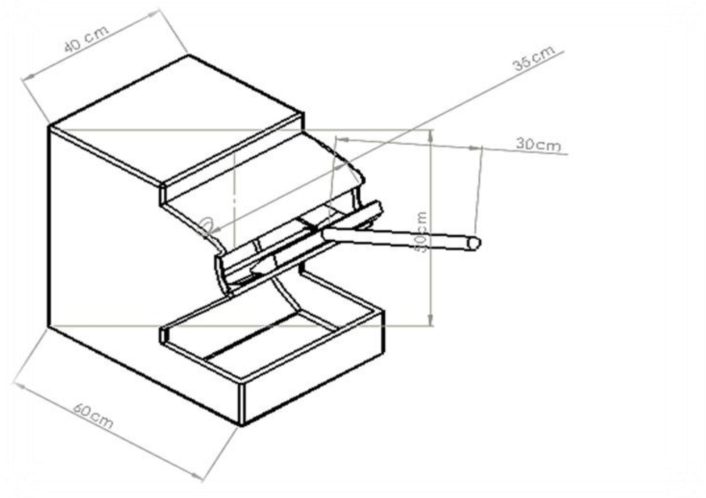


Figure 3.2: Casing grinder for raw biomass material

Figure 3.2 show the first idea design for the casing grinder. Casing grinder has entry for raw material to process. The blade design is place inside the casing and it has place for the pulley and support the blade. At the back of the casing has two hole and hole at the top for the support blade and another one hole for the motor shaft from outside.

Design also is continues from first idea concept, it just improve of safety when grinding process of raw material begin. It has small hole for only raw material and also have scope to push the raw material to go inside the casing grinder.

3.2.2 Second Concept Design

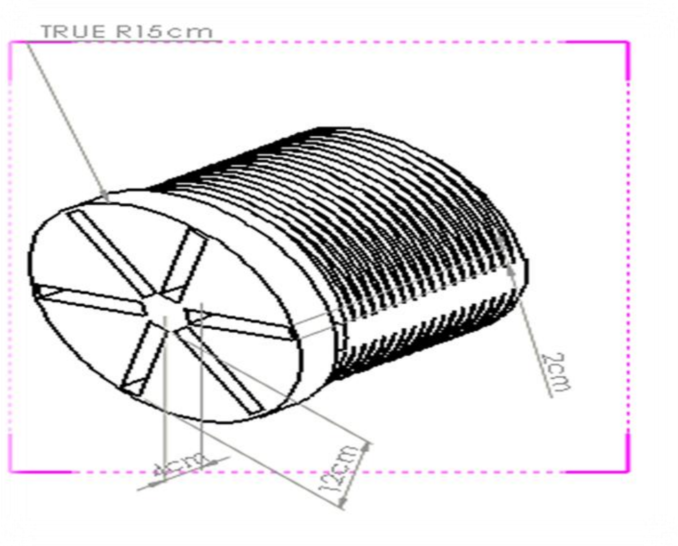


Figure 3.3: 2nddesign blade of grinder

A second design for grinding raw biomass material; it has six blades and has different size of blade shaft at the rear of main support theblades. The function of the rear blade grinder for the crunch of raw material, it is second stage after this cutting process at the main blade. At the square hole it has a blade for the cutting and that hole is a place for the cutting blade.

Designs develop from idea of tree chipper machine. A tree chipper or wood chipper is a machine used for reducing wood (generally tree limbs or trunks) into smaller woodchips. They are often portable, being mounted on wheels on frames suitable for towing behind a truck or van. Power is generally provided by an internal combustion engine from 3 horsepower (2.2 kW) to 1,000 horsepower (750 kW).

3.2.3 Third Concept Design

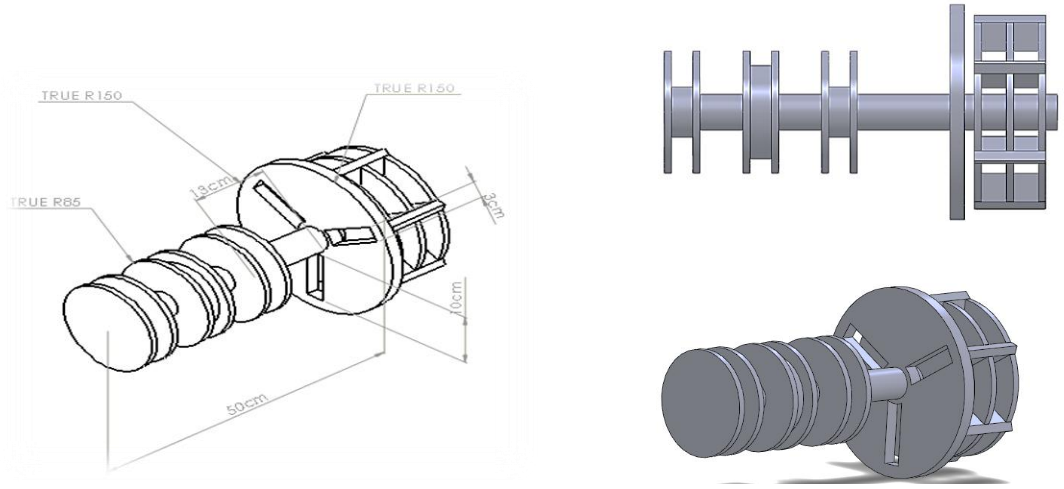


Figure 3.4: 3rdDesign Blade for Grinding

Third desing is development from the second design. It has different of type blade it has only use three cutting blade and also the cruncher blade it put infront of the main blade. The design of cruncher blade also has different as before, it put the parralle with the rotional of the blade.

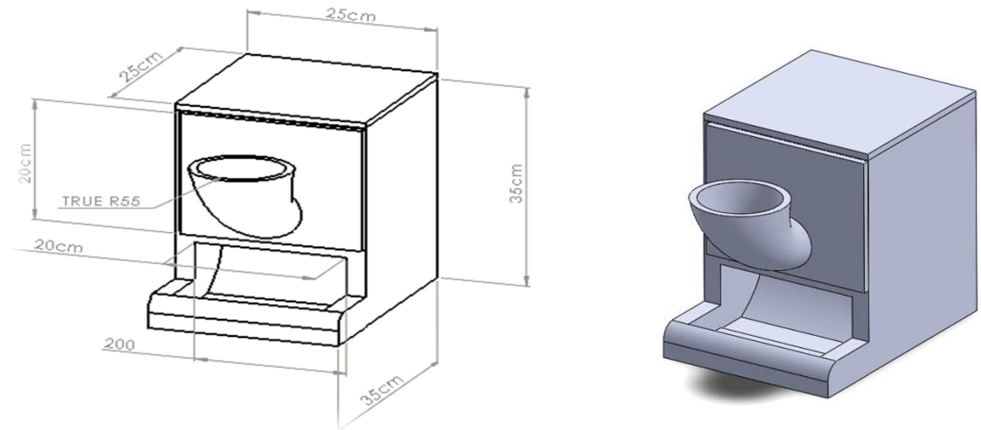


Figure 3.5: Concept Design casing grinder

A second concept design casing grinder for raw biomass material, inside of the casing has place for the blade design of moving vertically. Safety in the process grinding biomass material is priorities in this design. The entry of the raw material is a special design, this is because when a put raw biomass material inside the hollow it has edge so that it can be prevent finger or hand to go true inside of the cage. Indirectly, this design can avoid an accident from happen.

3.3 CONCEPT SELECTION

Table 1: Concept selection

DESIGN	1st	2nd	3rd
Low manufacturing cost	+	-	+
Easy to fabricate	-	-	+
Safety	-	+	+
Durability	+	+	+
Low maintenance	-	-	+
Functionality	+	-	-
TOTAL	**3**	**2**	**5**

From the above table, it showed the comparison for three designs that have been done. Based from the table, the high scores is design 3rd. design 3rd giving much advantage which is easy to fabricate, safety and low in maintained. But still have need modification and improvement from all design that has discuss.

3.4 FINAL DESIGN

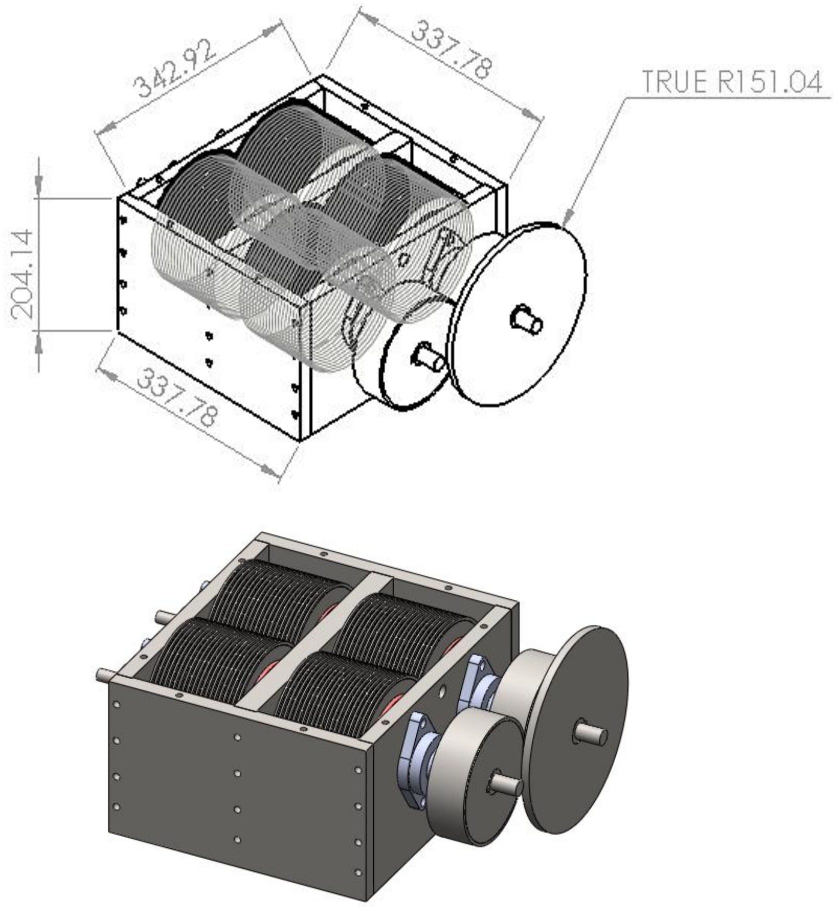


Figure3.6: Machine Grinding

A final design that include all the balde, and this design is more compitable from other.Final desgin study from literature review have been done, by combination and development of machine grinding have in market to be more compitble and functional. It able to crunsh of multipropse of biomassto be a small particle.this machine use of balde cutter that sychoronize on the shaft and suport by bloack at the middle of the machine.

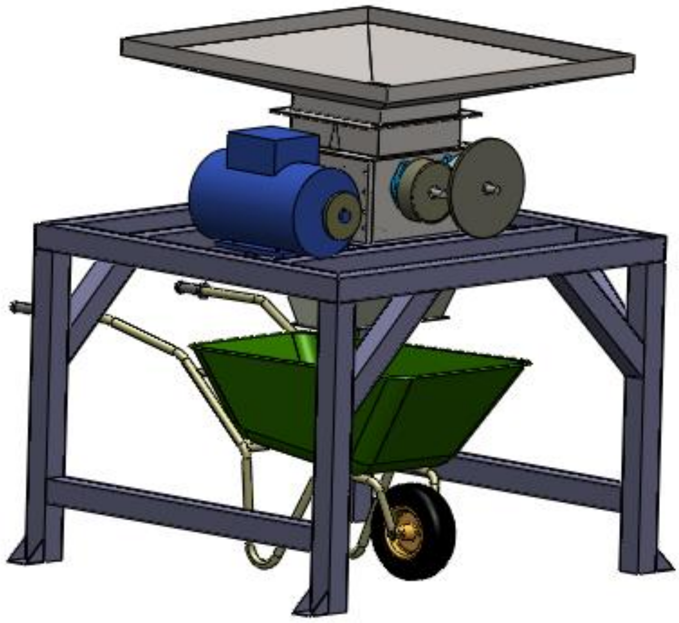


Figure3.7: Final design machine grinding

This a full final desigin of the mesh grinding with the frame that stand the machine cruncher with motor that support mechanism of the machine. The hight of frame machine suitable with hight of the wheel barrow.Final design is more renewable funcoinalty and more ergonomic for user. Futhermore, it also easy for raw matrial after the grind and crunch to collect in wheel barrow. From the litereture review have been study some machine have face some problem when to put the raw material inside the machine.From that this machine have design with top incoming for collect the materials of biomass to enter the machine cruncher.

