# DEVELOPMENT AND EVALUATION OF A LOW COST POWER OPERATED PADDY THRESHER-CUM-WINNOWER

By

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**THESIS**

Submitted in partial fulfilment of the requirement for the degree of

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## in
## Agricultural Engineering

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1996

# D E C L A R A T I O N

I hereby declare that this thesis entitled "Development and Evaluation of a Low cost Power operated Paddy Thresher cum Winnower" is a bonafied record of work done by me during the course of research and this thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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# C E R T I F I C A T E

Certified that this thesis entitled **"Development and Evaluation of a Low cost Power operated Paddy Thresher cum Winnower"** is a record of original work done independently by **Sri. Sureshkumar, P.K.,** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship.

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## SYMBOLS AND ABBREVIATIONS USED

| | | |
|---|---|---|
| Agric. | - | Agricultural |
| AMA | - | Agricultural Mechanization in Asia, Africa and Latin America. |
| ASAE | - | American Society of Agricultural Engineers |
| Ave | - | Average |
| CIAE | - | Central Institute of Agricultural Engineering |
| cm | - | Centimeter(s) |
| Co. | - | Company |
| Dept. | - | Department |
| Engng. | - | Engineering |
| et al. | - | and other people |
| etc. | - | et cetera |
| Fig. | - | Figure |
| FIM | - | Farm Implements and Machinery |
| FPM & E | - | Farm Power Machinery and Energy |
| FR | - | Feed Rate |
| g | - | gram(s) |
| GI | - | Galvanized Iron |
| Govt. | - | Government |
| G/S ratio | - | Grain / Straw ratio |
| h | - | hour(s) |
| ha | - | hectare(s) |
| hp | - | horse power |
| hp/h | - | horse power per hour |
| hp/ha | - | horse power per hectare |

| | | |
|---|---|---|
| IARI | - | Indian Agricultural Research Institute |
| ICAR | - | Indian Council of Agricultural Research |
| i.e | - | that is |
| IEP | - | Industrial Extension Project |
| IRRI | - | International Rice Research Institute |
| ISAE | - | Indian Society of Agricultural Engineers |
| ISI | - | Indian Standards Institution |
| J. | - | Journal |
| KCAET | - | Kelappaji College of Agricultural Engineering and Technology |
| kg | - | kilogram(s) |
| kg/h | - | kilogram(s) per hour |
| kg/ha | - | kilogram(s) per hectare |
| kg/min | - | kilogram(s) per minute |
| kg/s | - | kilogram(s) per second |
| KW | - | Kilo Watt |
| Ltd. | - | Limited |
| m | - | metre(s) |
| MC | - | Moisture Content |
| min | - | minute(s) |
| mm | - | millimetre(s) |
| m/min | - | metre(s) per minute |
| m/s | - | metre(s) per second |
| MS | - | Mild Steel |
| Man-h/ha | - | Man hour(s) per hectare |
| No. | - | Number(s) |
| p: | - | pages |

| | | |
|---|---|---|
| PAU | - | Punjab Agricultural University |
| PTO | - | Power Take Off |
| PV | - | Peripheral Velocity |
| Pvt. | - | Private |
| q | - | quintal(s) |
| q/h | - | quintal(s) per hour |
| Res. | - | Research |
| RNAM | - | Regional Network for Agricultural Machinery |
| rpm | - | revloution(s) per minute |
| Rs | - | Rupees |
| RTTC | - | Regional Training and Testing Centre |
| s | - | second(s) |
| SISI | - | Small Industries Service Institute |
| Tech. | - | Technology |
| TNAU | - | Tamil Nadu Agricultural University |
| UP | - | Uttar Pradesh |
| USA | - | United States of America |
| Viz. | - | namely |
| w.b. | - | wet basis |
| / | - | per |
| % | - | per cent |
| o | - | degree (angle) |
| $^{o}C$ | - | degree centigrade |

# INTRODUCTION

# 1. INTRODUCTION

Agriculture is the backbone of Indian economy. About 75 per cent of India's population lives in villages and depends on agriculture for its livelihood. Agriculture is the prime mover in the industrial life of the nation which is concerned with the mechanics of production. The agriculture sector has the potential of generation of largest productive employment.

The development of machinery and mechanical power to make man's efforts more effective and productive is one of the most prominent features of development. Without modern and efficient farm machinery, there can be no profitable agriculture.

Agricultural production of a country depends to a large extent on power available for farming. There is a direct relationship between the production of crop per unit area and the amount of power used per unit area. The power availability in India is only 0.4 hp/ha which is only half of the optimum power needed for improved agriculture. So, the power availability should be increased to meet the requirements.

Rice (*Oryza sativa*) is the staple food on which about one-fourth of the world's population depends. Paddy is the major cereal crop grown in India with an annual production of 75.95 million tonnes. It is reported that India earned more than 1000 crores of rupees from rice exports in the year 1993-94. In

Kerala an area of 5.37 lakh hectares is under paddy cultivation with an annual production of 10.84 lakh tonnes (Farm guide, 1995).

Paddy cultivation in Kerala is confronting a crisis today. Total cultivated area is diminishing at an alarming rate. At the same time, we could not achieve substantial increase in the productivity to bridge this gap. It is estimated that to meet our requirements of 30 lakh tonne per year internally we should increase either the total cultivated area or the productivity by 176 per cent. This indicates that it is high time for scientists, engineers and policy makers to review the existing situation and to take necessary steps for the revitalisation of paddy cultivation in the state.

The main reason for the gloom over paddy cultivation is that it has become uneconomical owing to the high production cost and low productivity. Labour charges are comparatively higher in the state and labour shortage is often felt especially during the peak cultivating season. Here comes the significance of agricultural mechanization. Mechanization will make paddy cultivation profitable and attractive not only by reducing the cost of production and drudgery but also by increasing the productivity.

Threshing is identified as the first operation now to be mechanized in paddy cultivation, since it is labour intensive and involves considerable human drudgery. Moreover, adoption of improper threshing methods results in post harvest loss and reduction in the net recovery of paddy. The traditional method of seed separation from the stalk are uneconomical, time consuming and laborious.

Most of the threshers available in India have complicated imported designs and their performance characteristics do not match with the local crop conditions. These flow through type designs are not popular in Kerala due to its high initial cost and power requirement. Moreover, the straw delivered from these machines are so damaged that the farmers cannot handle it properly. A preliminary survey conducted among the paddy cultivators revealed the need of developing a low cost medium capacity power thresher which can thresh around 200 kg grains per hour so that the paddy harvested from a hectare can be threshed in one day.

Although several attempts were made to develop threshers matching to the cultural practices of the state, a successful prototype is yet to be developed owing to the problems associated with cleaning system, grain collecting system and safety devices.

In this contest, it is proposed to develop a low cost power operated paddy thresher cum winnower with the following objectives.

1. To develop a low cost power operated paddy thresher with a capacity of about 200 kg/h. and acceptable to small and marginal farmers of the state
2. To design and fabricate an optimum winnowing unit for

the thresher

3. To design and fabricate a grain collecting system for the thresher

4. To evaluate the performance of the thresher cum winnower and to study the effect of different crop and thresher parameters on the threshing efficiency and capacity of the thresher,

5. To carry out economic appraisal of the developed thresher, and

6. To develop an empirical relationship between the energy requirement of the thresher and various crop and thresher parameters.

# REVEIW OF LITERATURE

# 2. REVIEW OF LITERATURE

A brief review of cultivation techniques, previous research studies on threshing practices, different types of threshers and winnowers, their testing and performance evaluation are presented in this chapter.

## 2.1 Cultivation

There are three seasons for the paddy cultivation in Kerala.

1. Virippu (Autumn) - First crop season - April-May to September - October.
2. Mundakan (Winter) - Second crop season - September - October to December - January.
3. Puncha (Summer) - Third crop season - December - January to March - April.

The rice can generally be grown either by broadcasting or by transplanting depending on the availability of water. The principal systems of cultivation in Kerala are Dry, Semi dry and wet land cultivation.

## 2.2 Harvesting

Paddy is allowed to stand in the field after maturity until it sundries to 14 to 15 per cent moisture level before harvesting. In some areas, paddy stalks are cut at 20 to 26 per cent moisture and stacked until it sundried to a lower moisture level before threshing. Studies shown that the paddy grain losses its moisture at a rapid rate after attaining the biological maturity and the rate of loss of moisture get reduced when it reaches below 18 per cent moisture. Study also indicates that 14 to 15 per cent moisture content in the grain under field conditions is a critical stage at which it become susceptible to moisture changes by weather conditions.

The paddy crop should be harvested about 30-35 days after 50 per cent of flowering. At this stage, the moisture content in the grains should be around 16 to 20 per cent. Early or late harvesting deteriorates the seed quality.

## 2.3 Threshing

According to Trivedi and Arya (1965), threshing may be defined as the group of operations that are designed to detach the desired product from the mass of the harvested crop material and their separation from the mass.

Threshing is the first post harvest operation to separate the grain (RNAM, 1983). It is labour intensive and the harvesting in rainy season would have the danger of deteriorating the quality of the grain if the crop is not threshed in a short time.

### 2.3.1 Threshing Methods

The common methods of threshing are

a. Manual threshing

b. Animal threshing

c. Mechanical threshing

Grist (1916) reported that the worst method of threshing is by trampling by foot, oxen or tractor wheels because it breaks the grain.

#### a. Manual threshing

Threshing by manual labour is slow and labour consuming.

Primitive threshing is done by spreading the ripe crop on a threshing floor where it is beaten either with sticks or flails or trampled by the hoofs of animals. Where sheaves are made the grain is often threshed out by beating the sheaves against slanting shielded grates (Hoppem, 1981).

