DEVELOPMENT OF A POWER-OPERATED COCONUT HUSKING MACHINE

By

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PROJECT REPORT

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KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY
TAVANUR – 679 573, MALAPPURAM DISTRICT
KERALA, INDIA
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DECLARATION

We hereby declare that this project report entitled **'Development of a Power-Operated Coconut Husking Machine'** 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: 17-12-2009

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CERTIFICATE

Certified that this project report entitled **'Development of a Power-Operated Coconut Husking Machine'** is a *bonafide* record of the project work done by Miss. Anu .S. Chandran (*Admission No:* 2005-02-008), Mr. Aneesh Mohan (*Admission No:* 2005-02-026), and Miss. Shabeena P.K. (*Admission No:* 2005-02-030) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship, fellowship, or other similar title of any other University or Society to them.

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Anu .S. Chandran **Aneesh Mohan** **Shabeena P.K.**

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**
M.S.	**Mild steel**
No.	**Number**
No.s	**Numbers**
rpm	**revolutions per minute**
s	**second(s)**
Sl. No.	**Serial number**
/	**Per**
%	**Per cent**

Chapter 1

INTRODUCTION

Coconut is one of the most important crops in Kerala. Coconut palm is also known as '*Kalpa-vriksha*' or '*tree of heaven*' as it provides many necessities of life including food and shelter. The coconut palm (*Cocos nucifera*) is a member of the family Arecaceae (palm family). It is the only species in the genus *Cocos*, and is a large palm, growing to even 30 m tall, with pinnate leaves 4–6 m long, and pinnae 60–90 cm long; old leaves breaking away cleanly, leaving the trunk smooth. The coconut palm thrives in sandy soils and is highly tolerant of salinity. It prefers areas with abundant sunlight and regular rainfall (150 cm to 250 cm annually), which makes colonizing shorelines of the tropics relatively straightforward. Coconuts also need high humidity (70–80 %+) for good growth, which is why they are rarely seen in areas with low humidity, like the Mediterranean, even where temperatures are high enough (regularly above 24°C).

Botanically, a coconut is a simple dry nut. The husk or mesocarp is composed of fibers called coir. Its inner stone or endocarp is the hardest part of the nut. The endocarp (the outside shell of the coconut) has three germination pores that are clearly visible on the outside surface once the husk is removed. It is through one of these that the radicle emerges when the embryo germinates. Adhering to the inside wall of the endocarp is the *testa*, with a thick albuminous endosperm (the coconut "meat"), the white and fleshy edible part of the seed. Hardness of the shell and husk increases with maturity. By the time the coconut naturally falls, the husk has become brown, the coir has become drier and softer, and the coconut is less likely to cause damage when it drops.

The origin of this plant is the subject of debate. Most authorities claim that it is a native to South Asia (particularly the Ganges Delta); while others claim its origin is in north-western South America. Fossil records from New Zealand indicate that small, coconut-like plants grew there as long as 15 million years ago. Even older fossils have been uncovered in Kerala, Rajasthan, Thennai in Tamil Nadu at banks of River Palar, Then-pennai, Thamirabharani, Cauvery and Mountain sides along Kerala borders, Konaseema-Andharapradesh, and Maharashtra (India). Mention is made of coconuts in the 2^{nd}–1^{st} century BC in the Mahawamsa of Sri Lanka. The later Culawamasa states that King Aggabodhi I (575–608) planted a coconut garden of 3 yojanas length; possibly this could be the earliest recorded coconut plantation.

It is mainly cultivated for its nuts from which the two important commercial products, the copra and the fibre are obtained. It can also be used for the production of by-products like oil, coir, coconut-shell powder, etc. Coconut palms are grown in more than 80 countries of the world, with a total production of 49 billion nuts. In 2007, the shares of coconut growing countries in production were: Indonesia (26%), Philippines (23%), India (23%), Sri Lanka (4.4%), and other countries (24%). The productivity of the crop is the highest in India with 7572 nuts/ha.

The States in India that are indulging in the production of this fruit; with their annual average production figures; are Kerala (6326 million nuts), Tamil Nadu (4867.1 million nuts), Karnataka (1209.8 million nuts), Andhra Pradesh (892 million nuts), West Bengal (323.5 million nuts), Orissa (274.6 million nuts), Maharashtra (273.4 million nuts), and Assam (204.9 million nuts). Kerala's contribution of coconut to India is 45.22%. Hence, Kerala is famous as the largest coconut growing State in India. It is famous also for the coconut-based products like tender coconut water, copra, coconut oil, coconut cake, coconut toddy, coconut shell-based products, coconut wood-based products, coconut leaves, and coir pith. Coconut is even termed as the backbone of Kerala's economy.

Nearly all parts of the coconut palm are useful. The palms have a comparatively high yield; up to 75 fruits per year. The name for the coconut palm in Sanskrit is *kalpa vriksha*, which translates as "the tree which provides all the necessities of life". In the Malay language, the coconut is known as *pokok seribu guna*, "the tree of a thousand uses". In the Philippines, the coconut is commonly given the title "Tree of Life".

A major problem concerned with coconut is its husking. The traditional tools used for husking include chopping knife or machete, crowbar (*paara*), etc. These tools make use of the principle of wedge and the principle of lever. The modern tools intended for small-scale husking are coconut husking machine, mini coconut-dehusker, KAU coconut husking tool (*Keramithra*), etc. Except for the crowbar, no other simple tool is beneficial in large-scale husking. A person skilled in husking husks 2500-3000 coconuts in about 6 hours using a crowbar. However, husking with a crowbar involves lot of drudgery. Therefore, it was felt that a power-operated husking machine in which the feeding of coconut one by one is manual but opening of husk is mechanical would be quite ideal. Such a machine was considered to make husking lighter and hence relieve the operators from drudgery. Since the feeding is manual, it was thought to be not displacing the labour from this sector. Hence, the present study was undertaken with the following objectives.

Objectives:

1. To design and develop a power-operated coconut husking machine.
2. To evaluate its performance in coconut husking.

In order to achieve the objectives, a coconut husking machine which made use of the twin-blade assembly as in the KAU Coconut Husking Tool (*Keramithra*) was designed and developed. It's opening and re-setting of the movable blade with respect to the stationary blade was designed to be carried out mechanically with a four-bar linkage assembly having a cam and follower mechanism driven by the power supplied by an electric motor. The design was such that it had quick-opening and quick-return arrangements for the opening and re-setting of the movable blade with respect to the stationary blade. Further, the cam and follower was so designed to dwell for a longer period to enable the blades to remain in the juxtaposed position for a longer time so as to allow more time for impaling the coconut on to the blades each time. Overall, the machine, as the first prototype, functioned satisfactorily. Also, it offered scope for further improvement. It was found that the average husking time was 14.5 s per nut. Though this duration is on the higher side compared to the husking using a crowbar, it was observed to be relieving the operator of the drudgery considerably. This is a great advantage. However, it is expected that, with further improvement and overcoming of the present shortcomings, it would prove to be a good machine requiring lesser husking time.