3.4.1 Part of Machine Design

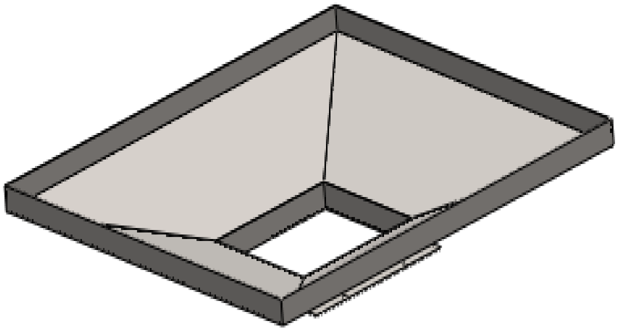


Figure 3.8: Top incoming

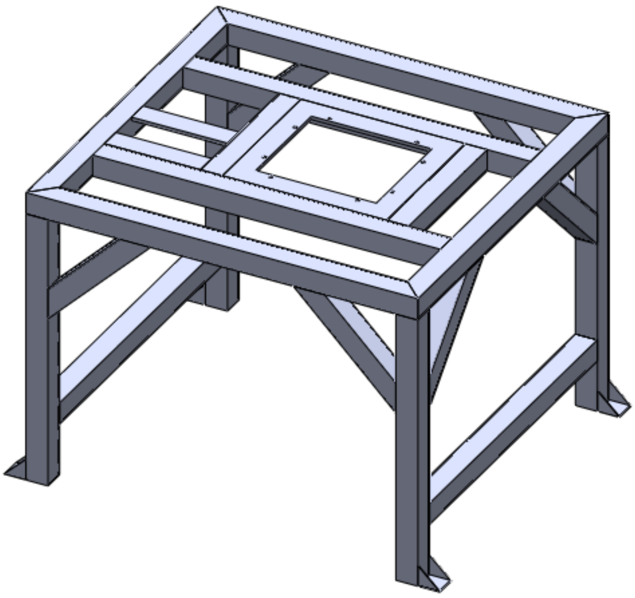


Figure 3.9: Frame machine

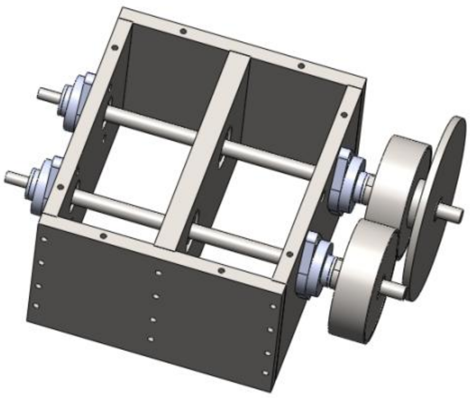


Figure 3.10: Housing blade

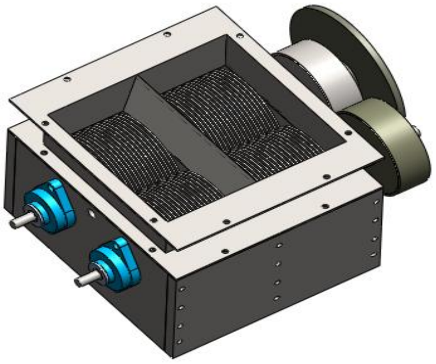


Figure 3.11: Machine cruncher

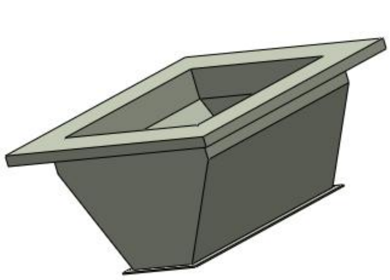


Figure 3.12: Exit area

3.4.2 Computational stress and strain analysis

The frame machine design is built in SolidWorks software and will be analyzing the strength of the frame using SolidWorks Simulation. SolidWorks is complete software with CAD and CAE software version that contains a core package in it such as easy-to use, single user interface for finite element modeling, results evaluation and presentation; and a suite of modelingcapabilities.

In a built the model in finite element analysis (FEA) the frame machine design part will be analysis by using static linear stress analysis. Frame machine design will select the element type, element definition and material of the frame machine which is ASTM A-36mild steel. After all of it done, all part will mesh each other. The force is exerted onto the top surface of frame machine design with different amount of load weight. At the main structure of frame machine, by assuming the maximum mass of machine cruncher is around 50kg, so the force exerted around the frame section with the amount of 500N. At the frame machine by assuming the machine cruncher and top incoming with the mount has a mass around 50kg. This is assuming the mass of induction motor, sprocket and chain, and others. For the failure criteria, maximum von Mises Stress Criteron will be used. The von Mises stress is used to predict yielding of materials under any loading condition from results of simple uniaxial tensile tests. The von Mises stress satisfies the property that two stress states with equal distortion energy have equal von Mises stress.

From the analysis result, the highest stress at the certain point will be determined and enhancement needed to improve the design. Some modification will be added toframe machine accordingly to ensure frame has a enough strength to support components, parts and machine grinding.

3.5 SPECIFICATION OF MACHINE GRINDER

- Power supply : 415 volts
- Motor support : 3 phase induction motor.
- Power of motor : 7.5 KW

- Size of machine grinder: 337.8mm X 342.92mm X 204.14mm

- Size of frame machine: 1250mm X 1352mm X 1026.20mm
- Total of size Machine : 1250mm X 1352mm X 1576.2mm

- Weight :

Weight of machine grinder	:	50kilogram
Weight of motor DC	:	75 kilogram
Weight of Frame machine	:	25 kilogram
Total Weight	:	150 kilogram

- Total blade : 80 blade cutter

3.6 MATERIAL SELECTION

Material that will be used to develop grinding machine is ASTM A36 Figure 3.12 mild steel which it is often used at all part of this machine. One property of mild steel is that it is malleable as it can be hammered and pressed into any shape. Steel is also ductile as it can be bent easily and very versatile. This metal also is cheap, vulnerable to rust, strong and stiff. It has excellent welding properties and is suitable for grinding, punching,tapping, drilling and machining processes. Besides that, ASTM A36 steel is easy to weld using any type of welding methods and the welds and joints so formed are of excellent quality.

Figure 3.12 : Mild steel Hollow Square

Figure 3.13 : Mild steel plate

Table 2: List of materials

TYPE OF MATERIALS	SIZE	QUANTITY
mild steel hollow square	80mm x 80mm	4
mild steel plate	3 mm thickness	2
Bright Mild Steel Angle	40 X 40 Square Edge	1

There is two part compartment of machine grinder which is machine cruncher and frame machine. For the frame machine material use mild steel hollow squareFigure 3.12 with is for the frame machine ASTM A36 mild steel hollow square with 80mm length, 80 mm width and 3 mm thickness. The reason for selecting this material is it has strength and stability. Besides that, for the top incoming and exit area machine crunchers use mild steel sheet metal 3mm thickness.

Mild steel sheet metal Figure 3.13 have advantages there is low cost ,wide variety available with different properties, high stiffness and also, most mild steels are easy to machine and weld.Typically, mind steel is stiff and strong. Although mild steel with more than 0.3% carbon requires special precautions when welding, mild steel presents far fewer problems than welding stainless steels. However because mild steel has a poor corrosion resistance and is prone to rusting, it shouldn’t be used in a corrosive environment without some kind of protective coating.

3.7 MECHANISMS

Mechanism is the important part in the project design to show how the machine operates. There are thousands of mechanism have been specified include simple or complete mechanism.

3.7.1 ThreePhase Induction Motor

Motor is used to make the part can move and function properly. Induction motor is the main parts of the rotation mechanism machine for the movement of roads and blade. Motor will connect to sprocket, chains and gearing to move the blade.An induction motor is a motor in which a rotating magnetic field in the stator coils causes induced current to flow in an auxiliary conductor. This current and magnetic field exert force on the auxiliary conductor in the rotation direction and cause the motor's rotor to rotate. Induction motors are widely used in everything from industrial machines to home appliances because they have a simple construction and are small, light, affordable, and maintenance-free. In an induction motor, the current induced by the auxiliary conductor exerts a large influence on its characteristics. It also causes strong magnetic saturation in the vicinity of the gap, in particular.

According to Faraday's law an emf induced in any circuit is due to the rate of change of magnetic flux linkage through the circuit. As the rotor windings in an induction motor are either closed through an external resistance or directly shorted by end ring, and cut the stator rotating magnetic field, an emf is induced in the rotor copper bar and due to this emf a current flows through the rotor conductor.By adjusting the induction motor the force can be control and the force apply to the induction motor can be calculated using the data below.

Figure 3.14:3-phase induction motor

Calculations of force apply being calculated based on data below:

Induction Motor Properties

Model No.	: AS1359
Motor Series	: IEC60034/60072
Power Supply	: three phase
Input	: 12V, 3Amp
Power	: 7.5 KW
Rated Rotation Speed	: 1450 RPM
Weight	: 75 kg

3.7.2 Induction Motor Torque Equation

Torque can be calculated in Imperial units like

$$T=\frac{p_{hp}\ 63025}{n} \tag{3.1}$$

Where

T = torque (in lb_f)

P_{hp} = horsepower

n = revolution per minute (rpm)

Alternatively

Torque can be calculated in SI units like

$$T=\frac{p_{W}\ 9.554}{n} \tag{3.2}$$

Where

T = torque (Nm)

P_W = power (watts)

n = revolution per minute (rpm)

Induction Motor Torque

Torque from an electrical motor with 7500 watts and speed 12 rpm can be calculated as

$$T = \frac{7{,}500\ \text{x}\ \ 9.554}{1450}$$

= 49.365 N.m

The angular velocity of induction motor

$$W = \frac{2\pi n}{60} \tag{3.3}$$

$$= \frac{2\pi \ 1450}{60}$$

$$= \frac{2900\,\pi}{60}$$

= 2.530 rad/ s

The force apply of induction motor

$$T = Fr \tag{3.4}$$

$$F = \frac{T}{r} \tag{3.5}$$

$$= \frac{49.35}{0.15}$$

= 329 N

From the calculation above, the angular velocity provided by 3-phase induction motor is approximately 2.530 rad/ s. however, the maximum force provided by 3 phase induction motor is approximately 329 N with 49.365 N.m torque. From the equation, it indicated that the rotation speed of selected motor was the main factor with influence the angular velocity of 3 phase inductionmotor and hence infects the force and torque also. When rotation speed increase, angular velocity will increase.

3.7.3 Frequency Converter Fe

Frequency Converter Fe in Figure 3.15 is an electronic device that converts alternating current (AC) of one frequency to alternating current of another frequency. The device may also change the voltage, but if it does, that is incidental to its principal purpose. It represents the economical line of converters with its compact format the standard frequency converter cover the entire drive range from 0.75 to 110 kW. Frequency Converter Fe is setting new standards in its class with all basic functions including simple installation, start-up and operation. It benefit because simple installation and operation scalable power range economical.

