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To Construct a Typical Areca Nut Dehusking Machine and Analysis on 4 Types of Areca Nuts Available in the Bangladesh Market

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Abstract

The economy of Bangladesh is improving at a remarkable speed and by 2030 it is expected that Bangladesh will have the 24th largest economy of the world. The Textile Industry is the key to have the 7.1% increase in GDP. But in this sector, in maximum cases, machineries are imported from different countries that costs huge amount. In many other sectors like auto-mobiles, electronics, mobile phones etc. at least assembling is being done. Therefore now it needs to develop manufacturing of machines by intellectual effort and money. Natural fiber is now a prospective research product for its successful utilization in composites. Among them Areca nut is a rising composite material which is applied at automobile, aerospace and construction engineering. Here an attempt has been originated to make an areca nut dehusking machine as a commencement of that journey of becoming self-contained in propagating manufacturing of textile machines. Initially the idea has been procreated from the carding machine. A main cylinder is dispensed which is grounded with sharp spikes. Two separate rollers are used as workers. These two rollers are also wired with sharp spikes. Two electrical motors are employed to supply power to the rollers. Some belts or chain drives are also used to decrease the number of individual motor. The cylinder is moving at a high speed of rpm i.e. 266 rpm, therefore it takes out the husk from the fruit. A conveyer belt is used in the feeding system to supply the nuts continuously between the cylinder and 1st roller. At the delivery system, a delivery sheet is kept at an inclined angle and a vibration is embarked for smooth delivery. Finally four types of available nuts are deployed available in the market to observe the performance of the machine. A good production (1636 nuts/hr) is achieved by this new machine. Manufacturing cost is also found less than the others recently made in the world.

Keywords: Areca nut, dehusking machine, roller & cylinder, production

1. Introduction

Bangladesh is South Asia's greatest jewel-a country braided with rivers, with a rich culture waiting to be explored by pioneering travelers. Like deriving crown in world cricket, in multifold areas, Bangladesh has ripened to fruition as the sustained and macro economy of robust growth, disinflation, rising reserves, declining interest rates, etc. Dramatically poverty has fallen from around 60% to 30% [1]. Among mentionable achievements, some are-market-based economy has matured as 44th largest in the world in nominal terms, 32nd largest by purchasing power parity, classified among the Next Eleven Emerging Market Economics and a frontier market [2], second fastest growing major economy, with a rate of 7.1% [3]. In this story of developing, Textile and clothing industries played the vital role. According to the approximation of the World Bank, the GDP of Bangladesh at USD became 173.82 billion by 2014 [4] and 416.3 billion by 2021 [5]. Now Bangladesh has turned into 2nd place in producing garments in the world [6].

Considering Bangladeshi's economy, the agriculture sector contributes 14.2% of the national GDP, and 42.7% of the workforce is employed here [7]. Varieties of agricultural products regarding different corn, fruits, berries, fish, seafood, dairy foods, etc. are formed [8].

Innovation is such a touchstone that it can perform a pivotal role in the development of the economy by strengthening the contributions of a country's intellectual property system. In this sub-continent, modernization in machinery and instrumentation was outset in 1964. SITRA initiated such kind of research. A lot of achievements were found in the high-speed reel, high-speed cams for knitting machines, impurities purifier, development of a miniature form of equipment, positive feed for knitting machines, two-for-one twisting machine, flyer spinning machine, ring frame for spinning fine jute yarns, electronic moisture meter, cotton openness measuring device, yarn abrasion resistance tester, dust pollution monitor, etc. The license was developed by them to manufacture commercially and their product was satisfactorily used in many factories [9]. Research on natural

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fibers is also a fancy era in the world that can transform the cosmos into a green sphere. Recently natural fibers have also been used in composite that is discovering the fanciest age. For instance, interior components of automotive and aircraft, packaging, paper, etc. are in development with hemp, flax, sisal, and more fibers. High tensile modulus, elongation at break, degradability, and low cost are the controlling attributes for this kind of exertion. For the adoption of such research, innovation of machines is also crucial [10]. Among natural fibers, Palm trees have executed a noble performance. Palm trees belong to the botanical family Arecaceae and are the only family in the order Arecales [11]. Areca nut is a natural lingo-cellulose fiber that is applauded for specific strength properties, low cost, low density, biodegradability, etc. [12]. Areca husk fiber is 4 cm on average and of two kinds considering fineness. The coarser one is about 10 times coarser than jute fibers. Another one is finer than jute fibers. A lot of products such as thick boards, fluffy cushions, dresses for winter, non-woven fabrics, etc. are outturn of areca nut husk fiber [13]. Areca nut or betel nut husk can contribute great support in aiming green world. Areca nut has mainly two parts, one is inside fruit and another outer shell or husk. Inside nut is completely edible. Outer shell or husk is normally considered as waste material [14]. The husk of areca nut is full of textile fibers. These fibers contain cellulose of 53.2% [15]. Therefore these fibers have the opportunity of research to work with.

Areca nut is an available fruit in Bangladesh. At every corner of houses in the villages, this is cultivated. Recently 4,000 acres of land have been cultivated. There 5000 tons of nut are produced [16] every year. However, the extraction equipment of the husk from the fruit has not been well established in Bangladesh. The production rate of the conventional machine is very less as 3 kg/hour. A simple machine is available in the countryside which is very slow to separate the inside fruit from its shell. Some new equipment should be generated for getting high production. In India lot of initiatives have been taken and they have successfully manufactured some areca nut dehusking machines. But in Bangladesh, very little research has been accomplished to meet such kind of need. A strong link is to be established between research, policy, and the media with a focus on innovation and local relevance rather than importing solutions. Therefore time comes for implementing innovative accession to research on machine design and building machines. Here an attempt has been made to create such kind of machine. This will shear off the husk of dry Areca nut at a higher speed.

2. Literature Review

2.1. Areca Catechu: Areca nut is available in many countries of Asia i.e. India, Bangladesh, Sri-lanka, Maldives, Indonesia, Laos, Cambodia, Thailand, Southern China, Taiwan, Vietnam, New Guinea, etc. 'Areca' originated from the Malabar coast of India and 'Catechu' is taken from the Malay word for palm. This fruit has many names, such as areca palm, betel palm, Indian nut, and Pinang Palm [17]. Figure 1 shows a plant having Areca Catechu and the fruits.

Fig 1: Areca Catechu and its fruits [18]

2.2. History: The proof of exact origin is not available. It is an assumption that it was grown 1st in Malaysia or Philippines. 2000 years ago, it was found in India that is told in Ayurveda [19].

2.3. Growth of Areca Catechu: The size of Areca Catechu is medium having a straight height of 66 feet. It has a trunk of 10-15 cm in diameter. The length of leaves is (4.9-6.6) feet and the shape is pinnate with many crowded leaflets [20].

Soil and Climate

Areca catechu can be produced at different soil. Best quality plant needs such soil that has good draining system. Heat from South-Western sun should not be directly fall on the plant. Irrigation must be sufficient. An annual rainfall of 750 to 4500 mm is needed. Hill is also a good place for planting Areca Catechu. Temperature is also a factor and this should be 10^0C to 40^0C [21].

Areca Nut

The areca nut is really one kind of berry. In the market, it is found in dried, cured, and fresh forms. At the beginning of growing, the husk is green in looking. The inside part at this time remains soft and therefore the total fruit can be cut by a typical knife. When it ripens, gradually the husk becomes yellow, brown, or orange and the inside part becomes hard. At that moment the fruit becomes difficult to cut. So, the special cutter is needed. Figure 2(a) shown green nuts and 2(b) shows ripen nuts.

(a) **(b)**

Fig 2(a): Areca nut in green form [22]
Fig 2 (b): In ripen form (hard) [23]

2.4. Composition of Areca Nut Husk Fiber (ANH)

Chemical composition of ANH fibers is going to be shown in the following table 1. This fiber consists of D-cellulose, hemicelluloses, lignin, pectin and proto-pectin, ash and other materials.

Table 1: Composition of areca nut husk fiber [24]

Composition	Average Amount (%)
α cellulose	53.2
Hemi-cellulose	32.98
Lignin	7.2
Fat and wax	0.64
Ash	1.05
Other materials	3.12

2.5. Areca Nut Production in Bangladesh

Areca nut is well known fruit in Bangladesh since the pre-historic period. There is no village where there is no Areca nut plant. It is a tradition to eat betel nut and leaf after eating breakfast, lunch or dinner or when there is a leisure time. Not only eating, it is also exported to different countries. Lot of foreign countries is earned every year here. An example of Chittagong district is shown at figure 3:

Fig 3: A view in Ukhia Upazilla in Cox'sbazar [25]

Areca nut amounting 0.5 million taka is marketed every day in an upazila named Ukhia in Cox's Bazar. 12000 families of Ukhia and Teknaf upazila cultivate Areca nut on around 5000 acres of land. In Bangladesh 36,500 hectares land is cultivated for areca nut where total production is 26,500 metric tons. These area are near sea shore of Bay of Bengal and therefore salty nature of soil helps to produce good amount of Areca nut. 10 tonnes per acre of land can be obtained from this area. Local government people are also very active in marketing. One nut is sold at 2.5 taka. These nuts are sold to different corners of Bangladesh. Even some Areca nuts are exported to India, Pakistan, Qatar, Saudi Arabia, UAE, UK etc. [26].

If the government and non-government organizations come forward to help the local betel nut cultivation, it would bring a huge development to the economy of the region and create self-employment schemes for the local unemployed youths, according to the sources concerned [27].

One plant produces the highest 547 nuts/year. (60 to 80)% part of a total nut is husk fiber. This fiber weighs 2.50 to 2.75 gm per one nut [28]. Therefore 3000 to 4000 tones areca nut husk fiber can be processed per year in Bangladesh. Traditional cutting system of Areca nut in the villages, a single cutter machine named 'Sosta' is used to cut Areca nuts into pieces. The rate of production is 3 kg/hour. Figure 4 shows a historical areca nut cutter machine.

Fig 4: Sosta [29]

2.6. Recent Areca Nut Cutting Machine in the Market

There are many areca nut peeling machines or dehusking machines in the Indian market. These are mainly of two types:

a) Manually operated and
b) Electric motor operated.

Again manually operated machines are of two types:

- Hand operated
- Pedal-operated

Electric motor-operated or operated by other sources.

i). Pedal Operated Dehusking Machine

Here the operation was done by a pedal and therefore skilled labor is required. It is not a continuous process. A scientist named M J Francis in Kerala invented this machine. It is priced at Rs. 850 and it can process 14 nuts in one minute. Figure 5 shows a pedal operated peeling machine.

Fig 5: Pedal operated peeling machine [30]

ii). Electrical Controlled Dehusking Machine

There is mainly a rotary shelling drum. 8 numbers of solid rubbers are mounted in its periphery. A concave is placed below it to assist shelling and pass down the dehusked material. By blowing of air steam, kernels, and husks are sent to the duct. At last husk or kernels are collected in a container. Change in concave is required for change in the size of the fruit. Overall result can give more efficiency and minimum breakage. Here better result is obtained for feeding dried fruit. A motor of 1 hp is used here. It can process 30 kg in an hour. Price is Rs 25000. Figure 6 shows an electrical controlled dehusking machine.

