Design and Manufacture of a High Efficiency Decorticator for the processing of Hemp Stalk

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A thesis submitted in partial fulfillment of the requirements for the degree of Bachelors of Engineering in Mechanical Engineering

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Islamabad, Pakistan

June, 2016

National University of Sciences & Technology

FINAL YEAR PROJECT REPORT

We hereby recommend that the dissertation prepared under our supervision by: Ahmad Jabbar (NUST201201267), Ahmad Mahmood (NUST201201051), Junaid Saleem (NUST201200962) and Umer Abdullah Al-Jozi (NUST201200440) Titled: **Design and Manufacture of a high efficiency decorticator for the processing of Hemp stalk** be accepted in partial fulfillment of the requirements for the award of Bachelors of Engineering in Mechanical Engineering degree with (A grade)

English and format checked by Ms Aamna Hassan, Signature:_________________

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Declaration

I/We certify that this research work titled "Design and Manufacture of a high efficiency decorticator for the processing of Hemp stalk" is my own work. The work has not been presented elsewhere for assessment. The material that has been used from other sources it has been properly acknowledged / referred.

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Copyright Statement

Dedicated to my parents

Acknowledgements

We all four members took efforts in this project. However, it would not have been possible without the kind support and help of various individuals and organizations. We would like to extend our sincere thanks to all of them who played their part in the completion of the project.

The team is highly indebted to Engineer Muhammad Naweed Hassan for his guidance and constant supervision as well as providing necessary information regarding the project whenever needed and also for his support and trust in completing the project. The team is also thankful to the parents of all the individual members for their utmost support and motivation.

A special gratitude goes out to Farooq Fabricators for their cooperation whenever required, all the staff at SMME and MRC for their assistance in completing the whole project.

Abstract

Wild hemp grows abundantly in the northern areas of Pakistan due to favorable environmental conditions. Majority of wild hemp is wasted by being burnt. Our aim is to bring this hemp, which is of great essence, to use. The fact that hemp is present in very large quantities across the northern areas of Pakistan makes our project sustainable. Presently, the cheapest option to process local hemp is to import hemp decorticators from China that cost PKR 300,000 per machine. Moreover, these decorticators are manufactured to cater the need of China. Since hemp plants in China vary in length and diameter from the hemp plant in Pakistan, the Chinese machine is both expensive and inefficient for processing local hemp. To overcome this shortcoming, our plan was to design and manufacture a high-efficiency hemp decorticator for the processing of local hemp.

We plan to manufacture a Hemp Decorticator at a reasonably lower price of around PKR 65,000 which best fits our local hemp which is both smaller and weaker. This decorticator will first peel off the primary fibers contained on the circumference of the hemp stalk, and then, it will shred the wooden core. With this machine manufactured, we can develop a local hemp decorticator market which is cost-efficient.

We initiated our project with a detailed literature review of the hemp plant and visited different parts of Islamabad where hemp was grown to get a range of the lengths and diameters of hemp plants that grow in Pakistan. After we were done doing our research, the next step was to come up with a design and prepare a CAD model of hemp decorticator. After several failed attempts and consult with our faculty advisor, we finalized our design. Once all the drawings were complete, our team stepped into the fabrication stage. We divided our team into two groups of two to speed up the fabrication. The main problems we faced while completing our project was material availability, costs and design complexity.

Four mechanisms are used in our manufactured hemp decorticator namely roller mechanism, peeling-off blades mechanism, crank mechanism and shredder mechanism. The whole design, working, power calculations, force calculations and all other details are shared in the report.

Following details are shared in the report:

- Sustainability and Advantages of Hemp
- Design and Manufacturing
- Machine Calculations

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Chapter 1
Introduction

1.1 Background

Hemp or '**bhang**' as we call it in local language might be infamous as a cheap intoxicant, but today's researchers believe that it is among the most productive and useful plants ever known to man. It was, in fact, cultivated for thousands of years and grown on a commercial scale till the last century; moreover, it also grows wildly in certain topographies. Hemp provides a sustainable alternative to many oil-based products and can also be used to make a variety of products from building materials to clothing to medicines. Unlike many crops, it can be grown easily in most locations and climates with minimum water and fertilizer inputs. Hemp is now being produced in US and Europe on a limited commercial scale. It grows wildly in the northern areas of Pakistan, but to grow it for commercial purposes, a license is needed from the Pakistan Narcotics Control Board.

Figure 1.1 Wild Hemp Grown in Northern Areas

Efforts are under way to find alternative solutions to the increasing natural hazards. The focus today in the West as well as in China is on the benefits of hemp. Its fiber length is up to **15 feet** whereas cotton fiber's is less than one inch. In the **1930s,** hemp was, in fact, considered a serious competitor to the newly developing technologies in the synthetic fiber, textile, timber and paper oil, composite wood, and pharmaceutical industries.

After many years of neglect, the 'industrial hemp' is now thriving in Australia, Austria, Canada, Chile, China, Denmark, Egypt, Finland, France, Germany, Great Britain, Hungary, India, Italy, Japan, Korea, New Zealand, Poland, Portugal, Romania, Russia, Slovenia, Spain, Switzerland, Thailand, Netherlands, Turkey and Ukraine.

1.2 Aim and Objectives

Processing the hemp requires a machine called "Decorticator" which extracts its useful materials, that is, hemp wood and fibers. Since no one in Pakistan has taken the initiative to examine the feasibility of this potentially lucrative crop, the most of the hemp is wasted by being burnt. Very small quantity of this hemp is used as fuel by people. We plan to bring this wasted hemp to use. Since the hemp is wildly grown, the raw material that our machine acquires is almost free of cost. Therefore, processing of this machine can generate great profits.

We aim to manufacture a processing machine (Decorticator) best fit for our local hemp which is both smaller and weaker as compared to the hemp that grows in West. A decorticator (from Latin: cortex, bark) is a machine for stripping the skin, bark, or rind off nuts, wood, plant stalks, grain, etc., in preparation for further processing.