Grist (1916) reported that in many countries, paddy sheaves are threshed on or adjacent to paddy fields. A tub about the size of a half-barrel is used. Inside the tub rests a ladder with rungs about 10 cm apart (Fig.2.1). Sheaves are beaten two or three times against the ladder, thereby removing the grain from the ears and collecting it in the tub. A screen is placed round the tub to prevent grain from scattering. Much paddy is also threshed by foot. When this is done, the worker prefers the

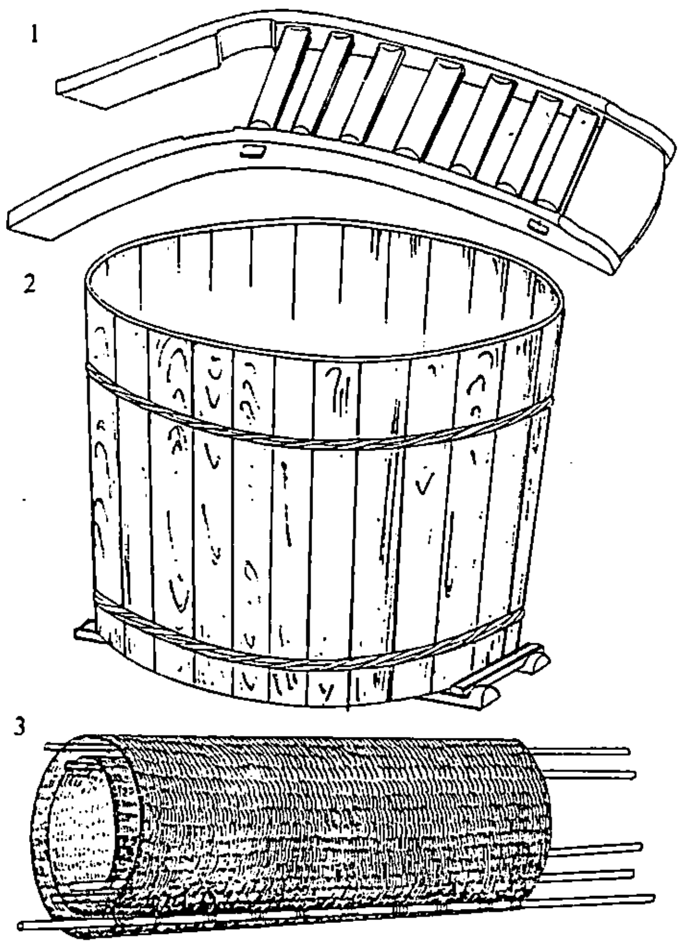


Fig. 2.1 Implements used in Hong Kong for threshing paddy.(1) threshing ladder (2) threshing tub (3) threshing mat

ears to be slightly damp to be less injurious to the feet.

Copeland (1924) gives the following techniques for threshing awnless paddy practiced in Late in the Philippines. A platform eight or ten feet high, with bamboo floor with cracks between slats, is erected. A rope is stretched above the platform which the workers hold with their hands while they perform threshing with their feet. The grain falls through the cracks, winnowed by the wind, and collected cleaned on a mat on the ground. An efficient worker separates as much as about 2,270 kg per day in this way. The remarkable feature of this method is the removal of the grain as fast as it is separated from the straw, so that the worker sees constantly what remains to be separated.

The most common method of threshing in Kerala is beating the harvests on a floor or beating by sticks or treading the grain.

**b. Animal threshing**

Threshing by bullocks is very common method used in villages. The harvest is spread on a clean threshing space, the bullocks are tied in line one after the other with the help of a strong pole fixed in the centre of the threshing space. Bullocks move round and round on the harvest and trample them continuously till the grains are completely separated from straw (Fig. 2.2). One man drives the bullock from the back (Sahay, 1977).

### b.1 Tree branch threshing

In order to accelerate the threshing process, some farmers use a bushy branch of tree hitched behind the bullock pair, loaded with sack full of earth or bundles of crop. This method in addition to the process of threshing by bullock trampling reduces the labour involved in shaking the crop, which is done to allow the threshed grain to trickle down to the threshing floor.

### b.2 Punched sheets threshing

Corrugated metal sheet with punched holes has been used for threshing. The sheet is hitched behind the bullock pair. The jaggered edges formed by punching holes in the sheet help to cut and tear the crop underneath, when dragged over it. Suitable weights are put on top of the sheet to make it work more effectively.

### b.3 Disk harrow threshing

The use of bullock drawn disk harrow for threshing has been demonstrated succesfully. A single action disk harrow has an added advantage that the churning effect due to angling of gangs helps in allowing the grain to shift down the bottom, thereby reducing the labour of shaking the crop. The farmer who owns a disk harrow primarily for tillage operations can make use of it with advantage without added investment in another threshing machine, if he desires to use only bullock power for the operation.

**b.4 Olpad threshing**

The olpad thresher was developed over six decades ago in the western part of India and has gained popularity in recent years. It has three parallel gangs one behind the other of serrated disks numbering 14 to 20 in a thresher. It is hitched behind a pair of bullocks and drawn over the spread crop with the driver sitting over it. Loading the thresher with weights increases its efficiency. The end product is similar to that obtained by bullocks trampling. Care is needed to keep the crop pile thick enough so that the disks do not penetrate to the threshing floor below (Fig. 2.3).

**b.5 Threshing sleds**

A threshing sled is an animal drawn implement consisting of two wooden boards, slightly raised in front which are fitted with short pegs, serrated knives or hard stones, inserted into holes on the underside of the boards. The operator stands on the implement, to add weight, and it is dragged over the crop spread on the floor, the knives or pegs rubbing out the grain and bruising the straw.

Fig. 2.2 Threshing paddy with bullock team

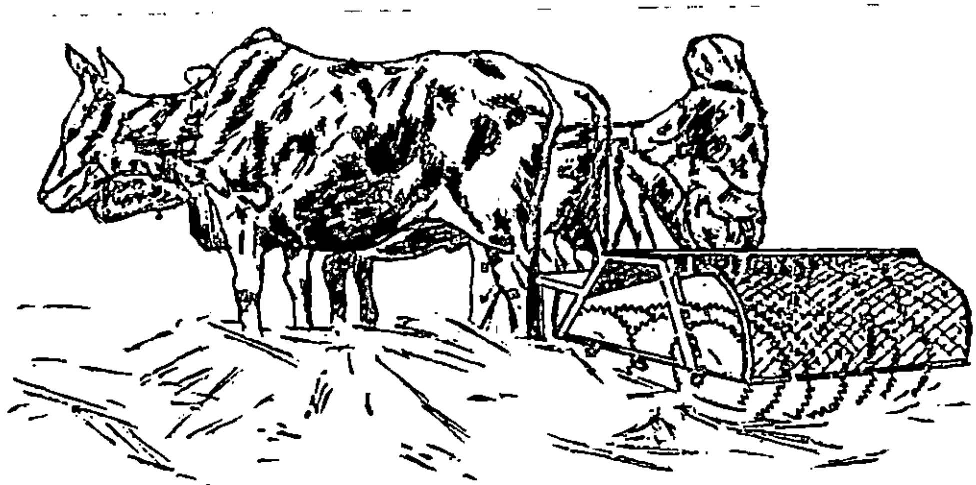

Fig. 2.3 Olpad thresher.
diameter of disks - 45 cm, disk spacing - 15 cm, number of disks - 20.

## C. Mechanical Threshing

Separation of grains from the ears can be achieved by striking the ears or by squeezing. In either case the ears are deposited on a hard surface. Both these factors are applied for the mechanical separation in threshing units (Kanafojski, 1976).

In 1785 Andrew Meikle, a Sctochman was the first to replace the heavy and laborious work with hand rasp-bars by mechanical work with the use of four revolving bars (rasp bars) attached to the circumference of a drum 25 cm in diameter (Fig. 2.4). Part of the drums circumference was enclosed by a sheet metal casing now called concave; threshing process took place in the space formed in between the two elements. The peripheral speed of the drum amounted to 4-6 m/s. Grain was delivered manually between two notched feeding shafts conveying grain into the slit place. The threshing machine described was driven by a hand crank.

As the drive by human or animal force was being replaced by mechanical drive - initially by the use of traction engines and, subsequently, by the combustion engine - the number of drum revolutions and its diameter were increased, and the shape of the rasp-bars, the design of the concave, the manner of feeding and such like factors were altered.

In 1835 an American named Turner was the first to employ a peg-tooth drum, to the surface of which, instead of rasp bars, teeth were attached. He also provided the concave with teeth.

With the passage of time this particular threshing unit also became the subject of modifications (Kanafojski, 1976).

In course of the past forty years, attempts have been made, and are continued to be made, to replace the classical rasp - bar or toothed threshing unit by some other systems in which deformation of straw would be less with a simultaneous appropriate separation of kernels from the ears. Attempts are also being made to construct threshing units enabling separation of all kernels and requiring no additional separation of kernels from the straw by means of straw walkers.

The Government of India imported several low H.P. threshers in view of the importance of timely threshing of paddy especially on small and medium farms and tested at several places (Sridharan, 1975). The performance of these machines was considered to be generally satisfactory at many places. Several design engineers, manufacturers and research institutions took special interest in the design and development of these machines.

According to ISI (1982) the rotary or Japanese pedal paddy thresher is one of the simplest devices which perform threshing efficiently (Fig. 2.5). It consists of a wooden threshing drum with wire teeth. The teeth in different rows are staggered. The drum is mounted on angle iron frame and covered from sides and bottom by MS sheets. The bottom side of the covered sheet is made sloping for collection of the threshed grains. The drum is

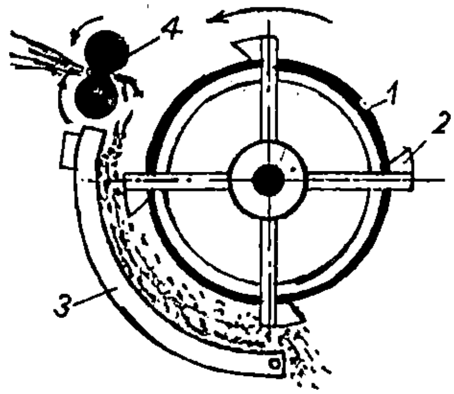


Fig. 2.4 Meikle's rasp-bar threshing unit.
(1) drum (2) rasp bars (3) metal sheet casing
(4) feeding shafts.

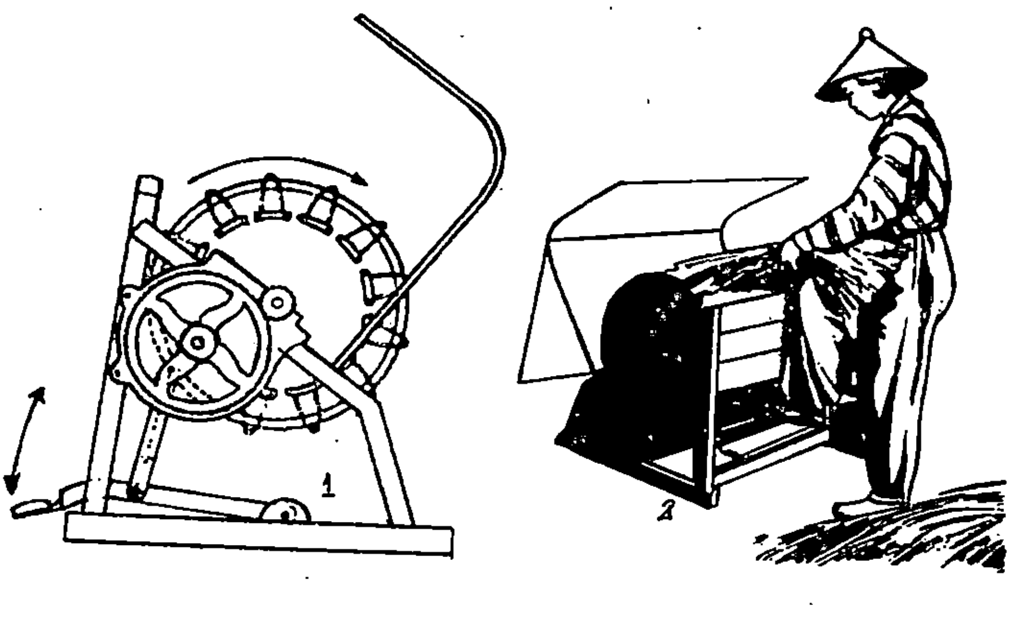


Fig. 2.5 Japanese paddy thresher.
(1) Sectional view (2) threshing with pedal operated machine.

pedal operated through gears. The cast iron gears providing an overall ratio of 1:4 speed gain from a treadle to achieve cylinder speed of about 400 rpm constitute the main driving mechanism. The diameter of the cylinder is 43 cm. One man operating the thresher can thresh about 1.5 to 2 quintals per day. Threshing is done by holding paddy crop bundles close to the teeth on the rotating drum. The wire teeth rotating in high speed hit the grain resulting in separation from earheads. The threshed grains falls down and are collected after threshing.