In the process of the selection of this project and its execution, the literature available in the topic was vastly reviewed and relied upon. A report on this review is presented in the ensuing chapter.

Chapter 2

REVIEW OF LITERATURE

Agriculture is the backbone of Indian economy. The advancement of science and technology gave rise to the development of agriculture. Now a day, a major problem in the agricultural sector is the displacement of labourers and the resultant shortfall in the availability of labourers. This is seriously affecting the farming operations which are highly time-bound. The problem is becoming more acute because of the lack of machines to take the place of the displaced labourers. The situation is not any different in the coconut-husking sector as well.

As said earlier, lack of suitable machines for husking coconuts is one of the major problems concerned with coconut farmers. Though a number of simple tools have been developed, none has found sound application in large-scale husking. At the same time, at the domestic level, small tools like machete, crowbar (*paara*), KAU coconut husking tool named Keramithra, etc., have wide acceptability. The first two are the most traditional tools.

According to Jippu (1999), coconut husking might have started with single-blade instruments like wedge-shaped rock pieces, sharpened wooden-crowbars, etc. He classified the manually-operated coconut husking tools broadly as:

a. Single-blade coconut-husking tool

   E.g., machete, axe, crowbar, etc.

b. Twin-blade coconut-husking tool

   E.g., coconut spanner, keramithra, etc.

c. Multi-blade coconut-husking tool

   E.g. CPCRI coconut dehusker

In the case of a single-blade coconut husking tool, its single blade act as both the *wedge* and the *lever*. As the *wedge* enters the husk longitudinally and normal to its surface, the husk is little ripped open and divided and then pushed aside. Then, the *blade*, in the case of a coconut resting on a floor/ground, or the *coconut*, in the case of the tool resting on a floor/ground, is *twisted* in a peculiar orientation, *as with a lever*, to widen the slit, detach a sector of the husk from the kernel, and scoop it out. In this twisting, the *wedge* or *blade* acts as the *lever* and provides a mechanical advantage greater than one. In husking using single-blade tools, all unit operations are carried out manually. Since a very large force is to be applied as the effort, due to the small mechanical advantage, husking is tough and hard, and hence involves considerable drudgery.

In respect of twin-blade or multi-blade coconut husking tool, the juxtaposed blades act as the wedge at the time of impaling the coconut on them. Further ripping open, detachment of one or more sector(s) of husk from the kernel, and its scooping out are carried by the moving blade actuated by an extended lever. Though the extended lever provides more mechanical advantage than that of the single-blade tool, husking is still laborious and involves drudgery; of course lesser.

It is in this light that a device which allows manual feeding but separation of husk with mechanical means is considered. In order to select a tool which can be considered for modifying to this extent, the survey of literature was firstly limited to the twin-blade tools.

The earliest known twin-blade husking tool developed was that of Waters (1946), which is a modified version of the smithy tongs. It had two lips sharpened like thin wedges. In the juxtaposed or closed position, it was swung and impaled on the coconut, and then separated to loosen the husk. The unit operations were repeated three or four times to finally take out the kernel. It is evident from its photograph and literature that it is not that much convenient to use. That could be the reason why it did not become popular at all.

Another twin-blade tool, which appeared to be better than that of Waters (1946) was of the tool developed by Titmas and Hickish (1929). This was a tool mounted on a wooden platform, and standing upright when placed on the floor. Coconut is held by hand and impaled on the stationary tool. The depressing of its foot lever each time caused the separation of one sector of the husk. Repetition of these operations three or four times caused complete removal of the husk. Resetting of its movable blade on to the stationary blade, to keep them in the juxtaposed upright position, was achieved with the aid of a tension spring of high spring constant. Slipping of the foot from the pedal when depressing would be causing quick return of the pedal, and any part of the leg or body coming in the way of its path is bound to get an impact, which may sometimes be inflicting injury. Moreover, depressing of the pedal in the standing posture of the operator and with one foot, in coconut husking is not that advantageous, as this action destabilizes the operator. These disadvantages might have prevented the acceptance of this tool.

Ganesan and Gothandapani (1995) invented a mini coconut-dehusker. It consists 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 and the tool made to impale on another portion of the remaining husk and the process of ripping open the husk is repeated. The operations are then repeated till complete husk is removed. It is understandable that husking using this tool involves more cumbersome unit operations. Each time, the operator has to bend for manipulating the coconut placed on the platform which could be at the ground level. Then, he has to rise and straighten up for lifting the tool and swinging it downwards against the coconut. This could be the reason for it not becoming popular. Besides, here too the blade actuation is manual. Based on the above, it was seen that it offered little scope for improvement to the level envisaged in this study.

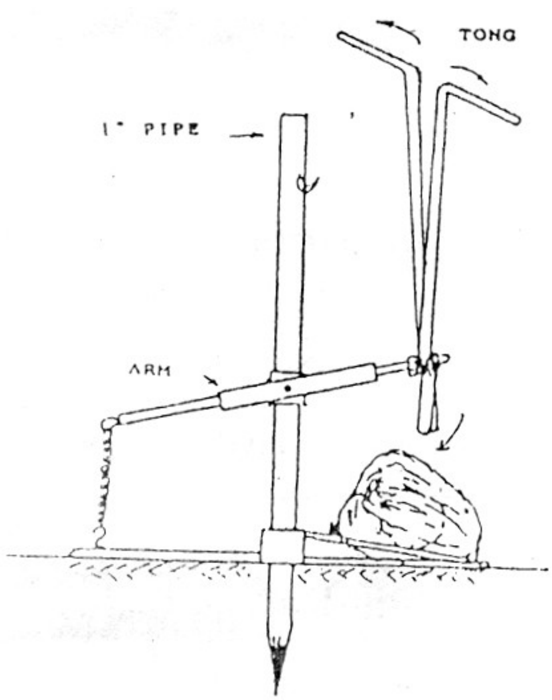


Fig. 2.1 Mini Coconut Dehusker
(*Ganesan and Gothandapani*, 1995)

The KAU Coconut Husking Tool (*Keramithra*) developed in the Kerala Agricultural University; as reported by Jippu and Joby (1998); is simple not only in construction but also in use. 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 both the hands on to 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 twice or thrice the husk can be separated completely from the coconut. It takes only about 8 to 20 seconds for husking a nut depending upon the variety, maturity of nut and skill of operator. It is light in weight (2.5 kg), and simple to use and handle. Though this tool is quite acceptable at the domestic level, it is not so in large-scale husking. In this case too, the actuation of movable blade is manual. Therefore, it was felt that the modification of this tool by incorporating a mechanical blade actuating mechanism would certainly turn out to be of great advantage.

