DEVELOPMENT OF A ROTARY MECHANISM WITH MANUAL FEEDING FOR HUSKING COCONUT

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PROJECT REPORT

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KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY
Tavanur – 679 573, MALAPPURAM DISTRICT
KERALA, INDIA
2008

DECLARATION

We hereby declare that this project report entitled '**Development of a Rotary Mechanism with Manual Feeding for Husking Coconut**' is a *bonafide* record of the project work done by us during the course of the academic programme in the Kerala Agricultural University and that the report has not previously formed the basis for the award to us of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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Dated: 11.01.2008

Kelappaji College of Agricultural Engineering and Technology
Tavanur

CERTIFICATE

Certified that this project report entitled '**Development of a Rotary Mechanism with Manual Feeding for Husking Coconut**' is a *bonafide* record of the project work done jointly by Sri. Gubash Azhikodan (*Admn. No. 2003-02-16*), Sri. Rajesh A. N., (*Admn. No. 2003-02-18*) and Sri. Edwin Benjamin (*Admn. No. 2003-02-21*), under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship, associateship, or other similar title of any other University or Society to them.

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GUBASH AZHIKODAN **RAJESH A .N** **EDWIN BENJAMIN**

Dedicated

to

The Almighty God

and

Our loving Parents

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SYMBOLS AND ABBREVIATIONS

Dept.	-	Department
e.g.	-	for example
Er.	-	Engineer
et al.	-	and others
etc	-	et cetera
Fig.	-	Figure
Fig.s	-	Figures
h	-	hour(s)
ha	-	hectare(s)
hp	-	horsepower
i.e.	-	that is
KAU	-	Kerala Agricultural University
KCAET	-	Kelappaji College of Agricultural Engineering and Technology
min	-	minute(s)
mm	-	millimetre(s)
M.S.	-	Mild Steel
No.	-	Number
No.s	-	Numbers
rev	-	revolution(s)
rpm	-	revolution(s) per minute
s	-	second(s)
Sl.No.	-	Serial Number
/	-	per
%	-	percent

Chapter I

INTRODUCTION

Coconut palm *(Cocos nucifera*) is the most significant of all cultivable palms. As is well known *Cocos* comes from the Portuguese word ‘*Macaco*’. Coconut is one of the most important crops in Kerala. Its uses are plenty as it provides drink, food, oil, fibre, thatch, and domestic utensils. Coconut tree is usually referred to as the *tree of life* because every part of the tree is useful to man. In *Malayalam*, coconut palm is known as *Kalpa-Vriksha* or *tree of heaven* as it provides many necessities of life including food and shelter. It is mainly cultivated for its nuts from which the two important commercial products, the copra and the fibre, are obtained. Certain by-products like oil, coir, coconut shell, fresh toddy (n*eera*), etc., are also obtained from its products.

In India, Coconut is generally grown in the coastal States like Kerala, Tamilnadu, Karnataka, Goa, Gujarat, West Bengal, Orissa, etc. State-wise production of coconut in India is depicted in Fig. 1.1.

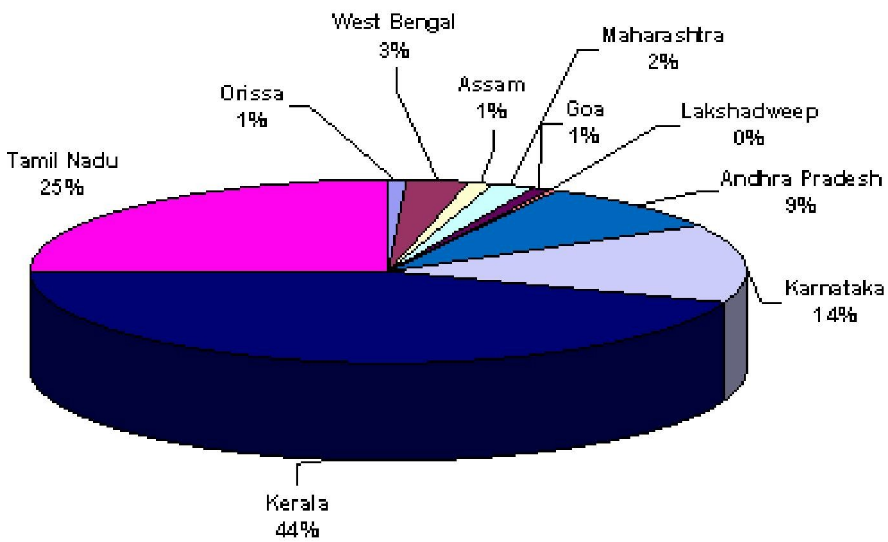

Fig. 1.1 State-wise production of coconut in India

The leader in the coconut sector in India is Kerala. Coconut can be even termed as the backbone of Kerala’s economy. Coconut and its products have a great deal to Kerala. Since Kerala is the major producer of coconut with a share of 44 % in India, a number of coconut industries are based in Kerala like the oil extraction industries, coir industries, *copra bazaars*, etc. Next comes the Tamilnadu having 25 % share. Coconut occupied approximately 8,73,200 ha in Kerala in 2005-06 and the production from it was 5289 million nuts.

Coconut husking is one of the major problems in this sector. This is more of a problem especially for women. It is a very strenuous job as it involves great drudgery. Large-scale husking is still being done in Kerala with the traditional crowbar known as *paara* in Malayalam. A skilled person husks about 3000 coconuts in a day in spite of the great drudgery involved in it. No efficient mechanical device for husking coconuts on a large-scale is known to be in existence despite its great need.

Some small tools are available for husking. They make use of the principle of wedge and the principle of lever. Even the traditional crowbar (*paara*) is based on these principles. Some other tools which make use of these principles are coconut husking machine (Titmas and Hickish, 1929), coconut husk removing tool (Waters, 1946), KAU coconut husking tool (Jippu and Joby, 1998), and mini coconut dehusker (Ganesan and Gothandapani, 1995). Since these tools are intended for only small-scale husking and that no machine is available for large-scale husking, this study was undertaken with the following objectives.

Objectives:

1. To develop a rotary mechanism for husking coconut
2. To develop a mechanism to manually feed the coconut to the husking mechanism
3. To evaluate its performance in coconut husking

In order to carry out the objectives, an experimental set-up comprising a rotary husking mechanism and a twin-lever-actuated platform to facilitate manual feeding of coconut was developed and tested. Both the assemblies were mounted on a machine lathe which was used as the test bed. Details of this study are presented in the chapters that follow.

Chapter II

REVIEW OF LITERATURE

Since ages, agriculture has been the occupation of majority of human population. In India also, agriculture has great deal to do. Agriculture is the backbone of Indian economy. The advancement of science and technology also gave rise to the development of agriculture. At present, Kerala is facing a shortage of labour, especially in the agricultural sector and more particularly in respect of major crops like rice, coconut, spices, and vegetables. This problem is likely to continue for a long period of time. Therefore, there is a necessity to address this problem right earnestly. Coconut being a major crop in Kerala, its problem requires attention on a top priority basis.

One of the major problems associated with coconut is the husking of coconuts. Husking is done both at the domestic level and coconut industry level. At the domestic level, the number of coconuts to be husked in a household in a day is very small. At the same time, thousands of coconuts have to be husked in a day in each coconut industry. At present, at the domestic level, this is carried out manually using small tools like machete, crowbar (*paara*), KAU coconut husking tool named *Keramithra* (Jippu and Joby, 1998), etc. The first two are most traditional tools. The traditional method of husking with chopping knife or the machete is difficult, time consuming, and risky. Though husking with a crowbar is quicker, it involves considerable drudgery. Hence, for large-scale husking, only skilled men do the husking with the crowbar. KAU coconut husking tool, though better for domestic applications, is not advantageous in large-scale husking. Therefore, there is a necessity to develop a powered system for large-scale husking. In order to study the prior art, a survey of the available literature was carried out widely. It was seen that literature on this aspect was far and few. However, portions relevant to this study are cited and discussed in this chapter.