The pedal threshers were recommended for threshing paddy, but the bundles which have to be lifted, held against the rotating drum and turned manually do not allow saving of energy, labour or time (Trivedi and Arya, 1966).

Sridharan (1972) reported that the pedal operated paddy threshers had been imparted and tried out in several parts of the country in the sixties. The output was very low in the order of 50 kg/h or so.

Threshing combs are said to have been invented in Japan about the year 1700 (Grist, 1916). Several makers in that country now produce both pedal and power driven machines of this description which are widely used throughout the country. The former have an output of about 100 kg paddy per hour or double this amount while two men tread. A 1 hp power thresher worked on this principle gives a capacity of about 270 kg paddy per hour.

According to Pradhan (1968) and Johnson (1969) power driven threshers were becoming popular due to the following reasons.

1. Unavailability of sufficient labourers during harvesting season.
2. Quick and time saving.
3. Some improved varieties are more difficult to thresh by the traditional methods.
4. Minimize the grain loss irrespective of the threshable character of the variety.
5. Studies show that crack ratio is higher in paddy samples threshed by beating.
6. Most of the improved varieties of paddy are weekly dormant and there is greater possibility of germination in the field of threshed by threshers.
7. Even small quantity of crop can be threshed separately without deterioration in the quality.

More than 60,000 threshers are manufactured every year for threshing wheat alone all over the country. These are operated by 5, 7.5 or 10 hp electric motors or tractors. The capacity ranges from 20 kg/h to 1500 kg/h. These mechanical thresher not only thresh the crop but also clean the grain and thus the quality of the grain is considerably improved as compared to traditional threshing. Efforts are being made to develop multi - crop threshers which can thresh all major crops like wheat, paddy, soyabean, pigeon pea, sorghum, maize etc. (Cart, 1986).

Irshad Ali (1983) reported that small power threshers are becoming increasingly popular among the Indian farmers. They are operated by 5 to 10 hp stationary engines, electric motors or tractors. He reported on the availability of a variety of threshers with varying cylinder designs and sizes. The threshing drum is cylindrical in shape and is generally provided with pegs on the periphery. The drum is rotated at about 600 to 700 rpm. The crop is threshed by the impact and rubbing action between the drum and the concave.

A cone-type thresher was designed, fabricated and tested at International Rice Research Institute, Philippines which showed that the principle of the con-type thresher was sound and gain a maximum output of 300 kg/h paddy using a 6 hp engine (IRRI, 1963). A PTO driven model with more power and screen area was also fabricated (IRRI, 1964). A 36 hp tractor stalled when the thresher was fed with straw and grain at a rate of 60 kg/min. The centrifugal nature of the cone thresher resulted in increased friction on the screen and drag on the drum, creating a high power requirement. Complete threshing was achieved, but even a 4.5 m. screen did not fully separate the grain from the straw. Efforts were made to improve the cone thresher and gave high threshing output but the grain cleaning performance was not satisfactory (IRRI, 1974).

A throw in type multi-crop axial flow thresher was developed at IRRI in 1972. It had wire loop threshing drum of 35 cm diameter and 127 cm length with a concave screen enclosing the full length of the cylinder. A 6.5 hp air cooled engine was used as prime mover. An axial flow thresher having peg-tooth cylinder with bolts of 1.1 cm in diameter as pegs gave better threshing performance and longer life in comparison with wire loop threshing cylinder.

IRRI has designed a portable combined thresher and winnower powered by a 5 hp engine which will thresh and winnow 300 to 600 kg of paddy per hour. IRRI TH - 7 (Fig. 2.6) and IRRI TH-8 axial flow threshers were developed at IRRI and they are of 500 kg and 1000 kg per hour capacity. 5 - 10 hp engine is required for operating these machines.

Peter and Garg (1968) developed a power wheat thresher at Allahabad Agricultural Institute, Allahabad. It was power operated peg tooth type operated by 5 hp electric motor or 7.5 hp diesel engine and required three persons for the entire operations. It was suitable for threshing wheat, sorghum, gram, barley etc. The weight of the thresher was 400 kg. On testing with wheat crop at 800 rpm, the output was 178 kg/h at a threshing efficiency of 96.9 per cent.

Harrington (1970) designed a multi - crop thresher having spike tooth cylinder and fixed concave on the basis of acceptance of Japanese paddy threshers and American wheat threshers which used spike tooth cylinders. The losses in both paddy and wheat were 3 per cent. The thresher was not suitable for straw making

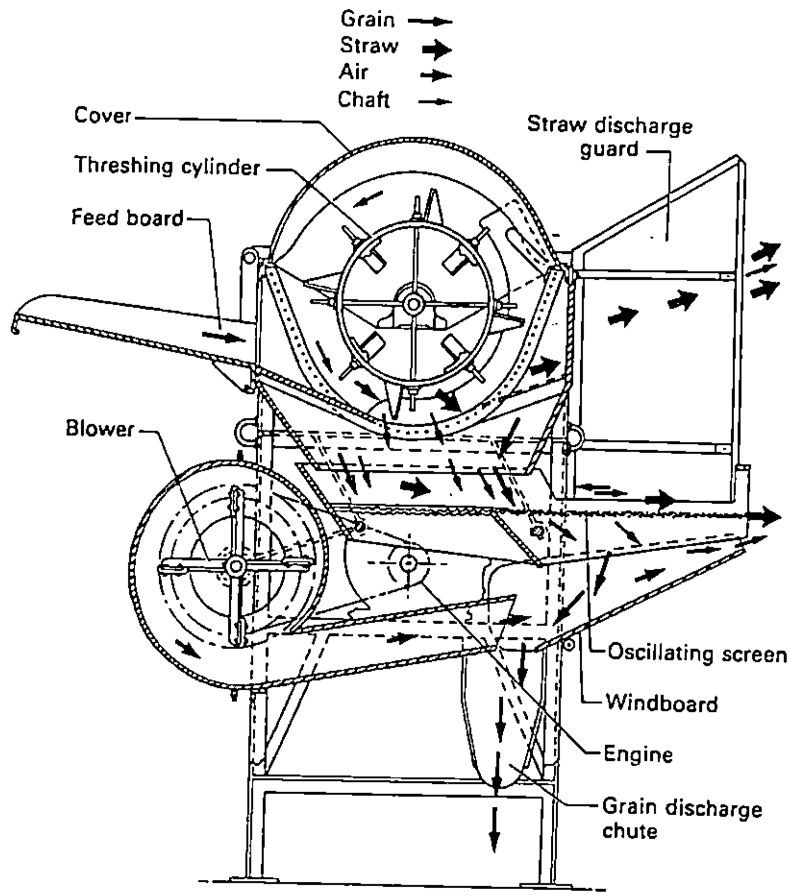


**Fig. 2.6 Schematic of IRRI TH - 7 axial flow thresher.**

as it normally reduced wheat straw to 25 to 50 per cent of original length depending upon cylinder speed and moisture condition. The cylinder tip speed ranged between 1200 to 1400 m/min resulting in less than 0.1 per cent unthreshed grain and between 800 to 1000 m/min resulted in less than 0.1 per cent visible damage. The unthreshed grains were less than 1 per cent.

An all crop thresher was developed by FIM Scheme APAU, Hyderabad. It was operated by 7.5 hp engine or electric motor and required 4 persons. Rice, wheat, sorghum, maize and pearl millet are threshed by this thresher. The output of different crops are 560 kg paddy, 400 - 500 kg wheat and 1200 - 1500 kg of sorghum and maize per hour respectively.

Pradhan (1968) reported about the plot type thresher of USA, the turnout of these types of power threshers is quite high. The thresher is operated by 3 to 3.5 hp motor. Three persons are required to operate this thresher. The output is varying from 175 to 200 kg grain per hour. The cost of threshing and the daily output are comparable to conventional threshing by 7 to 9 bullocks and three persons.

Peter (1970) designed and developed a power operate paddy thresher to meet the needs of small and marginal farmers who grow paddy, wheat, jowar, bajra etc. The threshing capacity of this thresher was 200 - 400 kg/h for paddy, 75 - 125 kg/h for wheat and 400 - 600 kg/h for jowar. This was operated by 3.5 hp engines. Speed of the drum was 550 - 850 rpm. It required three persons to operate.

Chabbra (1975) developed and tested an axial flow thresher on the basis of drawing procured from IRRI. He found that it can thresh paddy and wheat quite efficiently. In paddy threshing at 500 rpm the threshing efficiency was 100 per cent and feed rate was 710 kg/h which resulted into an output of 213 kg clean grain/h. To achieve 99% cleaning efficiency the blower losses were 9 per cent.

Nirmal and Sirohi (1976) developed a multi - crop thresher named Pusa 40 thresher, at IARI, New Delhi. It was powered by 5 hp electric motor and required 5 persons to operate. It can thresh wheat, rice, barley, pearl millet, safflower and sorghum. The capacity of the thresher is 200 kg/h for wheat (Fig. 2.7).

Singh and Joshi (1977) reported that the Japanese type threshers of 40 cm drum diameter and 90 cm width rotating at 400 rpm by a 3 hp electric motor gave an output of 145 kg/h paddy. A rasp-bar thresher of 28.5 cm drum diameter and 32 cm width gave an output of 139 kg/h of clean paddy. The energy needed per quintal of threshing and cleaning of paddy was 0.36 hp/h of manual and 1.64 hp/h of electric energy. For through feed rasp-bar thresher it was o.44 hp/h of manual and 0.72 hp/h of electrical energy.