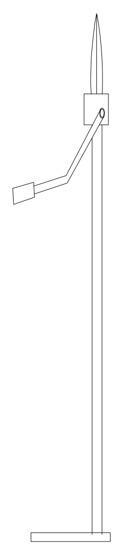


Fig. 2.2 KAU Coconut Husking Tool (*Keramithra*)
(*Jippu and Joby*, 1998)

According to Jippu (2007), the husking tools separately developed by Mr. Aboobekkar, T.P.; and Mr. 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. In these cases too, the blade/blades are actuated manually. On a comparison with the *Keramithra,* it was seen to be offering only lesser advantage. Hence, this too was not selected in this study.

In order to confirm the suitability of multi-blade tools for incorporating the modifications to satisfy the needs as contemplated, the survey was extended to the literature on them too.

In Central Plantation Crop Research Institute (CPCRI), Kasaragod, a manually-operated dehusker was developed and improved. It consists of three sharp separable blades, which initially faced upwards and in a juxtaposed position. In operation, the blades go up and outwardly by swinging about their pivots at the bottom. In the process, the husk of the coconut impaled upon the blades is 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. Moreover, not only that the feeding is manual but also its movable blade actuation is again manual. The major impediment with this device was its large size. Hence, it was found to be unsuitable for the type of modifications preferred in this study.

A rotary coconut dehusker was developed in the Kelappaji College of Agricultural Engineering and Technology (KCAET), Tavanur (Muhammad, 2002 and 2005). It was intented for large-scale application. This powered-machine consists 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 inlet and the drum is compressed slightly by the system and forced to execute rolling or revolutions. In the process, the blade penetrates the husk and punctures it along different planes. The shear force 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 nut emerges out at the outlet. In some cases, full coconuts with puctured and softened husk emerge out. Such coconuts require secondary operations to remove the husk. Based on the above, it was not selected for the type of modifications preferred in this study.

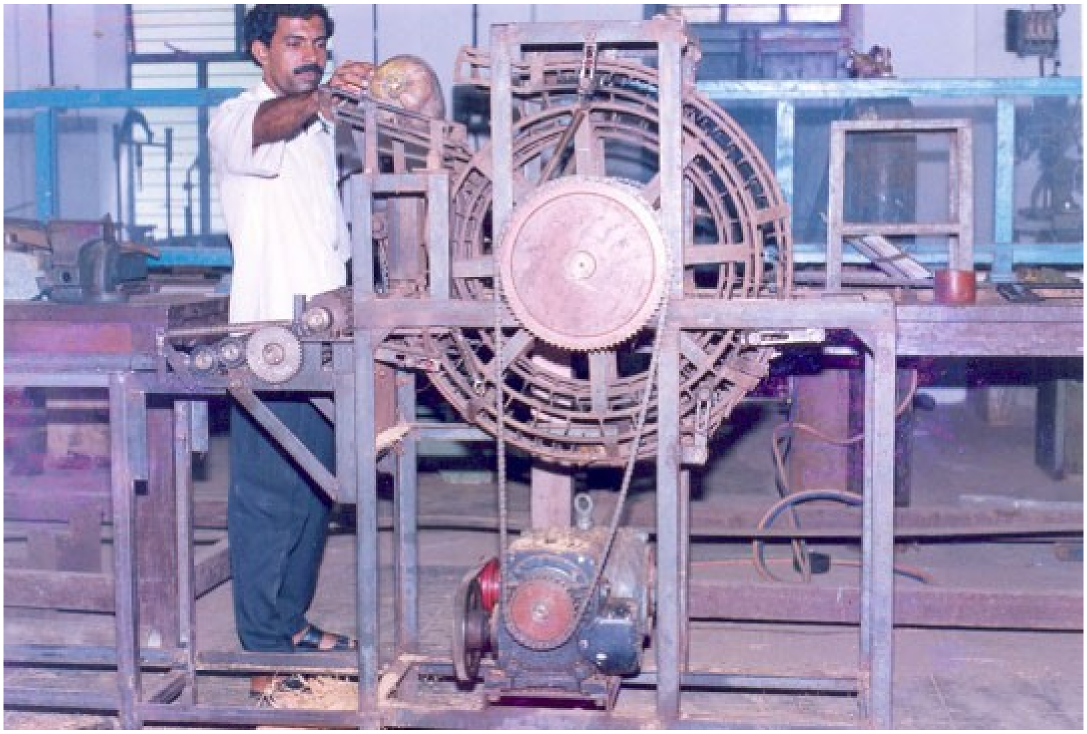


Fig. 2.3 Rotary Coconut Dehusker

(*Muhammad*, 2002)

A project on the development of a rotary mechanism with manual feeding for husking coconut was also undertaken at the KCAET, Tavanur (Edwin *et al.*, 2008). It was intented for large-scale application. The rotary mechanism comprised a segmented ring attached through three spokes to a main shaft and a spear-like curved blade. 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. However, this tool did not become a perfect solution for the present crisis in this sector. Since this machine was found unsuitable for the type of modifications suggested in this study, this too was not selected as the tool for improvement in this study.

In spite of the efforts taken at different places, an efficient tool for large-scale husking of coconut, in which the impaling of coconut is manual but ripping opening of the husk is mechanical, is yet to be developed. Comparatively, the one closest to having the potential to be developed into a tool as envisaged in the present study is the KAU Coconut Husking Tool (*Keramithra*). Hence, this tool was selected for modification and incorporating the power train.

Based on the above and others, it was envisaged to incorporate in it quick-opening and quick-return arrangements for the opening and re-setting of the movable blade with respect to the stationary blade. Besides, it was envisaged also to have a cam and follower which would dwell for a longer period to enable the blades to remain in the juxtaposed position for a longer time so as to allow more time for impaling the coconut on to the blades each time. Details of the materials and methods used in this study are presented in the next chapter.

Chapter 3
MATERIALS AND METHODS

To achieve the objectives, a coconut husking machine having a twin-blade assembly was designed and developed. It was envisaged to have an actuating system comprising a cam and follower connected to a hinged movable-blade for separating the movable blade from the stationary blade and then resetting the former on the latter quickly. The cam and follower mechanism was intended to allow dwelling of the two blades in the juxtaposed position for 280^0 and separation of the blades for the remaining 80^0, and then quickly resetting the movable blade to the juxtaposed position. Details of the experimental set-up developed are presented below.

The main parts of power-operated coconut husking machine include

1. Cam and cam shaft
2. Follower
3. Motor and Speed-Reduction Gearbox
4. Blade
5. Frame

Further descriptions of these parts of the machine are presented below.

3.1 Cam and camshaft

A half-way cam of nominal diameter 50 mm and displacement 50 mm was designed and made from mild steel (M.S.) flat of thickness 6 mm. Its profile is shown in Fig. 3.1. It's ascend is completed in 80^0 during which the cam displaces the follower connected at the other end to the movable blade through the connecting rod. The kinematic link is arranged in such a manner that the effort arm of the lever on which the blade is mounted swings about its hinge to open the blade tip through 18 cm. On completion of the ascend, the cam; being a half-way cam; gets disengaged from the follower. The compression spring against which the follower operates forces the follower to quickly retrace its path to its initial position. Correspondingly, it draws the blade to get back to the juxtaposed position. As the cam rotates through the remaining 280^0, the follower dwells. This forces the twin-blades to stay in the juxtaposed position for a longer duration. Such a dwell was planned for allowing the longer time required to impale the coconut on to the blades.