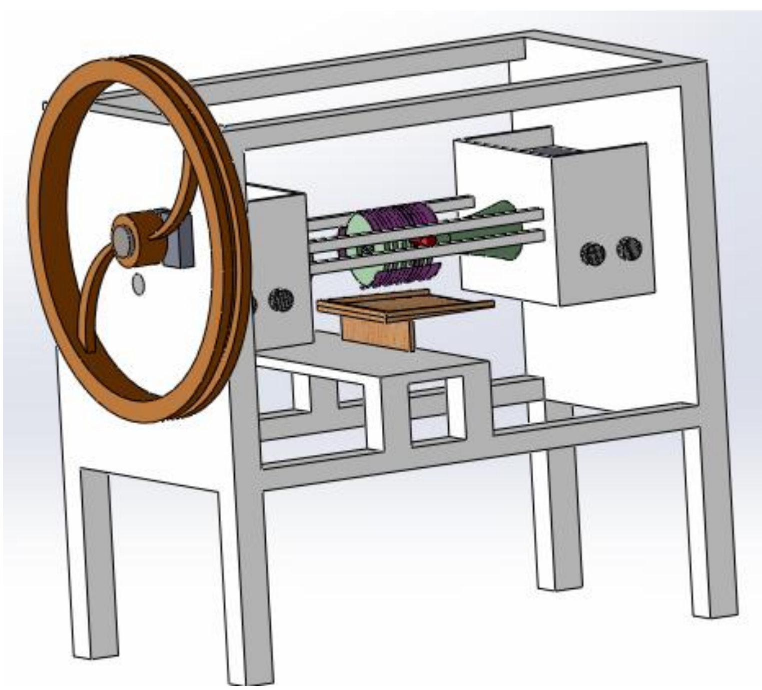


Figure 1.2 Decorticator CAD Design

Since hemp varies from region to region, imported decorticators are not efficient for local hemp. Moreover, imported Decorticator costs around PKR 300,000 and whereas we plan to manufacture Hemp Decorticator at a reasonably lower price of around PKR 65,000. This decorticator will first peel off the primary fibers, contained around the woody core of the hemp stalk, and then, it will shred the hollow wooden core often referred to as “hurds”.

1.3 Thesis Structure

The brief description of the contents of the remaining chapters in thesis is described below.

Chapter 2 Sustainability and Advantages of Hemp: This chapter provides a summary of what makes our project and our products sustainable. Moreover, it also gives a brief detail of all the advantages that we can take from our products, hemp fiber and hemp shiv.

Chapter 3 Design and Manufacturing: There are four different mechanisms that are used in our machine, namely roller mechanism, peeling-off blade mechanism, crank mechanism and shredder mechanism. This chapter gives us a detail of the design and manufacturing of our mechanism. Along with that, it also gives us the specifications of different mechanisms.

Chapter 4 Machine Calculations: While designing the machine, different calculations had to be made. We designed the RPMs and Power of different mechanisms of the machine as per requirement. Different calculations had to be made to determine these requirements. This chapter contains all the calculations that were made while designing the machine.

Chapter 5 Conclusions and Future Work: This chapter concludes the whole report and it proposes future recommendations that can improve the machine in various ways.

Chapter 2
Sustainability and Advantages of Hemp

2.1 Sustainability of Hemp

It is encouraging to see the trend to conserve energy and reduce man's impact on the environment increasing daily. In global terms, developed countries use energy and resources to fuel their construction industry that is wasteful and way beyond the ability of the planet to support such profligate consumption. Mass materials like cement and concrete cause significant pollution; use a lot of energy and non-renewable resources. Many of the materials such as insulation and finishes contain toxic chemicals like brominated fire retardants which can seriously damage or health as well as the ecosystem.

It has long been recognized that buildings and their use contribute significantly to CO_2 emissions however it seems there are two main approaches to creating a lower impact on the environment. There are those focused on getting mainstream construction to be more energy efficient, even though they still rely on high embodied energy products such as cement, bricks, concrete and steel. This focus is based on retaining the same style of construction using the same materials with more insulation (petrochemical-based) and solar technology to "reduce" the impact. It would seem the intent is to appease the environmental conscience without pain. In the UK, the construction and use of buildings accounts for over 50% of the carbon dioxide produced. Studies have shown that up to 200kg of CO_2 is emitted in the production of each square meter of walling for houses alone equating to 40 tonnes for the walls of a typical house using double brick walls.

The other approach has been to look at low impact alternatives that also are healthier and less polluting in both their manufacture and construction technique. Helping to reverse the damaging effects of greenhouse gases, Hempcrete locks up around 110kg of CO_2 per m3 of wall and provides one of the best value materials for low impact, sustainable and commercially viable construction. (Environmental Building news 2004)

Hempcrete or HLC (Hemp Lime Composite) is a composite construction material and building method that combines fast- growing, renewable carbon-sequestrating plant-based aggregates (hemp shiv) with a lime-based binder to form a lightweight material that is suited to solid walls, roof insulation and under-floor insulation and as part of timber-framed building. It also offers good thermal and acoustic performance and the ability to regulate internal relative humidity through hygroscopic material behavior, contributing to healthier building spaces and providing effective thermal mass. It is formed by mixing together hemp shiv and a lime-based binder. The lime binds the hemp aggregates together, giving the material modest structural strength and stiffness. Lime also protects the shiv from biological decay, mainly through its ability to wick water away from the shiv and its high alkalinity, as well as providing essential fire resistance.

A particular benefit of hempcrete is its capacity to sequester CO_2 into the building fabric. As government policy becomes increasingly concerned with reducing carbon emissions and finding more efficient ways of meeting carbon reduction targets, it seems possible that hempcrete can make a major contribution to this, offering a genuinely zero-neutral solution to sustainable construction.

2.2 Advantages of Hemp

Hemp has multiple uses and we plan to exploit each one of them. Although people are now aware of the various hemp uses, but no one has actually taken an initiative to benefit from it. Hemp decorticator processes the hemp to produce two products, hemp shiv and hemp fibers. Following are the industries to which hemp is an asset.