According to the reports from SISI (1980), Das (1981) and

Shanmugham (1981) a paddy thresher was designed and developed at College of Agric. Engng., TNAU, Coimbatore. It is a power operated rasp-bar type and is operated by 5 hp motor or 6 hp oil engine and requires 3 persons to operate. It is suitable for threshing wheat and rice. The capacities are 400 kg/h for wheat and 600 kg/h for paddy.

Shanmugham (1981) reported that a power paddy thresher was developed at RTTC, Vellayani, Kerala. It requires a 3 hp electric motor and 3 persons to operate. The threshing cylinder is of wire loop type.

Majumdar (1983) designed and developed a multicrop thresher suitable for threshing paddy, wheat, jowar, maize and soyabean. It is a machine with spike tooth cylinder operated by a 5 hp motor and is developed at CIAE, Bhopal. The weight of the machine was 400 kg and capacity on paddy was 300 kg/h a peripheral speed of 15 m/s.

Sharma _et al_. (1983) designed and developed a multicrop thresher for wheat and paddy at PAU, Ludhiana. This was operated by a 30 hp tractor or an equivalent prime mover. The spike tooth system of wheat threshing used in conventional thresher and axial flow threshing system of paddy were combined in this machine. Eight persons were required for continuous operation of the thresher. The weight of the machine was 685 kg. The operating speed was 750 rpm and the output were 800 and 400 kg/h respectively (Fig. 2.8).

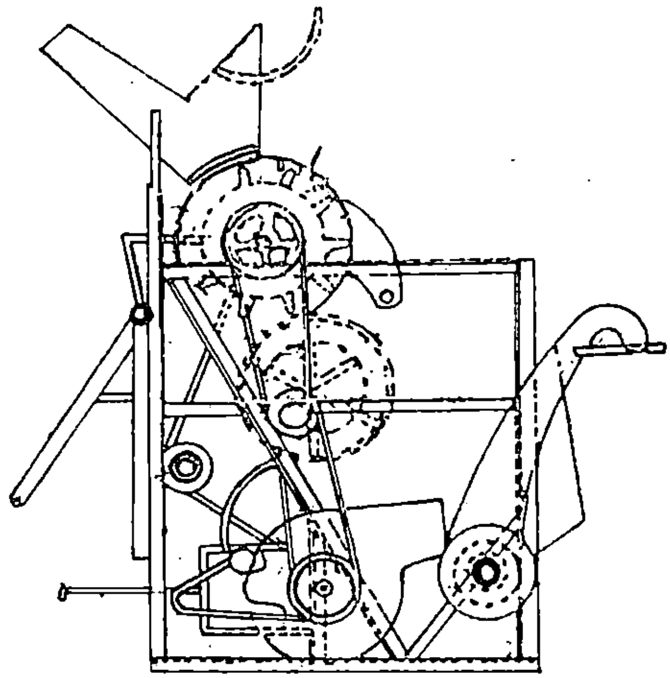

Fig. 2.7 Schematic of Pusa - 40 thresher.

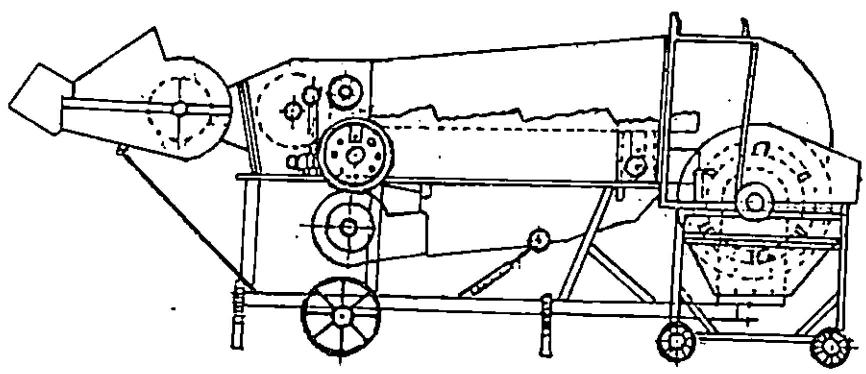

Fig. 2.8 PAU axial flow multi - crop thresher.

Sharma et al. (1984) developed another thresher at PAU, Ludhiana which can thresh wheat as well as paddy with minor adjustments. The machine when operated by a 5 hp electric motor or equivalent prime mover can give 200 kg and 400 kg clean grain of wheat and paddy per hour respectively. Comparison on labour requirement for paddy threshing by the multi - crop thresher with the traditional manual threshing indicated that there is labour saving of 12.5 man days/ha assuming the average yield of paddy as 7500 kg/ha. Labour requirement and cost of operation for threshing with this multi - crop thresher were almost same as that of the traditional wheat thresher.

Datt (1987) reported that the axial flow threshers designed by IRRI are being used in many south-east Asian countries with minor modifications for threshing paddy. Some entrepreneurs manufactured these machines in India and several demonstrations were organised. But the sales of these machines remained very much limited mainly because of the straw is cut into two or three pieces which is not acceptable to the farmers. To overcome this problem a straight through peg tooth type thresher model IEP-2 has been developed at CIAE-IRRI Industrial Extension Project. This thresher has a capacity of 600 kg/h of clean grain. The cost is about half of the cost of axial flow thresher of same capacity. This can be operated by the same 6 hp engine which is mounted on one metre self - propelled reaper. Thus the farmer purchasing both the reaper and thresher can save the cost of one engine.

Axial flow threshing principle was developed at IRRI, Manila, Philippines and used for threshing paddy. Attempts were made to modify this design for threshing wheat and also get fine straw. Prototype of this machine was, therefore, developed (Ahuja et al., 1980). The machine consisted of a threshing cylinder and aspirator blower. Threshing cylinder had two portions namely threshing and separation/bruising. In the first portion the threshing beaters, arranged in helical form, were found bolts and concave had smaller concave openings. In the second portions the cylinder was fitted with flat spikes. The axial flow of the material was achieved by providing louvres in the casing. Five gangs of cutters, two on the front and three at the back were provided which could flipped in or out of the cylinder casing. All the gangs of cutters were used while threshing wheat for making bhusa. One or two gangs were recommended to be used for handling long or wet paddy straw. Two centrifugal blowers mounted on the same shaft and reciprocating sieves were also provided.

John (1991) developed a low cost paddy thresher at KCAET, Tavanur. It was a hold-on type thresher consists of a base, side frames, front grain shield and a wire loop drum. The power was taken from a 0.5 hp motor and was transmitted to the cylinder shaft by belt and pulley arrangement. The optimum cylinder speed was 400 rpm. The capacity of the thresher at 14.26 per cent moisture content was reported to be 451.85 kg paddy per hour and the threshing efficiency was 95.08 per cent. The mechanical damage was negligible. The labour requirement of the thresher was two. The cost of operation of the machine was Rs 3.00 per quintal of grain.

Preman et al. (1991) designed and developed a hold-on type power paddy thresher at KCAET, Tavanur. The machine consists of wire loop cylinder for threshing and a blower for winnowing the threshed grains. The power for working the machine was taken from a 2 hp motor. The capacity of the thresher was 217 kg/h and the threshing efficiency was 98.3 per cent. Labour requirement for the thresher was three. The cost of operation for threshing and winnowing was Rs 9.50 per quintal.

**2.4 Principles of Threshing Machanisms**

Kepner et al. (1987) reported that threshing may be accomplished by

(i) impact of a fast-moving member upon the material,
(ii) rubbing,
(iii) squeezing pods,
(iv) a combination of two or more of these actions, or
(v) Some other method of applying the required forces.

Many different types and configurations of threshing devices have been developed, but very few have reached the stage of even limited field use. The three types generally employed in present day combines are axial flow rasp - bar cylinder, cross-flow rasp-bar cylinder and spike-tooth cylinders. Spike-tooth cylinders were used almost exclusively in both combines and stationary threshers prior to about 1930, but most of the combines now produced have rasp-bar cylinders. Spike tooth cylinders are still used to a limited extent, principally in rice.

## 2.5 Factors Affecting Threshing Effectiveness

Kanafojski (1976) reported about the factors which affect the quality and efficiency of threshing. These may be classified into the following groups:

A. Properties of threshed material depend on:

(1) its type and variety (facility of separation of kernels from husks or pods, tearing and crushing strength of stalks or blades)
(2) Moisture content of the material
(3) addition of green matter (random seeds or weeds)
(4) ratio of grain to straw by weight

B. Technical conditions depend on:

(1) type of drum
(2) peripheral speed of the drum (number of revolutions of the drum and its diameter)
(3) number of rasp bars or tooth and their shape

(4) angle of wrapping of the concave (length of concave surface)

(5) size of the working slit at its inlet and outlet openings

(6) shape and distribution of the concave bars.

C. Delivery of material to the drum depending on:

(1) feed value- that is, the thickness of the delivered material layer in unit time, dependent at a given feeding value on the speed of delivery

(2) positioning of delivered stalks with respect to the drum axis (with the ear stalks directed frontward, perpendicularly to the drum axis, or lengthwise feeding, with ear stalks positioned parallel to the ear stalks positioned obliquely to the drum axis)

(3) point of contact of the delivered material layer with the drum circumference.

Kepner et al. (1978) identified that the threshing effectiveness is related to:

(a) The peripheral speed of the cylinder

(b) The cylinder concave clearance

(c) The number of times the material passes the concave

(d) The number of rows of concave teeth used with a spike-tooth of crop

(e) The type of crop

(f) The condition of the crop in terms of moisture content, maturity etc.

(g) The rate at which material is fed into the machine.

Threshability varies widely with different crops and conditions. Some small seed crops, such as the clovers, are very difficult to thresh whereas barley and wheat are generally easy to thresh. Reducing the straw moisture content improves thresha bility (Arnold, 1964).

Cylinder speed is the most important operating parameter with regard to cylinder loss and also with regard to seed damage. Increasing the speed reduces the cylinder loss but may substantially increase damage. Susceptibility to damage varies greatly among different crops.

In general seed damage increases as the seed moisture content is reduced (Kepner _et al_., 1978).

Reducing the cylinder concave clearance tends to reduce cylinder losses and increase seed damage, but the effects are generally rather small in comparison with the effects of increasing cylinder speed.

Increasing the non-grain feed rate increases cylinder losses. Increased feed rate tends to reduce seed damage although the effect is usually small (Arnold _et al_., 1958).

Increasing the grain/non-grain ratio usually decreases the per cent cylinder loss at a given non - grain feed rate.