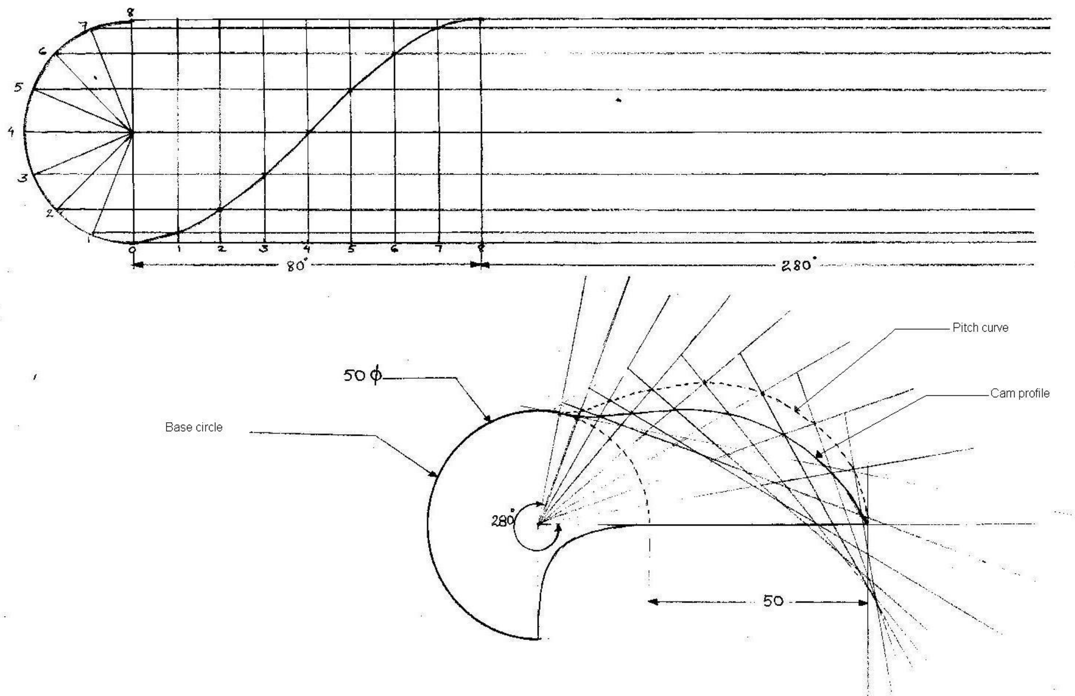


Fig. 3.1 Cam profile *All dimensions in* mm

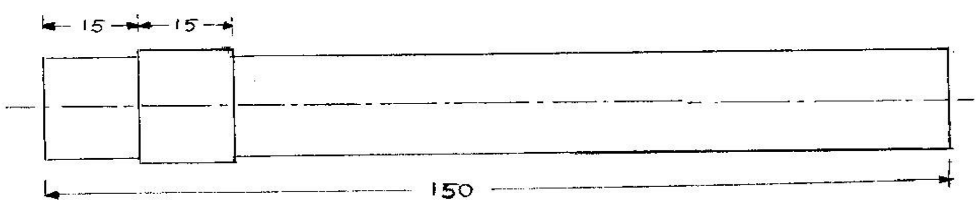


Fig. 3.2 Shaft *All dimensions in* mm

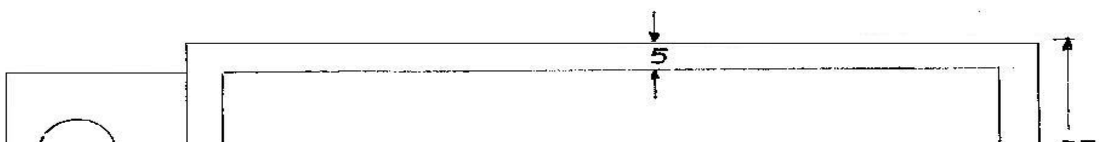
The cam was then firmly welded to a MS shaft of length 150 mm and diameters 20 mm and 22 mm. Position of the cam on the shaft is where the diameter is 22 mm (Fig.s 3.2 and 3.3). The shaft was then fitted in two ball bearings having inner diameter 20 mm. A V-pulley of diameter 150 mm was fitted on the top end of the shaft to receive the rotary motion from a speed reduction gear box.

Fig. 3.3 Camshaft

3.2 Follower

A cage-like follower of size 118 x 35 mm, as shown in Fig.s 3.4.a to 3.4.c, was made from MS flat of 25 x 5 mm. The cam operated on the inside of this cage. The cam was so placed that it acted on the inside vertical wall on the right-hand side of the cage shown in Fig. 3.4.a. The connecting rod was hinged to this follower along the hole shown on its left-hand side.

Fig. 3.4.a Follower



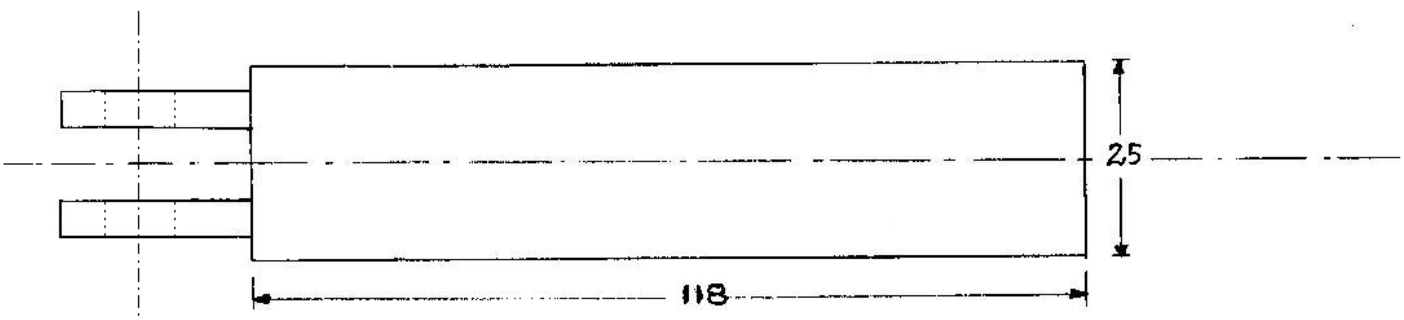


Fig. 3.4.b Follower (*Elevation*)

Fig. 3.4.c Follower (*Plan*)

All dimensions in mm

3.3 Motor and Speed-Reduction Gearbox (*Fig.* 3.5)

According to Jippu and Joby (1998), the time taken for husking a coconut using hand-operated coconut husking tool was found to be in the range 8-20 s. The design was, therefore, planned for completing the husking in 10 s and in 4 sectors of the husk. Further, the cam should rotate once for the removal of one sector of the husk. So, it was planned to have four revolutions in 10 s. Based on these criteria, the speed required for the camshaft was 24 rpm. Therefore, a motor of 1440 rpm and 1.5 kW (2.0 hp), and a speed-reduction gearbox (1:70) readily available in the college were used in this study and constructing its experimental set-up. The reduction in speed from 1440 rpm to 24 rpm was achieved by means of the said speed-reduction gearbox and various sizes of pulleys. Four pulleys were used in this equipment. The rotary motion of output shaft of the motor was transmitted to the input shaft of speed-reduction gearbox through a V-belt drive having pulleys of diameters 175 mm and 75 mm respectively. The rotary motion of output shaft of this gearbox was conveyed to the camshaft by means of another V-belt drive having pulleys of diameters 100 mm and 200 mm respectively.