Figure 3.15: Converter Fe.

Frequency Converter Fe have many advantage there is it substantial energy savings and longer service life of motor thanks to a freely definable V/F characteristic for load-dependent adaptation of voltage and frequency. It also, cans optimal efficiency and minimal operating noise to fine adjustable pulse frequency. Besides that, this converter can setting the motor in mode forward and revers rotation.

3.7.4 Sprocket and chain

Sprockets RS60-24 front and RS60-45 in Figure 3.16back are used in machineryto transmit rotary motion between two shafts where gears are unsuitable or to impart linear motion to a track.Sprockets and chains are also used for power transmission from one shaft to another where slippage is not admissible, sprocket chains being used. They can be run at high speed and some forms of chain are so constructed as to be noiseless even at high speed.

Figure 3.16: Sprocket and chain.

3.7.5 Gearing system

In order to crate rational movement at the shaft of blade, gearing systemFigure 3.17 is used to attach between the sprocket and motor. Gearing system allow the rotation crate by the motor transfer to the gear.There have two gears in this machinewith gearing system applied in the design, it’s going to be easy and smooth the rotation of process involve.All gearing need fabricate to make it suitable with the rotation of the machine.

Figure 3.17: Gearing.

3.8 MACHINE GRINDING FABRICATION

Fabrication will be made by using the most suitable process and machine. The most suitable is welding process are chosen and the bills of materials are completed. From the entire welding machine which had been list down on the literature review, a Metal-Inert Gas Welding will be used because it does not required high level skills to operate it.

Fabricating is the process of the fabricate the part of the machining using certain machine and process to cut, to attached, to assemble and finishing of the machine. Normally this process is take logiest section to complete in doing the project. It takes 3 or 5 week or more that to finish all the fabricating process. Fabricating part involves machine process, welding process if needed, cutting process, finishing process and so on.

3.8.1 Cutter Machine

This cutter disk machine use after all material has been deiced. The material will be cut based on the dimension that state in the technical drawing.

Figure 3.18: Cutting process.

3.8.2 Welding Machine

This machine is use after all cutting process has finish. A welding process is a type of consolidation processes to facilitate joining or assembly. It is a permanent joining of two materials, usually metals, by coalescence. Weld quality depends on geometry, presence of cracks, residual stresses, inclusions and oxide films.

MIG (Metal Inert Gas) or as it even is called GMAW (Gas Metal Arc Welding) uses an aluminum alloy wire as a combined electrode and filler material. The filler metal is added continuously.

Figure 3.19: MIG machine.

3.8.3 Grinding Machine

Grinding machine is the most command machine used to do finishing part so that the machine will have the smooth surface finished and allow the intricate geometry will have good surface and geometry finish. Beside that grinder machine also can be used to cut the plate of material by changing the suitable cutter.

3.8.4 Milling and Drilling Machine

Milling and drilling machine is the machine used to drill the part of the object that want to drill follow the drawing that has done. The size of drill can be change according to the diameter of hole want to drill. Drilling can be done by manual or computerized system. In this project, drilling machine is going to use to create a hole at the bar to allow the linkage can be attached to the bar. Placed where the screw is used to tighten the part is also need to be drilled so that hole can be created.

Figure 3.20: Milling and drilling machine.

3.9 FRAME MACHINE FABRICATION

After the frame of machine grinding has achieve the limit of factor of safety, the fabrication process will be start follow the dimension in technical drawing that had been selected. The beginning stage of machine grinding fabrication is built the frame for frame machine grinding. Frame machine will built using the hollow square 80mm x 80mm. The material that has been used was mild steel.

Frame machine fabrication process will start with the measuring of base machine length as a main reference. During frame machine fabrication, all of a measurement must be ensure in precise and exact value. Besides that, several mild steel need to cut 90 degree because some part of the frame need this angle to support and to make machine stand more stable**.**

Metal Inert Gas (MIG) Welding will be used in frame machine fabrication. The main Frame machine structure material which is ASTM A36 hollow mild steel tools and equipment that used in fabricate the chassis will be prepared.

Figure 3.21: Materials Preparation.

3.9.1 Top incoming and exit area fabricate

Sheet metal is use for to top incoming and exit area fabrication process. It will be built using the sheet metal plate 3 mm thickness. The material that has been used was mild steel. Cutting tool disc and grinder is use in this process to cut the sheet metal plate with the different size and shape.Top incoming is the place for the raw material biomass to put through the machine cruncher.

During the fabrication process, all of a measurement must be ensure in precise and exact, especially to make an angle between a plates. First sketch at the sheet metal is the method to make trapezium shape will be produce after the follows the angle that has make.

Than at the end of trapezium sheet metal, it needs to bend 90 degree use a manual bending. Manual bending is the way to use to bend the material like sheet metal by using viceto clamp sheet metal and use mallet to knock the sheet metal. This process will be repeated to make same process for the both top incoming and exit area fabrication.

Figure 3.22: Trapezium shape sheet metal.

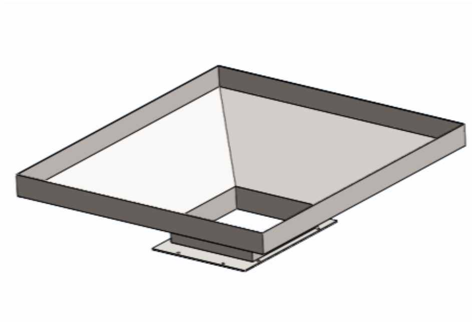


Figure 3.23: Top incoming.

3.10 MACHINE CRUNCHER FABRICATION

Machine cruncher is the important part in the fabrication process. It material was makingmust be ensured in precise and exact.

Figure 3.24: Assemble casing machine grinder.

Machine CNC and milling machine was used to fabricate each block component of machine cruncher. After all part of the block component machine was prepared, then assemble all part of compartment machine to make sure all precise. Firstly testing assemble the casing of the machine grinding, then follow by assemble all 80 blade at center shaft. Spacerhave put between the blades. Function of the spacer to make sureposition blade at the right alignment for the machine run smoothly.

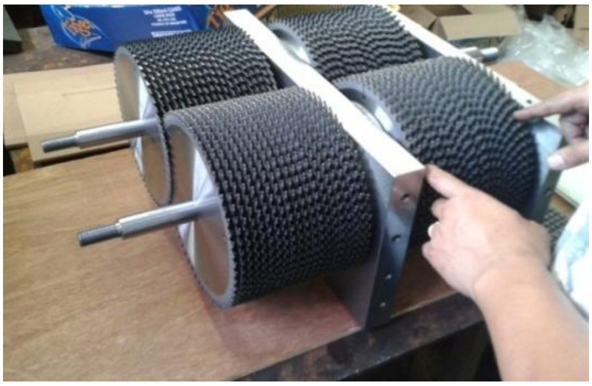


Figure 3.25:Assemble the blade.

CHAPTER 4

RESULT AND DISCUSSION

4.1 MACHINE GRINDING DESIGN

By using all the information from the literature review, research and after a few final adjustments, a final design is determined. Machine grinding is design in 3Dmodel, the real need some sketches about the design. After a few design was created, the result of discussion decide the final design of machine grinding. By using Solidworks software, the machine grinding had been design. In Solidworks, there are 3type of option file which are part file, assembly file and 2D drawing file. The machine grinding was started drawing in sketches in a part file with the complete radius and placing of the origin. To design this all aspect have to considered like the clearance and spacing of the frame to suitable fit in all the other part of the machine grinding, for example induction, gearing, and etc. The frame machine grinding also was designed to be simple to avoid any problem later during fabrication process. It was also designed suitable high with wheelbarrowand stable to stand machine cruncher and withhold the load applied onto it. The final design of the machine grinding, is shown in Figure 4.2.

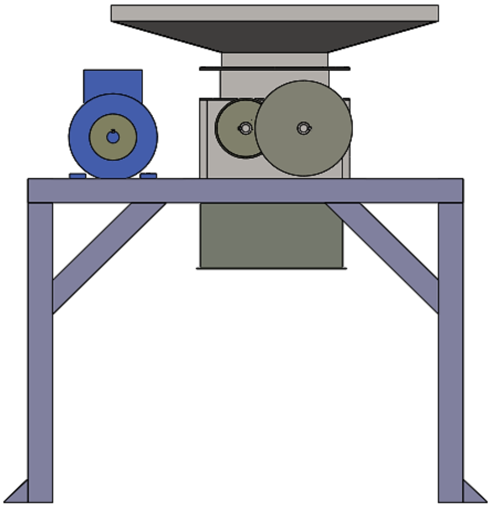


Figure 4.1: Side view Machine grinding design

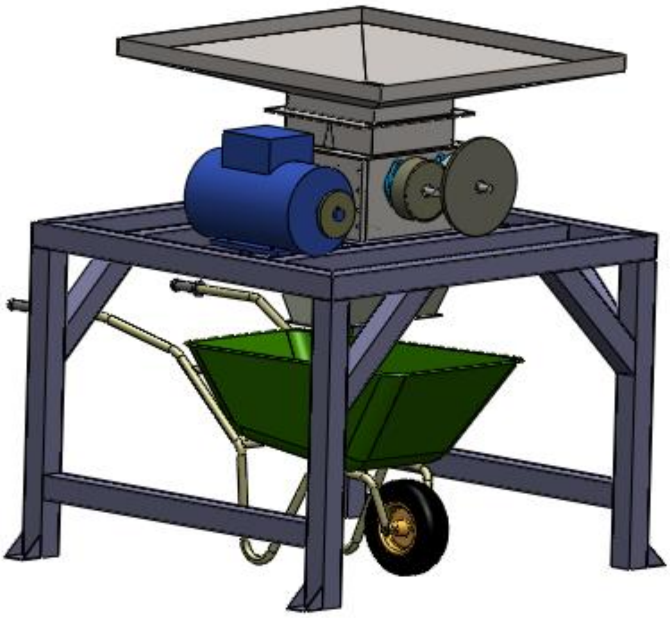


Figure 4.2: Isometric View machine grinding design with wheelbarrow

4.2 MAIN FRAME STRUCTURE

Frame structural of the machine is the most important part for the machine cruncher because with this base structural, all assembly of another part will be joining at the main body to complete the fabrication process. To allow that happen, the main frame structural must be tough enough to support the load from other part. For the frame structure, first the frame machine will be design actual like the machine using Solid Work software.

4.2.1 Simulation Result

Stress-strain simulation feature analysis of main frame sttructure using SolidWorks 2012software. In static load at the base frame are set as fixed geometry, forces are applied on the frame as the load from the components and the weight of the machine grinder. Force is the weight from the machine grinding. Finite Element Analysis (FEA) provides reliable numerical technique for analyzingframe structure design.The FEA software mesh the model with a number of small pieces of standard shape or element, connected at common points or nodes. Figure 4.2 illustrates frame structure 3D model with fixtures, loads and meshing

.

Table 4.1: Parameter for frame structure

PARAMETRS	
Material Steel	ASTM-A36
Total force applied	500N

After defining the material, the information where the restraint on the frame is specified. There is one load applied on the frame which is on the middle of the support the machine cruncher. The load applies is 500 N using uniform distribution on the frame. The result for this analysis can be view at Figure 4.2.