Coconut husking might have started with single blade instruments like wedge-shaped rock pieces, sharpened wooden crow bars, etc. According to

Jippu (1999), the manually operated coconut husking tools can be broadly classified as:

1. Single-blade coconut husking tools
   (e.g.:- Machete, Axe, Crow bar, etc.)

2. Twin- blade coconut husking tools
   (e.g.:- Coconut spanner, *Keramithra*, etc.)

3. Multi- blade coconut husking tools
   (e.g.:- CPCRI Coconut Dehusker, etc.)

Use of traditional tools, though consumes less time, much effort is needed to operate them; mainly the crowbar. As mentioned above, these tools are not at all suitable for large-scale husking.

In Central Plantation Crop Research Institute, Kasaragod, a manually operated dehusker has been developed and improved. The said system mainly consisted of three sharp separable blades, which initially faced upwards and in a juxtaposed position. In operation, the blades go apart outwardly by swinging about their pivots at the bottom. In the process, the husks of the coconut impaled upon the blades are torn apart and the nut is ejected. The impaling of coconut and actuation of the blades are carried out using a hand lever and a foot lever. This is however a cumbersome process and hence has not been accepted widely.

Ganesan and Gothandapani (1995) invented a mini coconut dehusker (Fig. 2.1). It consisted of a tong-like tool mounted on a pillar. The coconut kept on its platform is impaled from the top with the sharp jaws of the tool swinging downwards about the pillar. After penetration, the handles of the tool are pulled outwardly to separate the jaws. This leads to ripping of the husk into one sector. The coconut is then turned to make another portion of the remaining husk face the tool. The operations are then repeated till complete husk is removed.

The husking tool developed in the Kerala Agricultural University; as reported by Jippu and Joby (1998); is simple not only in construction but also in use (Fig. 2.2). It consists of mainly a stationary wedge, a movable wedge, a hinge pin, a wedge seat, a lever, and a pedestal with a base. The coconut is impaled with

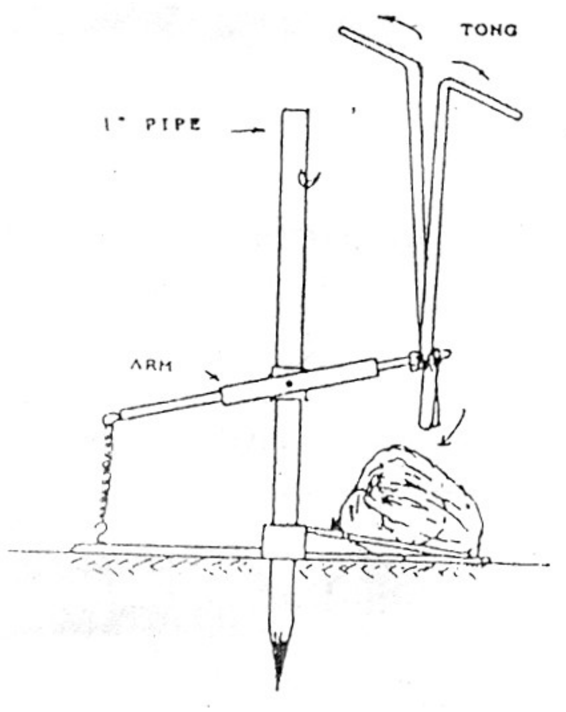

Fig. 2.1 Mini Coconut Dehusker
(*Ganesan and Gothandapani*, 1995)

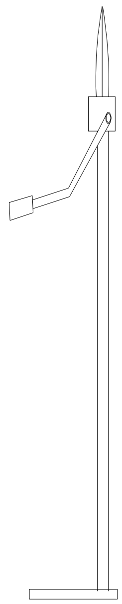

Fig. 2.2 KAU Coconut Husking Tool (*Keramithra*)
(*Jippu and Joby*, 1998)

both the hands on the two juxtaposed wedge-like blades oriented upwards. On pulling the lever upwards by one hand, the movable blade or wedge placed on the load arm of the lever swings away from the stationary blade loosening a sector of the husk from the nut. By repeating it twice or thrice the husk can be separated completely from the coconut.

According to Jippu (2007), the husking tools separately developed by Aboobekkar, T.P. and N. Narayanan are foot-operated. Upon depressing the foot-pedal downwards by one foot, the movable blade gets separated from the stationary blade, thus, ripping apart a sector of the husk of the coconut remaining impaled on the juxtaposed blades. Operations are repeated for completely removing the husk in three or four sectors.

All the tools cited above are fully hand-operated, foot-operated, or a combination of both. Not only ripping of the husk but also impaling of the coconut is done manually. So, human energy is to be expended in operating this tool. This is bound to cause fatigue to the operator. Therefore, further attempts were made by researchers to make powered-husking units. However, as evidenced from the literature, it has not met with appreciable success.

A rotary coconut dehusker (Fig. 2.3) was developed in the Kelappaji College of Agricultural Engineering and Technology, Tavanur (Muhammad, 2002 and 2005). It was intended for large-scale application. This powered machine consisted of a stationary concave enveloping a rotating drum. The clearance space between the drum and the concave formed a converging volute to accept the whole coconut at the inlet and accommodate the husked smaller nut at the outlet. Numerous small blades are fixed on the outer surface of the drum and the inner surface of the concave. The coconut fed at the inlet and in the clearance between the concave and the drum is compressed slightly by the system and forced to execute rolling or revolutions. In the process, the blades penetrate the husk and puncture it along different planes. The shear forces exerted upon the coconut by the blades of the rotating drum and the concave cause to rip open the husk along different planes. In some cases, the coconuts are completely husked and the nuts emerge out at the outlet. In some cases, full coconuts with punctured and softened husk emerge out. They require secondary operations to remove the husk. This was one drawback. In some cases, the removed husk remained entrapped within the concave clearance. This required stopping of the machine and manual removal of that husk. Similarly, there was breaking of the nuts. Because of these drawbacks, it was not considered for further development.

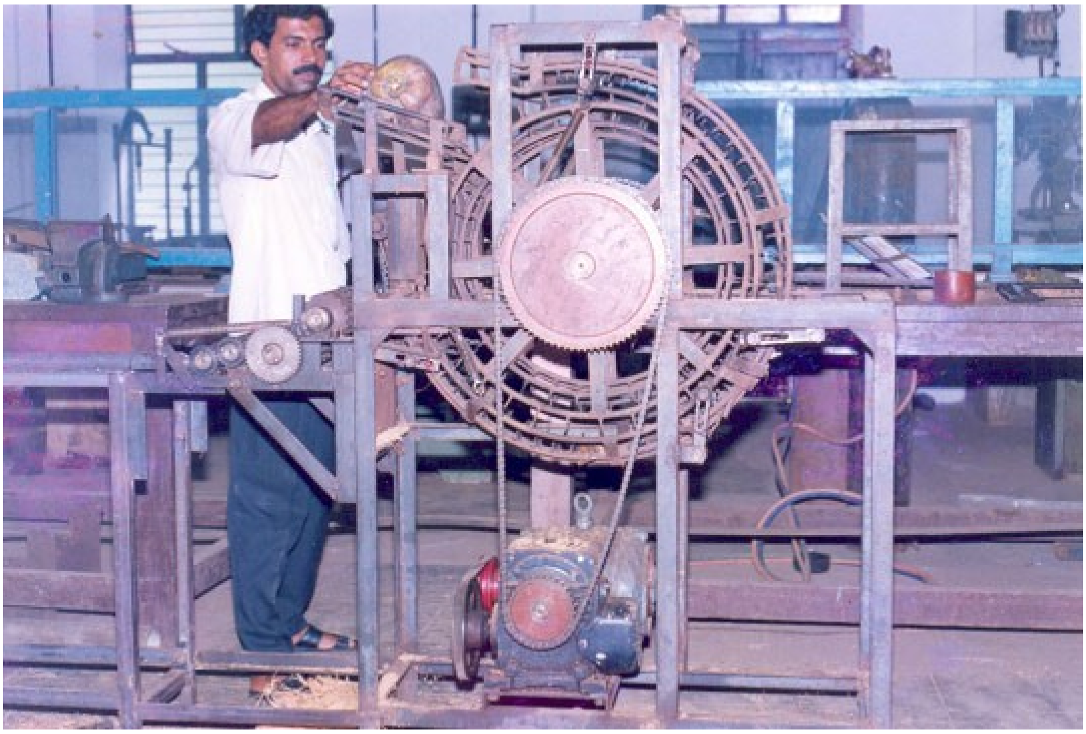

Fig. 2.3 Rotary Coconut Dehusker

(*Muhammad*, 2002)

Santhi (2006) has reported on a study conducted by her on a commercial model of a powered dehusker, produced and marketed by M/s. Process Ekuipment Engineers, Coimbatore. It caused breaking of nuts ranging from 8-17 %. Feeding of coconuts was not very convenient. Because of these drawbacks, this too was not considered very encouraging.