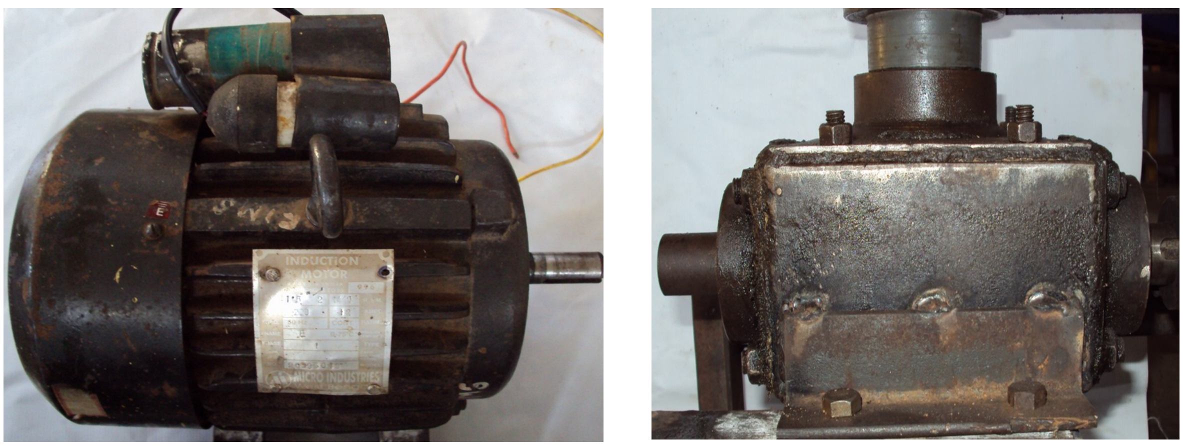


Fig. 3.5 Motor and speed-reduction gearbox

3.4 Blades (Fig.s 3.6 and 3.7)

The two blades used were of spring steel of size 70 x 50 x 3 mm. One blade was fixed on a 2-arm angular lever of channel cross-section 500 x 25 x 5 mm and length 150 mm along its neutral axis. It was provided a bend of 150^0, as shown in Fig. 3.7, to make it an angular lever in which the effort arm on the lower side measured 45 mm, and the load arm on the upper side measured 105 mm. Matching with this, there was a stand parallel to it. The stationary blade was fixed on this stand in a manner as to hold the two blades juxtaposed during idling and to enable their separation during stripping of husk.

Fig. 3.6 Fixed blade and movable blade

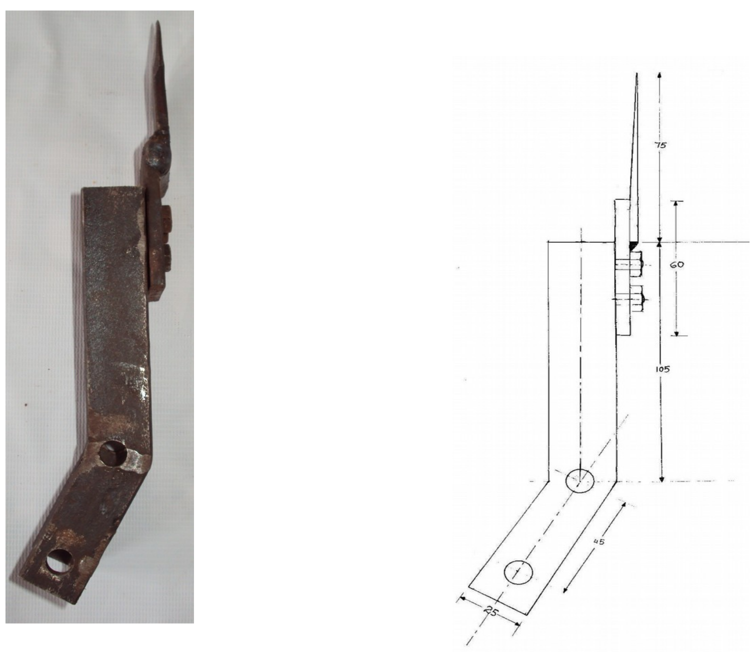


Fig. 3.7 Angular 2-arm lever with blade (Side View)

All dimensions in mm

3.5 Frame

Three separate frames were initially made using MS angle (35 x 35 x 5 mm) as the bases for (i) blade assembly, (ii) cam and follower assembly, (iii) speed-reduction gearbox, and (iv) electric motor. These were then joined into one integral unit according to the relative positions of each individual unit.

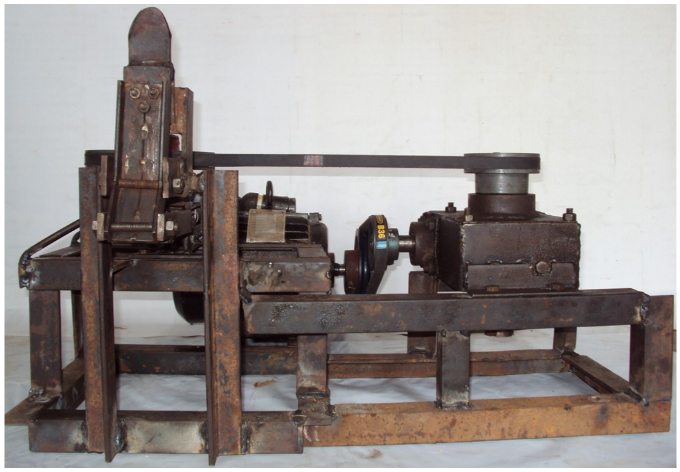


Fig. 3.8.a. Powered-coconut husking machine (*Front view*)