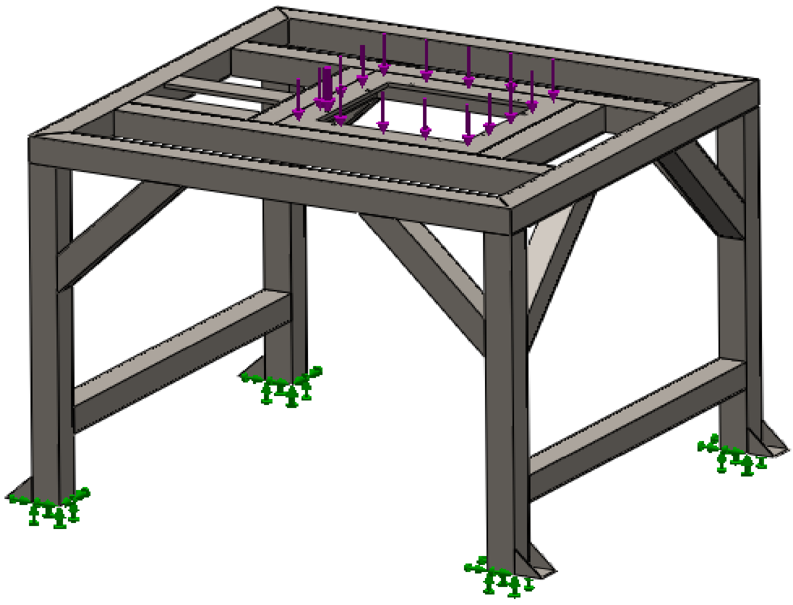


Figure4.3: Frame Structure analysis.

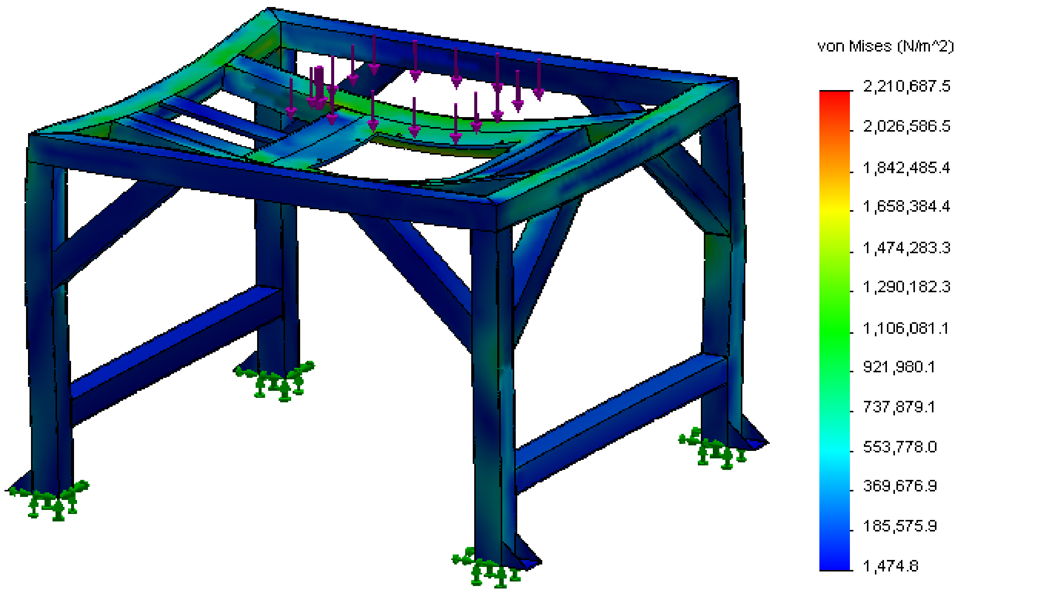


Figure 4.4: Isometric view of stress distribution on the frame.

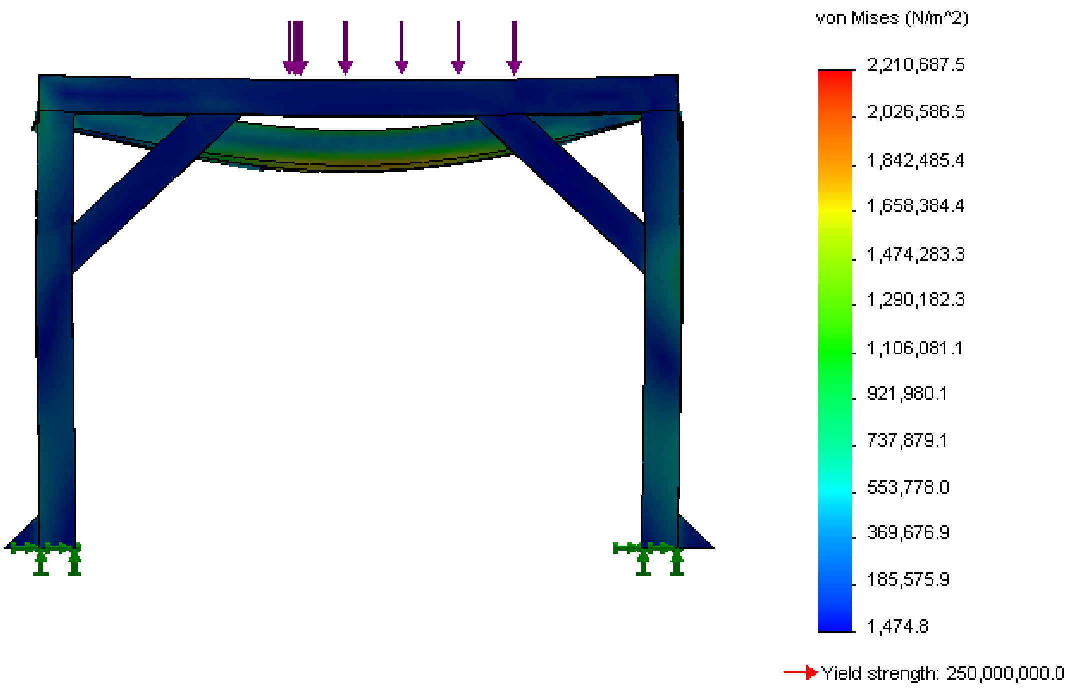


Figure 4.5: Side view of stress on the frame.

From Figure 4.4, it shows the result from analysis of frame structuralanalysis using Solid Workssoftware. The dark blue color is referring to the minimum value stress load in applied, while the red color is refer to maximum value of stress. From this analysis, each part of the structural showed differentcolor which is mean each single part hold different stress.The stress distribution can be seen where the highest stress is are at the restrains areas and at the joining part of the frame under the machine grinding area and the bottom frame. These occur because the areas around the restraint are fixed thus making the stresses focuses on those areas. But the design can still accept because the stresses are still in the safe range as indicated by the color on. The stress analysis result for minimum and maximum stress is show in table.

The critical part which is representing by yellow in color adepts the biggest stress which it can be bends if the load is too heavy. The bend will occur similarly like in Figure 4.5 which is where the yellowish color part will bend at first and then continues by nearest area. In other word, the critical point where the frame will likely to fail at excessive load. This analysis is very important of the material used before the fabricating process. Besides that, even though critical part has been determine, some part which might have chance to bend is shown in greenish color. This is because the maximum stresses at each color givedifferent maximum value of stress. The result also shows the stress value is lower than yield strength, thus suggesting the chassis is safe.

Apart from predicting stress distribution, the FEA software also calculates for strain, displacements and FOS. Figures below show the simulation results

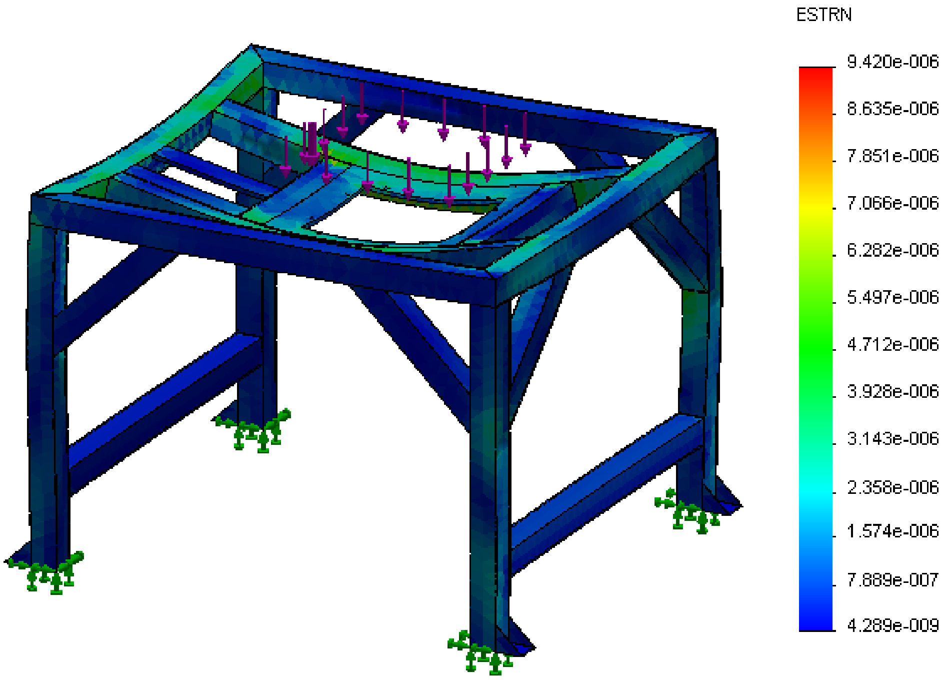


Figure 4.6: Isometric view of strainsimulationresult.

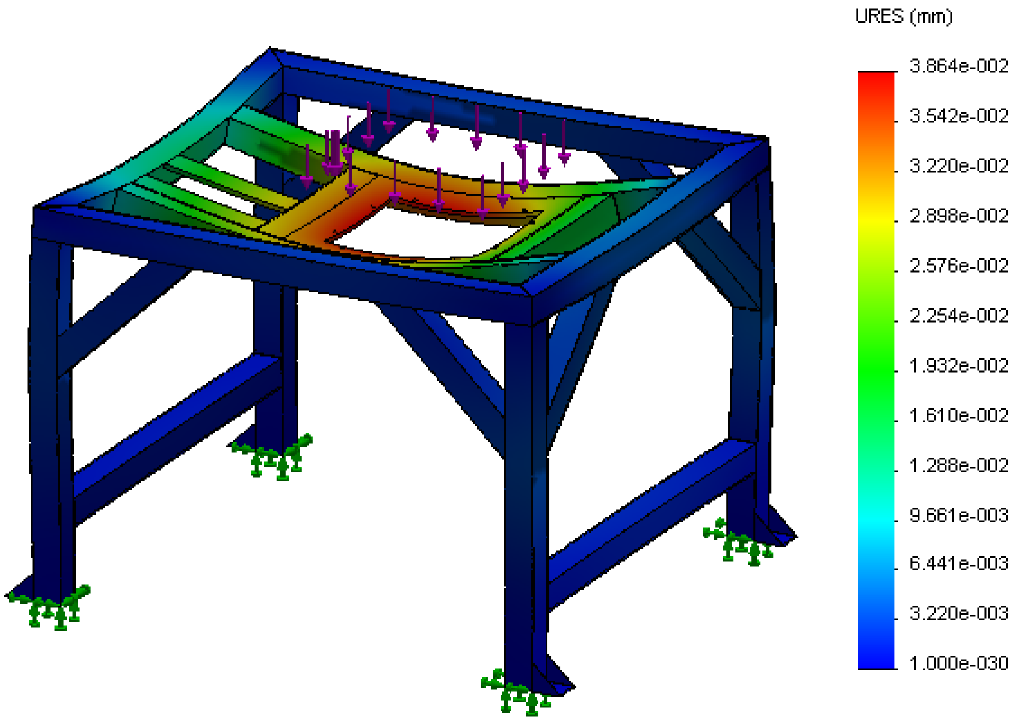


Figure 4.7: Isometric view of displacementsimulationresult.