## 2.6 Threshing losses

Sarath et al. (1981) evaluated the threshing losses while threshing five varieties of paddy by four different threshing methods. The methods are,

1. A pair of buffaloes treading on a cracked mud floor
2. 35 hp tractor circulating on a floor covered with a large jute sheet
3. A Izeki self feed mechanical threshing machine
4. A foot pedal drum type thresher

In this study they observed that threshing losses were mostly qualitative and measured by the percentage of broken kernels. The pedal drum threshing method consistently showed the lowest percentage of cracked kernels for five varieties studied while the buffalo and tractor treading methods had the highest levels, it was only 5 to 10 per cent. The other threshing methods had cracked kernels as high as 30 to 40 per cent. The foot pedal thresher represents a losses investment than any of the other three threshing methods. Also the stalk paddy transporting losses are eliminated by pedal threshing as it can be done in the field when the stalk paddy is cut.

## 2.7 Cleaning Mechanism

Cleaning of grain involves the separation of bulk straw, chaff, empty kernels and very light and fine impurities from the grain. In the simplest form straw and chaff is manually separated and the grain is dropped through across wind to remove the lighter impurities. Air can remove impurities that have different aerodynamic properties from the grain. Many different grain cleaning systems are used in threshers, depending mostly on the type of feeding method and threshing capacity. In the hold-on type of thresher, a major amount of the straw does not pass through the machine and only the removal of chaff and light impurities is necessary (Araullo et al., 1976).

Hoppem (1981) reports about different types of machines used for winnowing.

### 2.7.1 Winnowing baskets

These are used when only small quantities of grains are involved. The grain is first put into a flat shell - shaped basket which is shaken either with a circular or slightly forward and upward motion. The chaff and dirt work their way to the upper end of the basket and are discarded, and the heavy grains collect at the lower end. This method provides a clean sample, requires the cheapest and simplest equipment and is not arduous. It is however, extremely slow, the average rate being 45 kg/h.

### 2.7.2 Winnowing sieves

Winnowing sieves are usually open sieve, baskets, often suspended on tripods and shaken to allow the grain to drop through. Heavy chaff and straw is retained in the basket while light matter is blown away in the breeze (Fig. 2.9).

### 2.7.3 Winnowing fan

The winnowing fan is a hand-driven revolving fan mounted in a wooden housing which has a horizontal wind duct. The grain, chaff, wet seeds and short straw are fed from a hopper into the duct and as the mixture falls vertically the lighter materials are blown away by the blast of air. The strength of the blast is regulated by varying the speed of the fan (Fig. 2.10).

### 2.7.4 KERAGRO Winnower

The Kerala Agro Industries Corporation, a public sector corporation, developed a winnower suited to the small and medium farmers of the state at their Regional Office, Palakkad. The corporation have already marketed the machine and they demand a capacity of 800 kg of grain per hour. The machine has an overall length of 186 cm, width 60 cm and height 170 cm.

According to Kepner _et al_. (1978) the aerodynamic separation depends upon the existence of a differential between the suspen-

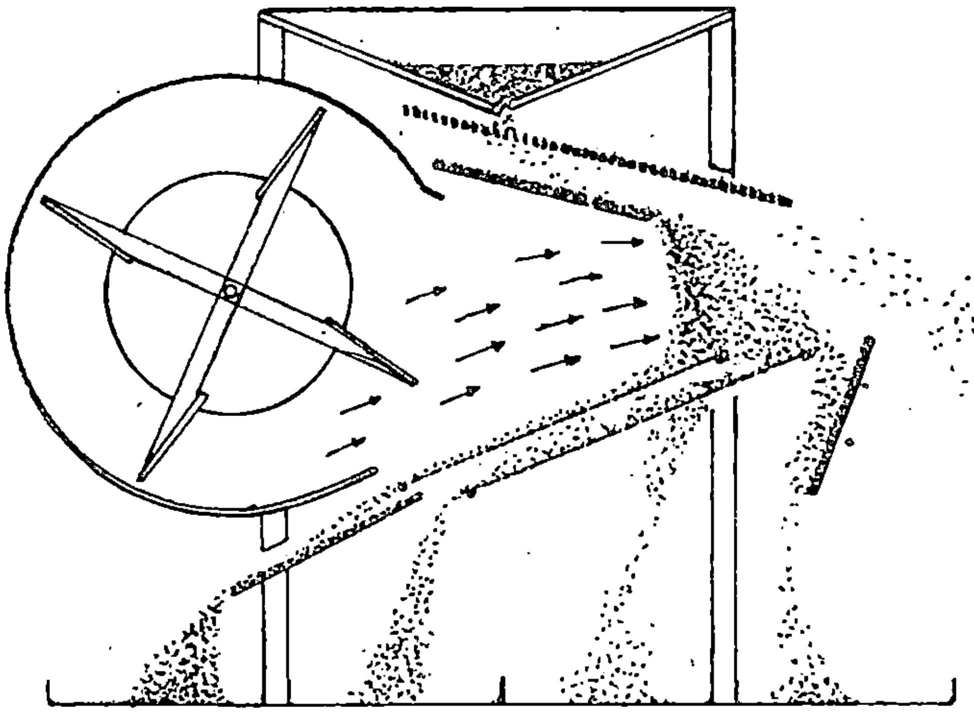

Fig. 2.9 Sectional view of a winnower.

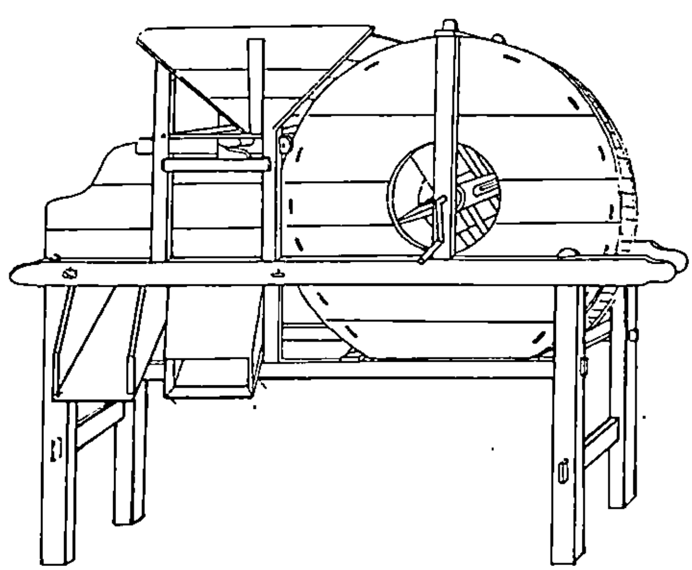

Fig. 2.10 A hand - winnowing fan.

sion velocities of the components to be separated. The suspension velocity is the air velocity required to support the pieces of materials against the action of gravity in a vertical air stream. Suspension velocities reported by Cooper from several sources ranges from 5.1 to 9.7 m/s for kernels of wheat, oats and barley, from 2.0 to 6.1 m/s for short pieces of straw and from 1.5 to 2.5 m/s for chaff.

Henderson and Perry (1976) reported about different types of fans used in Agricultural processing. According to them the fans are classified into,

1) Propeller fans
2) Axial - flow fans
3) Tube axial fans
4) Vane axial fans, and
5) Centrifugal or Radial - flow fan.

In these types centrifugal fans consists of a wheel or motor within a scroll spiral type housing. The air enters parallel to the shaft, makes $90^o$ turn in the fan wheel and is discharged from the wheel in a radial manner. These fans can be subdivided into,

i) forward-curved blade fans
ii) straight blade fans, and
iii) backward-curved blade fans.

In these the straight blade fans has a smaller number of blades arranged in a plane radiating from the shaft. The blades are normally about 2 to 3 times as long as they are wide. This type of fans has the ability to handle dirty air and to convey materials that go through the fans or to develop pressures beyond the range permissible with lighter weight fans.

### 2.8 Power requirement

The threshing action of the drum on the plant mass is accompanied by repeated impact on the latter and its deformation in the interspace of the drum and the concave. The total tangential force on the beaters or spikes on the drum consists of the impact force Pl and the extensive force P2 that is,

$$P = P1 + P2 \text{ ...........(1)}$$

The force $P_1$ may be determined by equating the impulse force 'Pl' with the change in momentum of the plant mass, that is,

$$P_1 \Delta t = \Delta q(u_2 - u_1)$$

$$\text{or } P_1 = q\ (u_2 - u_1) \text{ ....(2)}$$

where, q - is the feed rate of plant mass, kg/s

t - is the duration of impact, s

q - is the quantity of plant mass which suffers the impact, kg

$u_2$ - is the speed of the plant mass after impact, m/s

$u_1$ - is the speed of the plant mass before impact, m/s

The force $P_1$ accounts for the resistance to shifting of the plant mass, and it can be approximated by making it proportional to the total resistance at the drum periphery $P_1$ that is

$$P_2 = f\, P_1 \quad .........(3)$$

where, f - proportionality co-efficient called wear co-efficient.

substituting $P_1$ and $P_2$ in equation (1)

$$P = q\,\frac{(u_2 - u_1)}{1 - f}$$

(Klenon *et al.*, 1985)

They have also developed an equation for the rough estimation of power requirement in threshing.

$$N = q\,\frac{(u_2 - u_1)}{1 - f} + Au + Bu^3$$

where,

$N$ - the total power required to run the threshing drum

$q$ - feed rate of plant mass

$u_1$ - speed of plant mass before impact

$u_2$ - speed of plant mass after impact u - Peripheral velocity of threshing drum

f - wear co-efficient

A - co-efficient for friction

B - windage co-efficient

Arnold and Lake (1964) reported that the power requirement for threshing decreased substantially as the cylinder diameter was increased from 305 mm to 533 mm, but decreased only slightly between 533 mm and 686 mm.

# MATERIALS AND METHODS

# 3. MATERIALS AND METHODS

The design criteria, selection of individual components of the Thresher cum winnower and the method of evaluation are presented in this chapter.

## 3.1 Requirements

The primary requirements of a paddy thresher cum winnower suited to the socio economic conditions of the farmers of Kerala State are

(1) The equipment should have a capacity not less than 250 kg/h so that the paddy harvested from a hectare can be threshed and winnowed in a day of 8 hours.

(2) The thresher should be simple in construction and the cost should be low

(3) It should have maximum threshing efficiency

(4) The straw should not be damaged while threshing

(5) The grain loss should be minimum

(6) Cost of operation should be low

(7) Seed damage should be minimum

(8) Threshing and winnowing operations should be done simultaneously in a single equipment

(9) Cleaned grains could be collected easily from a single outlet

(10) The thresher could be operated atleast by a 2 hp

electric motor

(11) Labour requirement should be low

(12) The thresher could be operated easily and safely

(13) The thresher could be easily transported from one place to another.

In view of attaining these requirements, a power operated hold-on type thresher cum winnower has been designed, fabricated and tested at KCAET, Tavanur.