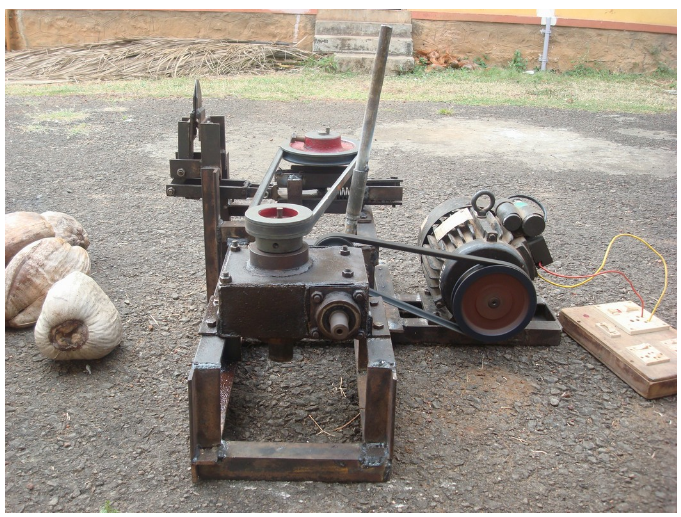


Fig. 3.8.b. Powered-coconut husking machine (*Side view*)

3.6 Operation

Initially, the coconut is impaled with both hands on the two juxtaposed wedge-like blades oriented upwards. The power from the motor is transmitted to the speed- reduction gearbox with the help of a V-belt drive. This power is transmitted to the camshaft using another V-belt drive. The cam rotating at 24 rpm pushes the follower which in turn pulls the effort arm of the angular 2-arm lever through the connecting rod between them. This action separates the movable blade from the stationary blade. In the process, a sector of the husk is loosened and separated from the kernel. The cam is designed in such a manner that when the cam displaces the follower by 50 mm, the tip of movable blade moves by 180 mm from the tip of stationary blade. The quick-return mechanism comprising the half-way cam and the compression spring on the rear side of the follower quickly re-sett the movable blade to its initial position. The coconut is then turned, impaled, and the operations repeated till complete husk is removed.

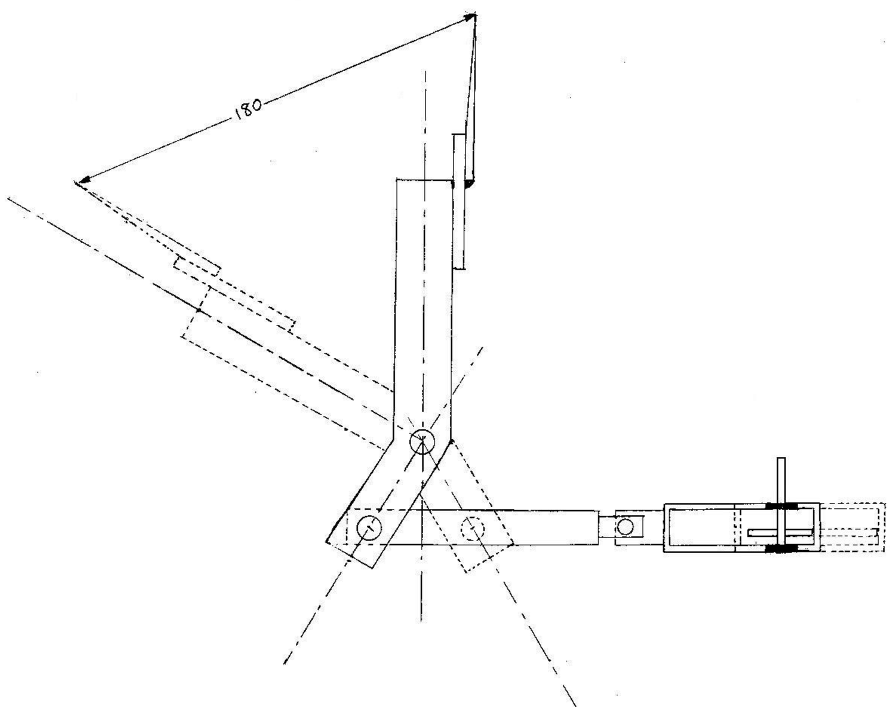


Fig. 3.9

Schematic representation of blade opening

The experimental set-up was used in carrying out the experiments relating to husking. The coconuts used in the study were those collected from a local coconut oil mill. Since the samples were randomly collected from a heap, no observation could be made about the variety of the coconuts. However, the samples were divided into the two lots of dry coconuts and green coconuts. Time required for husking a sector of the husk was noted besides the total time for husking a coconut. Number of sectors into which the husk was split also got noted. Thickness of the husk along its longitudinal profile at five locations was also noted for drawing conclusions about the profile.

Results of the study are presented in the chapter that follows. Discussion on the results is also presented in it.

Chapter 4

RESULTS AND DISCUSSION

The results presented and the discussion on them are included in this chapter under the following sections.

4.1. Husking rate
4.2. Husking effectiveness
4.3 Coconut profile

4.1 Husking rate

Data of the experiments on husking rate for green and dry coconuts are presented in Tables 4.1 and 4.2 given below. Samples include two lots of 20 green coconuts and 20 dry coconuts.

Table 4.1 Husking duration, number of husk-sectors, and mean time for removing one husk-sector of green coconut

Sl. No.	Husk-sector, *No.*	Total husking time, *s*	Mean husking time per husk-sector, *s*
1	4	**20**	5.0
2	4	17	4.3
3	3	13	4.3
4	4	16	4.0
5	4	20	5.0
6	5	15	3.0
7	4	14	3.5
8	5	18	3.6
9	3	13	4.3
10	4	14	3.5
11	4	20	5.0
12	4	13	3.3
13	4	**12**	3.0
14	5	14	2.8
15	4	16	4.0
16	4	16	4.0
17	4	13	3.3
18	4	15	3.8
19	4	13	3.3
20	3	12	4.0
Mean	4.0	15.2	3.8

Table 4.2 Husking duration, number of husk-sectors, and mean time for removing one husk-sector of dry coconut

Sl. No.	Husk-sector, No.	Total husking time, s	Mean husking time per husk-sector, s
1	4	22	5.5
2	4	11	2.5
3	4	14	3.5
4	5	10	2.0
5	4	12	3.0
6	4	**9**	2.3
7	3	12	4.0
8	4	14	3.5
9	3	12	4.0
10	4	9	2.3
11	5	13	2.6
12	4	23	5.8
13	4	10	2.5
14	3	13	4.3
15	4	18	4.5
16	5	18	3.6
17	4	9	2.3
18	4	**24**	6.0
19	4	22	5.5
20	4	9	2.3
Mean	4.0	14.2	3.6

It is seen from Table 4.1 containing the results of evaluation of the husking of the green coconuts that the mean time required for completely husking a coconut is 15.2 s and the mean time for separating one sector is 3.8 s. The minimum and maximum time required for complete husking of a green coconut was 12 s and 20 s respectively.