Fig 6: Electricity controlled dehusking machine [30]

iii). Latest Dehusking Machine

Gandhi Krishi Vigyan Kendra was the scientist of the Post-Harvest Technology Centre at the University of Agricultural University in Bangalore. 2 sharp-edged flaps are assembled here. One is stationary and another is movable. A linkage mechanism is engaged here through the pedal. A hopper is used that can hold 20 kg of areca nut. The total machine is made of mild steel, mounted on iron steel. The dehusking mechanism is made of steel spring. This is the latest machine as it can process freshly harvested mature green Areca nuts. Its production rate is better than previous any machine i.e. 160 kg in eight hours and the price is Rs. 3500. But more skilled manpower is required here. There is also a disadvantage i.e. 50% of the husk is removed by this machine and the rest is to be removed by hand. Figure 7 shows a latest dehusking machine.

Fig 7: Latest dehusking machine [30]

2.7. Research Development on Areca Nut Fiber

India had already performed lot of task on ANF. Every year almost 6 lakh tones of areca husk is collected here [31]. A great achievement was performed by Georgy Sunny Chandran kunnel in Kerala. A blended fabric was produced consisting 70 per cent areca nut husk and 30 per cent cotton. It was applied on a sari as the design of embroidery [32]. It indicated enormous potentiality of utilizing areca nut husk fiber. Figure 8 shows the invention of sari that uses the embroidery made from 30% cotton and 70% areca nut husk fiber.

Fig 8: Embroidery made of Areca nut husk fiber & cotton [32]

Again areca nut husk was environmentally sustainable. Farmers could get some economic benefit. More research was accomplished on shirts, draperies, furnishings etc. Actually this type of innovation is applicable for heavy fabrics. At the beginning, some woman hand work was initiated. In some other research works, warp is used as cotton and weft is used as areca nut husk fiber. Dye and bleaching-ability was also successfully observed on the products.

In the fashion market this kind of design was attractively accepted [32].

If 70% cotton is blended with 30% areca nut husk fiber, the produced yarn shown less stress strain curve than the yarn produced from coconut fiber and also it shows better strength and elongation. This yarn can be used in technical application and home textiles [33]. Areca nut husk fiber is also extensively used in polymer composites for owning good chemical and electrical resistance with better thermal and acoustic insulating properties. Moreover it is biodegradable, non-toxic and eco-friendly. By this hardboards, non-woven fabrics, cushions, fabricating automotive, building, packaging, construction, military equipment parts etc. can be produced. This is because areca nut husk fiber is lightweight, strong and has good strength to weight ratio. Again everything is possible at low cost [34].

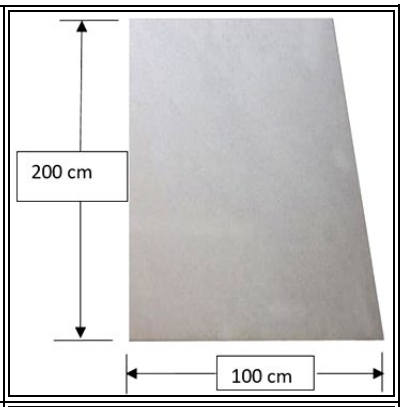
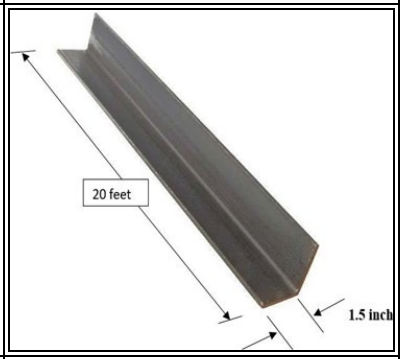
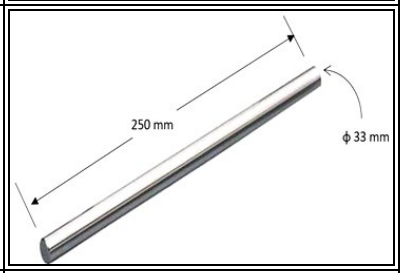
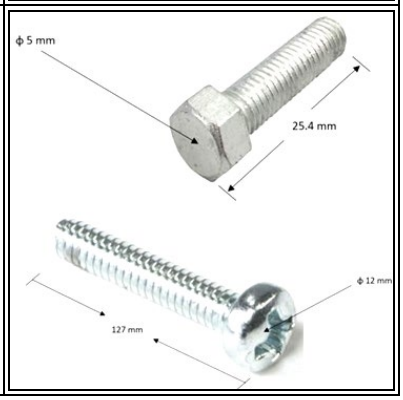
2.8. Necessity of Developing Areca Nut Dehusking Machine in Bangladesh

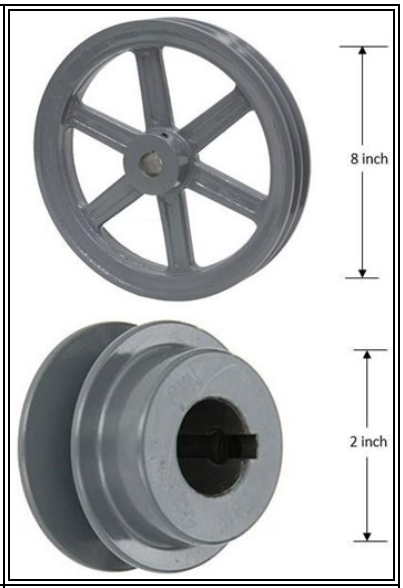
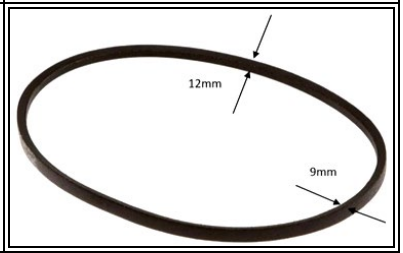
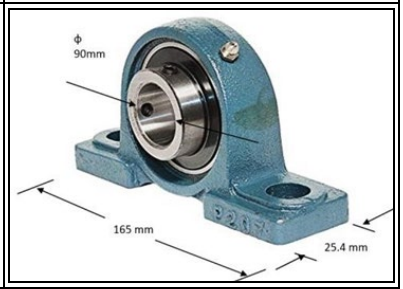
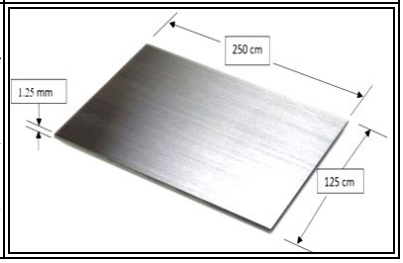
For processing Areca nut fiber, 35 to 40 percent of total cost is consumed for dehusking. Normally peeling of Areca nut is a laborious task by hand by which 24 kg can be cut per day with skill. But this skill is rare among village man and woman. Moreover manual process can cause injury. Therefore developing machine is important which had been introduced already at different countries of sub-continent. Initially invented machines were not so efficient to dehusk nuts and production was not so high. Manufacturing cost was also very high. Therefore developing a suitable machine at lower cost was a basic need to amplify use of Areca nut fiber.

3. Material Used in the Machine

The machine is manufactured from the materials those are available in the market. Table 2 shows their information:

Table 2: Material used in this machine

Mild Steel sheet	2000×1000×1.5 mm	• Used in applications those do not need high strength of alloy steels and high carbon • Provides high surface hardness and a soft core	
MS Angle	20 feet×1.5 inch×4mm	• Hot dip galvanized by hot rolled technique • These are fit for using in building construction, bridges construction, industrial structures, transmission tower etc.	
MS Shaft	1. Hollow shaft: Diameter is 63 mm. 2. Solid shaft: Three types have been used. They are 33, 50.8 & 63 mm.	Maintained by IS: IS2062, IS2830, IS2831, 15C8, 20C8, 25C8, C10, C20, 10C4, C1.I, C1.II	
Screw	**1.** Length:1 inch & diameter:5 mm **2.** Length:5 inch & diameter:12 mm **3.** Length:1/1.5 inch & diameter:8 mm	Not mentionable	

Belt pulley	Length:(2-8) inch Thickness:20 mm	Made of cast iron	
Belt	A-31, 33, 34,45,79 where the numbers refer length of belt in mm, width is 12 mm and thickness is 9 mm.	Not mentionable	
Bearing	UC bearing 207: Length: 165 mm, House thickness: 1 inch, dia 90 mm; UC bearing 205: 140 mm, 1 inch & 70 mm respectively; UC bearing 205: Outside diameter: 52 mm & inside 25 mm, thickness 15 mm	Bearing house is made of cast iron. Roller bearing is used here and made of alloy steel. Available brands of bearing are SKF, Nachi, NTN	
Galvanized Steel Sheet	2500×1250×1.25 mm	• Pure zinc coating • Can be used for indoor and outdoor machine frame • Steel finish • Lustrous silver color-Painting is easily accomplished • Length tolerance is ±2 mm and thickness tolerance is ±0.2 mm.	

4. Method (Design, Machine Processing, Manufacturing and Setting)

4.1. Design of Different Components

a) Schematic Design of the Machine: There are three components.

- Feeding unit
- Processing Unit
- Delivery Unit

Feeding Unit: A box is used here. Nuts are fed here. At a side a belt is set at an angle where many pockets are attached. When the belt is moving in a continuous path, the pockets are taking nuts up as nuts fall in the pocket naturally for the construction design of box. The nuts are fallen into the cylinder roller and worker rollers at the processing unit. The feeding unit is shown at figure 9.

Processing Unit: Here a cylinder is used to perform the main operation i.e. opening the shell from the nuts. Two worker rollers assist the cylinder. All the surfaces are covered with wire clothing. At the bottom of cylinder, a rough plate is used that is also designed with wire clothing. So, here there are two action zones. 1st action is occurred when areca nuts are passed through cylinder and working rollers. 2nd action is acted when processed nuts are passed between cylinder and rough plate surface. Processing unit is also shown at figure 9.

Delivery unit: The processed nuts are forced towards the delivery unit. It consists of two plates those are connected one over another. The total is set in vibration and at an angle. Moreover the upper plate is designed with lot of holes having different sizes of diameter of inside nuts. The processed nuts at first will go to the upper plate. If inside nuts are perfectly opened or broken (but separated), through the holes, those fall in the second plate. If not, as vibration is applied, all are gradually sent forward. At the front side, a door is kept through which all rest components go out which reach foremost side. At the bottom plate, at the front and left side, the door is designed. Nuts which fall through holes can go out easily through this designed door. Fig 9 also shows the delivery unit.