2.2.1 Food

Hemp seeds can be eaten raw, ground into a meal, or made into dried sprout powder. The leaves of the hemp plant can be consumed raw in salads. Hemp can also be made into a liquid and used for baking or for beverages such as hemp milk, hemp juice and hemp tea. Hemp's seed-oil is cold-pressed from the seed and is high in unsaturated fatty acids. In 2011, the U.S. imported $11.5 million worth of hemp products, mostly driven by growth in demand for hemp seed and hemp oil for use as ingredients in foods such as granola.

Figure 2.1 Hemp Seeds

100 grams of hulled hemp seeds supply 586 calories. They are 5% water, 5% carbohydrates, 49% total fat and 31% protein. Hemp seeds are notable in providing 64% of the Daily Value (DV) of protein per 100 gram serving. Hempseed amino acid profile is comparable to other sources of protein such as meat, milk, eggs and soy. Hemp seeds are a rich source of vitamin B, minerals, manganese, phosphorus, magnesium, zinc, iron and dietary fiber. Approximately 73% of the energy in hemp seeds is in the form of fats and essential fatty acids.

2.2.2 Building Material

Concrete-like blocks made with hemp and lime has been used as an insulating material for construction. Such blocks are not strong enough to be used for structural elements; they must be supported by a brick, wood, or steel frame. However, hemp fibers are extremely strong and durable, and have been shown to be usable as a replacement for wood for many jobs including creating very durable and breathable homes.

Figure 2.2 Hempcrete brick

The first example of the use of hempcrete was in 1986 in France. In the UK, hemp lime was first used in 2000 for the construction of two test houses in Haverhill. In the UK, the hemp houses were monitored in comparison with other standard dwellings by BRE. Completed in 2009, The Renewable House is one of the most technologically advanced made from hemp-based materials. The first house in US made from hemp-based materials was completed in August 2010 in Asheville, North Carolina.

2.2.3 Paper

The first identified coarse paper, made from hemp, dates to the early Western Han Dynasty, two hundred years before the nominal invention of papermaking by Cai Lun, who improved and standardized paper production using a range of inexpensive materials, including hemp ends,

Figure 2.3 Hemp Paper

Approximately 2000 years ago. Recycled hemp clothing, rags and fishing nets were used as inputs for paper production.

In 1916, U.S. Department of Agriculture chief scientists Lyster Hoxie Dewey and Jason L. Merrill created paper made from hemp pulp and concluded that paper from hemp hurds was better than those used with pulp wood. The chemical composition of hemp hurds is similar to that of wood, making hemp a good choice as a raw material for manufacturing paper. Dried hemp has about 57% cellulose (the principal ingredient in paper), compared to about 40-50% in wood. Hemp also has the advantage of a lower lignin content: hemp contains only 5-24% lignin against the 20-35% found in wood. This lignin must be removed chemically and wood requires more use of chemicals in the process.

Around the year 2000, the production quantity of flax and hemp pulp total 25000-30000 tons per year, having been produced from approximately 37000-45000 tonnes fibers. Up to 80% of the produced pulp is used for specialty papers (including 95% of cigarette paper). Only about 20% hemp fiber input goes into the standard pulp area and are here mostly in lower quality wood pulps. With hemp pulp alone, the proportion of specialty papers is probably at about 99%. The market is considered saturated with little or no growth in this area.

2.2.4 Fiber

Hemp fiber has been used extensively throughout history, with production climaxing soon after being introduced to the New World. Items ranging from rope, to fabrics, to industrial materials are made from hemp fiber. Hemp is often used to make sail canvas, and the word canvas derives from cannabis. Today, a modest hemp fabric industry exists, and hemp fibers can be used in clothing. Pure hemp has a texture similar to linen.

Figure 2.4 Hemp Fiber

The cotton-based textile industry here in Pakistan is, according to recent reports, now having to import raw cotton from places such as Kunduz in Afghanistan, to meet its requirements as cotton growers face one problem after another, with the twin evils of climate change and bollworm infestations. These cost a fortune in toxic chemicals to control. Replacing cotton with ‘industrial hemp', this being highly resistant to adverse weather conditions and unattractive to pests, could go a very long way in maintaining the financial viability of the textile industry. This industry, according to former National Assembly speaker Syed Fakhr Imam, employs 40 per cent of Pakistan's industrial labor. Cotton production also takes up a tremendous amount of prime agricultural land which, with an ever-expanding population to feed and lack of food security being a major issue, could be better utilized for food production as 'industrial hemp' does not require a very fertile land. This crop is perfectly happy on 'marginal' land and on steep mountain slopes where little else will grow.

2.2.5 Biofuels

Biodiesel can be made from the oils in hemp seeds and stalks and alcohol fuel (ethanol or, less commonly, methanol) from the fermentation of the whole plant Filtered hemp oil can be used directly to power diesel engines. In 1892, Rudolf Diesel invented the diesel engine, which he intended to power "by a variety of fuels, especially vegetable and seed oils, which earlier were used for oil lamps.

Production of vehicle fuel from hemp is very small. Commercial biodiesel and biogas is typically produced from cereals, coconuts, palmseeds and cheaper raw materials like garbage, wastewater, dead plant and animal material, animal feces and kitchen waste.

Figure 2.5 Hemp Biofuel

Chapter 3
Design and Manufacturing

3.1 Theory

We have designed the machines for doing two major tasks. The first desired task is to peel off the outer fiber from the hemp stalk and the second one is to shred the inner wood. The design for the peeling mechanism was inspired by the hand planer mechanism whereas the shredder mechanism was inspired by observing the local 'sugarcane cutting machine'. The design also includes a feeding mechanism for the hemp stalk.

3.2 Main Mechanisms

There are four main mechanisms in our hemp decorticator.

1. Roller Mechanism
2. Peeling-off Blade Mechanism
3. Crank Mechanism
4. Shredder Mechanism

3.2.1 Roller Mechanism

There are two roller mechanisms in our decorticator, both powered by a single-phase 110 Watts Gear Motor having 100 RPM through a pulley mechanism. The first roller mechanism feeds the hemp into the blades assembly where the fibers are peeled off whereas the second roller feeds the hemp into the shredder.