In large-scale husking using a crowbar (paara), carried out by skilled labourers, a mean duration of only 8 s is required. Similarly, the mean duration for husking using the KAU coconut husking tool named *Keramithra* is 12 s. So, the husking time for the present tool is comparatively longer. This is mainly due to the inexperience in husking using the new tool. With training and more experience, it shall be possible to reduce the time requirement. Further, it shall also be possible to reduce the time requirement by making the cycle-time of camshaft still shorter. There is scope for doing so.

From Table 4.2, the mean husking time for a dry coconut is 14.2 s and the mean time for separating one husk-sector was 3.6 s. The maximum and minimum durations taken for complete husking were 24 s and 9 s respectively. Whatever stated above for reducing the husking time for green coconuts are applicable to the dry coconuts too.

Table 4.3 Husking time for each lot of 5 coconuts

Lots	1	2	3	Mean
Husking time, (s)	79	89	95	88

The time required for husking 3 lots of 5 coconuts each is presented in Table 4.3. From this, it is evident that the total time is more. This is because the time got included the time for all unit operations involved in husking. Of course, longer time requirement was again due to the reasons cited above.

4.2 Husking Effectiveness

Data of the experiments on husking effectiveness are given in Tables 4.4 and 4.5.

Table 4.4 Number of husk-sectors detached from green coconuts and its frequency of occurrence

Sl. No.	Husk-bit No.s	Frequency of occurrence	
		No.s	%
1	3	3	15.0
2	4	14	70.0
3	5	3	15.0
4	6	0	0.0
5	7	0	0.0
6	8	0	0.0
Total	33	20	100.0

Table 4.5 Number of husk-sectors detached from dry coconuts

and its frequency of occurrence

Sl. No.	Husk-bit No.s	Frequency of occurrence	
		No.s	%
1	3	3	15.8
2	4	13	68.4
3	5	3	15.8
4	6	0	0.0
5	7	0	0.0
6	8	0	0.0
Total	33	19	100.0

Husking effectiveness is evaluated by accessing 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 4.4 indicate that there are only three coconuts, which got completely husked by splitting into *three* bits (*i.e*. 15 %). Most of the coconuts got husked by splitting into *four* sectors or bits. In respect of green coconuts, Table 4.4 shows that 70% of them could be husked by splitting the husk into *four* sectors. Those required splitting into pieces in excess of *four* were only 15%. However, no coconut required splitting into sectors more than *five*. Therefore, in the present study, splitting of husk into *four* sectors was considered the best option next to *three* sectors, for the husking effectiveness.

In respect of dry coconuts too, *three* coconuts got completely husked by splitting into *three* sectors (Table 4.5). Such cases were 15.8%. Those required splitting into a *four* bits were 68.4%. Those required splitting into pieces in excess of *four* were 15.8%. None required splitting into sectors more than *five*. Therefore, whether the coconuts are green or dry, husking effectiveness was nearly similar for both.

4.3. Coconut Profile

Using the data presented in Tables 4.6 and 4.7, the longitudinal profile of the cross-section of the coconuts was drawn (Fig. 4.1)

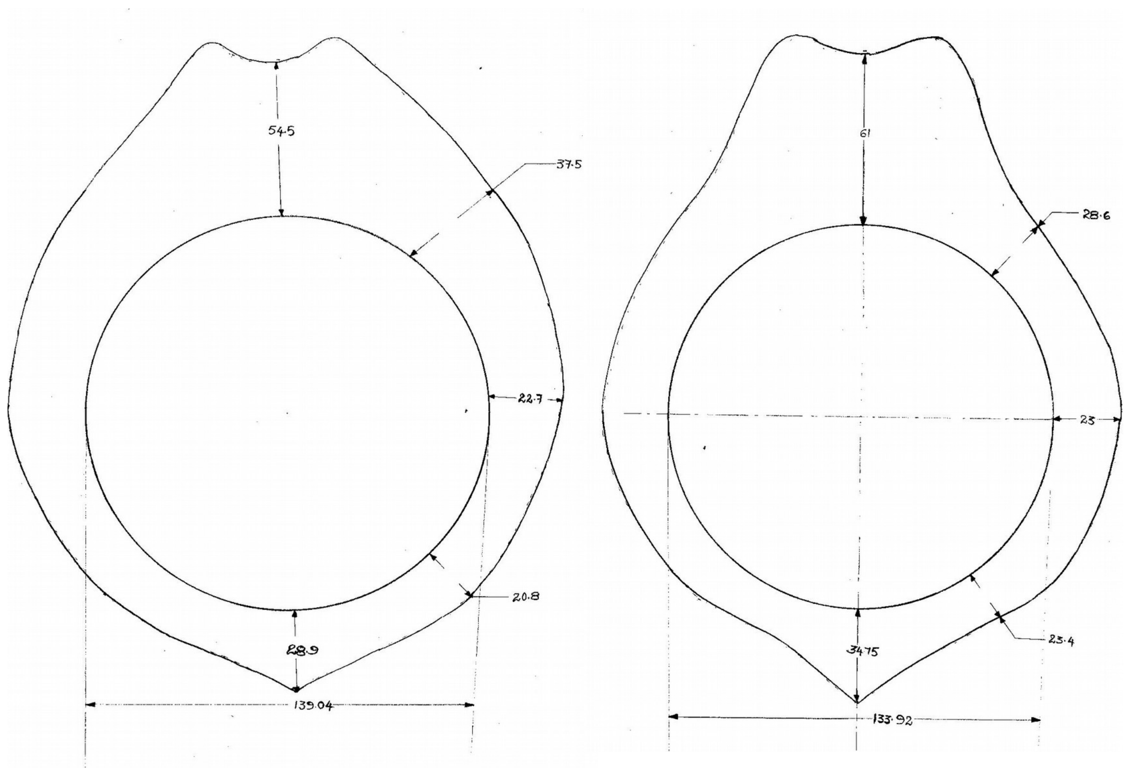
Table 4.6 Husk thickness for green coconuts (*From a longitudinal cross-section of husk*)

Sl. No	Husk thickness at the location from pedicel end, *mm*				
	At pedicel end	At apex	At ¼ th distance	At ½ th distance	At ¾ th distance
1	7.0	3.0	3.7	3.3	2.1
2	4.0	2.8	3.3	2.5	2.8
3	7.8	3.2	4.1	1.4	0.9
4	8.1	3.1	3.8	2.6	3.7
5	3.9	2.9	2.1	0.8	1.9
6	5.5	2.5	3.6	2.2	1.8
7	3.5	3.1	3.8	2.3	2.6
8	5.0	2.6	3.0	2.5	1.5
9	5.0	2.5	3.0	1.5	2.5
10	6.0	1.9	5.2	3.0	1.7

Table 4.7 Husk thickness for dry coconuts (*From a longitudinal cross-section of husk*)

Sl. No	Husk thickness at the location from pedicel end, *mm*				
	At pedicel end	At apex	At ¼ th distance	At ½ th distance	At ¾ th distance
1	7.5	3.5	2.8	2.0	1.5
2	6.5	4.0	2.5	2.0	1.5
3	5.0	3.5	3.5	2.5	1.5
4	6.0	4.0	3.0	2.5	2.5
5	5.0	3.0	3.0	2.0	1.5
6	6.0	4.0	2.0	2.0	1.5
7	6.0	4.0	3.0	2.0	1.5
8	6.0	3.0	3.0	2.0	1.5
9	6.0	2.5	3.0	3.0	3.0
10	7.5	3.0	3.0	2.5	2.0

It confirms that, as expected, the thickness is more at the pedicel end; almost twice as that at the other locations. The thickness at the apex end too is generally more compared to the locations at $1/4^{th}$, $1/2^{th}$, and $3/4^{th}$ distance from the pedicel end. The maximum thickness is to be known when fixing the height of the blades. The general profile obtained from the study is presented in Fig. 4.1.