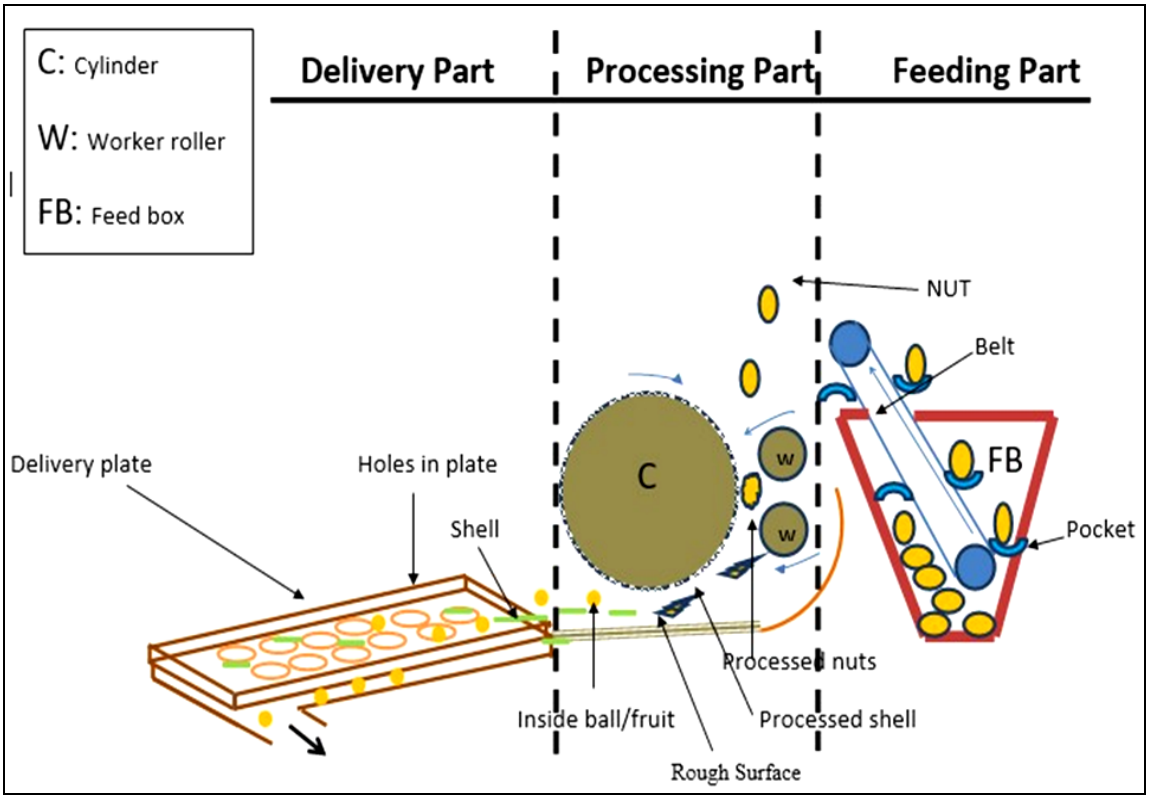


Fig 9: Schematic design of Areca nut dehusking machine

b) Design of the Feeding Unit

A box is designed where all the nuts will be kept. A conveyer belt is to be added through the box that will carry the nuts to the processing unit. A special rubber is used for making the belt. This rubber was used in an old spinning machine (carding machine). The rubber is cut and formed in the shape of belt. Some pockets are to be attached with the belt those will carry the nuts. The same material of the rubber is cut and joined with the belt by sewing thread. The mouth of the pocket is designed in three dimensional V-shape. One side is attached with the belt and another side is used to pick up nuts. The box is again made between U and V shape. The side walls at bottom are not reached at one point line like V. The walls are rather like a square area. But the side walls are inclined as V. The length of this pocket bottom is 15 cm and width is 14 cm. At the top the length is 43.5 cm and width is 33 cm. Half part of the bottom surface is kept blank. By this hollow space, the belt can move in a continuous path. The width of the belt is 8 cm. In the design of pocket, the length and width are kept 5 cm each and highest depth is kept is 6 cm. On the way through the hole, a rubber door is designed. It will work as a valve and it will go only up. When the belt is moving up, with it also the pocket goes up. During going up of the pocket, the valve opens and again it shuts. The valve is given to keep the nuts in the box and again it will open when the pocket goes up. A picture showing the total feeding unit is shown in the figure 10. Another picture at 4.3 shows the design of the feeding box.

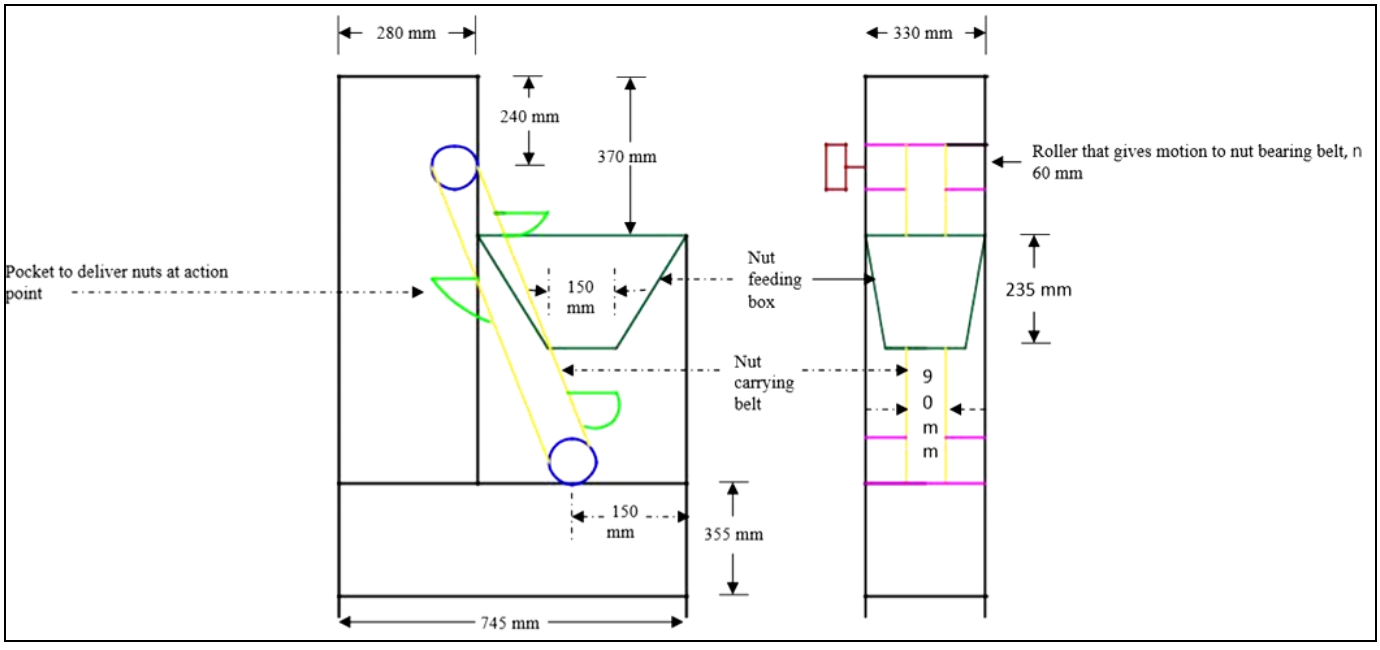


Fig 10: Feeding Unit

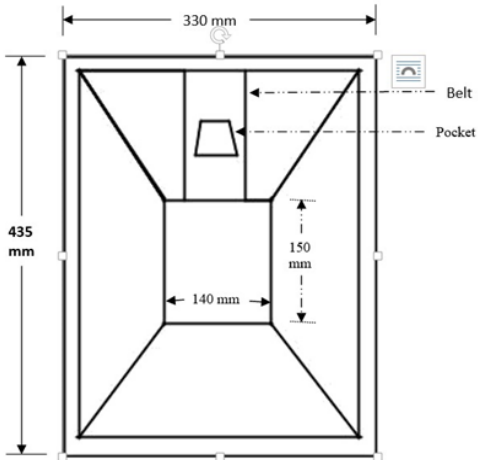


Fig 11: Upper view of feeding box

c) Design of the Main Cylinder

Total arrangement of cylinder adjacent components are shown at figure 12 and 13.

d) Design of the Delivery Unit

Delivery Plate: A plate is designed in vibration state. The rectangular plate has a length of 51 cm and width of 23.5 cm. At three sides, wall is given except the connection side. Through this side, processed nuts enter into the plate. The height of the wall is 8 cm. The delivery plate is set into at inclined state. The plate is also cut into some holes. The diameter of the holes is designed as 3 and 2.6 cm as the average diameter of the fruit of betel nut is near at these sizes. Again the delivery plate consists of two floors. The above mentioned floor is the main part which is already described. The bottom part is situated at 2 cm bottom of the upper one. Here the wall is designed as 4 cm in height. Two floors are attached each other by two connecting bars at two sides. The width of the bar is 2 cm. The unit is shown in the figure of 14.