Within a roller mechanism, there are two rollers present at the bottom, powered by the motor with 3:1 pulley ratio giving it 33 RPM. The second roller at the bottom is powered by the first one using a belt with 1:1 pulley ratio. There is an adjustable roller present at the top which adjusts its position using two springs depending on the diameter of hemp. The diameter of hemp increases along the length varying from 18mm to 40mm. Therefore, when in idle position, there is a gap of 18mm between the bottom rollers and the upper roller. As the diameter of hemp increases, the two springs of the adjustable roller, which have a stiffness of 150 N/mm each, compress to let the hemp pass. The force of the springs is good enough to both have a good traction on hemp and to keep it rolling smoothly.

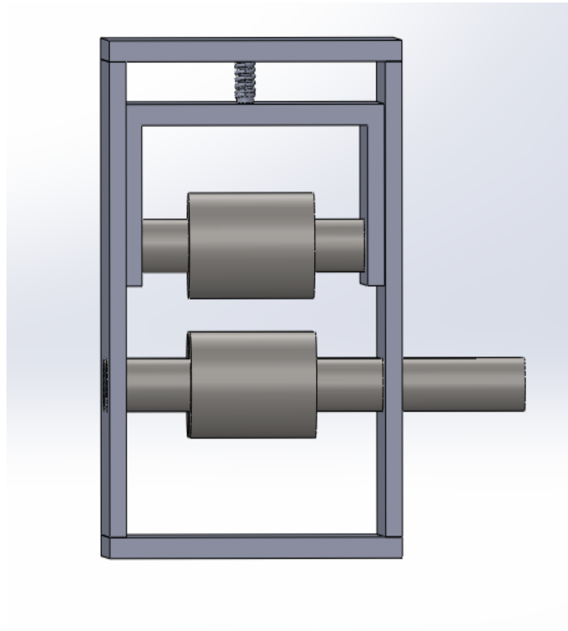


Figure 3.1 Manufactured Rollers

Figure 3.2 CAD design of Rollers

Following are the specifications of the roller mechanism:

Roller Material	Mild Steel
Motor Power	110 Watts (single-phase)
Motor RPM	100
Pulley Ratio	1:3
Roller Diameter	35mm
Length of Lower Rollers	100mm
Length of Upper Roller	70mm
Stiffness of each Spring	150 N/mm
Total Stiffness	300 N/mm
Bearings	20mm ball bearing (6004)
Roller RPM	33
Feed Speed	60 mm/s
Feed Force of a Roller	455.5 N
Feed Force of a Roller Mechanism	911.0 N

3.2.2 Peeling-off Blade Mechanism

Peeling-off mechanism consists of three blade assemblies, each having blades sandwiched between two plates. Each blade assembly consists of two semi-circular, 3.5 inches diameter, mild-steel plates, each embedding high-speed steel (HSS) blades. These blades are brazed on the steel plates. These semi-circular steel plates are attached with two springs in a position that they keep a gap of 18mm between them to let the hemp pass. As the diameter of hemp increases, these springs stretch to up to a length where the gap increases to 45mm. The semi-circular plates are placed between two slotted plates providing a sliding motion in one direction only restricting all other movements of the sandwiched blades.

Figure 3.3 Manufactured Blades Assembly

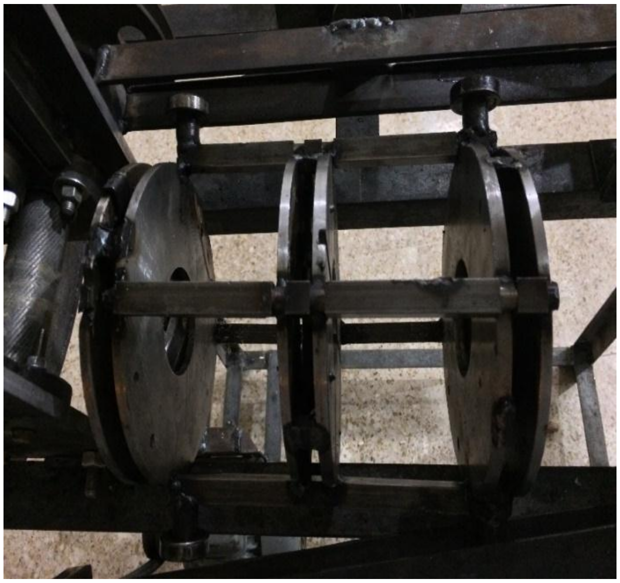
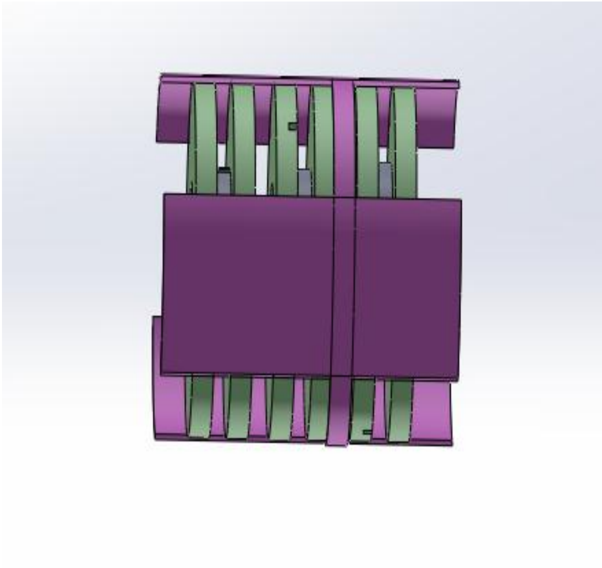


Figure 3.4 CAD design of Blades Assembly



Each blade assembly is at 60° from the prior one to make sure the outer layer of the hemp peels off completely. This mechanism is powered by a single-phase 200 Watts Gear Motor with 100 RPM which is attached to an adjustable flywheel to convert the rotary motion into to-and-fro. Following are the specifications of the peeling-off mechanism

Blade Material	High-Speed Steel (HSS)
Plates Material	Mild Steel
Blades' Plates Diameter	90mm
Outer Plates Diameter	180mm
Blade's Cutting Angle	60°
Assembly Length	230mm
Assembly Weight	7.5kg

3.2.3 Crank Mechanism

The crank mechanism is designed to convert the rotary motion of the motor to to-and-fro motion for peeling-off blade assembly. A single-phase 200 Watts Gear Motor is used for the crank mechanism that has an RPM of 100. A flywheel is pressed fit on the motor's shaft and a connecting rod is used to connect the to-and-fro moving peeling-off blade mechanism to the rotating flywheel. The distance of the point of connection of connecting road to the axis of rotation of the flywheel is equivalent to the amplitude of the to-and-fro motion.