Green coconut **Dry coconut**

Fig. 4.1 Profile of the longitudinal cross-section of green and dry coconut

The summary and the conclusions of this study, as evident from the results and the general observations are presented in the chapter that follows.

Chapter 5

Summary and Conclusion

One of the major post-harvest operations performed on a coconut is its husking. The traditional tools used for husking include chopping knife or machete, crowbar (*paara*), etc. These tools make use of the principle of wedge and the principle of lever. The modern tools that are used for small-scale husking are coconut husking machine, mini coconut-dehusker, KAU coconut husking tool (*Keramithra*), etc. Except for the crowbar, no other simple tool is beneficial in large-scale husking. A person skilled in husking using a crowbar husks 2500-3000 coconuts in about 6 hours. However, husking with a crowbar involves lot of drudgery. Therefore, there is an urgent necessity for developing a power-operated husking machine in which the feeding of coconut one by one is manual. Such a machine is bound to relieve the operators from drudgery and make husking more light. It was in this consideration that the present study was undertaken with the following objectives.

1. To develop a power operated coconut dehusker with manual feeding.
2. To evaluate its performance during husking.

To achieve the objectives, a machine was designed and developed. It generally consisted of mechanized opening of movable blade and manual feeding of coconut one at a time to remove the husk in, preferably, three sectors, one by one. For the quick resetting of the movable blade to the stationary blade, a quick-return mechanism was incorporated by designing and using a half-way cam. The cam was mounted on a camshaft and fixed to the frame after providing bearings and bearing housings. The follower was like a rectangular cage made of mild steel, and connected to the movable blade by means of a connecting rod. Stationary blade was fixed on the frame. A 2-hp electric motor of 1440 rpm was used to provide the drive. It was coupled to a speed-reduction gearbox through a V-belt drive. The gearbox was, then, connected to the camshaft using another V-belt drive. All the components were fixed to a frame.

The cam was designed in such a manner that when the cam displaced follower by 50 mm, the tip of the movable blade moved 180 mm away from the tip of fixed blade. The quick-return mechanism for quick resetting of the movable blade was designed and developed by incorporating a half-way cam and a compression spring arrangement at the rear side of the follower.

In operation, initially, the coconut is impaled with hands on to the upright and juxtaposed wedge-like blades. The cam rotating at 24 rpm pushed the follower which in turn pulled the connecting rod hinged to it. And, the connecting rod pulled the effort arm of the angular 2-arm lever on which is mounted, at its load-arm end, a blade. This caused the movable blade to swing away from the stationary blade; of course by remaining within the husk of coconut. This action forced this blade to rip open a sector of the husk. The coconut is then withdrawn and impaled again to rip open another sector of the husk. This is repeated three or more number of times; up to five times; to achieve complete husking.

Fifty coconuts; twenty-five green coconuts and another twenty-five dry coconuts obtained from a local coconut oil mill was selected and used for testing. Observations recorded in respect of each coconut were husking duration, number of husk-sectors, mean time for separating each husk-sector, and frequency of occurrence of certain numbers of husk-sectors; *viz*., 3, 4, and 5.

Results indicated that the husking of green coconuts took a mean time of 15.2 s for completely husking a coconut and 3.84 s for husking one sector or bit. The minimum and maximum durations observed were 12 s and 20 s in the case of green coconuts. The mean husking time for dry coconut was 14.2 s for completely husking a coconut and 3.59 s for husking one bit. The minimum and maximum durations observed were 9 s and 24 s in the case of dry coconuts. Therefore, this time duration is satisfactory when compared with *Keramithra*. However, there is still scope reducing the husking time through experience and by re-designing the system to operate faster.

Therefore, the study and the results indicated that the husking machine developed under the study has a potential for large-scale adoption; of course with further refinement.

Suggestions for Future Work

Though the machine serves its purpose with satisfactory results, the major inconvenience is its heavy and bulky nature. Hence possible suggestions are given to make the machine compact, attractive and user-friendly. By replacing the single phase motor and speed reduction gear box in the present model with a variable speed motor of required hp, we can reduce the size as well as weight of the machine. More over, it is also possible to have flexible blade opening and closing time with the use of variable speed motors. The belt tension can also be adjusted by using suitable number of idler pulleys in the power transmission unit. Inspite of all the above inconveniences, the machine can perform with appreciable efficiency and we can hope that this innovation can revolutionalize the coconut husking technology.

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ABSTRACT

Development of a power-operated coconut husking machine

A power operated coconut husking machine consists of a mechanized opening of blades with manual feeding of coconut one at a time. A half way cam is designed and is mounted on a cam shaft and is fixed to the frame. The follower is a cage, made of mild steel, which is connected to the movable blade by means of a rectangular extension which acts as a pivoted joint. Stationary blade is fixed on the frame. A 2.0 Hp motor of 1440 rpm is connected to the speed reduction box to reduce the speed by means of pulleys of suitable diameter. The whole components are fixed on the frame. Initially, the coconut is impaled with both the hands of the two juxtaposed wedge-like blades oriented upwards during its closed position. The power from the motor is conveyed to the speed reduction box with the help of a V belt. The power from the motor is reduced by speed reduction box. This power is transfered to cam shaft by using another V belt. The cam rotating at 24 rpm pulls the follower which inturn connected to the movable blade and thus the blade is opened. The cam is designed in such a manner that when the cam displaces the follower by 50mm, the tip of the movable blade moves180mm away from the tip of fixed blade. A quick return mechanism for quick resetting of the movable wedge or blade is also provided by using a spring arrangement at the rear end of the follower. When the cam pulls the follower backward, movable blade will get an angular path and it separates the husk of the coconut. The coconut is then turned and the operations are then repeated till complete husk is removed. The mean husking durations for 25 each green and dry coconut was respectively 14.1s and 15.1s. The maximum durations for husking the green and the dry coconuts were respectively 20s and 24s and the minimum 12s and 9s respectively. The number of pieces into which the whole husk of a coconut was split came to 3 to 5 for both green and dry coconuts. As a whole, considering its performances, the mechanism developed in this study appeared to be promising. Higher efficiency of this machine can be achieved by incorperating some slight modifications.