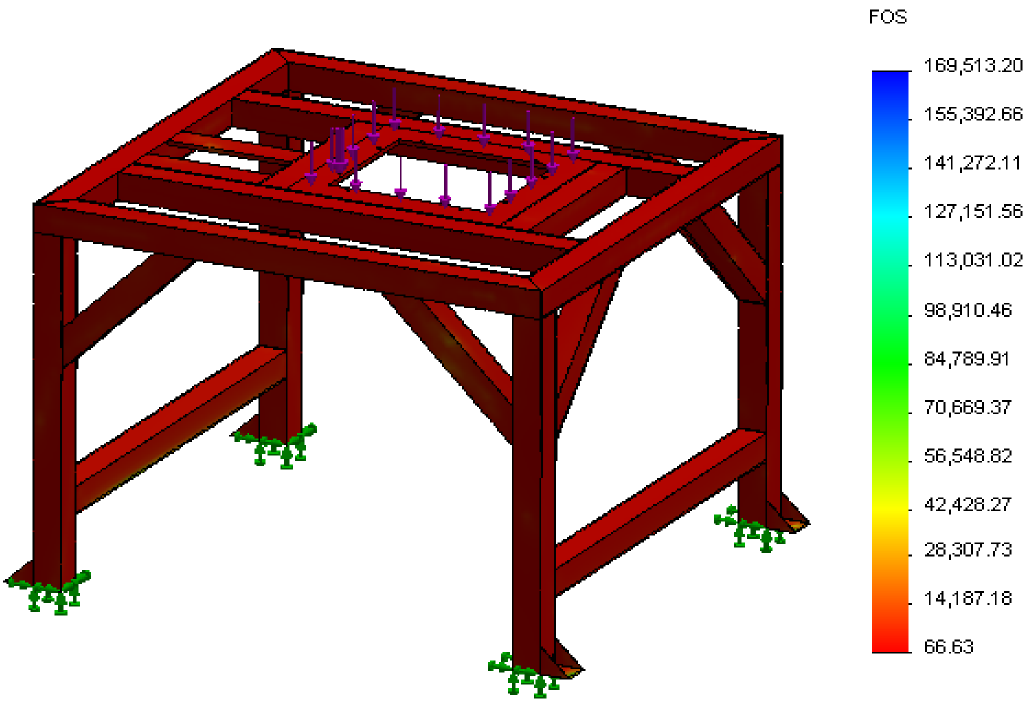


Figure 4.8: Isometric view of factor of safetysimulationresult.

Table 4.2: Result for the frame structure

Name	Type	Min	Max
Stress	VON: von Mises Stress	1474.81 N/m^2	2.21069e+006 N/m^2
Strain	ESTRN: Equivalent Strain	4.28901e-009	9.42015e-006
Displacement	URES: Resultant Displacement	0 mm	0.0386447 mm
Factor of Safety		66.6305	169513

In the strain simulation result Figure 4.6, the maximum of strain value is 9.42015×10^{6}. Highest strains occur at the joining point between frame of machine. From the result its shown the maximum strain is less than the maximum allowable strain, this machine grinding is safe condition. From the displacement simulation result Figure4.7,it shows the maximum value of displacement that deform is 0.0386447mm. From the study, the elongation of mild steel is on 70% from the actual length.

The simulation result for FOS shows in Figure 4.8 for most of the frame machine grinding is having FOS minimum value it is a 66.6305.There is FOS value must be greater than 1, for the minimum value also have already greater than 1 so it very safety. The overall of the result shows the frame machine grinding is good and safe to use as a frame machine grinding equipment. Figure4.9 shows the factor of safety simulation result.

4.3 SHAFT MACHINE GRINDING

Shaft machine grinding is the part inside the machine grinding that support of the blade weight. When a grinding process the shaft willrotatesand it will be most important part for the machine grinding to support rotating of the blade.Shaft of the machine grinding also, will be assembly with 80 blade and also spacer between the blades. To allow that happen, the Shaft machine grinding must be tough enough to support the load from other part.

4.3.1 Simulation Result

Stress-strain simulation feature is available in AGLORsoftware. In static load at the bearing that support of shaft are set as fixed geometry, forces distribution are applied on the shaft as the load from the blades and the weight of the spacer between the blade. Force is the weight from the blade and spacer. Finite Element Analysis (FEA) provides reliable numerical technique for analyzing frame structure design.The FEA software mesh the model with a number of small pieces of standard shape or element, connected at common points or nodes.

Table 4.3: Parameter for shaft machine grinding

PARAMETRS	
Material Steel	ASTM-A36
Distribution force applied	100N

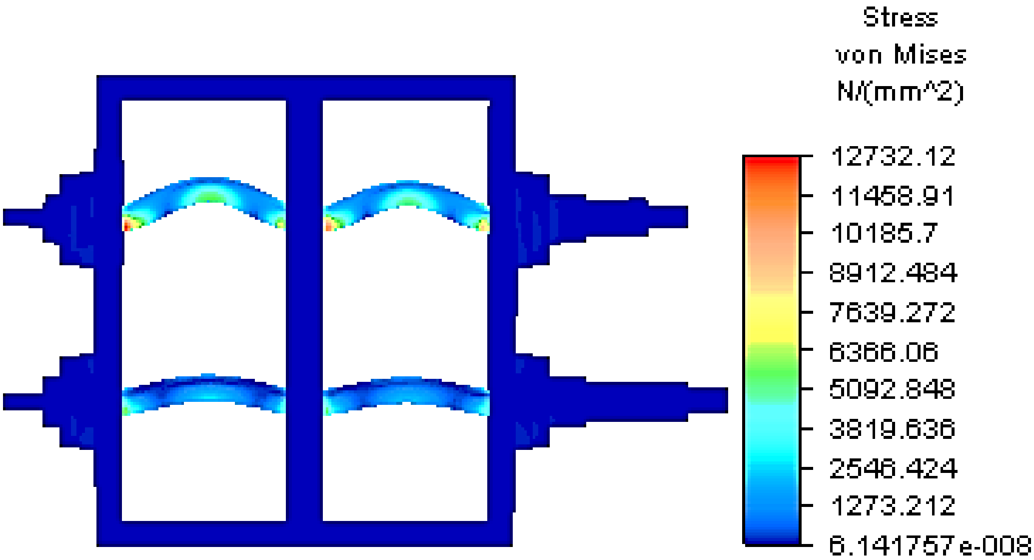


Figure 4.9: Top view of stress distribution on the shaft machine grinding

Table4.4: Stress Von Mises

Stress Von Mises	**Value N/(mm^2)**
Maximum	12732.1
Minimum	6.14176e-008

Table 4.5: Strain Von Mises

Strain Von Mises	**Value N/(mm/mm)**
Maximum	0.0864444
Minimum	4.16993e-013

4.4 MACHINE GRINDING FABRICATE

In the machine grindingfabrication, many of part on the machine grindingwas created and assemble handmade by using the university facilities especially FKM welding laboratory, solar house facility and many others.

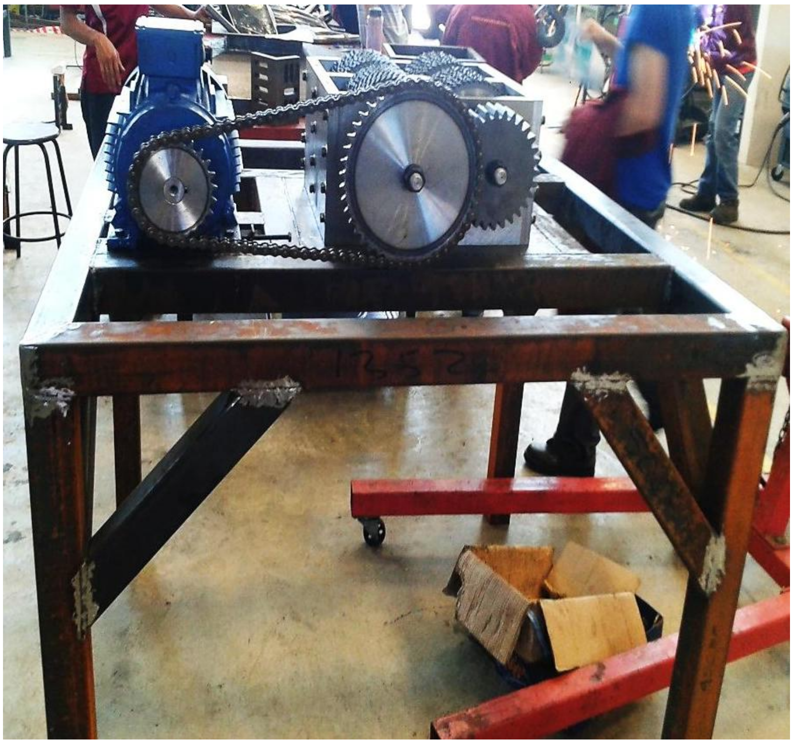


Figure 4.10: From gearing view of machine grinding

4.5 ASSEMBLE THE COMPARTMENT

The final stage in development of rough grinding equipment for raw biomass resource is assembling parts and components onto the frame machine. The part of machine cruncher will be assembled at the middle of frame machine that has prepared. Following by gearing compartment will be mounted at the shaft in the machine cruncher. Sprocketand chain will be assembled together after assemble gearing system. The chain will be tight with suitable ratio between the machine sprocket and induction motor sprocket.Then, it follow by assemble the converter Fe at the place of the frame machine. After doing in assembling, the machine will be test run after done wiring installation due to get the result of frame machine strength and function. The optimum size of frame machine that support all of components and parts can be seen after assembling process that has done.

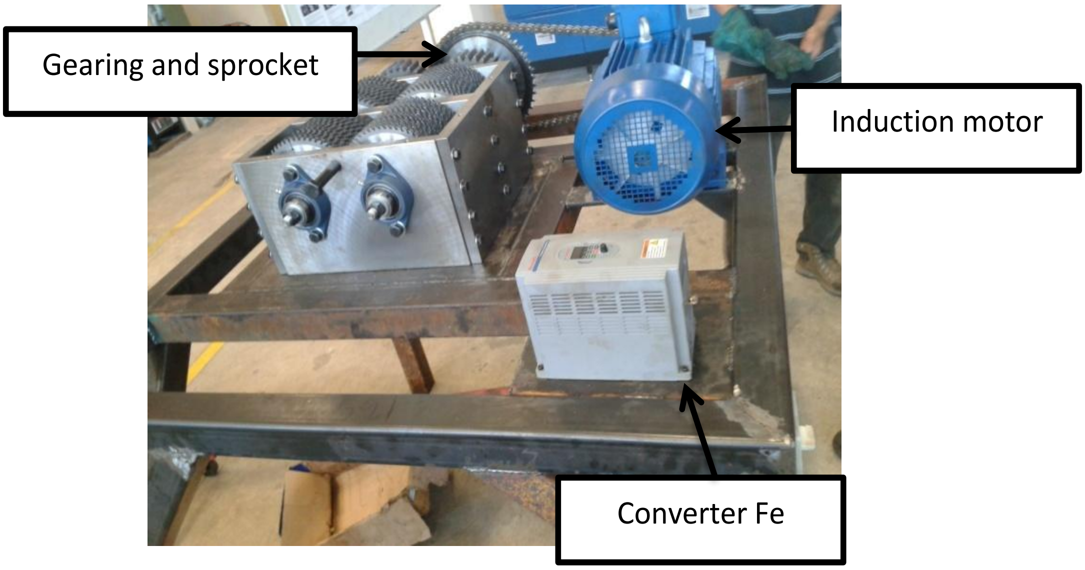


Figure 4.11: Part of Installation

Figure 4.12: From motor view of machine grinding

Figure 4.13: From front view of machine grinding

4.6 INSTALL WIRING SYSTEM

4.6.1 Induction Motor Wiring

This part is very important to ensure three phase induction motor installation is done perfectly and running properly. If wrong setting for voltage value connection for induction motor, it can cause serious damage. Induction motor have power supply voltage is 415 v for 3 phase, the setting the motor terminal in star connection.