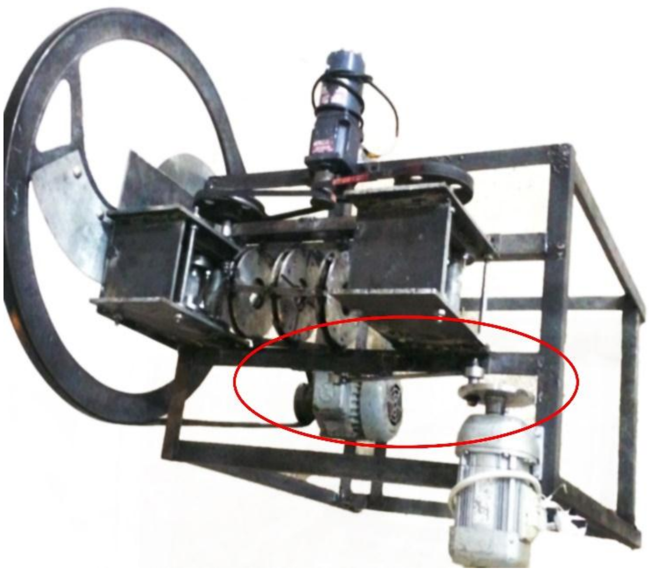


Figure 3.5 Manufactured Crank Mechanism

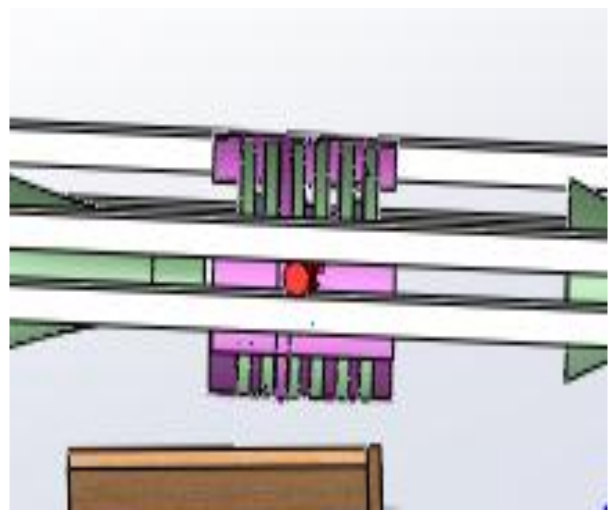


Figure 3.6 CAD design of Crank Mechanism

The peeling-off blade assembly is placed in two slots, each on each side, with bearings attached to provide smooth rolling motion. The flywheel is made adjustable by making a radial slot to fix the connecting rod. The slot varies from 25mm to 50mm radius of the flywheel which means we can vary the maximum displacement of the to-and-fro motion from 50mm to 100mm.

Following are the specifications of the crank mechanism:

Motor Power	200 Watts (single-phase)
Motor RPM	100
Flywheel Diameter	130mm
Connecting Rod Length	260mm
Range of Maximum displacement of to-and-fro motion	50mm-100mm

3.2.4 Shredder Mechanism

Shredder is powered by a three-phase 1 horsepower motor with 1400 RPM. The diameter of the shredder is 750mm whereas the diameter of the pulley pressed fit on the shredder motor is 100mm. It is attached to the shredder with a V-belt with 1:7.5 pulley ratio giving the shredder 190 RPM. The shredder has two blades that are designed to cut the hemp in small pieces.