## 3.2 General layout and details of the Equipment

The developed thresher cum winnower has the following units:

(1) Threshing unit

(2) Winnowing unit

(3) Grain collecting tray

(4) Prime mover and power transmission system, and

(5) Main frame.

### 3.2.1 Threshing unit

The threshing unit consists of a cylinder, a cover and a concave. The specifications put forth by the Bureau of Indian Standards (IS 3327 - 1962) was followed in the fabrication of the threshing cylinder. A loop type design was adopted for the drum of 450 mm diameter at the tip of the wire loops. The length of the cylinder was selected as 750 mm in order to facilitate the holding of paddy sheaves by two persons simultaneously against the threshing drum. Twelve equally spaced wooden slats of 70 mm width, 20 mm thick and 750 mm length bolted to two end rings forms the cylinder. The end rings of diameter 310 mm were fabricated with MS flat of 40 x 6 mm size. Two MS flat pieces of same size were welded diagonally across to the ring in order to fix the shaft at the centre by drilling a hole at the centre. An MS bush of 40 mm outer diameter and 26 mm inner diameter was fixed to each of the ring. The shaft was passed through the bushes and fixed to the cylinder by tightening the bolts provided.

The threshing teeth were made of GI wires of 4 mm diameter (Plate No. 1). The wires are curved into loop shape and fixed to the wooden slats in such a way that the distance between the fixed ends of each wire is 35 mm. The threshing teeth projects 50 mm above the slat. The straight ends of the teeth were driven through the holes drilled on the slats and are bend inward and nailed, to avoid slipping during operation. The distance between the tip of the two adjacent teeth in a slat is kept as 40 mm. The loops are fixed to the slats in such a way that when assembled, the teeth on the two adjacent slats come staggered to each other (Fig. 3.1).

Cylinder shaft:

The cylinder shaft is made of MS rod and is having a length of 1080 mm. The cylinder is fixed to the shaft. The shaft is designed to take a maximum load of 2 hp. Based on the earlier

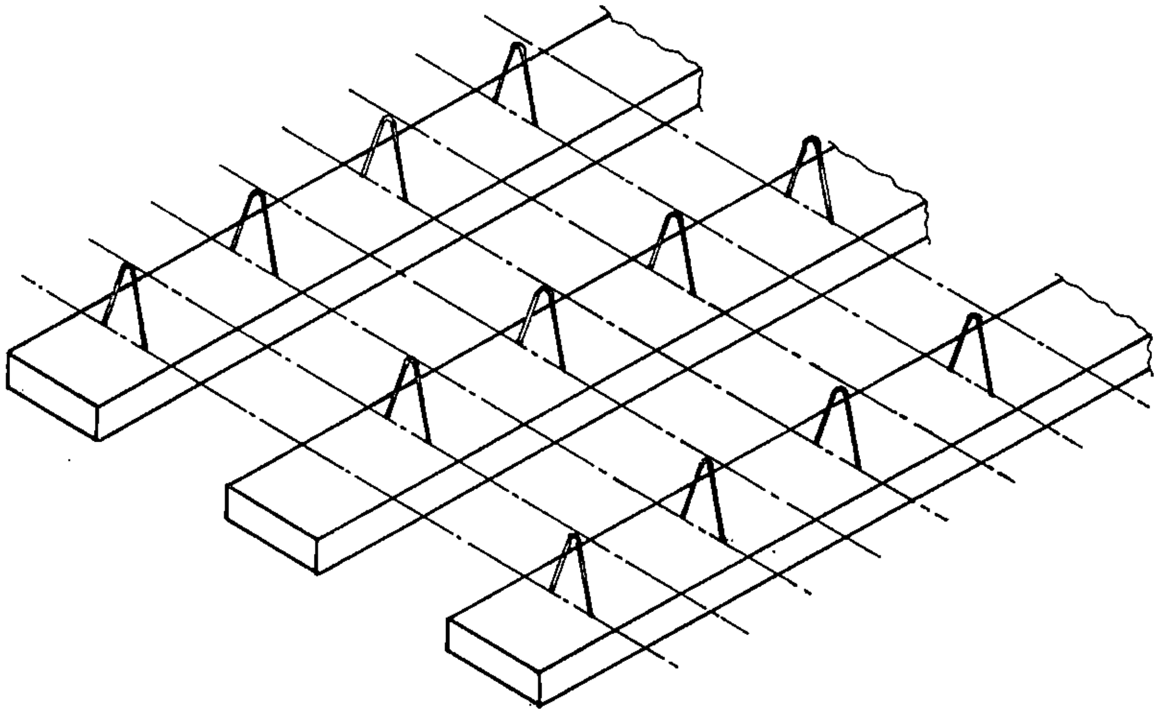

Fig. 3.1 Staggered arrangement of wire loops on wooden slats.

design the diameter of the shaft is selected as 25 mm (Preman _et al._, 1991). Two V - belt pulleys are provided at both the ends of the shaft to transmit power. Two ball bearings of 6305 size is fixed to the shaft ends at a distance of 800 mm between them and are fixed to the frame using bearing cases.

Covering the cylinder is important to prevent accidents during operation. Otherwise there are chances of hiting of grains on the eyes of the operator. Therefore, the cylinder is covered completely with 22 gauge GI sheet except the portion for feeding paddy sheaves. Provisions are given to split up the cover into parts in order to enhance easy maintenance.

A concave made of 8 mm MS rod is provided at the bottom of the cylinder (Plate No. 2). The concave is fixed to the frame in such a way that the clearance between the drum and concave can be varied and fixed at positions by tightening two nuts.

A feeding tray made of 20 gauge MS sheet is fixed to the frame as a continuation of the concave. The angle of the tray with respect to the frame can also be made adjustable to match with concave positions. The tray has 910 mm length and 264 mm width. A wooden beeding of 18 mm width, 15 mm thick and 910 mm length is fixed on the top of the feeding tray at a distance of 180 mm from the feeding end. This is a safety precaution to prevent the operator's hand from hitting the rotating drum.

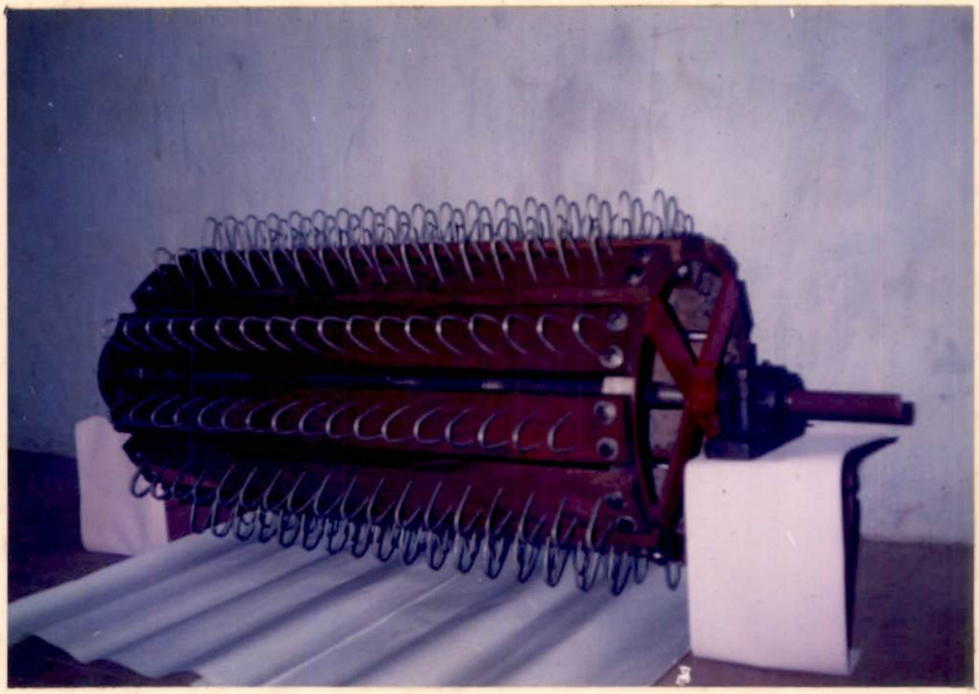

Plate No.1  Threshing cylinder mounted on shaft

Plate No.2  The concave

### 3.2.2 Winnowing unit

The winnowing unit consists of two parts, a sieve and a set of blowers.

The sieve is provided at the bottom of the concave in order to separate the straw pieces and broken ear heads from the threshed grains. The sieve also gives a uniform spreading of grains which enhance an easy winnowing. The sieve is made of MS sheet of 870 mm length and 750 mm width mounted on an angle frame. The holes are of oblong shape of 4 x 18 mm with its longer side in the direction of grain flow. The sieve is suspended on the main frame at 4 points so that manual shaking can be done when required. It is suspended in a slightly slanting position towards the front to enhance easy grain flow.

The blower unit comprises of two blowers mounted on a single shaft. Each blower consists of a fan of four blades and the blower cover (Plate No. 3). The blades are made of 18 gauge MS sheet of 120 x 320 mm size. Four angle pieces were welded around a bush at right angles, radially the shaft. The bush can be slided over the shaft and can be fixed on the shaft by tightening the screws provided. Two such bushes and angle piece set are used for fixing 4 blades of the blower unit. Such two blowers are used in the winnowing unit (Plate No. 4).

The blower is provided with a spiral casing made of 18 gauge GI sheet. Circular openings are made at the sides of the casing

Plate No.3 Spiral casing of the blower

Plate No.4 Blower blades mounted on shaft so that the air enters the blower parallel to the shaft makes a $90^{o}$ turn at the rotating blades and discharges in a radial manner. Slide covers are fixed at the openings to control the air flow.

Each blower has an overall width of 360 mm and length of 598 mm. The size of the opening at the discharge end is 100 x 360 mm. The top of the blower casing is fixed to the main frame using L - shaped clamps.

The blower is fixed to the frame in such a way that the centre to centre distance between the blower shaft and cylinder shaft is 600 mm and the blower shaft is at 582 mm above the ground.

### 3.2.3 Grain collecting tray

A tray, for collecting the clean grains, made of 18 gauge GI sheet is fixed below the blower unit. The tray is supported by two MS rods at the two sides fixed to the main frame. The collecting part of the tray has a trapezoidal shaped cross section and has an inclination towards the opening made at one end. The grains dropped from the sieve are winnowed by the blower and the clean grains are collected in the tray. The foreign particles such as straw pieces, dust and the immature grains are blown off.

The tray has an overall dimensions as given below.

length = 900 mm

width = 660 mm

Collecting portion:

Right side bottom width = 150 mm

Left side bottom width = 205 mm

Top width = 445 mm

Height:

Near opening = 132 mm

Far end of opening = 114 mm

### 3.2.4 Main frame

The whole frame is made of MS angle of 35 x 35 x 2 mm size and has the following diamensions (Plate No. 5).

height = 1008 mm

width = 455 mm

Length = 910 mm

At the base of the frame, two MS angle pieces of 37 x 37 x 5 mm size and 860 mm length is welded parallel to the ground, to get seating. The threshing cylinder is mounted on the top of the frame at a distance of 210 mm from the feeding end.