From the above, it appeared that a rotary system with a manual control over feeding was a better option. In view of the same, this study was undertaken with the objectives as cited in the preceding chapter.

Chapter III

MATERIALS AND METHODS

To achieve the objectives, an experimental set-up was designed and developed. It consisted of mainly a rotary mechanism for husking and a hand-lever-assisted mechanism for feeding of coconut one at a time. Details of these are presented below.

The rotary mechanism developed for husking was mounted on a machine lathe for the sake of regulation of speed, and convenience of feeding and testing. Accordingly, the major parts of the rotary husking mechanism are as follows.

1. Main Shaft
2. Segmented Ring
3. Blade

Similarly, the hand-lever-assisted feeding mechanism, also mounted on the same machine lathe, comprised the following main parts.

1. Main Platform
2. Auxiliary Platform
3. Movable Platform
4. Hand-lever

Further descriptions of the experimental set-up are presented below.

3.1 Machine Lathe

A machine lathe available in the Machine Shop of the Kelappaji College of Agricultural Engineering and Technology, Tavanur, was used for mounting the experimental husking and feeding mechanisms (Fig. 3.1). This facilitated as the test bed. Its relevant specifications are given below.

1. Brand : New Bharat
2. Model/Type : HGN/4
3. Horsepower : 3 *hp*
4. Speed : 30, 75, 110, 160, 240, 400, 575, 1235 *rpm*
5. Swing diameter over carriage : 220 *mm*
6. Length between centres : 2370 *mm*

Fig. 3.1 Machine Lathe with Experimental Set-up

The mechanism for husking, being rotary, was provided with a main shaft. One end of this shaft was held with the lathe chuck. Other end of this shaft was mounted on the dead centre fixed on the tail stock. This arrangement facilitated rotation of the husking mechanism at the designated speeds of the lathe. However, in order to match with the speed of manual feeding, the head stock spindle rotated the husking mechanism at its lowest speed of 30 rpm. Next higher available speed of 75 rpm was found, during explorative studies, to be quite detrimental as it caused severe damage to the nuts. Hence, this speed was not selected. For the same reason, the other available higher speeds of the lathe were also not considered in this study. Since the lathe was being used as the test bed, speeds other than that of the lathe could also be not used in this study.

3.2 Main Shaft

A mild steel (M.S.) shaft of length 600 mm and diameter 25 mm was selected (Fig.s 3.2 and 3.3). As stated above, it was rotated with the lathe chuck at 30 rpm. This shaft carried a segmented ring frame and the blade.

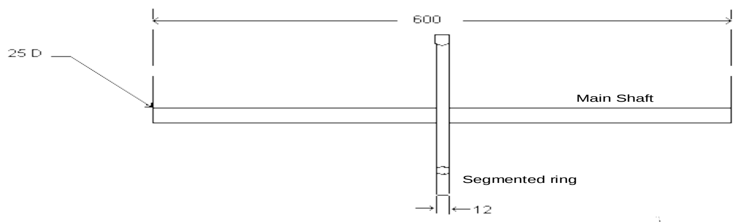

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Fig. 3.2 Main Shaft (*Top view*)

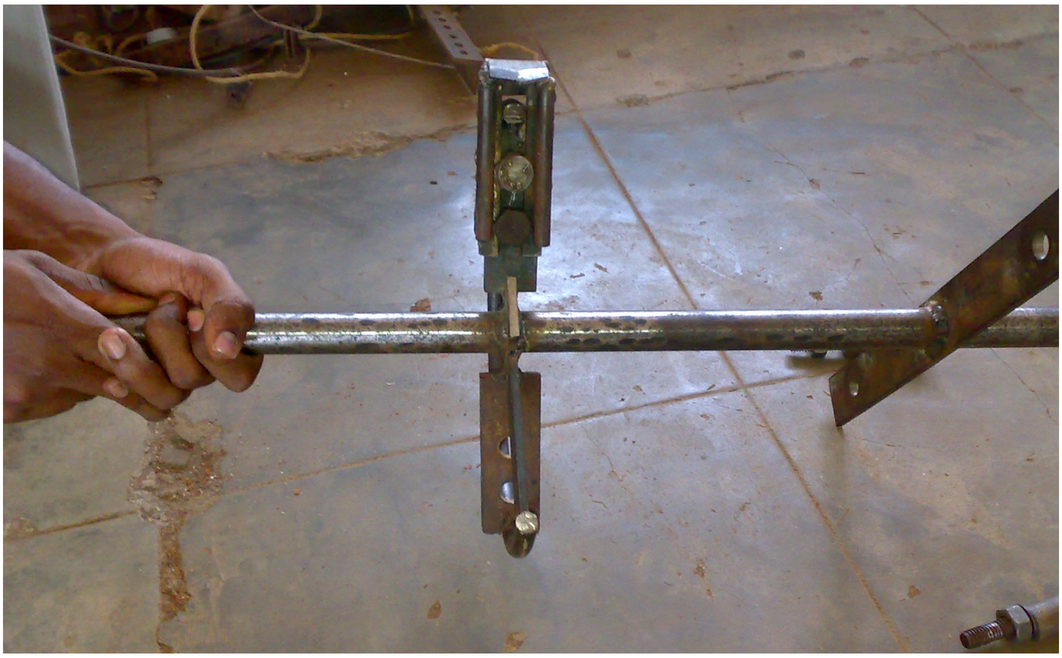

Fig. 3.3 Main Shaft with Segmented Ring

3.3 Segmented Ring

A 229^0-segment of a ring of outer diameter 120 mm was fabricated from a M.S. rod of diameter 12 mm and firmly fixed to the main shaft through three spokes placed 90^0 apart (Fig. 3.4). One pair of diametrically opposite spokes was made of M.S. flat of 45 x 5 mm. The other spoke was made with M.S. flat, 25 x 5 mm in size. Two bases made from M.S. flat, 45 x 5 mm, and carrying two holes of diameter 12 mm, which provided the base for fixing the blade, were welded radial to the shaft.