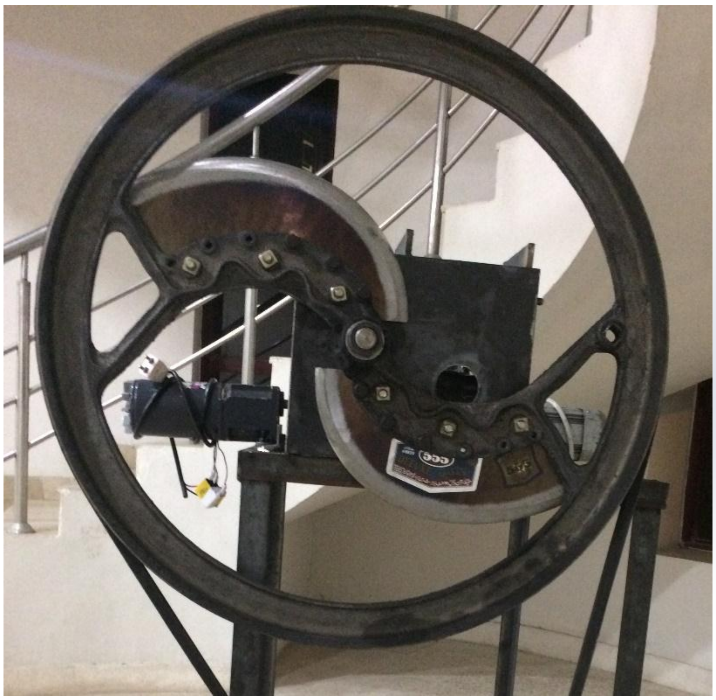


Figure 3.7 Manufactured of Shredder

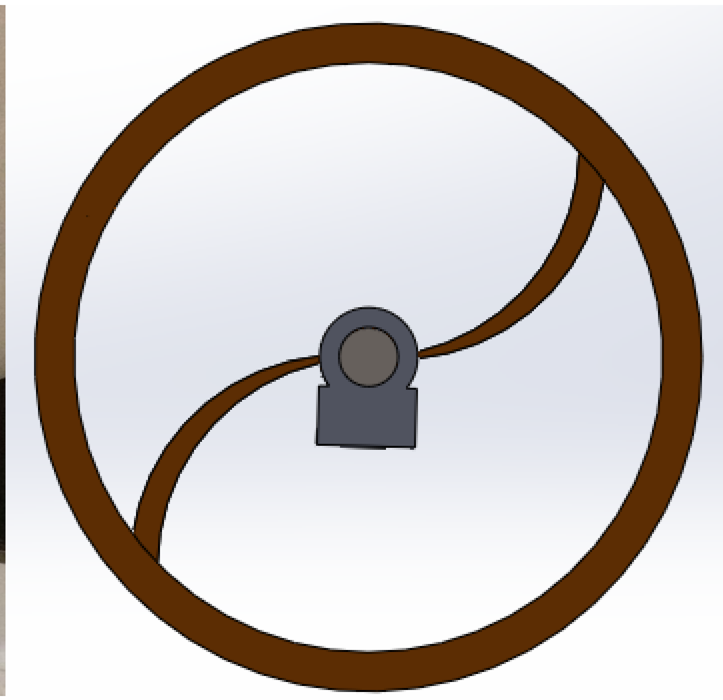


Figure 3.8 CAD design of Shredder

Following are the specifications of the shredder mechanism:

Shredder Wheel Material	Casted Brittle Carbon Steel
Shredder Blade Material	High-Carbon Steel
Motor Power	750 Watts (three-phase)
Motor RPM	1400
Pulley Ratio	1:7.5
Shredder Wheel RPM	190
Wheel Diameter	750mm
Pulley Diameter	100mm

Chapter 4
Machine Calculations

4.1 Roller Mechanism Calculations

4.1.1 Feed Force of Rollers

$$MotorPower = 110W$$

$$Power/_{Roller} = \frac{110}{4} = 27.5W$$

$$W_{roller} = \frac{2\pi N_r}{60} = \frac{2\pi(33)}{60} = 3.45\,rad/_{s}$$

$$P = \tau\omega$$

$$\tau = \frac{P}{\omega} = F_{feed}\,r$$

$$F_{feed} = \frac{P}{r\omega} = \frac{27.5}{\left(\frac{0.035}{2}\right)(3.45)} = 455.5N$$

Feed Force per Roller = 455.5 N

Feed force per roller mechanism = 455.5*2 = 911.0 N

4.1.2 Roller RPM

$$Motor\_rpm = 100$$

$$Pulley\_ratio = 1:3$$

$$Roller\_rpm = \frac{1}{3}(100) = 33.33 \approx 33$$

Roller RPM= 33

4.1.3 Feed Speed

$$v = r\omega = (17.5)(3.45) = 60.4 \approx 60\,mm/_{s}$$

Feed Speed= 60 mm/s

4.1.4 Traction Force of Upper Roller

Case 1 (x = 0) :

$$F_t = mg + Kx$$

Where,

m= mass of upper roller assembly

K= total stiffness 0f springs

$$F_t = (1.5)(9.81) + (100 \times 15 \times 2)(0)$$

$$F_t = 14.72N + 0N$$

$$F_t = 14.72N$$

Traction Force with upper roller springs uncompressed = 14.72N

Case 2 (x = 30mm) :