Plate No.5  Main frame and collecting tray

### 3.2.5 Prime mover and Power Transmission System

The power required to operate the machine is taken from a single phase 2 hp electric motor of 1440 rpm. The motor was fixed at the bottom of the frame.

The power transmission system consist of V - pulleys and belts of B - section. The power required to operate the cylinder and the winnower is taken from a 2 hp single phase electric motor. The power is transmitted from the motor to the cylinder shaft and from there to the blower shaft (Fig. 3.2). The pulleys are provided at two ends of the cylinder shaft for balancing the forces on the shaft. Pulleys are selected for the required speed using the relation

$$N_1 D_1 = N_2 D_2$$

where, $N_1$ - speed of the driving shaft in rpm

$D_1$ - diameter of the pulley on the driving shaft

$N_2$ - speed of the driven shaft in rpm

$D_2$ - diameter of the pulley on the driven shaft.

The lengths of the belts are calculated using the relation

$$l = 2x + \pi(r_1 + r_2) - (r_1 - r_2)^2 / x$$

where, l - length of the belt

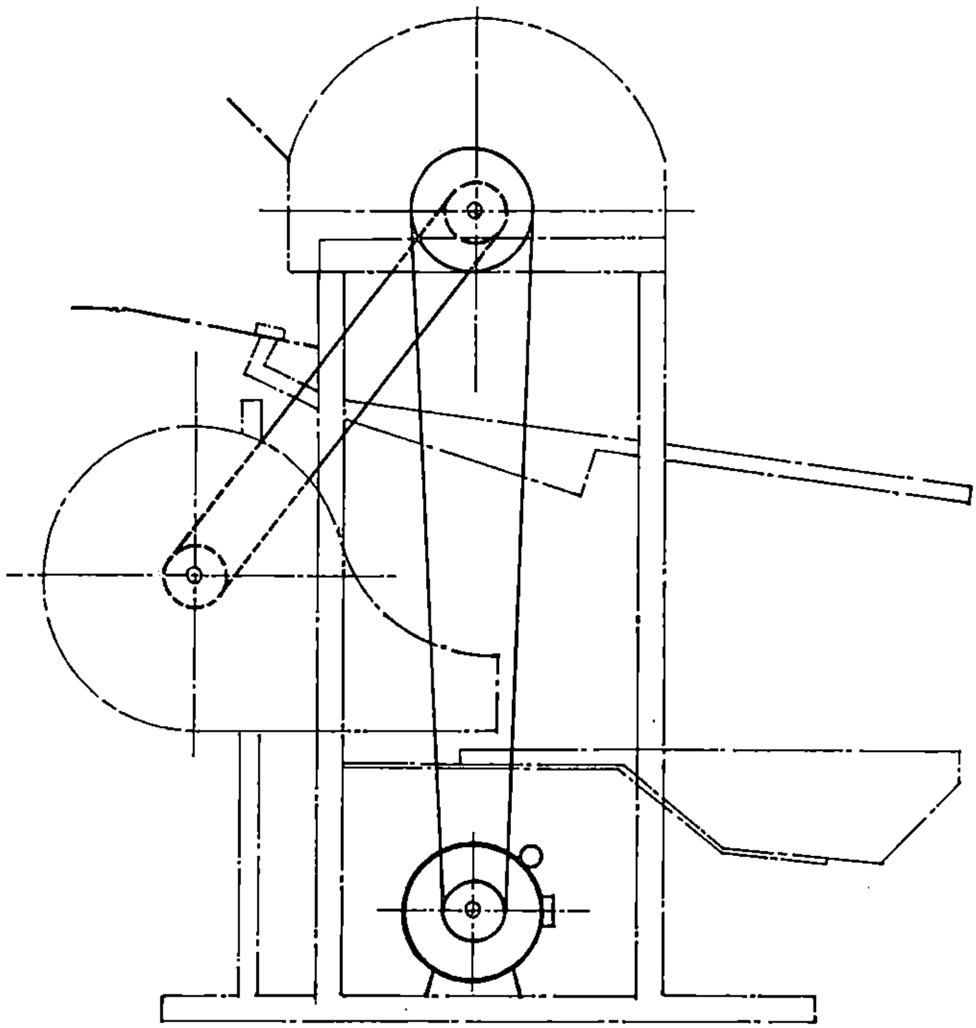

Fig. 3.2 Schematic of power transmission system.

x - distance between the centres of the driving and driven shafts.

$r_1$ - radius of the pulley on the driving shaft.

$r_2$ - radius of the pulley on the driven shaft.

The diameter of the pulleys selected to get different speeds of the cylinder shaft and the belt lengths are presented in Appendix - A.

The sectional side view of the equipment is shown in Fig. 3.3. The overall views of the equipment is exhibited in Plate No. 6 and Plate No. 7, and the specifications are given in Appendix - B.

## 3.3 Experimental Programme

The developed machine has been tested in the laboratory as well as in the field in order to study the performance of the machine. Data on different aspects of the threshing unit and winnowing unit are tabulated and analysed.

### 3.3.1 Laboratory tests

The thresher cum winnower has been tested under no-load condition to study the power consumption, speed of the cylinder shaft when used with different sized pulleys, air velocity at the exit of the blower and the mechanical failure, if any, to the individual parts of the machine.

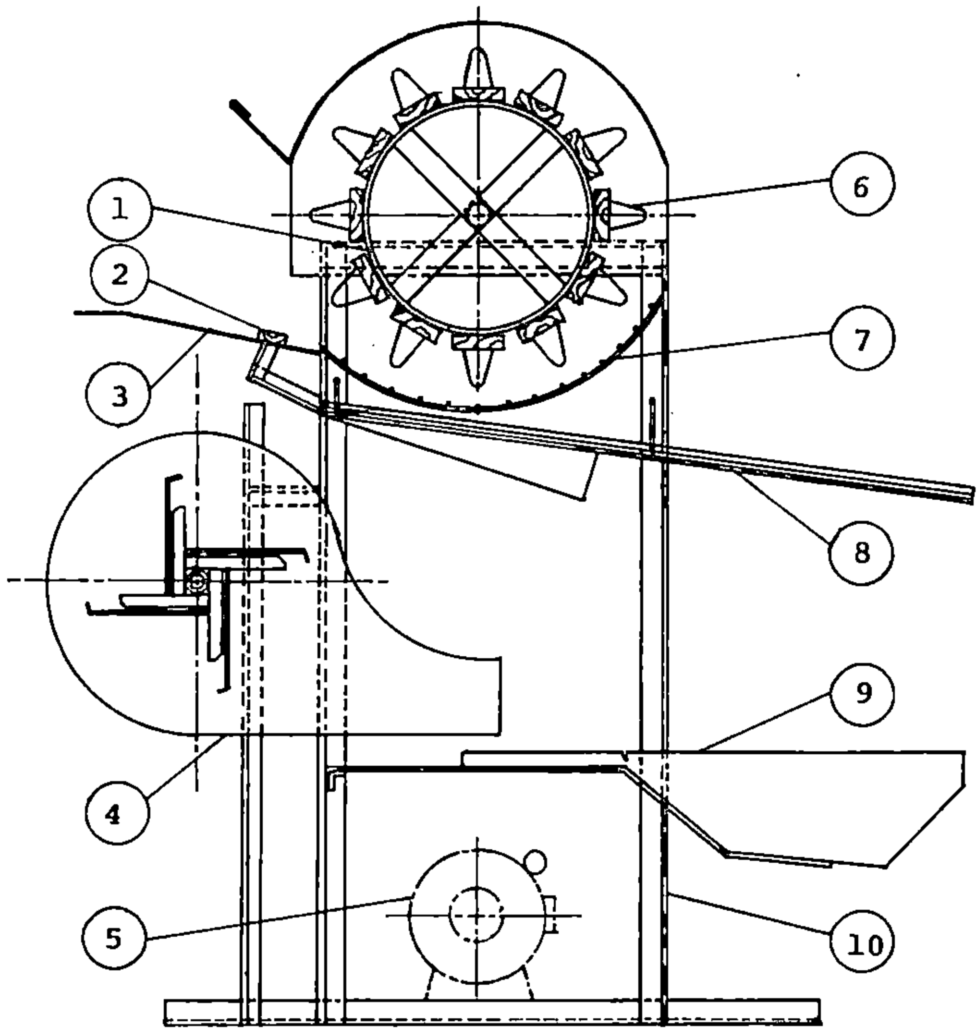


Fig. 3.3 Sectional side view of the thresher cum winnower.

1. Threshing cylinder
2. Safety bar
3. Feeding tray
4. Blower
5. Prime mover
6. Wire loop
7. Concave
8. Sieve
9. Collecting tray
10. Main frame

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Plate No.6 A view of the developed low cost thresher cum winnower

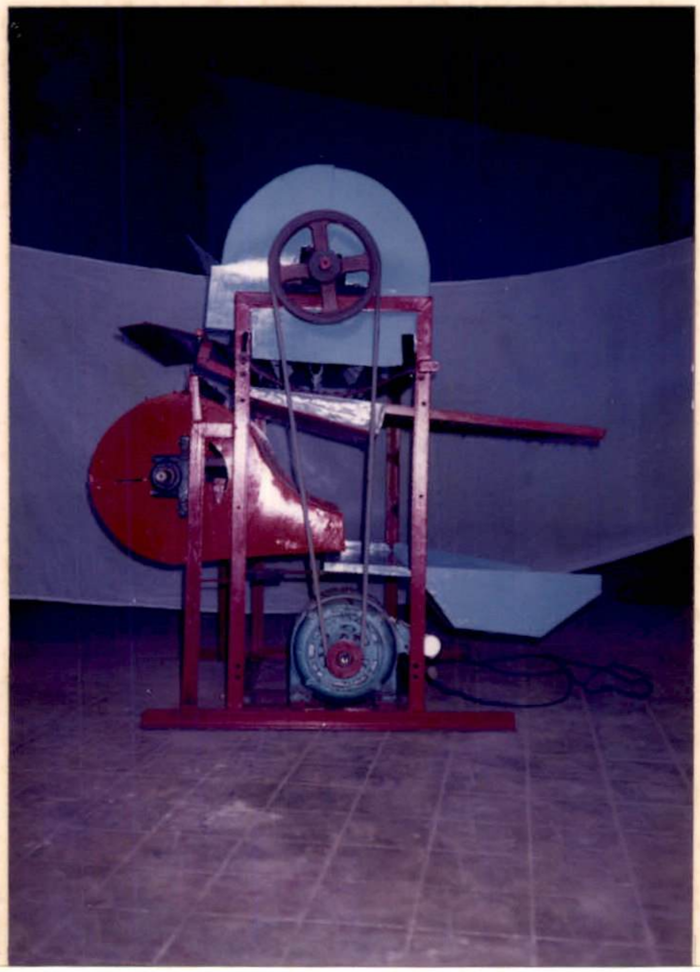

Plate No.7 Side view of the developed low cost thresher cum winnower

To find the power requirement of the thresher, an ammeter and a voltmeter have been connected to the electric circuit coming to the motor and the readings have been noted for every speed change (Plate No.8 & 9). The power requirement is calculated by using the formula,

$$P = VI \cos \phi$$

where, P - Power requirement in Watts.