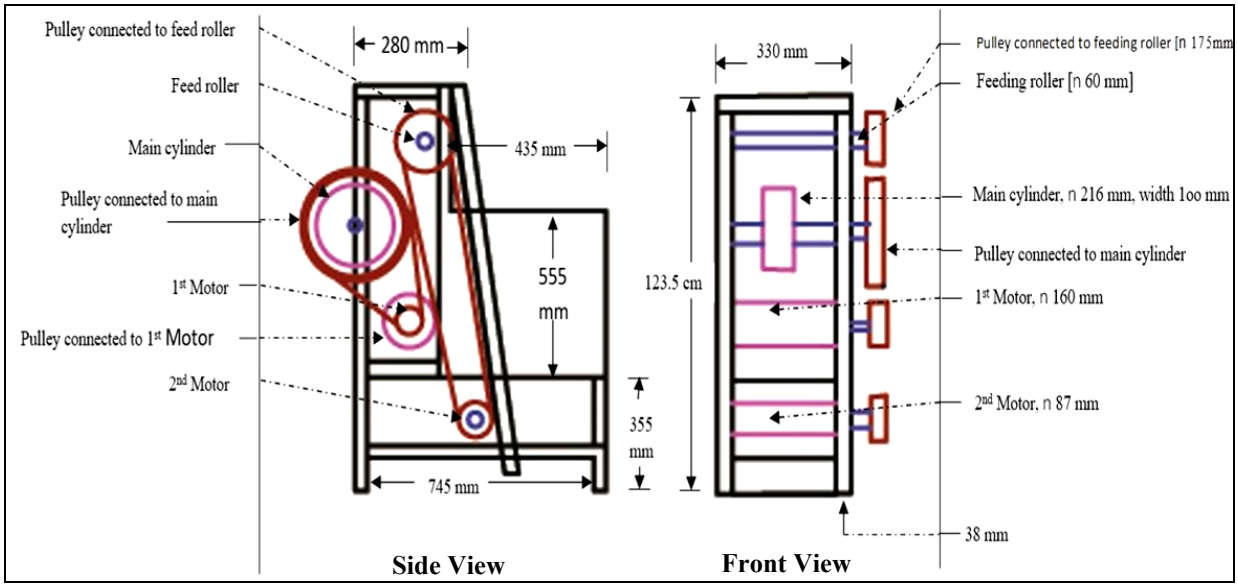


Fig 12: Main Cylinder

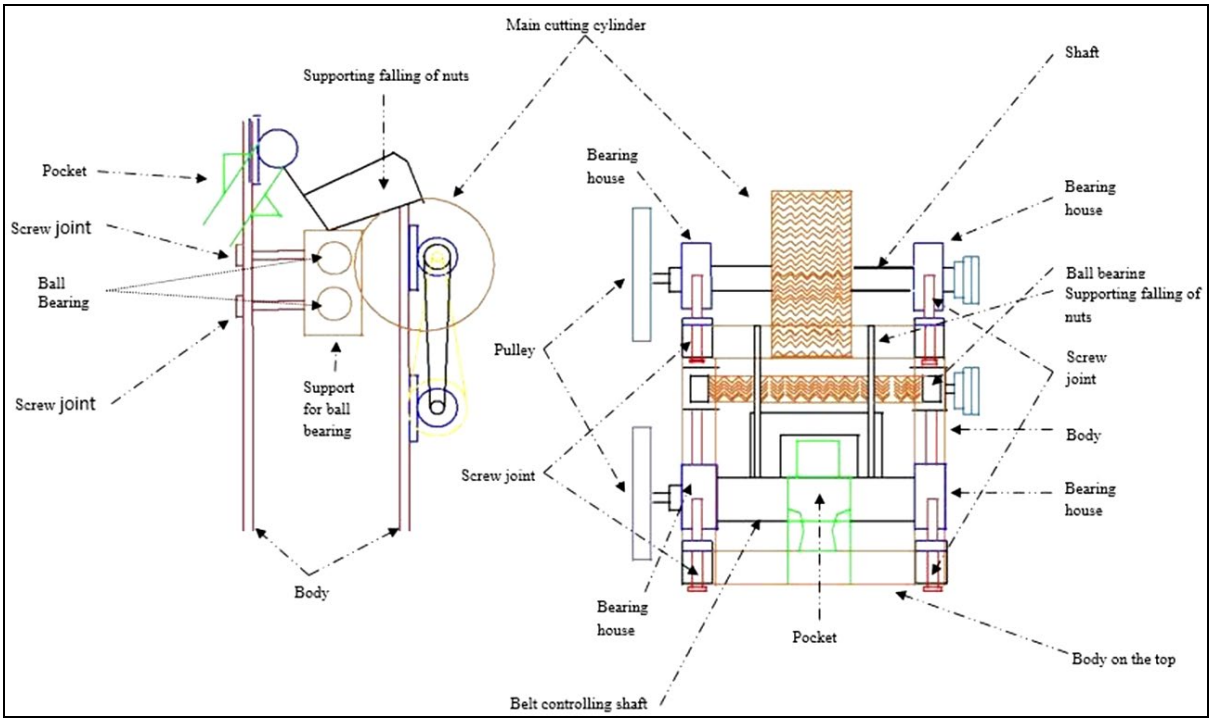


Fig 13: Another view of main cylinder

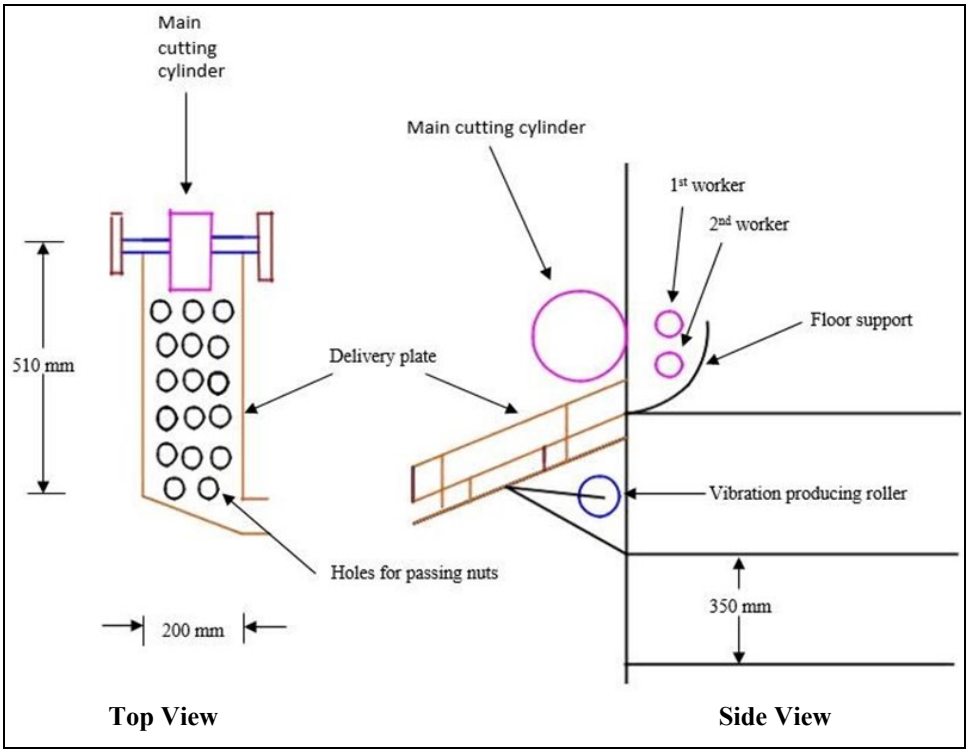


Fig 14: Delivery unit

Arrangement for Vibration:

The delivery plate is also designed to set in vibration state. For this, a rod is used to join the supporting plate and the rod gets motion from a shaft indirectly connected to the main motor. This shaft is joined in the main body by a support of UC bearing 205. In the shaft, at the joining, a heart cam is set with the connecting rod for it's to and fro motion. The shaft is actually gets motion from the shaft connected to the cutting cylinder by belt driven pulleys.

A design of delivery plate having vibration is shown at figure 15.

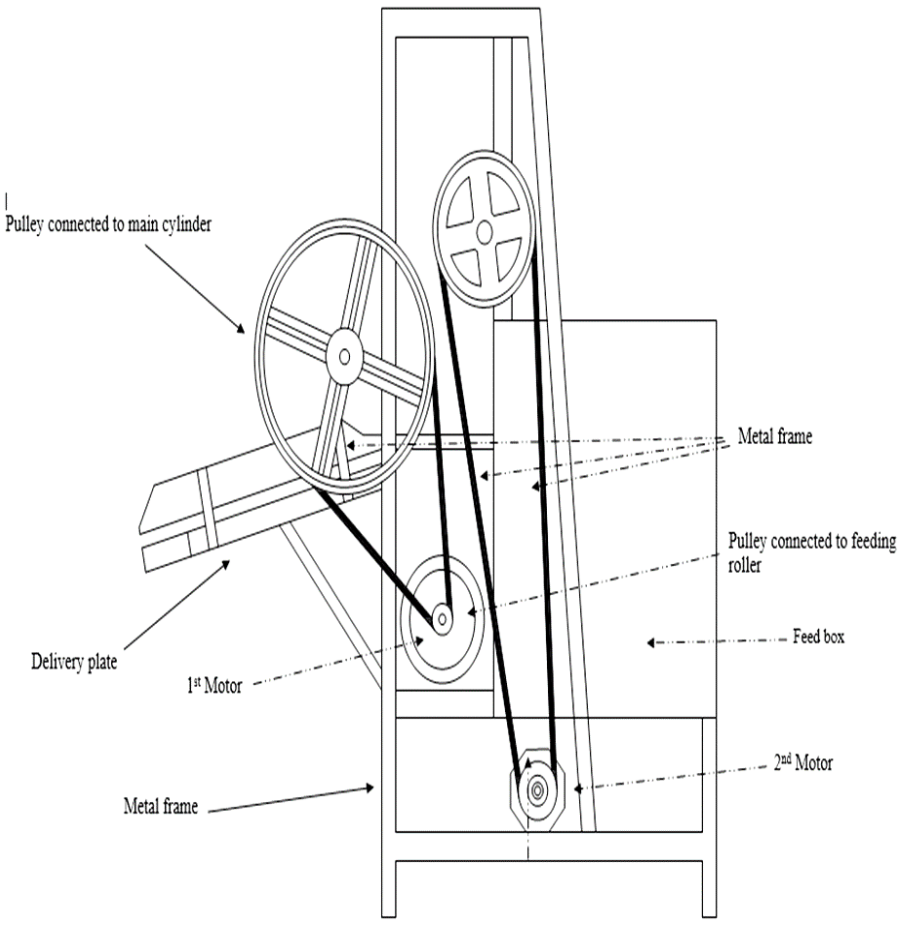


Fig 15: Delivery plate with vibration

e) Total 3D view of the machine

A 3D view is drawn by CAD that is shown at the figure 16.

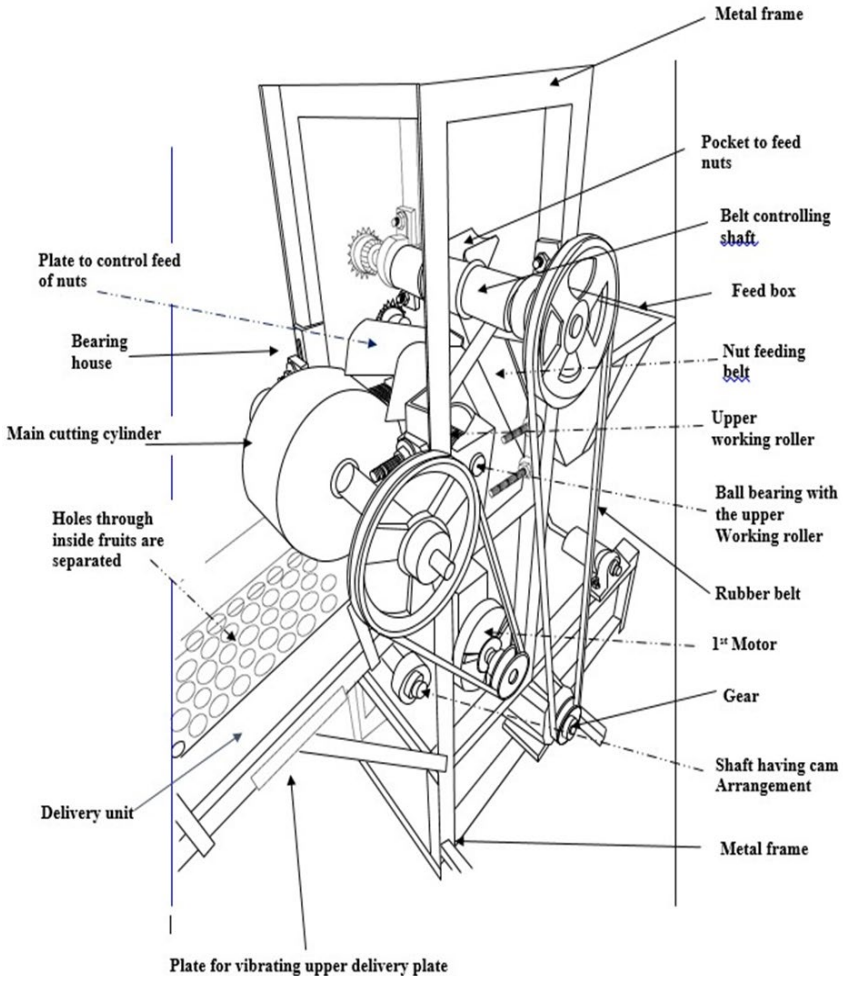


Fig 16: 3D view of the new manufactured total machine

4.2. Different Manufacturing Processes

a) Welding Joint

Electrical weld system is used. Electrode rod is used to join. Typical welding is shown at figure 17 (a) and (b).

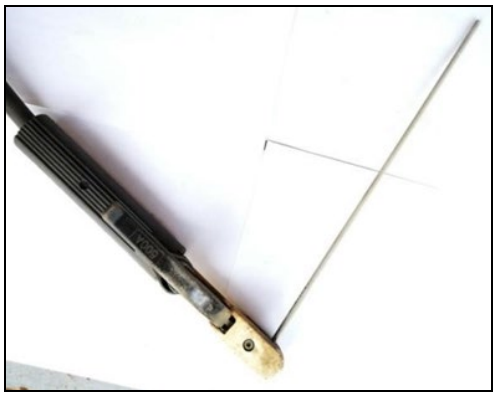


Fig 17(a): Electrical welding source

Fig 17(b): Electrical welding system

Fig 17 (a & b):

b) Screw Joint

In the body of the machine, 3 types of screw were used to join different components. Those are shown at the following:

Body: MS Bolt having diameter of 5 mm, length is 1 inch (25.4 mm).