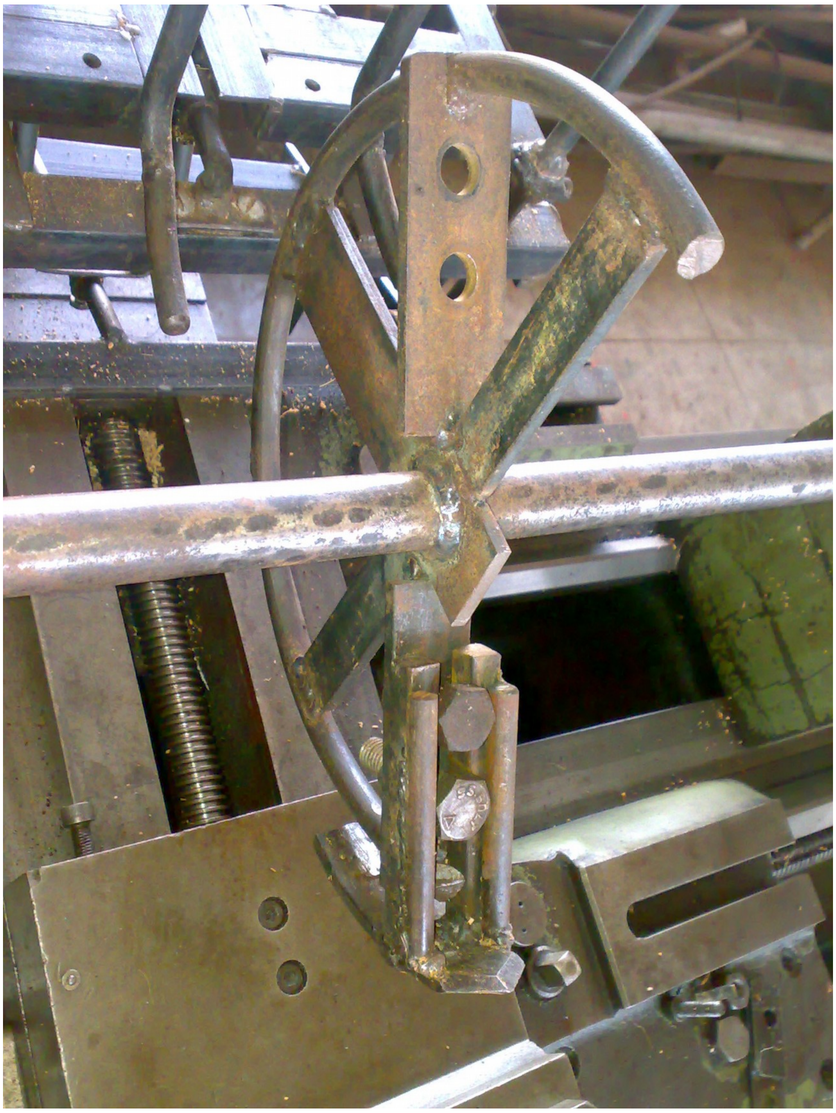

Fig. 3.4 Segmented Ring with Shaft

3.4 Blade

A blade of length 100 mm was made from M.S. flat of size 100 x 35 x 5 mm (Fig.s 3.5 and 3.6). One end of it was sharpened like a pointed spear. It was provided with a curvature of radius 145 mm lengthwise. Two M.S. square rods of size 100 x 12 mm were welded perpendicular to the blade as shown in the figures.

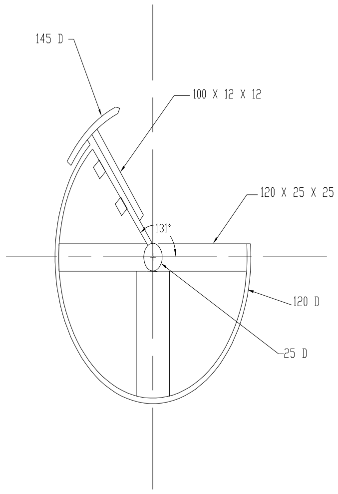

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Fig. 3.5 Blade Assembly (*Side view*)

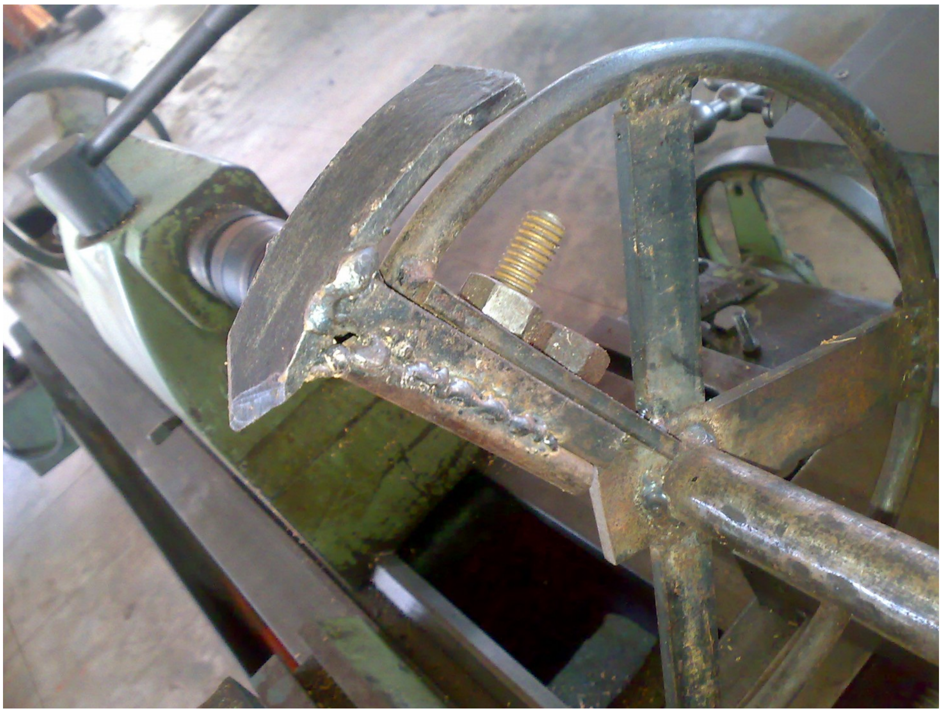

Fig. 3.6 Blade

These were welded parallel to each other lengthwise but 12 mm apart. This arrangement provided a slot for varying the radial distance of the blade from the shaft and the segmented ring. This provided the facility for varying the depth of penetration of the blade into the husk.

3.5 Main Platform

This is a platform so designed to accommodate on the carriage of the lathe an auxiliary platform and a pair of hand-levers (Fig.s 3.7 and 3.8). Its shape and size are as shown in the figures. It was made from pieces of M.S. angle. Fore-end of it rested on the rear end of the V-bed way for the cross-slide. It was then firmly secured to the carriage through a pair of screws. A circular rod, together with a small sleeve and its set screw, was fixed on top and across this platform and positioned at its centre. This sleeve served as the pivots for the twin hand-levers. By fixing the sleeve at different locations on the rod, it was possible to relocate the pivot position according to the size ranges of coconuts.

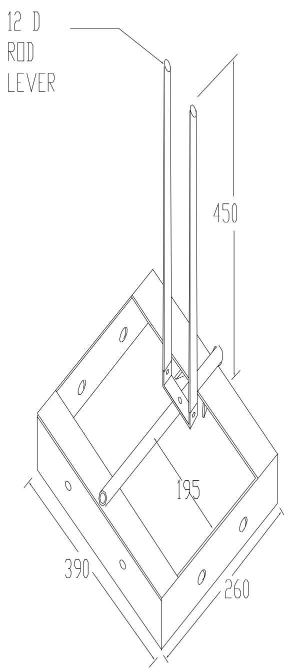

Fig. 3.7 Main Platform (*Isometric view*)

Fig. 3.8 Main Platform

3.6 Auxiliary Platform

This is a platform mounted directly on the main platform (Fig.s 3.9, 3.10 and 3.11). It is so designed as to facilitate the varying of (i) height, (ii) angle of inclination, and (iii) closeness of this platform to the main shaft. This is made possible by providing slots on the supporting pedestals and the sides of this platform. Its size and form are presented in the said figures. This platform carried at its centre, but across and at its top, a circular rod together with two sleeves and its set screws to facilitate sliding of the movable frame towards or away from the shaft when respectively feeding coconut to the blade or withdrawing it whenever required, but generally after the separation of each sector of the husk.