.

To connect the induction motor with star delta starter, need to take out all cooper bars from motor terminal. It means not use a cooper bar. Because the star delta starter use a 6 cables for run the motor. There are four color wire use it is red, yellow, blue and black. The red wire will connect to the U1 label inside casing at the terminal box induction motor. Following by yellow wire connect to V1 label and blue wire will connect to W1 label inside the terminal box induction motor. The black will be connecting to the earth wire.

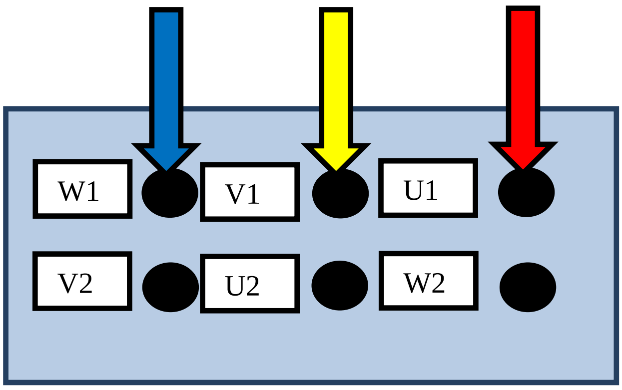


Figure 4.14: Diagram wiring terminal box induction motor

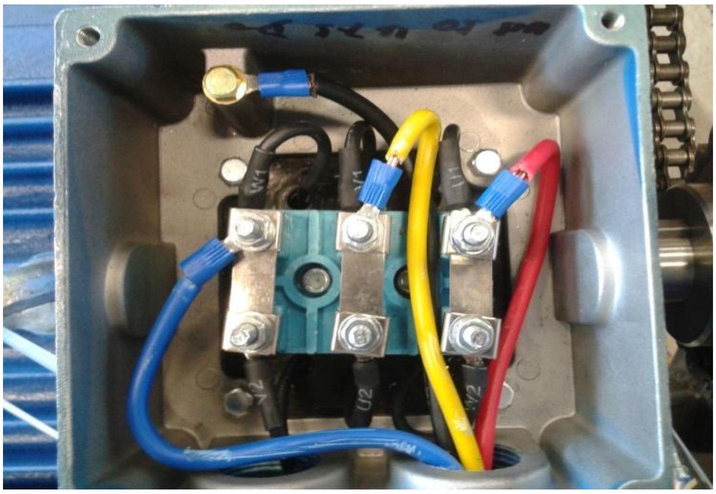


Figure4.15: Terminal box induction motor.

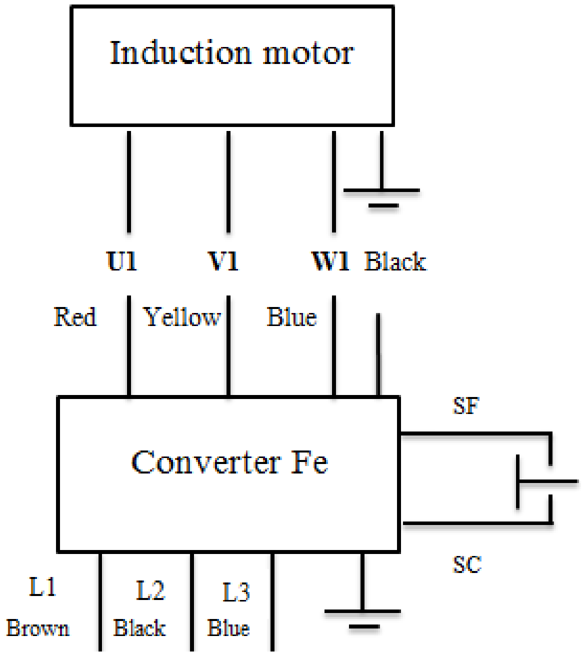


Figure4.16: Diagram wiring Induction Motor to Converter Fe

4.6.2 Frequency Converter Fe

Afterinstallation wiring systemin the terminal box induction motor, the wire will be connect to the converter Fe. Inside the cover frequency converter Fe have code for connection of wire. Connect the U1, V1, and W1 from induction motor to the terminal inside the converter Fe. U1 red color wire connect to terminal U, V1 yellow color wire connect to terminal V and W blue color wire connect to terminal W inside the converter Fe. Lastly, for the earth wire from three phase induction motor connect to PB.

After finish the connection from induction motor to converter Fe, connect power supply only to main power supply terminals L1, L2 and L3. Connecting power supply to other terminal will damage the frequency converter. Ensure that the power supply voltage is within the allowable voltage range specified on the nameplate. The grounding terminal must be properly grounded to avoid electric shock and fire and reduce interfere nose. Insulated crimp s terminals must be used to connect terminals and conductors, to ensure the ratability of connection. After wiring connection, remove all residual loose wire, which may fall in the frequency converter and cause a failure.

Table 4.6: Main circuit Terminals

TERMINAL	**Description**
L1, L2, L2	Main power supply inputs
U,V,W	Frequency converter output (to be connected to the motor)
PB	Reserved terminal for external breaking resistor (applicable to 0.75 to 15 kW frequency converter)
P1, (+)	DC positive bus outputs

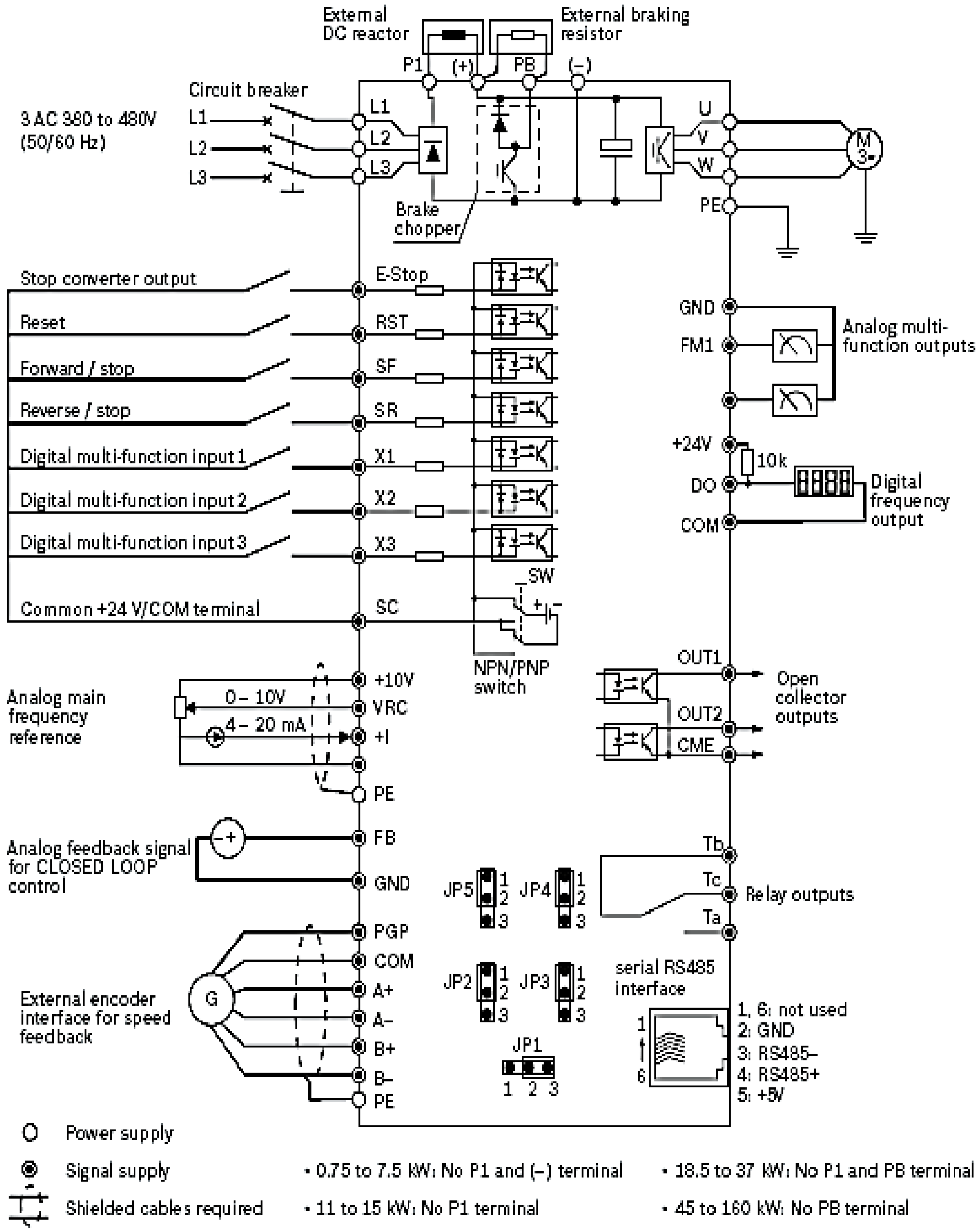


Figure4.16: Block diagram Frequency Converter Fe

(Source: Bosch Rexroth AG 2012)

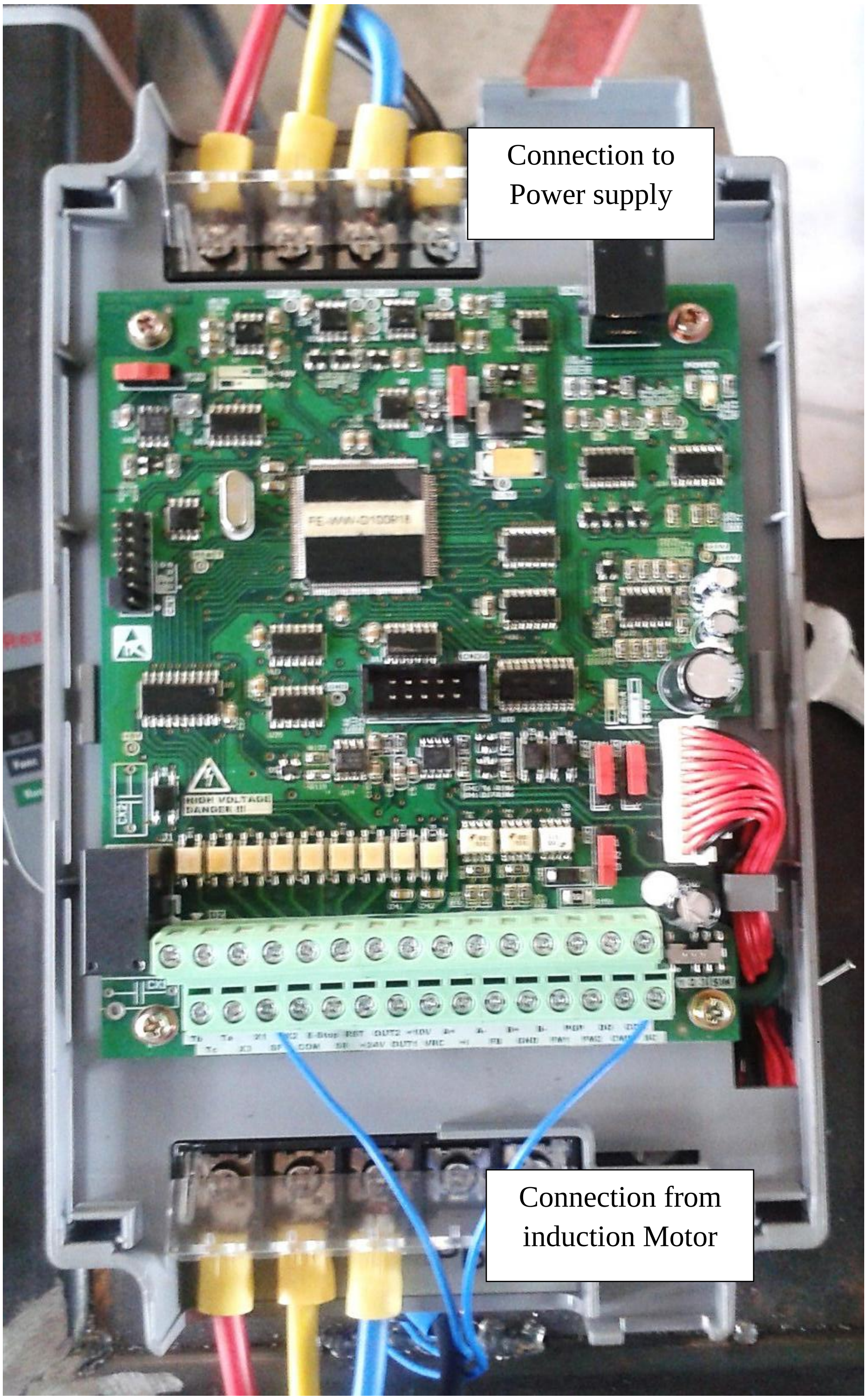


Figure 4.17: Inside the converter Fe

4.7 TESTING THE MACHINE GRINDING

Three type of biomass or organic material use during testing the machine there is palm oil fiber, empty fruit bunch (EFB), and cake. From this testing can show the functional of the machine grinding. The sample was taken from IBRA RESOURCES SDN.BHD. That company was use the biomass material to produce fertilizer.