At bearing house near the cylinder: Diameter is 12 mm and length is 5 inch (127 mm). At other bearing houses: 8 mm bolt having length of 1 inch (25.4 mm) and 1.5 inch (38.1 mm).

c) Connection by Belt Pulley

Belt pulley of different sizes are used to transfer the motion. Those are written in the following:

With cylinder (it is set at the shaft that is connected and right side of feed-delivery axis): 8 inch

With feed roller (it is set at the shaft that is connected and at the same side as the upper one): 7 inch

Cylinder to cam: c1) This pulley is set on the shaft of the cylinder: 2 inch c2) This pulley is set on the Cam shaft: 5 inch

With upper worker roller: driver (fixed at cam shaft): 2.5 inch, driven (fixed at the shaft of upper worker roller): 4 inch
With lower worker: driver (fixed at cam shaft): 2 inch, driven (fixed at the shaft of lower worker roller): 8 inch All have thickness of 20 mm.

d) Belt Drive

Belt of different sizes drives motion to different components and those are shown here: With the cylinder (it connects the pulley at the shaft of cylinder and the pulley that is connected at the shaft of gear motor): A-45 model is used. 45 refer the length of belt in cm. Its diameter is 12 mm and thickness is 9 mm.
With feed roller (it connects the pulley at the shaft of feed roller and the pulley that is connected at the shaft of 2nd motor): A-79 model is used of same diameter and thickness.
With cam shaft (it connects the pulley that is connected to the cylinder and the pulley connected with cam shaft): A-31 is used.
With cam shaft to upper worker roller (connection is with the pulley at camshaft and the pulley at upper worker roller): A-33.
With cam shaft to lower worker (connection is with the pulley at camshaft and the pulley at lower worker roller): A-34.

e) Setting of Bearing

For joining different components, following bearings are used:
With cylinder UC bearing 207 is used. Length is 165 mm. House thickness is about 1 inch (25.4 mm) and diameter is 90 mm.
Other bearings in the body: UC bearing 205. Length is 140 mm. House thickness is about 1 inch and dia is 70 mm.
Other bearings in the cylinder and worker rollers: Ball bearing 205. Outside diameter is 52 mm and inside is 25 mm. Thickness is 15 mm.

f) Surface development of cylinder, worker rollers & bottom surface

The surface of the rollers is mainly responsible for the cutting performance of nuts. Special teeth are to be developed here. Again surface of the bottom floor is to be cut into teeth.
These are accomplished by-
Teeth are made in milling machine or shaper machine
Grooving is done Lathe machine
Curved Surface is also made by forging

Surface Development of Cylinder

Actually this is a big roller that is solid and collected from old ship. It was looked very ordinary. Because it was with rust. For preparation at first it was taken to milling machine. The tooth of the milling bit is the deep helical grooves running up the cutter, while the sharp blade along the edge of the flute is known as the tooth. The tooth cuts the material, and chips of this material are pulled up the flute by the rotation of the cutter. There is almost always one tooth per flute, but some cutters have two teeth per flute. This process is shown at figure 18.

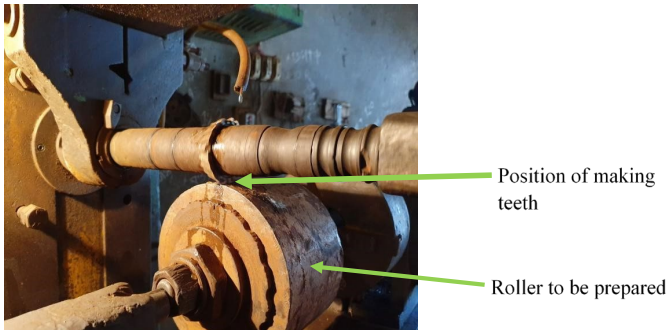


Fig 18: Development of cylinder in milling machine

At the beginning, teeth is made on the circular surface to the axis in the shaper machine. As the surface is circular, shaper machine is used. Otherwise milling machine can be used. For the making teeth to the direction of circle, the solid roller is taken to lathe machine.

Development of Helping Rollers' Surface

Helping rollers are small in diameter. Therefor shaping machine is not needed. Teeth is directly made on milling machine. Total process is almost same as the previous process. In the milling machine, teeth is made to the axis in the circular surface. Then it is taken to lathe machine. Their teeth is made to the direction of circle. The process is shown at figure 19.

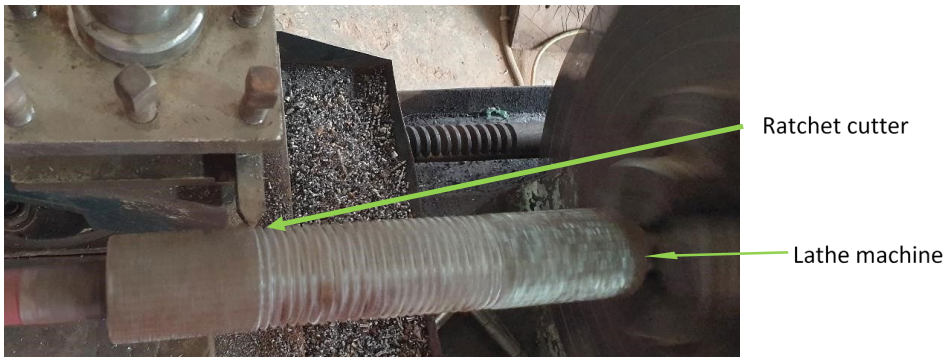


Fig 19: Development of roller in lathe machine

Development of Abrasive Bottom Surface

Groove cutting on lathes is a multi-step machining operation. The term grooving usually applies to a process of forming a narrow cavity of a certain depth on a cylinder, cone or a face of the part. The groove shape is a significant part of it, will be in the shape of the cutting tool. Grooving tools are also used for a variety of special machining operations.

Grooving tool is usually a carbide insert mounted in a special tool holder, similar to any other tool. Designs of grooving inserts vary from a single tip to an insert with multiple tips. Inserts are manufactured to nominal sizes. Multi tip insert grooving tools are used to decrease costs and increase productivity.

Cutting tools for grooving are either external or internal and used as variety of inserts in different configurations. The most important difference between grooving and turning is the direction of cut. Turning tool can be applied for cuts in multiple directions; grooving tool is normally used to cut in a single direction only. A notable exception is an operation known as necking (relief grooving), which takes place at 45 degree, where the cutting insert angle and the in-feed angle must be identical l (usually at 45). There is another application of a two axis simultaneous motion in grooving, a corner breaking on the groove. Strictly speaking, this is a turning operation. Although a grooving tool is not designed for turning, the nuts are passed through cylinder and helping rollers. But the nuts are not fully opened. Therefore some more actions are to be accomplished. A little consideration shows that in this kind of performance, action is only done in the nip points. That is why a new technique should be applied where a continuous abrasive action is happened. If two curved surfaces can be set close through which nuts will be passed, nuts may face continuous scratchy effect. Here another condition is important to consider that the nuts are gradually becoming small. So, the passage should be continuously finer. To fulfill all these targets, initially a flat steel bar is taken to set under the main cylinder. Now the design is to be according to the above-mentioned plan. Initially it was taken into the forging device. Here by applying heat and beating, a curved bar is produced. The curving design is accomplished in such a way that the radius of the curve is gradually decreased.

Secondly it is taken to the ratchet cutter to make teeth to the line parallel to the axis of the roller and then to the lathe machine to cut teeth on the circular surface of the roller that is shown previously.

4.3. Machine Manufacturing

a) Body Frame

A design of body is planned that is made of MS.

At the bottom a rectangular frame is designed. Length of this frame is 74.5 cm and width is 33 cm. Height is kept as 35.5 cm from the ground. At the left side of this frame, again a vertical rectangular frame is designed. This vertical frame has a height of 88 cm. The width is kept as 33 cm and length is 28 cm.

At the front or left side of the vertical frame, delivery unit is situated. At the back side or right side of the vertical structure, feed unit is placed on the bottom structure.

In the height of vertical structure, from the top at 31 cm, a pair of UC bearing 207 is set to place the main cylinder unit in it. Again from the ground, at a height of 39 cm another pair of UC bearing 205 is set to give a to and fro motion to the delivery plate. At the back part or right of vertical structure, another pair of UC bearing 205 is set to fix the shaft that rotates the belt to pick nuts at the feed box. At the top and right corners of the bottom frame, another pair of UC bearing 205 is fixed at another shaft that hold the other end of the belt. A set up of all the bearing houses are shown at the figure 20.

On the left or front side of the bottom horizontal structure, on the MS angle, a gear motor is placed to give motion to the shaft directly that holds the main cylinder. The motor has Horse Power of 0.75. In the bottom connecting rod of the bottom structure, in the middle position another motor is set. This gives motion directly to the shaft that gives motion to the belt in the feed box.

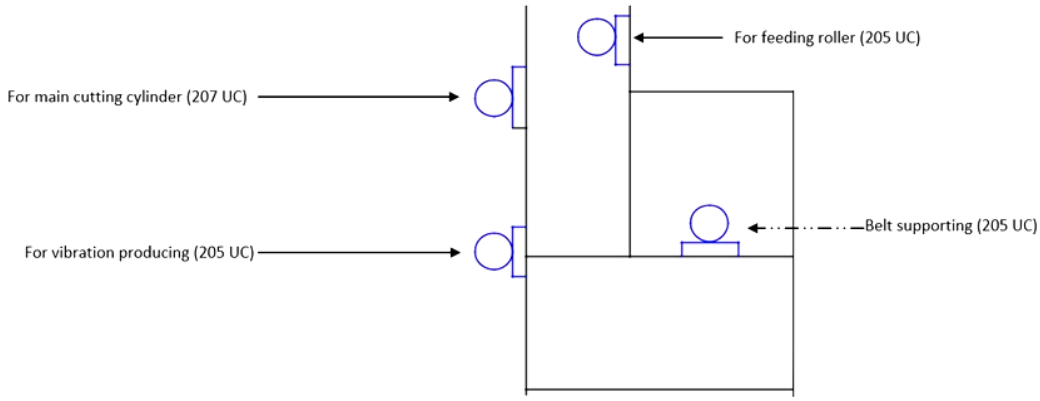


Fig 20: Side view of Bearing House

b) Motion of the Belt

A shaft is set at the right connecting rod of the vertical structure. A pulley is connected with this shaft. This shaft has a diameter of 17.5 cm. This pulley is driven by a belt from 2nd motor that is situated at the bottom. It has Horse Power of 2. The length of the motor is 14.5 cm.

This shaft has diameter of 6 cm that is used here to connect the belt at other end. When the belt moves in the continuous path, it keeps a gap of 6.5 cm between two parts of the belt.

c) Main Cylinder

A cutting cylinder is mainly introduced here which has a circle diameter of 216 mm and body length of 100 mm. It is made of cast iron. The surface of the cylinder is specially cut into very sharp 3d based small blades set at an angle. This is specially arranged in lathe machine and milling machine. In the analysis of density, to the direction of connection, 7 teeth is kept in one inch and 4 to the direction of continuous length. Depth of each tooth is kept as 3 mm. This is shown at figure 21.