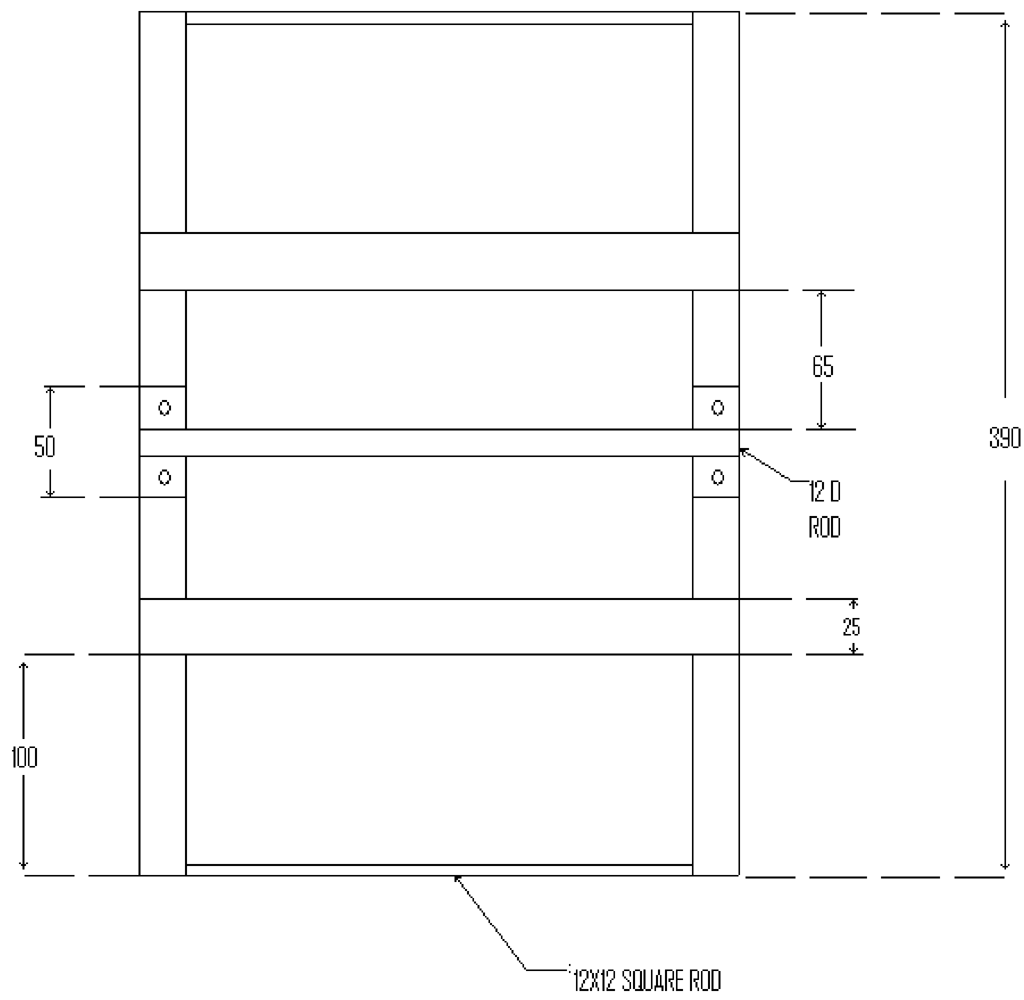

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Fig. 3.9 Auxiliary Platform (*Plan*)

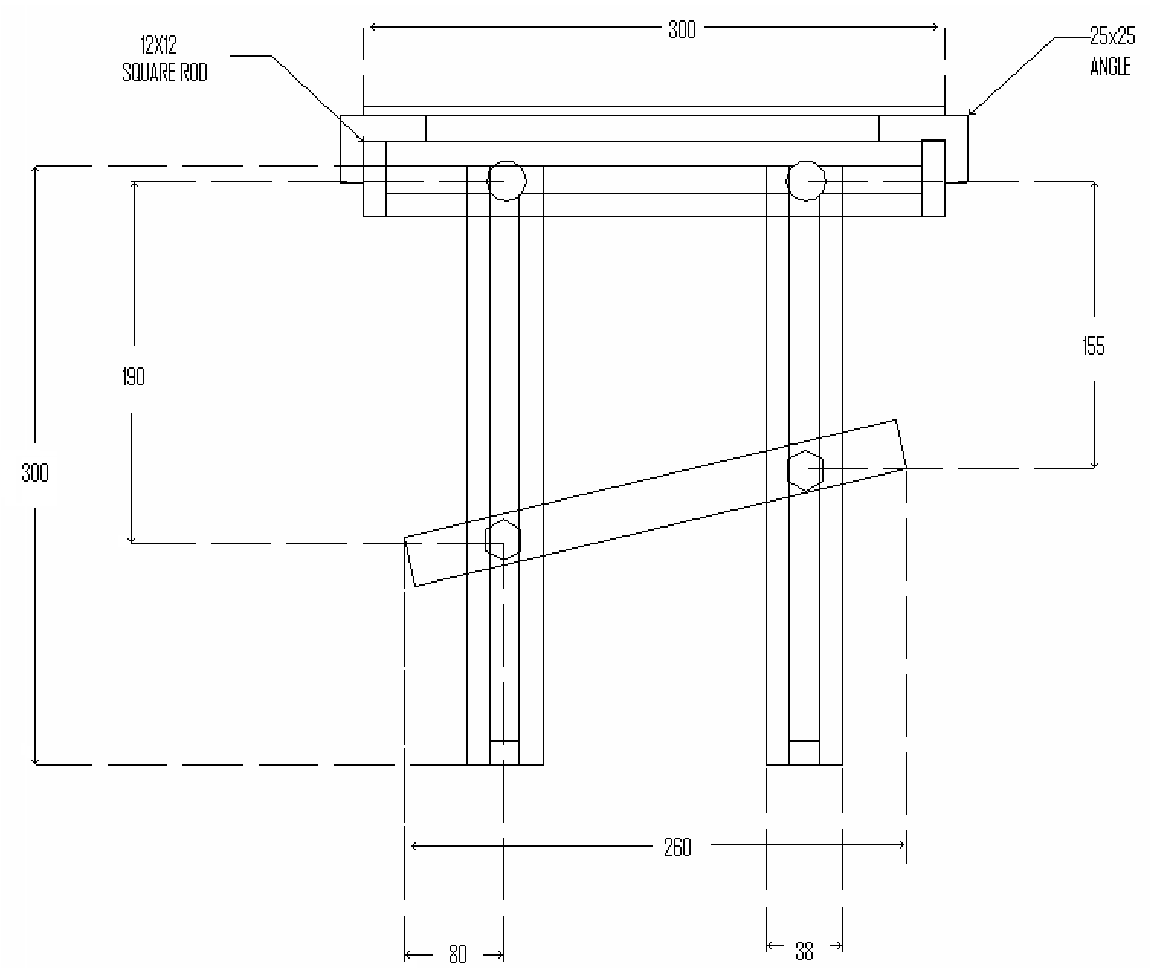

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Fig. 3.10 Auxiliary Platform (*Side view*)

Fig. 3.11 Auxiliary Platform

3.7 Movable Platform

According to the scheme of things in this project, removal of husk from the coconut, sector by sector, was with a rotating blade upon feeding the coconut to the said blade. But, after the removal of a sector of the husk or due to any other reasons like jamming of husk, improper husking, etc., the coconut was to be drawn away from its earlier position to manually reorient the coconut and feed again. This was required also on termination of the husking of a coconut. This to and fro motion was made possible with the movable platform (Fig.s 3.12, 3.13 and 3.14) made to slide on the auxiliary platform. This platform rested on the auxiliary platform. The said rod positioned on top of the auxiliary platform passed through the movable platform and restrained the latter's to and fro sliding to a fixed trajectory. The two sleeves fixed at selected positions on the said rod decided the terminal position of the movable platform when sliding to and fro. Its movement was effected basically with the twin hand-levers. Two limiting rods positioned in front of the movable platform with a clearance of 30 mm over the blade width limited the forward movement of the coconut with respect to the movable platform. These limit rods were provided an inverted ‘U’ shape to facilitate the husk removal. The shape and size of the platform are as presented in the figures.