$$F_t = mg + Kx$$

$$F_t = (1.5)(9.81) + (100 \times 15 \times 2)(0.030)$$

$$F_t = 14.72N + 90N$$

$$F_t = 104.72N$$

Traction Force with upper roller springs fully compressed = 104.72N

4.2 Peeling-off Blade Mechanism Calculations

4.2.1 Linear Motion of Peeling-off Blade Mechanism

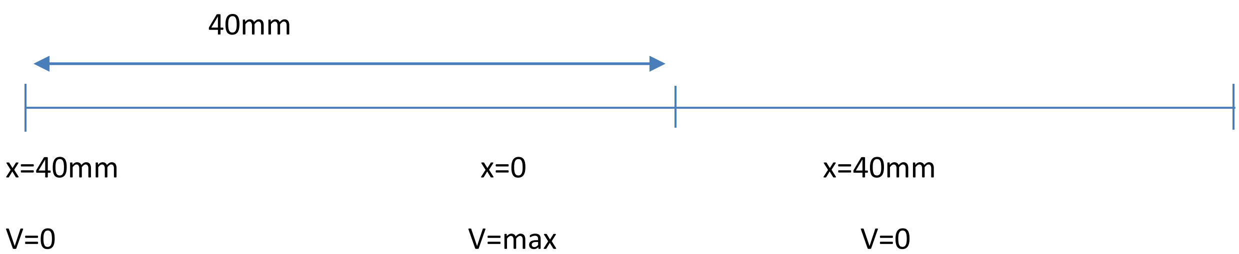
$$Motor\_Power = 200W$$

$$Motor\_rpm = 100$$

$$Flywheel\_rpm = 100$$

$$Linear\_Motion = 100 \, {}^{cycles}\!/_{\min}$$

$$Linear\_Motion\_Amplitude = 40mm$$



$$x = A\sin\omega t$$

$$v = A\omega\sin\omega t$$

$$a = -A\omega^2\sin\omega t$$

$$A = 40mm$$

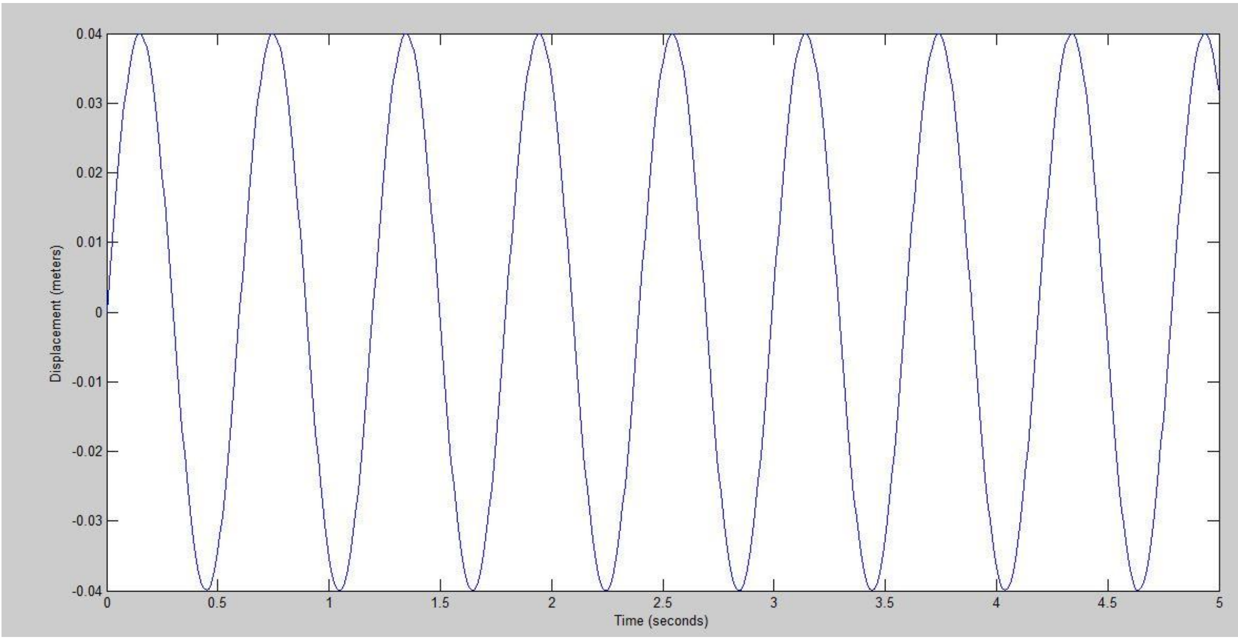
$$A = 0.04m$$

$$W = \frac{2\pi N}{60}$$

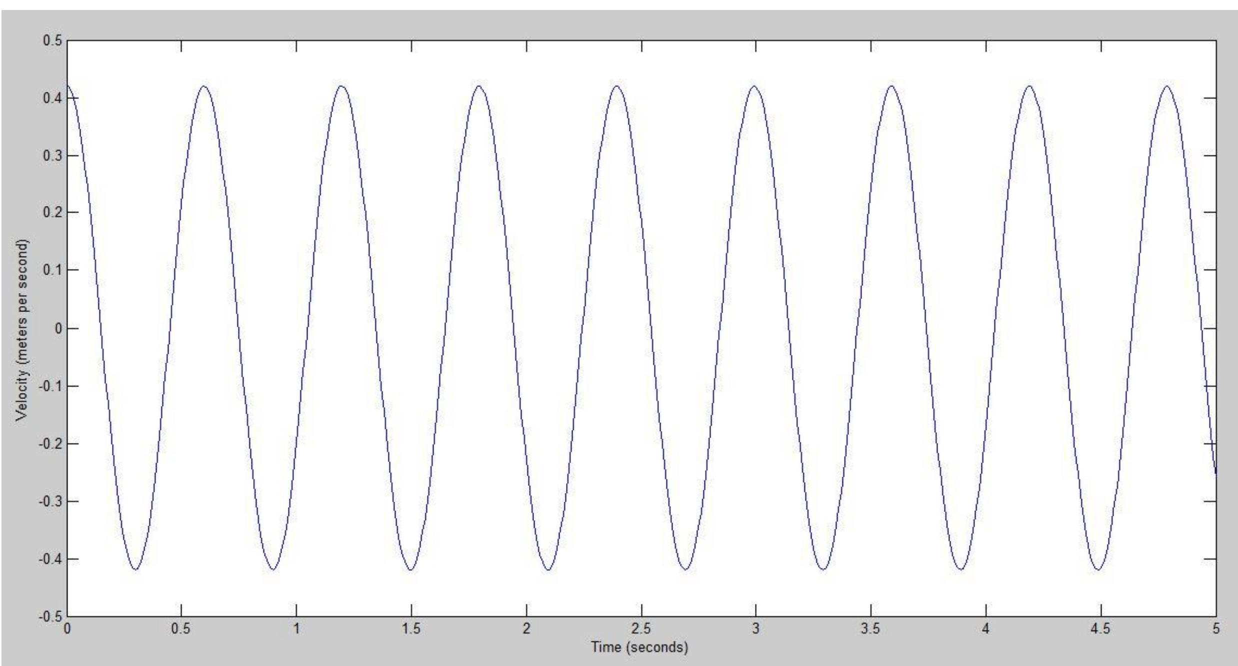
$$W = \frac{2\pi(100)}{60}$$

$$W = 10.5 \, {}^{rad}\!/_{s}$$

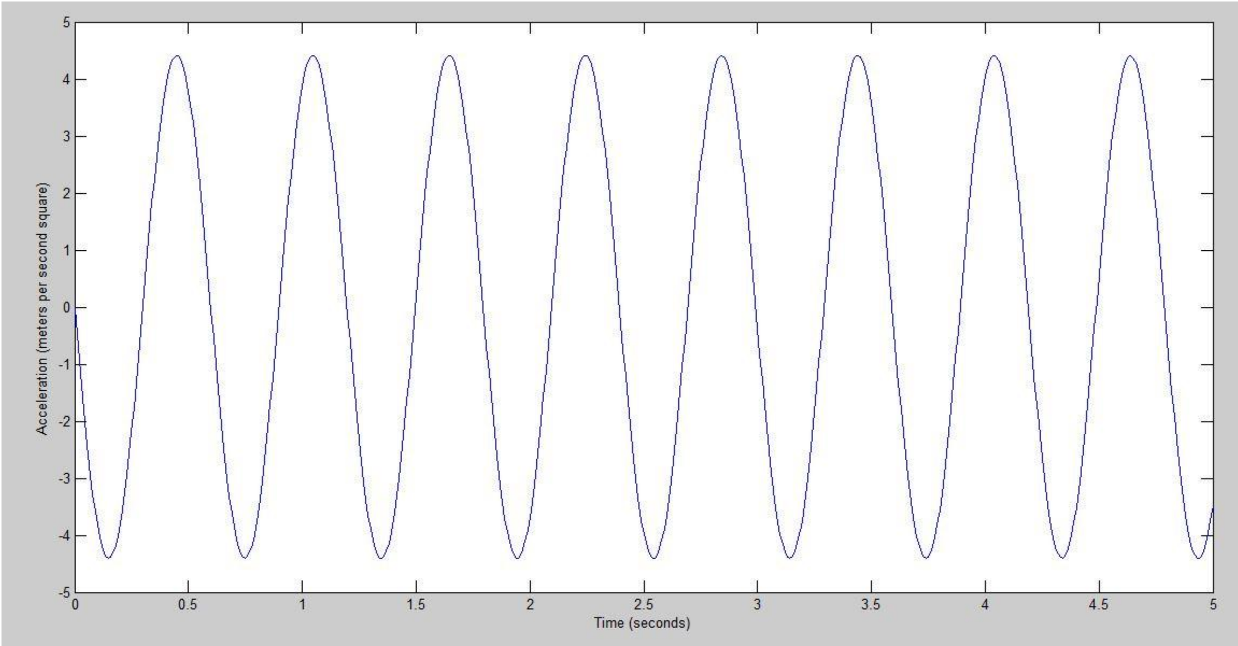
$$x(t) = 0.04\sin[(10.5)t]$$



$$v(t) = 0.04 \times 10.5\cos[(10.5)t] = 0.42\cos(10.5t)$$



$$a(t) = -0.04 \times (10.5)^2 \sin[(10.5)t] = -4.41\sin(10.5t)$$



Kinematic Equations:

$$x(t) = 0.04\sin[(10.5)t]$$

$$v(t) = 0.42\cos(10.5t)$$

$$a(t) = -4.41\sin(10.5t)$$

4.3 Shredder Mechanism Calculations

4.3.1 Shredder RPM

$$Motor\_Power = 746W$$

$$Motor\_rpm = 1400$$

$$Pulley\_ratio = 1:7.5$$

$$Shredder\_rpm = \frac{1}{7.5} \times 1400$$

$$Shredder\_rpm = 186.7 \approx 190$$

4.3.2 Length of Hemp Shiv Cut

$$No.\_of\_cuts\_per\_\min = 186.7 \times 2 = 374\, {cuts}/{\min}$$

$$No.\_of\_cuts\_per\_second = \frac{374}{60} = 6.23\, {cuts}/{\sec}$$

$$Feed\_speed = 6.1\, {cm}/{\sec}$$

$$Hemp\_shiv\_length = \frac{6.1}{6.23} = 0.98cm = 9.8mm$$

4.3.3 Cutting Impact Force

$$Power = 746W$$

$$Shredder\_angular\_velocity = \frac{2\pi N}{60} = \frac{2\pi(186.7)}{60} = 19.54\, {rad}/{s}$$

$$P = \tau\omega$$

$$746 = \tau \times 19.54$$

$$\tau = 38.18N.m$$

$$Cutting\_radius = r_c = 150mm$$

$$r_c = 0.15m$$

$$F_c = \frac{T}{r_c}$$

$$F_c = \frac{38.18}{0.15}$$

$$F_c = 254.5N$$

Cutting Impact Force of Shredder = 254.5 N

Chapter 5
Conclusions and Future Work

5.1 Conclusions

As stated earlier, the purpose of this project was to extract fiber and shredded inner wood from the hemp stalk. The machine was manufactured according to the design and it was successful in fulfilling this purpose. The machine peeled off more than 60 percent of the fiber and produced shredded hemp 'shiv' of appropriate size. We designed the machine to peel off maximum fiber from around the circumference of hemp. The machine did achieve this with its three peeling off blade assemblies given an angle of 60 degrees to each. Secondly we were aiming for around 1 cm size for 'shiv'. We designed and manufactured the shredder according to this requirement and were able to get approximately 1cm 'shiv' size. Moreover, many other important parameters like the RPM of the peeling off blade assemblies, the sizes of the rollers, the distances between each component (rollers, peeling off blades and shredder) and the power of the motors played a major part in fulfilling these tasks effectively.