Fig 21: Teeth arrangement in cylinder

Angle between teeth is set as negative angle. Negative angle is designed as the speed of the main cylinder is very high and it lasts long. This is shown at figure 22

The motion of the main cylinder is directed clockwise to pass the nuts forward. This is connected to a shaft of MS. The length of the shaft is 300 mm and have diameter of 54 mm. For the circular movement (that produces the main action of cutting), the shaft is connected to two bearings at two corners. UC bearing 205 and 207 are used here. These two bearings are fixed at a middle position of two frames of the body in the machine. The frame is mainly made of MS and at different positions of the frame; hole is cut to join the bearing by screw.

For the rotation of shaft, at the outside of the machine frame.

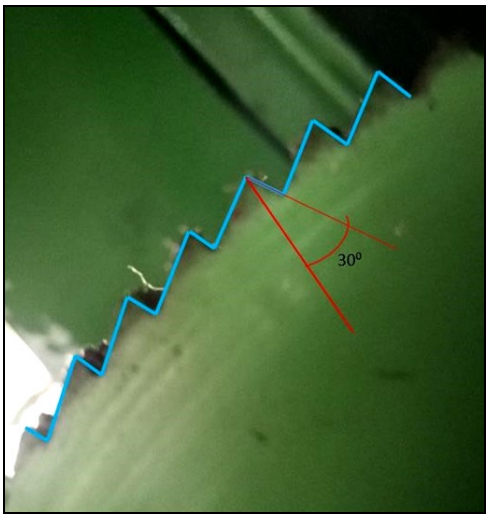


Fig 22: Negative angle among the teeth

The pulley has a diameter of 350 mm and made of cast iron. Here various pulleys of different sizes can be set according to required speed. A rubber belt drive specified as A-45 controls the motion between the mentioned pulley and the motor. The motor is almost circular in shape and diameter is 160 mm. A pulley having diameter of 1.5 inch is used in the motor that is connected to the belt drive.

d) Working (Driven) Rollers

Two small rollers having diameter of 2 inch are set with the main cylinder roller to assist the cutting operation. These rollers are made of low alloy steel. Surface is also cut in the form of special 3d tooth like the surface of main cylinder. Here density is kept as 7/inch to the direction of connection and 4/inch to the moving direction. Depth is set as 2.5 mm. The picture is shown in the following figure 23.

Fig 23: Teeth arrangement in working roller

Here the angle is kept as positive angle. Because helping rollers mainly assist the main operation. As the main cylinder is designed positive angle, negative angle in the helping rollers can give a better result. The view is shown at figure 24.

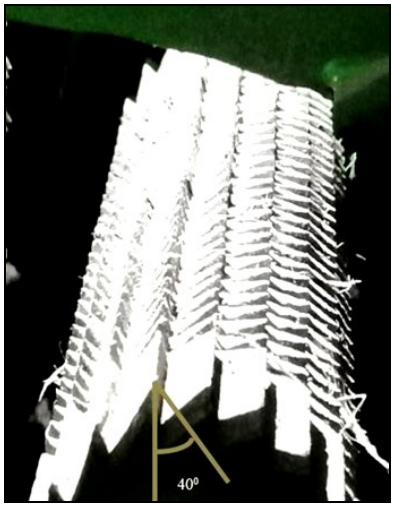


Fig 24: Positive angle in the helping roller

Motion of both rollers is directed to the opposite of delivery side. It means the motion of both the helping cylinder is directed to the clockwise direction i.e. the motion is opposite to the falling direction of nuts. The design is modeled in this form so that the speed of falling nuts is slightly decreased. Here nuts get some more time to be reacted through. The distance between two rollers is kept very less so that nuts cannot be passed through. Again distance between cylinder and rollers is very important. At the entry, the distance is kept as 50 mm and at the end it is 30. The distance can be adjustable. At the opposite side of shaft of main roller, a pulley is set from which the motion is transferred by belt to other two pulleys. With two pulleys, two shafts are connected and with each shaft a helping roller is set.

f) Bottom Rough Surface

For more action to the nuts, after stroke between cylinder and helping rollers; a rough surface is designed. This is an angular surface that is produced at shaper machine. The length of surface is kept as 150 mm and the width is also kept as 150 mm. Surface is again cut in lathe machine to produce special teeth.

g) Setting at Main Cylinder: 40^0

Main setting lies at the main cylinder point as this is the main crushing point with a supporting arrangement of helping rollers and bottom rough surface. The nuts are at first fed between main cylinder and worker 1 where the distance is kept the maximum i.e. 24 mm. This distance is selected according to the average size of the nuts those are available in the market. The 2^{nd} crushing point is between main cylinder and 2^{nd} worker where distance is kept around 22 mm. As some crushing will be occurred at 1^{st} point, 2^{nd} crushing point is kept little narrow. At the 3^{rd} point (between main cylinder and initial point of bottom rough surface), a distance of 20 mm is kept). At the later part of bottom rough plate, a distance of 18 mm is kept between main cylinder and rough plate. An arrangement of setting is shown at the figure 25.

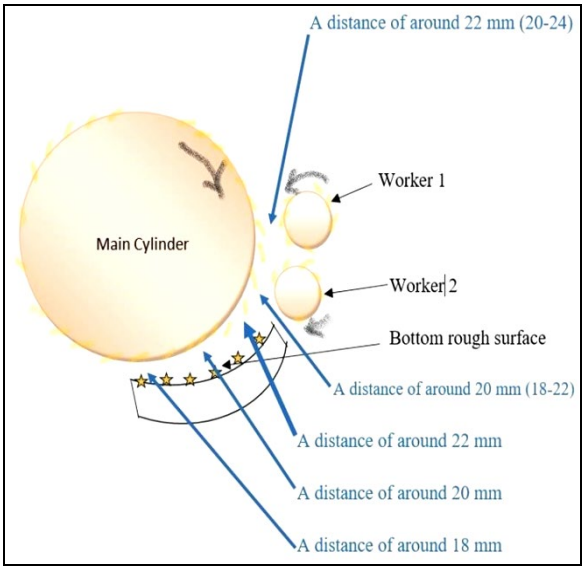


Fig 25: Different setting at main cylinder area for action

h) Supporting Material at Delivery Part

A support is given to hold the inclined plate with the main body. It consists of two flat bars at two sides and a bridge plate. The bottom part of the connecting bar is connected at the joint situated at the front body at a height of 35 cm from the floor. From the front body, the other side of the supporting bar is joined at a horizontal distance of 25.5 cm. The upper part is again joined to a plate having wall at two sides which help the delivery plate to fix in a position. The walls are set at two corners of the plate. The length of the bar is 31 cm and width is 2.5 cm. The length of the plate is 15.5 cm and height is kept as 2.5 cm. This plate keeps the delivery plate tight.

4.4. The Machine Specification with Dimensions and Setting:

The machine has different components which have either specific dimensions, setting or different information. Those are summarized at the table 3.

Table 3: Machine Specification

Component	Dimensions	Setting/Power	Main Element	Supporting Parts
Total structure	L: 75 cm W: 124 cm B: 33 cm		Mild steel	MS angles UC bearing
Motor	Gear motor	0.75 HP		
	Normal motor	2 HP		
Feed box	L: 43.5 cm W: 33 cm B: 55.5 cm		Mild steel	
Delivery plate	L: 51 cm W: 23.5 cm B: 8 cm		Galvanized steel	
Main cylinder	L: 10 cm D: 21.6 cm		Cast iron	
Driven rollers	L: 10 cm D: 2.54 cm		Low alloy steel	
Distance from main cylinder to…	Upper driven roller	24 mm		
	Lower driven roller	22 mm		
	Starting part of rough surface	20 mm		
	End part of rough surface	18 mm		
Priming			Red oxide	
Paint		4 coats	Nippon Epoxy	

4.5. Speed of Different Components

The dehusking machine consists of different movable components. These components transfer motion to different pulleys or gears which actually let happen all the operation. Analysis of production can be controlled by these. Table 4 shows speed of different rollers.

Table 4: rpm of different moving components

Sl. No.	Moving components	rpm	Surface Speed (ft/min)
1	Feed roller	49	30.3
2	Main cylinder	266	592.4
3	Intermediate shaft (before the delivery plate)	106	27.8
4	Upper helping roller	66	34.6
5	Lower helping roller	26.5	13.9

4.6. Electricity Consumption

Two motors are used here, one is of 2 horse power and another 0.75 horse power.

We know that, 1 HP = 0.746 kilowatt

Therefore, 2 HP = 1.492 KW hour and 0.75 HP = 0.56 KW hour

Total = 1.492 + 0.56 = 2.0515 KW hour

4.7. The Spectacle Structure

After making the structure, covering by steel is accomplished around the whole structure. Finally the machine is painted with beautiful green color. It looks as figure 26 (a), (b) and (c).

Fig. 26 (a): Back side (feeding) **Fig. 26 (b):** Front or side view

Fig. 27 (c): Delivery side

5. Results & Discussions

5.1. Selection of Nuts for Processing

Dehusking of Areca nut is not always an easy task. It can be an easy process if it is performed in dry condition. But initially the nuts have lots of moist when these are taken from the tree at harvest time. Therefore, it should be kept in mind that the dehusking machine is capable of dehusking fibers at both moist and dry condition. Therefore, crush type of force is generated here. The crush is accomplished at three stages which are between upper helping roller & cylinder, lower helping roller & cylinder and cylinder & lower abrasive surface. All these crushing effects result in a reasonable dehusking to the fed nuts. A nut has normally an oval shape where the circumferences at different corners are nearer. Here gauges (distances between the crushing points) were selected according to the average circumference of the nuts. Therefore, every nut is dehusked at an amount as it has some chance to fall into the crushing points. Because the gauges are smaller than the circumference of any nut at any position.

In the market of Bangladesh, mainly 4 types of nuts are Available. Before analysis, characteristics i.e. circumference, weight, moisture value and hardness of the nuts are to be defined. Hardness was also measured with the common instrument that is available in lab. This is Shore D (Durometer) hardness tester that follows the standard as MSZ EN ISO 8682003. The process is very simple. A needle is pushed into the material by a given force in a given time. The counter moves accordingly and the angle deflected shows the measurement. The produced hardness is inversely proportional to the form of the push given by needle [35]. These 4 types have been taken and these are shown in the Table 5.

Table 5: Different Nuts

Type of Nuts	Green Nuts	Ripen Nuts	Dried Nuts	Retted Nuts
Picture				
Description of nuts	Collected from trees when the husk is green [81]	The husk becomes yellowish or orange [81]	The husk becomes little blackish [81]	The husk is soaked in the water for 5 to 7 days [82]
Circumference at middle	12 mm	11.5 mm	9.2 mm	(9.2-12) mm
Average Weight	35 gm	22 gm	10.4 gm	24 gm
Moisture% at the initial stage (around)	71.5%	47%	34%	87%
Moisture Regain% at standard atmosphere	16.2%	14.3%	10.3%	31.7%
Shore Hardness	82 degree shore	61 degree shore	39 degree shore	33.5 degree shore

5.2. Dehusking Speed of the Machine

The dehusking machine has been developed as a sample machine where large production was not a main target. Therefore a moderate size has been taken that has been shown before. Moreover production depends on mainly speed. An average speed has been set at the beginning. Later on it was found that a slower speed could give a better result. Nuts have been fed at different amount and production rate is observed. A collection of different nuts have been fed where 4 types of nuts were available.