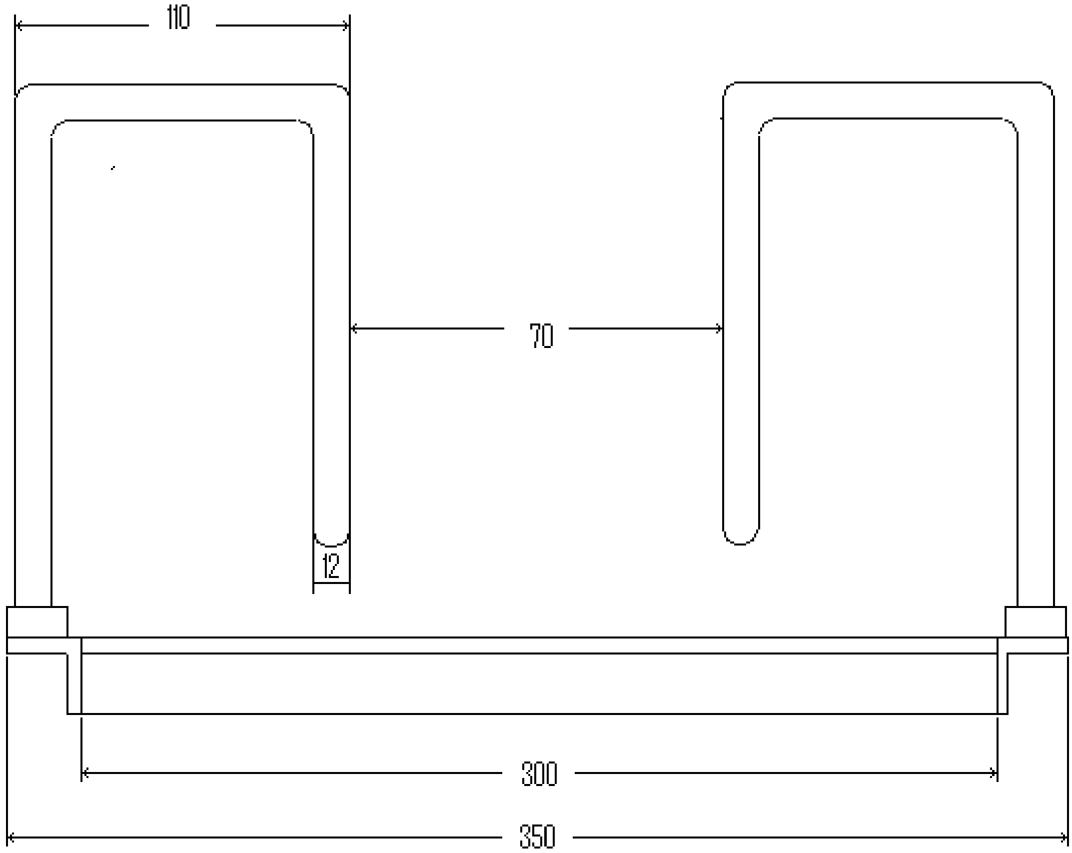

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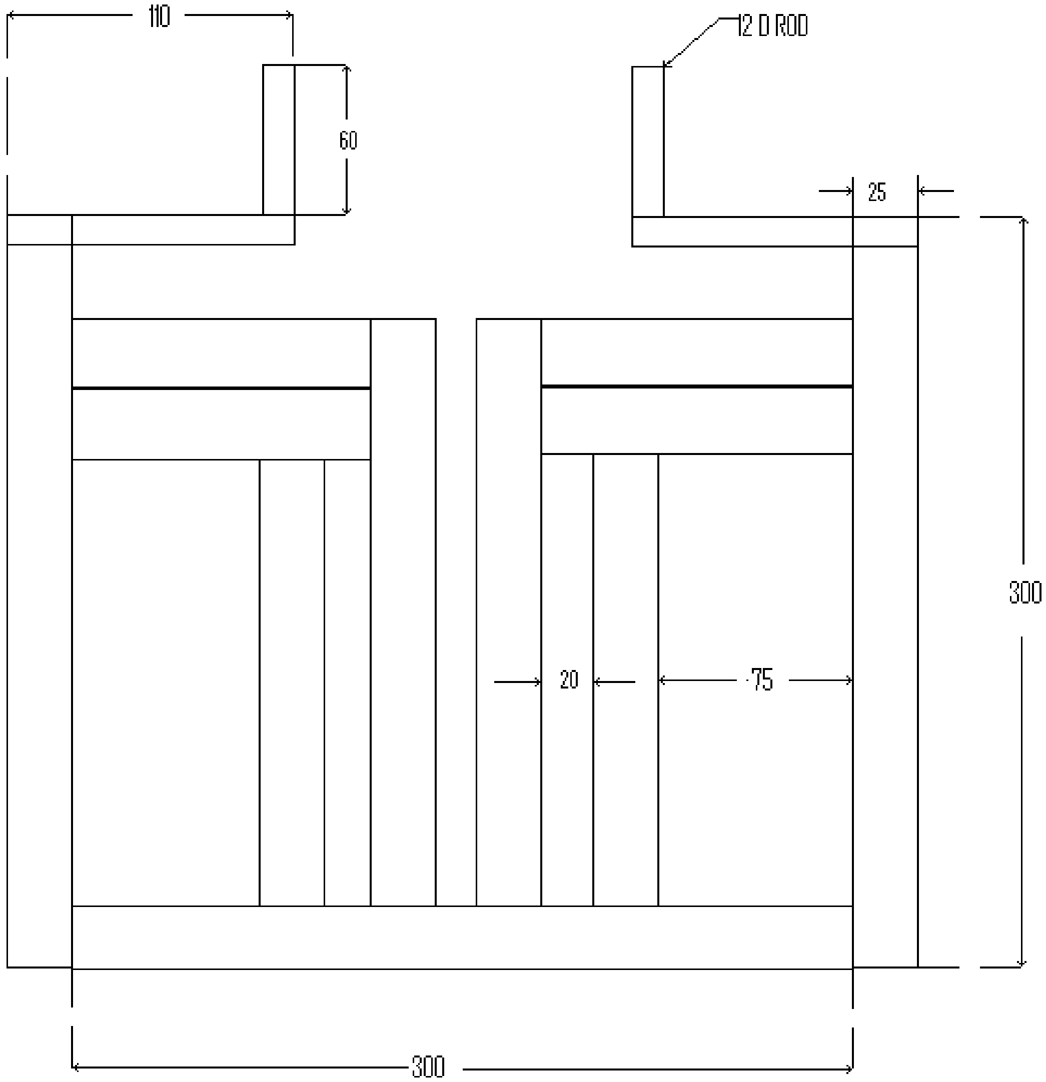
Fig. 3.12 Movable Platform (*Elevation*)



All dimensions in mm
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Fig. 3.13 Movable Platform (*Plan*)

Fig. 3.14 Movable Platform with Twin Hand-lever

3.8 Twin Hand-lever

A pair of hand-levers which could be operated together manually was provided to press the coconut against the rotating blade (Fig. 3.14). The twin hand-levers provided the mechanical advantage required to feed the coconut to the rotating blade. The bottom ends of these two levers were pivoted to the sleeve on the rod of the main platform. The levers oriented upwards, passed through the auxiliary platform and the movable platform. The rod and sleeve arrangement on the main platform assisted in relocating the hinges of these levers at different locations. These levers were made from M.S. rods of 12 mm diameter. They were 400 mm long.

3.9 Operation

Initially, the twin hand-levers were withdrawn to their rear-most position. The coconut was then placed on the movable platform, and in front of the twin hand-levers. Upon pushing the hand-lever forward, the coconut was moved forward till it contracted the limiting rods on the movable platform. Thereafter, further forward pushing of the rods caused the movable platform along with the coconut to move towards the blade. This movement of the movable platform continued till it reached its foremost position. This position was pre-determined according to the depth of penetration required. From explorative studies, it was considered most advantageous to have these limiting rods occupy a position 25 mm behind the blade. The rotating blade pierced the husk and generally separated a sector of the husk (Fig.s 3.14, 3.15, and 3.16). The levers were then pulled backwards manually. This caused the movable platform to move backwards together with the coconut. The coconut was then reoriented on the movable platform and fed again. If the husking was complete, a new coconut was placed on the platform and the operations were continued.

Fig. 3.15.a Experimental set-up - *in operation*

In this manner, coconuts collected from a local oil mill were used for testing. The sample consisted of 30 coconuts; green coconuts 15 in number and dry coconuts constituted the rest 15. Experiments were carried out separately for the green and dry coconuts. Major dimensions of the coconuts were also measured and recorded. Observations recorded in respect of each coconut were husking duration, number of husk-bits, mean time for separating each husk-bit, damage, frequency of occurrence of certain number of husk-bits; viz. from 3 to 8. The data and its analyses are presented in the next chapter.