Figure 4.18: Cake palm oil materials

Figure 4.19: Machine testing

4.7.1 Problems Encountered

After run and testing the machine, some problems were happened at the blade, and also at nut tight the shaft. This problem happened because the material of biomass use have the another particle like small rock, and also the nails. Besides that, when put the material inside the machine the material biomass will not distribute in the right place. This can make the blade bent and make it pressure between the blade and was given a pressure to the shaft and make the nut tight the shaft become loose.

Figure 4.20: Blade bent and nut loose.

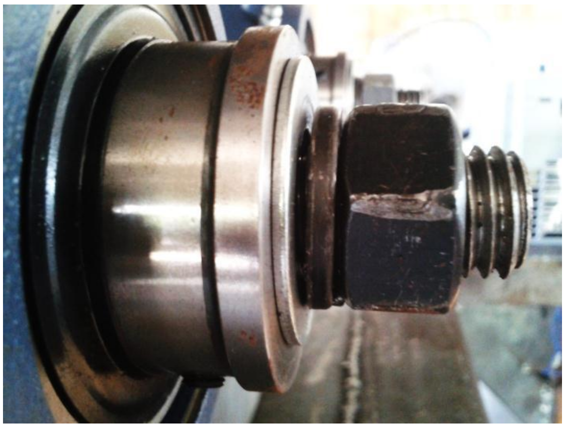


Figure 4.21: Blade bent and nut loose

4.7.2 Problem Solved

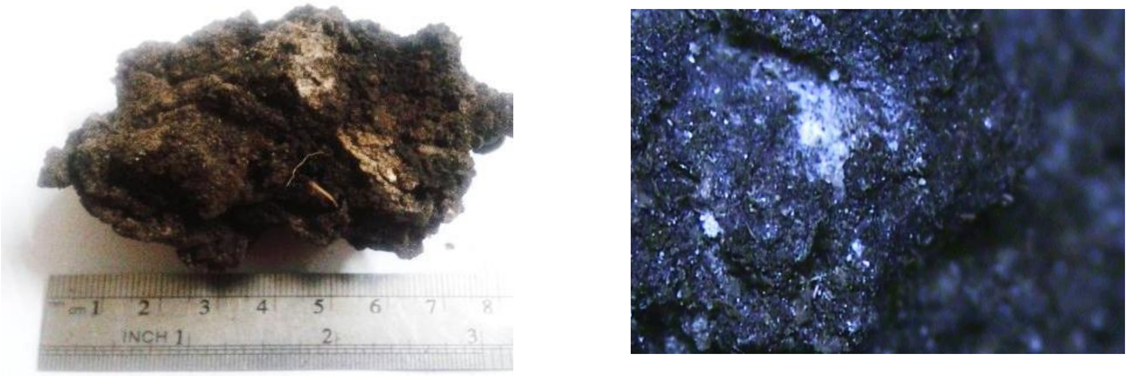
Machine grinding need to modified, to overcome the problem of nut loose at tight of shaft and the blade bent, the. For the nut loose the nut was add another nut, to be double nut and put the pin to hold fix to the middle shaft. This can make the nut always tight even the force or pressure happened between the blades. Then for the blade bent, the spacer has made at the top incoming. With the standard size of the space will filter the over size of the raw material of biomass. This spacer also has focused their space toward the center between the blades inside the machine.

Figure 4.22: Spacer at top incoming.

Figure 4.23: Pin lock at shaft.

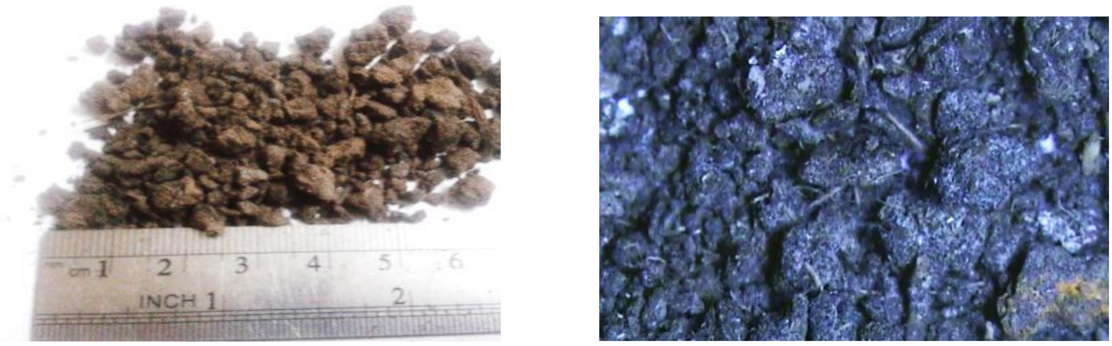
4.8 RESULT FROM OUTPUT MATERIALS

4.8.1 Cake Palm Oil sample



(a) (b)

Figure 4.24: (a) Cake Palm Oil before grinding process and (b) it structure particle.



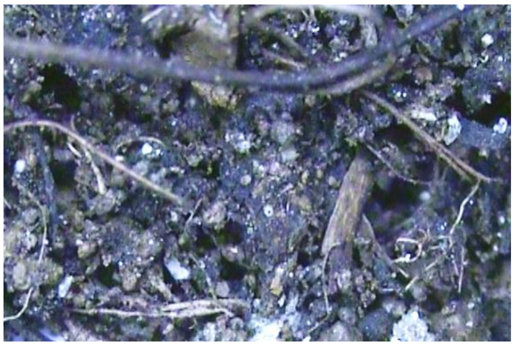
(a) (b)

Figure 4.25: (a) Cake Palm Oil after grinding process and (b) it structure particle.

4.8.2 Fertilizers ensiled sample

(a) (b)

Figure 4.26: (a)Fertilizers ensiledbefore grinding process and (b) it structure particle.



(a) (b)

Figure 4.26: (a)Fertilizers ensiledbefore grinding process and (b) it structure particle.

Initially, machine grinding no load run at different speeds from power consumption at different speeds from 200 to 600 rpm was determined at different sampling frequencies from 1 to 24 Hz. No-load power data were fitted as a function of speed. While machine grinding was running, the raw material passed down through exit area at the bottom in to wheel barrow and material was collected inside wheel barrow. There are two type output materials to be a sample it is cake palm oil and fertilizer ensile. The samples were screening using optical measurement to see a structure of particle after grind and measure size of the sample.

Cake palm oilbefore use machine grinding, materials size around 90mm to 100mm.there is a large size before it going to grinding process. By using the optical measurement show the compact of structure of cake palm oil, it can see at the Figure 4.24. After sample through the grinding process by machine grinding, the size of the sample is finer it is around 2mm to 4 mm. By using the optical measurement also show the structure of the cake palm oil is more crumble. Figure 4.25

Fertilizer ensiles before use machine grinding, materials size around 30mm to 70mm.there is a large size before it going grinding process. By using the optical measurement show the compact of fertilizer ensiles, it can see at the Figure 4.26. After sample through the grinding process by machine grinding, the size of the sample is finer it is around 2mm to 4mm. By using the optical measurement also show the structure of the cake palm oil is more crumble .it can see at the Figure 4.27.The standard size of material was produce after use this machine, even there are two type of different material. Size of materials produces after use this machine around2mm to 4mm, this standard sizes of materials are archive.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

As a conclusion, the development of rough grinding equipment for raw biomass resource has been developed. The conceptual design was fully requirement of the machine grinder which is enough space for compartment and having the ability to stand a loading. By referring the actual dimension of components and part, the space for all components was provided. The strength of frame machine grinding and shaft machine grinding has been proved in computational stress and strain analysis.

The frame and shaft machine grinding was a strong enough to support all the loading from result of simulation, the stress of von Mises Stress is lower than yield strength of the material mild steel type ASTM-A36 which mean the machine grinding is pass and safe condition according to von MisesHecky theory. Fabrication process was proceeded after get the positive result in simulation.

The machine has been function and running properly to grind the rough raw biomass and standard size of particle was produce it is around 2mm to 4mm.Therefore, the objective of the development of rough grinding equipment for raw biomass resource has been successfully archives.

5.2 RECOMMENDATION

For the recommendation in future research, the blade of the grinder should be replaced to another blade for the higher resistance when it process. This is because, when grinding process to put biomass material into machine, there is another particle with raw biomass material likes the stone, nail, and hard particle. Before this, deiced to use of the blade, type circular saw blade for lowest cost of material in fabrication and but it still can grind or cut the different material. So for the recommend, use the diamond grinding tool to grind the material. There is because, the diamond grinding tools have many advantage like high wear resistance, change in dimension is small can lead to good grinding quality and high grinding precision and long lifespan, long dressing period can greatly increase the work efficiency, and improve the workers' labor environment and decrease the product's labor intensity.

REFERENCES

Annoussamy, M., G. Richard, S. Recous, and J. Guerif, 2000. Change in mechanical properties of wheat straw due to decomposition and moisture. Applied Engineering in Agriculture 16(6): 657-664.

Austin, L.G., 1971. A review: introduction to the mathematical description of grinding as a rate process. Powder Technology. 5(1): 1-17.

Balk, W.A., 1964. Energy requirements for dehydrating and pelleting coastal Bermuda grass. Transactions of the ASAE 4:349-351;355.

Ebling, J.M., and B.M. Jenkins, 1985.Physical and chemical properties of biomass fuels. Transactions of the ASAE 28(3):898-902.

Fang, Q., E. Haque, C.K. Spillman, P.V. Reddy, and J.L. Steele, 1998.Energy requirements for size reduction of wheat using a roller mill. Transactions of the ASAE 41(6):1713-1720.

Greenberg, A.R., A. Mehling, M. Lee, and J.H. Bock, 1989.Tensile behaviour of grass. Journal of Materials Science 24:2549-2554.

Hassan M.A, ShiraiY, 2003. Palm biomass utilization in Malaysiaforthe production of bioplastic.

Hall, C.W., and Davis D.C. 1979.Processing Equipment for Agricultural Products. The AVI Publishing Company, Inc. Westport, Connecticut

Hauhouot, M., J.B. Solie, G.H. Brusewitz, and T.F. Peeper,1997. Roller and hammer milling cheat (brooms secalinus) to reduce germination as an alternative to herbicides. Paper No. 971002, ASAE, St. Joseph, MI.