Hence the machine works effectively and fulfills all the requirements. The machine has speed up the process of peeling off and shredding as compared to manual process. It is thus very promising for using this machine on an industrial scale. Moreover, if some small adjustments are made to this machine, it can be used for many other crops like jute, sugarcane etc. It can also be used to perform only one task of either peeling off or shredding at a time.

5.2 Future Works

5.2.1 Future of Hemp

In the last decade, hemp has been widely promoted as a crop for the future. This is stimulated by new technologies which make hemp suitable for industrial paper manufacturing, use as a renewable energy source (biofuel), and the use of hemp derivatives as replacement for petrochemical products.

The increased demand for health food has stimulated the trade in shelled hemp seed. Hemp oil is increasingly being used in the manufacturing of body-care products.

Jesse Ventura was a vocal proponent of hemp cultivation while governor of Minnesota, though agricultural policymakers within his administration felt that hemp cultivation could not compete economically with crops such as corn and soybeans.

5.2.2 Future Recommendations

Currently, the peeling off mechanism peels off the outer fiber of hemp in small pieces. The straight blades in the to-and-fro moving inner plates are brazed on the supporting plates. If round blades with proper cutting angle are fabricated, better results can be achieved. It will both increase the efficiency of the peeling-off mechanism and increase the length of fibers we obtain from the hemp.

Moreover, hemp found in different parts of world varies in diameter and strength, so the decorticators imported from China and US are suitable for their local hemp, not ours. We can make our decorticator adjustable in a way that we can make to-and-fro assemblies that can easily be replaced for different diameters and lengths of hemp that are available. This adjustable design makes this machine versatile. With only little improvements, it can be made flexible enough to be used for a variety of plant stalks, for example, sugarcane. This can be done by making even more flexible or easily replaceable blade mechanism.

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