Fig. 3.15.b Experimental set-up - in operation (*Another view*)

CHAPTER IV

RESULTS AND DISCUSSION

Results of the test conducted in evaluating the system developed under the study are presented and discussed below. The results are organized under three sections.

1. Husking rate
2. Husking effectiveness
3. Mechanical damage

4.1 Husking rate

Data of the experiments on husking rate are presented in Tables 4.1 and 4.2 given below. Table 4.1 is related to the green coconuts and Table 4.2 to the dry coconuts. The samples comprised 15 green coconuts and 15 dry coconuts.

Table 4.1 Husking duration, number of husk-bits, and mean time for removing one husk-bit of green coconuts

Sl. No.	Size		Husking Time	Husk-bit	Mean Time for Removing One Husk-bit
	Length	Diameter			
	(mm)	(mm)	(s)	(No.)	(s)
1	187	137	35	4	8.8
2	197	156	***51***	6	8.5
3	196	140	25	5	5.0
4	200	162	23	5	4.6
5	200	155	11	5	2.2
6	185	145	28	6	4.7
7	205	115	28	5	5.6
8	190	130	14	4	3.5
9	190	145	25	5	5.0
10	185	135	11	4	2.8
11	200	140	12	4	3.0
12	210	145	40	4	10.0
13	175	140	43	5	8.6
14	170	140	15	4	3.8
15	165	110	***7***	4	1.8
Mean	190	140	24.5	4.7	5.2

Table 4.2 Husking duration, number of husk-bits, and mean time for removing one husk-bit of dry coconuts

Sl. No.	Size		Husking Time	Husk-bit	Mean Time for Removing One Husk-bit
	Length	Diameter			
	(mm)	(mm)	(s)	(No.)	(s)
1	225	150	26	4	6.5
2	200	145	20	4	5.0
3	210	155	41	5	8.2
4	215	140	19	6	3.2
5	220	145	36	6	6.0
6	200	150	19	5	3.8
7	180	135	16	4	4.0
8	205	130	13	4	3.3
9	200	160	33	5	6.6
10	170	127	***12***	4	3.0
11	235	145	46	6	7.7
12	205	150	21	4	5.3
13	205	145	15	4	3.8
14	205	145	25	4	6.3
15	235	150	***50***	7	7.1
Mean	207	145	26.1	4.8	5.3

It is seen from Table 4.1 containing the results of evaluation of the husking of green coconuts that the mean time required for completely husking a coconut is 24.5 s and the mean time for separating one bit is 5.2 s.

These are by all means too long. In comparison, large-scale husking of coconuts using a crowbar (*paara*) carried out by skilled labourers required a mean duration of only 8 s. Similarly, the mean duration required by a man for husking coconuts using the *KAU coconut husking tool* named *Keramithra* is 12 s. The problem observed in the case of the system developed under the study is slipping of the blade from the loosened husk-bit even before total detachment of that bit from the coconut. This required feeding of the same husk-bit to the blade a second time or even more times and hence resulted in more time requirement. The factors responsible for this problem have already been identified and the same are being incorporated under the suggestions for future work.

It was seen also that, in one case, the green coconut got husked in even seven seconds. Therefore, the system developed in this study has the potential to do the husking in such a short time, which is comparable to even the manual methods mentioned above. The maximum time required for the complete husking of green coconut was 51 s. This is too long a duration and unjustifiable too. This was mostly due to the stickiness of the husk and also the reasons cited above. Further improvement of the system is likely to take care of this problem.

It is discernible from Table 4.2 that the mean husking time for a dry coconut is 26.1 s and the mean time for separating one bit is 5.3 s. Both the durations are high as in the case of green coconuts. Reasons for the long durations are the same as that of the green coconuts. As stated, it requires further improvement of the assembly.

In respect of the dry coconuts, the minimum and maximum durations taken for complete husking were 12 and 50 s respectively. As already accepted, these durations have to be reduced by modifying the system.

4.2 Husking effectiveness

Data of the experiments on husking effectiveness are given in Tables 4.3 and 4.4.

Table 4.3 Number of husk-bits detached from green coconuts and its frequency of occurrence

Sl. No.	Husk-bit (No.)	Frequency of occurrence (No.)	Frequency of occurrence (%)
1	3	0	0.0
2	4	7	46.7
3	5	6	40.0
4	6	2	13.3
5	7	0	0.0
6	8	0	0.0
Total	33	15	100.0

Table 4.4 Number of husk-bits detached from dry coconuts and its frequency of occurrence

Sl. No.	Husk-bit (No.)	Frequency of occurrence	
		No.	%
1	3	0	0.0
2	4	8	53.3
3	5	3	20.0
4	6	3	20.0
5	7	1	6.7
6	8	0	0.0
Total	33	15	100.0

Husking effectiveness is evaluated by assessing the number of husk-bits into which the husk is split when husking a coconut. Practically, the minimum number of bits into which the husk has to be split for complete husking is *three*. Hence, this is considered the most effective husking. Results presented in Table 4.3 indicate that none of the green coconuts got completely husked by splitting into three bits. This was observed to be due to the small sweeping angle of the blade. Since a large sweeping angle was found to damage the nut, it required that the sweeping angle be small. The minimum number of bits required in the present study was four. In respect of green coconuts, Table 4.3 shows that 46.7 % of them could be husked by splitting the husk into four bits. This was due to traversing of the blade through only small segments of the husk. As stated above, sweeping through wider segments became detrimental as the blade, in the process, more often impinged upon the coconut shell and damaged it. Therefore, in the present study, splitting of the husk into four bits was considered the best option next to three bits, for the husking effectiveness. Results indicate that as much as 53.3 % of the green coconuts had to have their husk split into bits in excess of four. This too is due to the reasons cited in the section just preceding this. In addition, when coconut is fed a second time, sometimes the husk gets split along another plane and results in smaller bits. The fact that 46.7 % of the green coconuts could be completely husked by splitting into just four bits is quite encouraging. Further modification of the mechanism is likely to improve the husking effectiveness.

In respect of dry coconuts too, none got completely husked by splitting into three bits (Table 4.4). As with the green coconuts, these too required splitting into a minimum of four bits. Such cases were 53.3 %. Those required splitting into pieces in excess of four were 46.7 %. Therefore, whether the coconuts are green or dry, husking effectiveness was nearly similar for both.

However, the percentage of coconuts husked by splitting into three bits using this mechanism has to be enhanced considerably and made 100 % or closer to it. It appears that this can be achieved by modifying the blade assembly. Concerted efforts are required along these lines.

4.3 Mechanical damage

Mechanical damage is indicated by either crack(s) on the shell extending into the meat or severe rupture or puncturing of the shell to expose a portion of the meat. The data from the experiments on mechanical damage are presented in Table 4.5 below.

Table 4.5 Number and percentage of nuts damaged of green and dry coconuts

Coconut Type	Coconuts Husked	Nuts Damaged			
		By Surface Cracking		By Puncturing	
	(No.)	(No.)	(%)	(No.)	(%)
Green Coconut	15	0	0	0	0
Dry Coconut	15	0	0	2	13.3

According to Table 4.5, none of the green coconuts were damaged during husking. This fact is quite encouraging. However, in husking dry coconuts, two of the fifteen coconuts were punctured by the blade. An examination of the damaged nuts showed that one of the nuts was already a rotten nut and hence did not have the strength to withstand the compressive stress induced by the blade through even its spongy husk. This was, therefore, considered a matter of no concern. In any case, even if undamaged, that nut would not have been normally traded. Rupturing of the other nut was due to carelessness of the operator. Had he enforced timely withdrawal of the coconut, instead of re-feeding it when encountered with a light seizing of a husk-bit by the blade, possibly no damage would have been caused to that nut. Not only this case but also the others, during the explorative studies, indicated that the damage was often due to inaction of the operator in timely withdrawing the nut. After the removal of a bit of the husk, the nut remains exposed and feeding of that part again to the blade caused the blade to impinge upon the exposed nut and puncture it. So, by exercising caution, it is possible to eliminate or minimize the extent of damage caused in this manner. However, it is also essential to incorporate a fool-proof method in the husking mechanism to prevent the operator from feeding the exposed shell a second time to the blade.