Hill B, and Pulkinen DA, 1988. A study of the factors affecting pellet durability and pelleting efficiency in the production of dehydrated alfalfa pellets. A Special Report.Saskatchewan Dehydrators Association, Tisdale, SK, Canada.

Ige, M.T., and M.F. Finner, 1976. Optimization of the performance of the cylinder type forage harvester cutterhead. Transactions of the ASAE 19(3):455-460.

Iwaasa, A.D., K.A. Beauchemin, J. G. Buchanan-Smith and S.N.Acharya, 1995. Assessment of stem shearing force for three alfalfa cultivars grown under dryland and irrigated conditions. Canadian Journal of Animal Science 75(1):177-179.

Kamaruzaman, S. MohdYusoff, Honad Baharuddin Y Ed., 2000. Renewable Energy- Resources and Application in Malaysia, Pusat Tenaga Malaysia, Kajang.

Lopo, P, 2002. The right grinding solution for you: roll, horizontal or vertical. Feed Management 53(3):23-26.

Mani, S., L.G. Tabil, and S. Sokhansanj, 2002.Grinding performance and physical properties of selected biomass. Paper No. 026175, ASAE, St. Joseph MI.

Marcotte, D., P. Savoie, D. Hamel, and L. P. Vezina, 2002.A mobile extractor for alfalfa fractionation. Paper No. 021070, ASAE, St. Joseph, MI.

Mohsenin, N., 1986.Physical Properties of Plant and Animal Materials, Gordon and Breach publishers Inc., Amsterdam, The Netherlands.

Mohsenin, N., and J. Zaske, 1976. Stress relaxation and energy requirements in compaction of unconsolidated materials. Journal of Agricultural Engineering Research. 21:193-205.

Molenda.M., M.D. Montross, J. Horabik, and I.J. Ross, 2001. Mechanical properties of granular feed ingredients. Paper No. 01-4019, ASAE, St. Joseph, MI.

NL Panwar, SC Kaushik, S Kothari, 2011.Role of renewable energy sources in environmental protection a review Renewable and Sustainable Energy Reviews

Nelson G.B., G.C. Nelson, and H. White, 1982. Densification: cuber versus typical pellet mill. Annual Conference Report-41:98-99, Hawaiian Sugar Technologists, Honolulu, Hawaii.

PD. Lund, 2009. Effects of energy policies on industry expansion in renewable energy Renewable Energy, 34

Pasikatan, M.C., G.A. Milliken, J.L. Steele, E. Haque, and C. K. Spillman, 2001. Modeling the energy requirements of first-break grinding. Transactions of the ASAE 44(6): 1737-1744.

Prince, R.P., D.D. Wolf, and J.W. Bartok, Jr., 1968.Mechanical properties of corn stalks. Research Report 29, The University of Connecticut, Storrs, Connecticut.

R Sims, HH Rogner, K Gregory, 2003. Carbon emission and mitigation cost comparisons between fossil fuel, nuclear and renewable energy resources for electricity generation.

Roskamp Champion, 1992. Hammermills for particle size reduction. 2975 Airline circle, Waterloo, IA 50703

Schell D J, Harwood C, 1994. Milling of lignocellulosic biomass: results of pilot-scale testing. Applied Biochemistry and Biotechnology 45/46:159–168.

Schubert, G and S. Bernotat, 2004. Comminution of non-brittle materials. International Journal of Mineral Processing 74S:19-30.

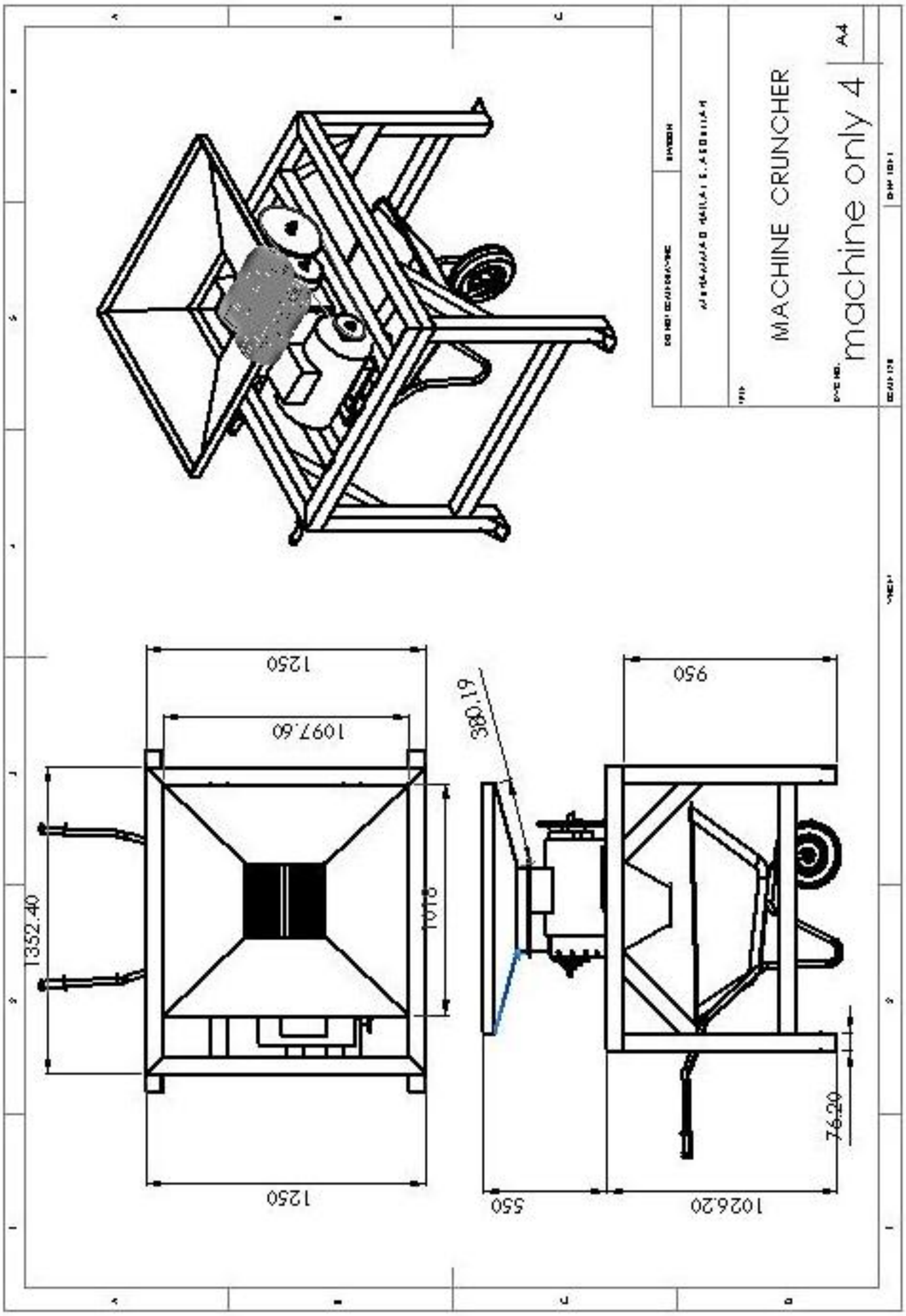
APPENDIX A

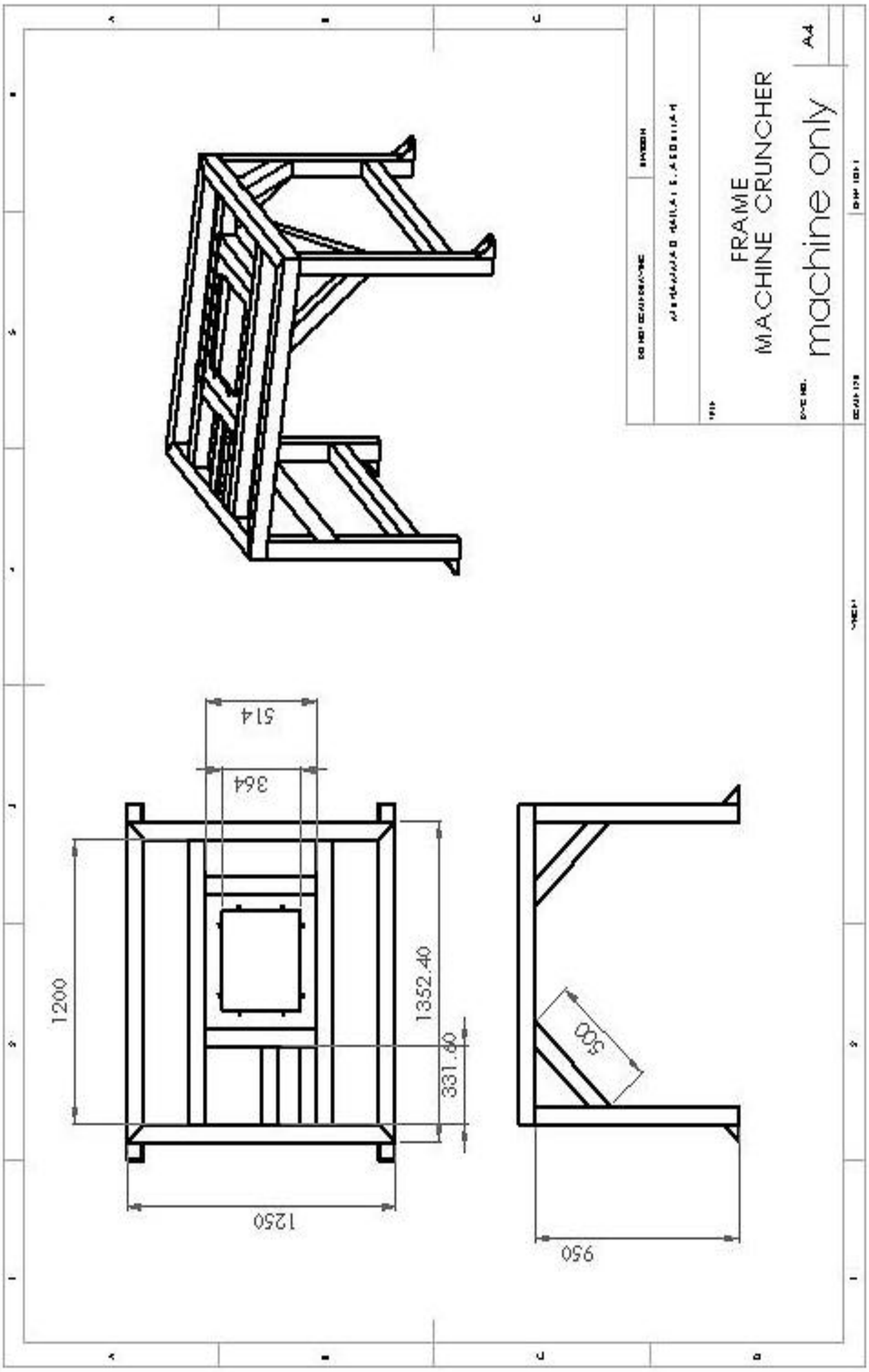
GANTT CHART

	SCOPES	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
FYP 1	Renewable energy and raw material characteristics	■	■	■	■											
	Concept design grinding equipment		■	■	■	■	■	■	■	■	■	■	■	■	■	
	Conceptualization and computational analysis												■	■	■	■
	FYP1 draft report preparation					■	■	■	■	■	■	■	■	■		
FYP 2	Component mechanism fabrication	■	■	■	■	■	■									
	Mechanism assembly							■	■	■	■					
	Operation and modification											■	■			
	Final report preparation			■	■	■	■	■	■	■	■	■	■	■		

APPENDIX B

ENGINEERINGDRAWING OF MACHINE GRINDING/CRUNCHER




FRAME
MACHINE CRUNCHER
machine only
A4
514
364
1200
1352.40
500
1250
950