Initially 150 nuts are fed and a total time of almost 12 min was needed. During the production 3 times stoppage was occurred. It is a problem for the machine to stop because the nuts are trapped between two rollers.

It has been already mentioned that there are different sizes of nuts available in the market. The gauge of the rollers are fixed according to average sizes of nuts. But the collection of nuts from the market was randomly done. Therefore stoppage time is needed to be calculated for correct production rate.

2nd time 150 nuts have been fed where total 10 min and 57 sec was needed for passing 150 nuts. 6 times stoppage were occurred that took 8 min & 11 sec. So real time of passing nuts through the machine was 2 min 45 sec. Therefore it is found that 3273 nuts can be fed within one hour. So, according to 1st trial:

Production Rate: Almost 3300 nuts/hr.

At this speed all the nuts are analyzed. Considering efficiency, it is seen that out of total10 minutes 57 seconds, 2 min 45 sec was mainly engaged and rest time wasted. Therefore, Efficiency: 25.11%

5.3. Analysis of Dehusking

Four types of nuts are fed here. As their internal condition is not same, different result is found. Analysis rate is based on the condition of dehusked nuts those are obtained after dehusking. Total number of nuts are fed at the dehusking machine (100 were fed) and finally condition of dehusking was observed. Four types dehusking were named. 1st one is named as Type A where nuts are perfectly dehusked & splitted into two parts. 2nd one is named as Type B where nuts are splitted into two parts and one part is spread flatly. 3rd one is named as Type C where nuts are divided into two parts but there was very less dehusking. 4th one is named as Type D where nuts are crushed. Among 100 nuts finally it was counted how many nuts are found for each type of condition. Those amounts are directly expressed into percentage as total 100 nuts were taken. Those are analyzed one after another at the following.

a) Dehusked green areca nuts

At figure 28 green nuts have been shown which demonstrate good dehusking. Many nuts are fed here together and after passing through the dehusking machine, following type of duhusking was found.

Fig 28: Dehusked green nuts

Their comparative analysis is shown at the following table 6:

Table 6: Comparison of 4 types of dehusked green nuts

Dehusking Parameter	A Type	B Type	C Type	D Type
Image				
Dehusked Nut%	41%	16%	38%	5%
Splitting of Husk	2 half shells	2 half shells	2 half shells	As crushed, lot of parts of husk
Separating nuts from husk	Very good	Average	Very bad	Average
Structure of shell	No change of half circular shells	2 half shells where some part is flattened at one side	No change of half circular shells	Husk is completely broken into different small attached components
Opening or individualization of fiber	No	Very less	Very less	Good
Damaging of fibers	No fiber is opened	No fiber is opened	No fiber is opened	7%

Extraction% of Green Areca Nut Fiber

100 green areca nuts were passed through the dehusking machine those have a weight of 4.4 kg. Extracted fibers were measured and the weight was 2.11 kg. Finally non-extracted parts are collected and weight is found as 0.93 kg.

$$\text{So, Extraction\% is: } \frac{Weight\ of\ extracted\ fiber}{non-fruit\ content} \times 100\% = \frac{2.11\ kg}{(2.11+0.93)\ kg} \times 100\% = \frac{2.11\ kg}{3.04\ kg} \times 100\% = 69\%$$

The rate of extraction is good as fibers are not obtained at the individual form, rather fibers are attached with one another and are found as small part of shell. Some fibers are found as individual form.

Condition of Manually Extracted Green Areca Nut Fiber

After dehusking, a manual process has been applied to collect areca nut fibers. It was certainly a slow process. Bur it gives good collection of Areca nut fibers as figure 29:

Fig 29: Collection of green nut husk fibers

b) Dehusked Ripen Areca Nuts

75 nuts were passed through the dehusking machine. Among 75 nuts, at first 26 nuts were dehusked finely. Initially condition of dehusking was looked well. The picture is shown below at figure 30.

Fig 30: Dehusked ripen areca nuts

Their comparative analysis is shown at the following table 7:

Table 7: Dehusking result of 4 types of dehusked ripen nuts

Dehusking Parameter	A Type	B Type	C Type	D Type
Dehusked nut%	22%	18%	36%	24%
Image				
Splitting of husk	Divided into 2 shells	Divided into 2 shells	Divided into 2 shells	Half shell is converted into individual fibers and half less
Separating nuts from husk	Full	Half	Not at all	Good
Structure of shell	2 full half shells	Converted into 2 unequal shells	2 full half shells having nuts inside	The shell is almost completely broken
Opening/individualization of fiber	Very less	Very less	Very less	good
Damaging of fiber	Not mentionable	Very less	Not considerable	Very less

Extraction% of Ripen Areca Nut Fiber

100 ripen areca nuts were passed through the dehusking machine those have a weight of 5.25 kg. Extracted fibers were measured and the weight was 1.8 kg. Finally non-extracted contents are collected and weight is found as 1.98 kg.

$$\text{So, Extraction\% is: } \frac{Weight\ of\ extracted\ fiber}{Weight\ of\ non-fruit\ content} \times 100\% = \frac{1.8\ kg}{(1.8+1.98)\ kg} \times 100\% = \frac{1.8\ kg}{3.78\ kg} \times 100\% = 48\%$$

Here some fibers are found as individual form, maximum fibers are attached with one another and are found as small part of shell.

Condition of Manually Extracted Ripen Areca Nut Fiber:

After processing by the machine, a manual hand peeling process give good collection of ripen fiber as figure 31:

Fig 31: Collection of ripen nut husk fibers

c) Dehusked Dried (Black) Areca Nuts

In the same production rate, these are also tested and the result is found as figure 32:

Fig 32: Dehusked dried areca nuts

The comparative analyses of dehusked dried areca nut is shown at the following table 8.

Table 8: Dehusking result of 4 types of dehusked dried nuts

Dehusking Parameter	A Type	B Type	C Type	D Type
Image				
Dehusked Nut%	9%	18%	64%	9%
Splitting of husk	Divided into 2 shells	Splitted into finely opened & individualized fiber	Splitted into finely opened & individualized fiber	Splitted into finely opened & individualized fiber
Separating nuts from husk	Full	half	Very less	Very less
Structure of shell	One shell remain same and another is crushed a little	Converted into 2 shells of mass made of opened and entangled fibers	Spherical swelled shell	Half crushed
Opening/individualization of fiber	Very less	good	Very good	Very good
Damage of Fibers	No	No	No	No

Extraction% of Dried Areca Nut Fiber

100 dried areca nuts were passed through the dehusking machine those have a weight of 1.06 kg. Extracted fibers were measured and the weight was 0.33 kg. Finally non-extracted parts are collected and the weight was found as 0.44 kg.

$$\text{So, Extraction\% is: } \frac{Weight\ of\ extracted\ fiber}{Weight\ of\ non-fruit\ content} \times 100\% = \frac{0.33\ kg}{(0.33+0.44)\ kg} \times 100\% = \frac{0.33\ kg}{0.77\ kg} \times 100\% = 43\%$$

Here fibers are individualized very fine. Though fibers are not separated, but can be parted very easily by hand.

Condition of Manually Extracted Dried Areca Nut Fiber

A hand peeling method has given a good collection of dried nut husk fibers as figure 33:

Fig 33: Collection of dried nut husk fibers

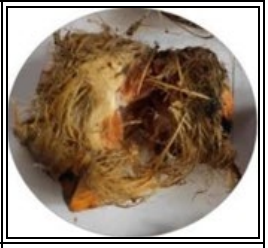
d) Dehusked Retted Areca Nuts

These are rarely used and rarely found. Some people in Bangladesh like this kind of nuts. These have not good dehusking result. When these are passed through the dehusking machine, the dehusking is found as figure 34:

Fig 34: Dehusked retted areca nuts

Their comparative analyses is shown in the following table 9:

Table 9: Dehusking result of 4 types of dehusked retted nuts

Dehusking Parameter	A Type	B Type	C Type	D Type
Image				
Dehusked nut%	32%	16%	32%	20%
Splitting of husk	Splitted into maximum opened & individualized fiber	Splitted into partially opened & individualized fiber	Splitted into finely opened & individualized fiber	Splitted into opened & individualized fiber
Separating nuts from husk	Full	Not but partially divided	Not but divided	Half
Structure of shell	shell is converted into finely opened & individualized fibers	Partially divided and shell is converted into partially opened fibers	Converted into 2 shells of mass made of opened and entangled fibers	Half part is crushed half and another at different angles
Opening/individualization of fiber	Very good	good	Average	good
Damage of fibers	No damage	4%	Less	40%

Extraction % of Retted Areca Nut Fiber

100 dried areca nuts were passed through the dehusking machine those have a weight of 1.80 kg. Extracted fibers were measured and the weight was 0.87 kg. Finally non-extracted shell part with fibers are separated and the weight was found 0.39 kg.

$$\text{So, Extraction\% is: } \frac{Weight\ of\ extracted\ fiber}{Weight\ of\ non\ fruit\ content} \times 100\% = \frac{0.87\ kg}{(0.87+0.39)\ kg} \times 100\% = \frac{0.87\ kg}{1.26\ kg} \times 100\% = 69\%$$

Here fibers are also individualized very fine. Though fibers are not separated, but can be parted very easily by hand.

5.4. Analysis on Fiber Damage

Actually this machine is manufactured based on deshusking i.e. separating inside nut from outer shell. Opening or individualizing of fibers was not a primary target. Therefore opening or individualizing was not occurred at the satisfactory level. As opening was less, there was less chance of damaging of fiber. Moreover some damaging is found and that is shown by the following figure 35:

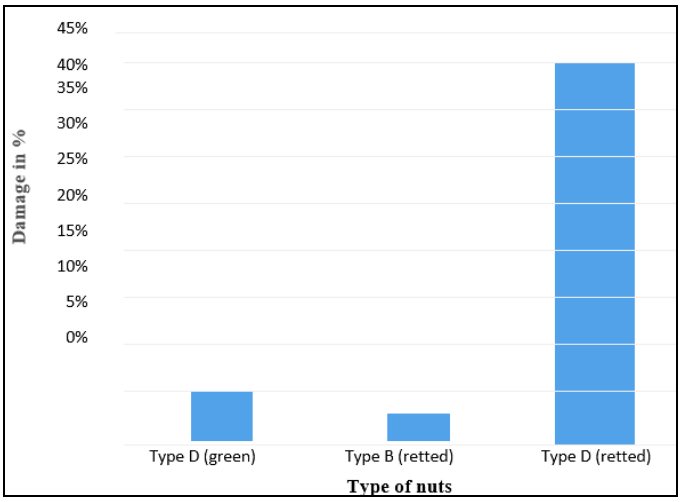


Fig 35: Damaging of fiber

Finally it is observed that retted nuts give the highest amount of fiber damage as it was soaked in the water for long time, therefore strength was decreased. A low amount of fiber damage is also found for green nuts as green nuts are relatively harder or stronger and for crushing more damage was occurred to the outer shell. Among the retted fibers, type D shows the highest amount of damaging fiber as it is crushed.

5.5. Finding Optimum Level of Dehusking Production

After getting the initial production rate, a minimum level of stoppage time was targeted. Here it was observed that nuts fell between the crushing rollers for a quicker speed and if took more time to pass, one or two were trapped. Therefore it was understood that a slower speed could decrease the probability of trapping. Finally nuts were fed manually in such a way that one nut was passed and a gap was given (one pocket is kept empty) before feeding the second one. It means that the speed was half of the previous one.