Therefore, analyses of the actual husking operation and the results presented in Table 4.1 through Table 4.5 indicate that the feeding mechanism developed under the study has the potential to be incorporated in a powered husking machine with manual feeding of the coconuts; of course, with improvements as proposed in this report.

Chapter V

SUMMARY AND CONCLUSIONS

Since ages, coconut has been a major crop in the coastal regions in India. In Kerala, this is true for the entire State. Substantial portion of Kerala's economy in the agricultural sector is sustained by the coconut. However, due to the exodus of considerable labour force from this sector, agricultural operations related to coconut have been suffering. One of the major post-harvest operations performed on coconut is its husking. Though domestic-level husking has been made simpler with the recent development of the KAU Coconut Husking Tool, large-scale husking still continues to be performed using the traditional crowbar (*paara*) due to the absence of an efficient and effective powered husking machine. Husking with crowbar, though quicker, involves huge drudgery. So, there was a necessity to develop a machine to bridge the said gap. It was in consideration of this that the present study was undertaken with the following objectives.

4. To develop a rotary mechanism for husking coconut
5. To develop a mechanism to manually feed the coconut to the husking mechanism
6. To evaluate its performance in coconut husking

In order to achieve the objectives, an experimental set-up was developed and tested. For the sake of convenience, the experimental set-up was mounted on a machine lathe existing in the Machine Shop of the Kelappaji College of Agricultural Engineering and Technology, Tavanur. The rotary mechanism comprised a segmented ring attached through three spokes to a main shaft, and a spear-like curved blade; its curvature being concentric when the blade remains 25 mm away from the segmented ring. The blade carried a slotted radial spoke to enable its mounting on the segmented ring. In operation, the blade rotated downwards on the husking side to enable the blade to husk the coconut during its downward travel.

To facilitate the manual feeding and the turning of coconut after the separation of each sector of the husk, a set of three platforms; (i) a main platform, (ii) an auxiliary platform, and (iii) a movable platform; was fabricated as part of the experimental set-up. This was mounted on the rear end of the carriage of the lathe. The main platform remained directly fixed on the carriage and supported on top of it the auxiliary platform which in turn supported on its top the movable platform. A set of twin hand-levers hinged to the main platform and projecting through the other two platforms helped in moving the movable platform towards or away from the husking blade.

In operation, the coconut placed on the movable platform was moved together with the movable platform towards the blade. The blade traversing downwards on that side pierced through a sector of the husk and separated it. Using the hand-levers, the platform together with the coconut was drawn backwards. The coconut was then turned about its longitudinal axis to expose another sector of the husk. The coconut was again fed to the blade by operating the hand levers. The operations were repeated till the coconut was fully husked.

Thirty coconuts; fifteen green coconuts and another fifteen dry coconuts obtained from a local coconut oil mill was selected and used for testing. Major dimensions of the coconuts were measured and recorded. Other observations recorded in respect of each coconut were husking duration, number of husk-bits, mean time for separating each husk-bit, damage, frequency of occurrence of certain number of husk-bits; viz. from 3 to 8.

The results indicated that the husking of green coconuts took a mean time of 24.5 s for completely husking a coconut and 5.2 s for husking one bit. In each case, this is too long a time. The reason for it was the slipping of the blade from the loosened husk-bit even before total detachment of that bit from the coconut. However, the minimum and maximum durations observed were 7 s and 51 s respectively. It showed also that the mechanism had the potential to husk the coconut in such a short time; *i.e.*, 7 s.

The mean husking time for a dry coconut was 26.1 s and 5.3 s for removing one bit. The reason for these long durations was the same as that of the green coconuts. The minimum and maximum durations taken for complete husking of dry coconuts were 12 and 50 s respectively. Therefore, these durations have to be reduced by modifying the system. It requires further improvement of the assembly.

With regard to husking effectiveness, none of either the green coconuts or the dry coconuts got completely husked by splitting into three bits which is the most ideal. The minimum number of bits required in the present study was four. In respect of green coconuts, 46.7 % of them could be husked by splitting the husk into four bits. But, as much as 53.3 % of the coconuts had to have their husk split into bits in excess of four. As with the green coconuts, the dry coconuts too required splitting into a minimum of four bits. Such cases were 53.3 %. The dry coconuts requiring splitting into pieces in excess of four were 46.7 %. Therefore, whether the coconuts are green or dry, husking effectiveness appeared to be somewhat similar for both.

With respect to mechanical damage, none of the green coconuts were damaged during husking. This fact is quite encouraging. However, two of the fifteen dry coconuts were punctured by the blade. But, one of them was already a rotten nut. But, the other ruptured due to carelessness of the operator which resulted in feeding the exposed portion of the shell, a second time to the blade.

Therefore, the results indicated that the husking and feeding mechanisms developed under the study have the potential to be incorporated in a powered husking machine with manual feeding of the coconuts; of course, with improvements as proposed in this report.

Chapter VI

SUGGESTIONS FOR FUTURE WORK

The mechanisms developed under this study have great potential to be improved. Suggestions for the same are stated below.

1. The movable platform has to be given in its front side a profile that matches with the general profile of the coconuts. This is needed to provide adequate clearance for the unobstructed movement of the husk-bit when getting detached from the coconut. At present it is narrow.

2. The twin hand-levers have to be provided either a curvature towards the blade, or small rough projections where the coconut contacts the levers, or both to prevent the lifting of the rear side of the coconuts when the blade depresses it in the front.

3. Two concave rods are to be placed in front of the movable platform, in such a way as to provide a slight horizontal clearance over the blade width. They should remain concentric to the segmented ring, when the movable platform is in its most forward position. Vertically, the clearance between each of the said concave rods and the blade tip should be close; better if less than the mean thickness of the husk. This is needed to prevent the slipping of blade from the husk-bit.

4. The spoke of the curved blade should be made concave on the inside for proper hooking of the blade to the husk and the husk's sliding towards the main shaft along the spoke. It is needed also for removing a larger husk and further for removing the husk cleanly in one full bit without bruising the husk.

These improvements are considered to be advantageous in rectifying the present drawbacks and improving the performance of these mechanisms considerably.

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ABSTRACT

Development of a Rotary Mechanism with Manual Feeding for Husking Coconut

A rotary mechanism having a single blade mounted on a segmented ring attached to a main shaft through three spokes was developed. A movable platform for supporting the coconut and feeding it to the rotating blade was also developed. The movable platform rested on an auxiliary platform for regulating its motion. A twin hand-lever arrangement enabled the moving of the movable platform towards the blade and backwards. Both the mechanisms were mounted on a machine lathe which formed the test bed. The blade was rotated at a speed of 30 rev/min. The coconut placed on the movable platform was pushed, together with the movable platform, towards the rotating blade using the twin hand-levers. The blade pierced the husk on one side of the coconut and ripped open a sector of the husk. Using the twin hand-levers, the movable platform, together with the coconut, was then moved backwards. The coconut was turned about its longitudinal axis enabling to feed another sector of the remaining husk to the blade. The coconut, together with the movable platform, is again pushed towards the blade for the blade to detach another sector of the husk. By repeating the operations, the entire husk was removed. The mean husking durations for 15 each green and dry coconuts were respectively 24.5 and 26.1 s. The maximum durations for husking the green and the dry coconuts were respectively 51 and 50 s and the minimum 7 and 12 s respectively. The number of pieces into which the whole husk of a coconut was split came to 4-6 for the green coconuts and 4-7 for the dry ones. During the experiments, none of the green coconuts got mechanically damaged. Though two of the dry coconuts got damaged, one was a rotten nut. The other was damaged due to non-withdrawal of the coconut after the separation of the husk-bit from that part. This was hence an avoidable damage. As a whole, considering its performances, the two mechanisms developed in this study appeared to be promising. It also requires further improvements.