2nd time 50 nuts have been passed and it took 1 min & 50 secs for passing. Here no stoppage was found. Production here is found as 1636 nuts/hr i.e. nearly half of the production rate.

So, we can say that...

Optimum level of production: almost 1636 nuts/hr

5.6. Tensile Strength of Different Nut Fibers

Fiber bundle strength is tested for checking the tensile strength. Test is done by FibroStelo of MAG brand. This instrument follows constant rate of loading principle. The result for four different nuts is shown at figure 36 by a graph.

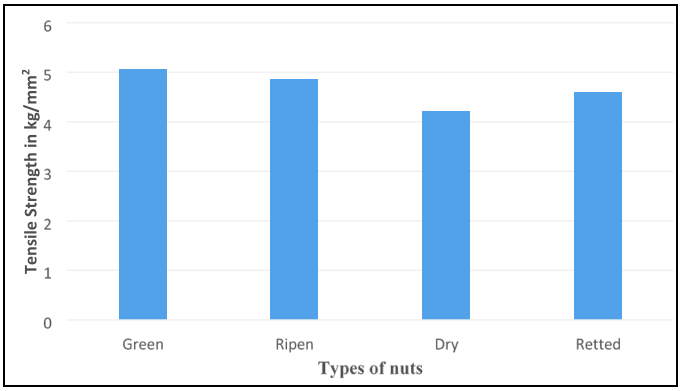


Fig 36: Comparison of Tensile strength

Green, ripen, dried and retted nuts shows elongation of 3.4%, 3.35%, 2.65% and 3.10% respectively during the test. Here it is seen that all kind of nuts have almost same tensile strength. Therefore dehusking is independent of this factor.

5.7. Comparative Analysis on Dehusking

All four types of nuts are analyzed here which are available in the market of Bangladesh. Green and yellowish nuts are mostly found in the market, necessarily these are converted to dried and rotten for the need of customer. In the previous discussion, all results are shown individually. Here all the results are combined at figure 37 to compare at a glance.

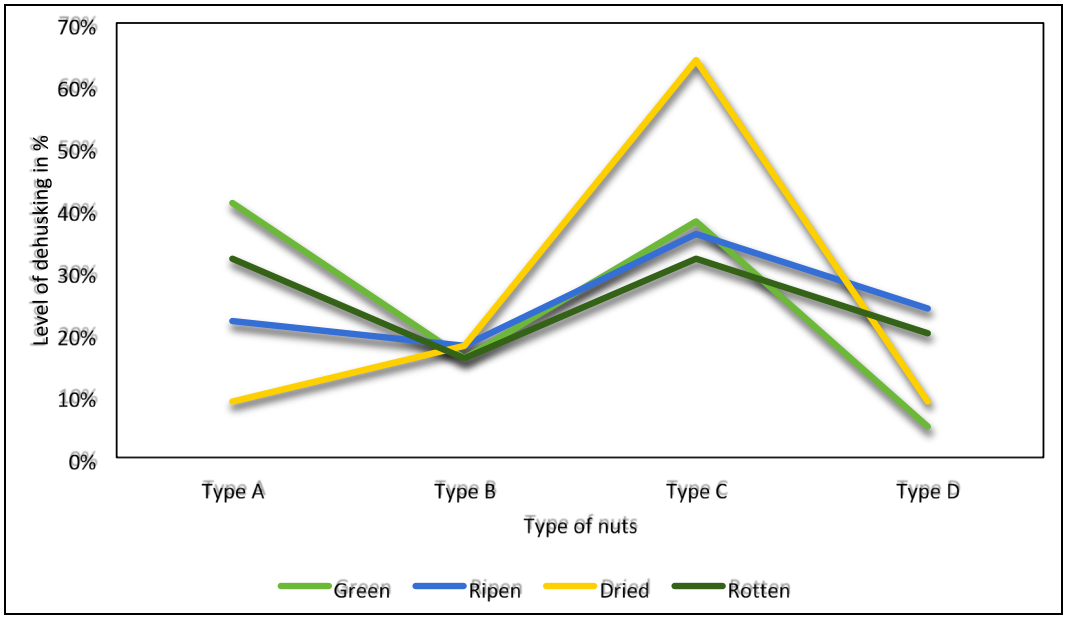


Fig 37: Level of dehusked different nuts

Now they are analyzed according to the type of result found in the dehusking of this machine:

Type A (Perfect separation of nuts and splitting into two parts): This can be considered as better result as dehusking is found better. From this state, fibers can be collected at the longest length. Success rate of this developed machine is good as this result is found maximum for green nuts. Age of green nuts is very less. Therefore these fibers may have the highest life to process. At green stage, moisture% is very high. It might be the reason, nut is easily come out from the outer shell. Therefore good separation is possible. The 2nd peak is found for rotten nuts. The reason is same as the previous one. At rotten condition, moisture again increases and therefore attraction force between nut and outer shell decreases. As moisture is decreased for ripen & dried nuts, nuts cannot come out from outer shell easily. Therefore in the graph, their result is seen at the bottom. Again good result of retted one may not be accepted as ideal result, because fibers obtained from retted one is not good for processing. But fibers are finely opened and dehusking is found very well.

Type B (Half separation of nuts, splitted into 2 parts: one spread flatly): This state of dehusking is not so good as the previous one as full separation of nut is not found here. Again this type of dehusking for all kind of nuts is found less than the previous one. Therefore it is out of consideration.

Type C (Less separation and splitting into 2 shells): In this state, nut is attached with outer shell. But individualization and parallelization of fibers are found very well. Again the highest performance (64%) is shown by dried nuts. At the previous time, green nuts showed better result i.e. 41%. Actually both are good at two separate state. If fibers are needed at green condition and nuts are finely collected to use it as by-product, type A is better. But if the machine is to provide good paralyzed and individualized fiber at the beginning, certainly type C at dry condition is the best. Again type C of green nuts shows good result (39%). Here good parallelized and individualized fibers can be obtained at green state. A little problem is found at type C state i.e. nut is attached with the outer shell. In this case, good result can be obtained by passing nuts through the dehusking machine more than once. Ripen and rotten nuts also show good result at type C state.

Type D (Crushed): Performance of this state of dehusking is not so good as nut is nearly crushed. But there is good opening of fibers. This state of dehusking is not found as type A or type C. Ripen nuts shows a little good result. But this cannot be considered for dehusking at optimum level.

5.8. Cost Analysis

Target of this thesis was to develop the machine with lower cost. But sample development is not so easy in Bangladesh as the workshop people are normally not so interested to work with new idea or they want lot of money for working. In the production stage, costing can be decreased for more amount.

However a costing related to market price is given here at table 10:

Table 10: Cost analysis

Material	Unit to Measure	Cost/unit	Total unit (approx.)	Total price (tk.)
MS sheet	kg	150	56	8400
Structure with ms rod	kg	150	150	22500
Ms angle	kg	150	100	1500
Bearing	Piece	450	6	2700
Motor (2 HP)	Piece	5500	2	11000
Main cylinder	kg	150	30	4500
Teeth developing for main cylinder	Processing at milling machine	4000	1	4000
Driven roller	kg	150	20	3000
Gear casting for main cylinder	Processing at milling machine	2500	2	5000
Pulley	Piece	600	10	600
Sprocket	Piece	2200	2	4400
Main belt with pockets	Making	1000	1	1000
Other belts	Piece	800	1	800
Curved plate	Piece	4000	1	4000
Feeding box	Piece	4000	1	4000
Delivery plate	Piece	2000	1	2000
Screw	Set	3000	1	3000
Paint	Total machine once	5000	1	5000
Total cost:				87400/=

Here making charge is to be considered minimum 30000/=. So, total cost will be:
87400+30000=117400/=.
An Indian machine costs averagely 1.4 lakh rupee i.e. 1,79,000 taka. Therefore 179000117400=61600 taka is saved. Quality is almost same considering dehusking.

5.9. Comparison of Production

Table 11 shows the comparison among the market and this machines:

Table 11: Comparison of Production

Pedal operated dehusking machine	Electrical controlled dehusking machine	Latest dehusking machine	This machine
(Indian Brand)	(Indian Brand)	(Indian Brand)	
420 nuts/hr	1250 nuts/hr	500 nuts/hr	1636 nuts/hr

6. Conclusion

Many different type of successful dehusking machines have already been developed where different technology is used. It was a try of six years ago when in Bangladesh there was no such creation of dehusking machine. Therefore there are many limitations of this machine. But arrangement of gears and motion transfer can be a good example for processing any kind of this machine. Making teeth by milling machine, grooving by lathe machine etc. are the design processing tool for metal surface and learning these is very important for a mechanical engineer as well as textile engineer.
Finally considering performance of this machine, many factors are to be considered. The form of fiber in collection time (green/dried state), condition of separation of nuts from outer shell, necessity of individualization and parallelization of fibers etc. are to be analyzed.
However following comments can be stated:
If dehusking is needed good & fibers are needed in green state, green nuts are to be selected for dehusking. Here automatic individualization or parallelization cannot be good. Another machine can be developed for further opening of fibers where fiber can become individual and parallel. Again dehusking amount is found not so high here.
In the other hand, if some individualization and parallelization of fiber is required, dried nuts should be selected for dehusking. Here dehusking amount is also high. But separation of nuts is not found good.
If both are required i.e. good dehusking as well as good opening and individualization, retted nuts are best; in that case lifetime of fibers are to be tested for target product.
Again the efficiency of this machine is found not so satisfactory. One reason is using one pair of crushing/worker rollers. We know that in the jute breaker card there are two sets of stripping and working rollers and at the finisher card there are at least four pairs of such set. Here more crushing points surely can give good result.
Therefore modification of this machine may give excellent result of dehusking or peeling fibers. Practicing of producing this kind of machine will help to manufacture any kind of mechanical device in Bangladesh.

6.1. Limitations

As mentioned before, this machine was started to manufacture 6 years ago and therefore performance is not up to satisfactory. Some of the drawbacks are discussed here:
A shaker machine is required to separate the fibers from attached fruits as many times inside fruits are attached with the surroundings.
In jute carding machine, there are two to six pairs of workers and strippers that can process jute fibers perfectly. Here there is one set of rollers that is not enough.
Crushing point should be longer enough that two or three nuts can be crushed together.
Speed of different rollers are not adjusted easily.
According to the design of delivery zone, vibration system does not work properly.
In the market there are areca nuts of different sizes. Here average size is taken. In case of bigger or smaller nuts, setting is to be adjusted. Therefore easily adjustable setting is to be developed.
There are also some more limitations. Some high technology can make the cleaning system more efficient. Some display can be added those show speed of different rollers. Use of servo-motor can increase the efficiency of controlling speed.
However a novel try of making such kind of machine will give inspiration to the students of Bangladesh to make a bright-full future in next generation.

6.2. Suggestions

All of the limitation have been discussed here. If these limitation can be solved, a very good machine can be produced. Again this machine is mainly developed for

dehusking. As main target is to produce good fibers to make yarn, addition of some other device is important that can convert dehusked outer shell into good individual and parallel fibers. This addition mechanism can be attached at the delivery side so that individual and parallel fibers can be obtained simultaneously. Some kind of chopping components can be added those can separate fibers. However research is needed for perfect result.

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