V - Volt meter reading, Volts.

I - Current in amperes

$\cos \phi$ - Power factor (Generally 0.8)

The rpm of the shafts are measured using dial type tacheometers. Air velocity is measured using anemometer. The reading from the anemometer gives the distance travelled by the air stream for a particular time period.

**3.3.2 Field Tests**

Field tests have been conducted to study the threshing efficiency, cleaning efficiency and capacity of the thresher at different peripheral velocities of the cylinder and at different moisture levels of the crop. Paddy variety 'Red Triveni' harvested in summer season is used for the test and has been done at Kelappaji College of Agricultural Engineering and Technology, Tavanur.

Plate No.8  Set-up for measurement of power requirement of the thresher

Plate No.9  Testing of the thresher cum winnower under no load condition

The machine has been tested at four different peripheral velocities of the cylinder viz., 508.93, 565.49, 720.99 and 848.43 m/min. The corresponding rpm of the cylinder shaft has been 360, 400, 510 and 600. Different sized V - pulleys are used to get these speeds.

The different levels of moisture content of the crop are 19.5% (w.b.), 16% (w.b.) and 14% (w.b.). The moisture content of the grain is determined by air oven method keeping the sample in the oven at $130 \pm 2\,^{o}C$ for 16 hours.

A known weight of 10 kg of crop was taken for testing each time. Two persons fed the bundles simultaneously to the machine (Plate No. 10). The threshing time for each test run was recorded. The threshed and cleaned grains collected in the tray were weighed. The unthreshed broken earheads separated by the sieve also were collected and weighed. The grains blown along with the chaff and dust were also collected and weighed and were recorded as partially cleaned grains. Weight of the straw was also recorded. The above procedure was repeated five times for all the combinations of the cylinder speed and moisture content of the crop.

A voltmeter and an ammeter were connected to the electric circuit of the motor and the readings of which were recorded for each test run. The threshing efficiency, cleaning efficiency, capacity, feed rate, grain straw ratio and the power requirement were calculated for each time and tabulated. Graphs were plotted

Plate No.10 Field evaluation of the thresher cum winnower under load conditions to study the effect of peripheral velocity and moisture content on threshing efficiency and capacity.

### 3.4 Calculations

1. Total grain input

$$A = B + C$$

where, A - total grain input per unit time by weight.

B - Weight of threshed grain collected per unit time.

C - weight of unthreshed grain collected per unit time.

2. Percentage of unthreshed grain = C/A X 100
3. Threshing efficiency = 100 - Percentage of unthreshed grain.
4. Cleaning efficiency = D/B X 100

   D - Weight of fully cleaned grain per unit time.

5. Capacity, Q = B/t X 3600

   Q - Capacity of the machine in kg/h

   t - Time required to thresh the grains in seconds.

6. Power requirement, P = VI Cos $\phi$

   where V - Voltage of the electric supply, Volts.

   I - Current used by the motor, Amperes.

   Cos $\phi$ - Power factor.

## 3.5 Computer analysis for developing an equation for Energy Requirment of the Thresher cum Winnower

Development of an empirical relationship between the Power Requirment and the various thresher and crop parameters is done by Multiple Linear Regression Analysis using Computer package MSTATC.

The general equation for Multiple Linear Regression for 'p' independent variables is,

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots\ldots\ldots + \beta_p X_p + E$$

where,

$\alpha$ = the Y intercept

$\beta_1, \beta_2, \beta_3, \ldots\ldots \beta_p$ = the partial regression co-efficients

E = the error term.

Generally we omit E from the equation. The values of $\beta_1$ measures the change in the mean value of Y per unit change in $X_1$ holding $X_2$, $X_3$, ....,$X_p$ constant. The values $\beta_2$, $\beta_3$,.... have similar meaning. For this reason $\beta$'s are called Partial Regression Co-efficients of Y on X's.

The quantities $\alpha$, $\beta_1, \beta_2, \ldots, \beta_p$ are estimated by $a_1$, $b_1$, $b_2, \ldots, b_p$ respectively from the given sample. Hence the sample regression model is given by

$$y = a + b_1 x_1 + b_2 x_2 + \ldots\ldots + b_p x_p$$

The assumptions made in the multiple linear regression are ,

i. The regression model is linear and of the form,

$$y = a + b_1 x_1 + b_2 x_2 + \ldots\ldots + b_p x_p$$

ii. The values of 'y' are independent of each other,

iii. The values of 'y' are normally distributed, and

iv. The variance of 'y' values is the same for all values of $x_1, x_2, \ldots, x_p$.

### 3.5.1 Variables selected for the analysis

1. Y, the Dependent variable = Power Requirment of the Thresher cum Winnower.
2. $X_1$, Independent variable 1 = Moisture Content of the crop.
3. $X_2$, " " 2 = Peripheral Velocity of the cylinder.
4. $X_3$, " " 3 = Feed Rate.

5. $X_4$, " " 4 = Grain/Straw ratio of the crop.

Three levels of moisture contents of the crop and four levels of peripheral velocities of the cylinder have been taken for testing the machine, as explained in 3.3.2. Five replecations each for all combinations of moisture content and peripheral velocities have been taken and used for the analysis.

# RESULTS AND DISCUSSION

# 4. RESULTS AND DISCUSSIONS

The results of the laboratory studies and field evaluations of the Hold-on type Power Paddy Thresher cum Winnower are presented in this chapter.

## 4.1 Laboratory studies

The study was conducted in the laboratory to analyze the performance of the thresher cum winnower at no load conditions. The speed of the cylinder when used with different sized pulleys, the power requirement at different speeds and the air velocity at the blower exit are presented in Appendix - C. These results clearly indicate that there is no significant difference in the power requirement of the thresher at varying cylinder speeds. The average power requirement was observed as 0.88 hp.

The air velocity at the exit of the blower unit increased from 5.44 m/s to 7.02 m/s as the cylinder speed increased. An air velocity of 5.85 m/s is optimum since the terminal velocity of the straw pieces is 5.8 m/s. The optimum air velocity is observed corresponding to a cylinder speed of 400 rpm.

The thresher was operated for one hour each for all the cylinder speeds and the mechanical defects to components were observed. The mechanical failure was negligible and the machine worked at almost constant speed for each test run.

## 4.2 Field Evaluation:

Field tests were conducted to study the efficiencies of threshing and cleaning and the capacity of the thresher at three different moisture levels of the crop and at four different peripheral velocities of the cylinder. The threshing efficiencies and capacities are presented in Tables 1,2, and 3. Tables 4, 5, and 6 show the cleaning efficiencies.

It is observed that the threshing efficiency varied from 90.02 to 99.26 %. The cleaning efficiency varied from 88.30 to 94.05 %.

The power requirement for the equipment is maximum when tested with crops having higher moisture levels (19.5 % w.b.) and is varied from 1.35 to 1.5 hp (Appendix - C) under load conditions.

### 4.2.1 Effect of Peripheral Velocity on Threshing Efficiency and Capacity

The graphs (Fig. 4.1 and 4.2) show the effect of peripheral velocity on threshing efficiency and capacity respectively, for different moisture levels of the crop.

From the graph (Fig. 4.1) it is seen that the threshing efficiency increased with an increase in the peripheral velocity,

Table No: 1 Threshing efficiency and Capacity at 19.5 % (w.b.) M C

| Sl. No. | Test No. | Peripheral Velocity (m/min.) | Weight of crop (kg) | Threshing Time (s) | Feed rate (kg/h) | Feed rate (kg/h) Ave. | Threshed grain (kg) | Un threshed grain (kg) | Weight of straw (kg) | Grain input (kg) | Threshing Eff000ency % | Threshing Eff000ency Ave % | Capacity (kg/h) | Capacity (kg/h) Ave. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | | 10 | 62 | 580.60 | | 3.600 | 0.220 | 6.000 | 3.820 | 94.24 | | 209.03 | |
| 2 | 2 | 508.93 | 10 | 62 | 580.60 | | 3.650 | 0.150 | 6.100 | 3.800 | 96.05 | | 211.94 | |
| 3 | 3 | (rpm 360) | 10 | 61 | 590.20 | 582.60 | 3.650 | 0.180 | 6.000 | 3.830 | 95.30 | 95.50 | 215.41 | 213.43 |
| 4 | 4 | | 10 | 63 | 571.40 | | 3.820 | 0.160 | 6.150 | 3.980 | 95.98 | | 218.29 | |
| 5 | 5 | | 10 | 61 | 590.40 | | 3.600 | 0.160 | 6.100 | 3.760 | 95.97 | | 212.46 | |
| 6 | 1 | | 10 | 57 | 631.60 | | 3.930 | 0.120 | 5.900 | 4.050 | 97.04 | | 248.21 | |
| 7 | 2 | 565.49 | 10 | 56 | 642.80 | | 3.760 | 0.110 | 6.050 | 3.870 | 97.16 | | 241.71 | |
| 8 | 3 | (rpm 400) | 10 | 58 | 620.70 | 629.50 | 3.850 | 0.100 | 5.950 | 3.950 | 97.47 | 97.25 | 238.97 | 240.58 |
| 9 | 4 | | 10 | 57 | 631.60 | | 3.820 | 0.110 | 6.000 | 3.930 | 97.20 | | 241.26 | |
| 10 | 5 | | 10 | 58 | 620.70 | | 3.750 | 0.100 | 6.000 | 3.850 | 97.40 | | 232.76 | |
| 11 | 1 | | 10 | 53 | 679.20 | | 3.580 | 0.260 | 6.000 | 3.840 | 93.23 | | 243.17 | |
| 12 | 2 | 720.99 | 10 | 54 | 666.70 | | 3.630 | 0.220 | 6.000 | 3.850 | 94.28 | | 242.00 | |
| 13 | 3 | (rpm 510) | 10 | 54 | 666.70 | 676.82 | 3.620 | 0.230 | 6.050 | 3.850 | 94.03 | 93.82 | 241.33 | 244.46 |
| 14 | 4 | | 10 | 53 | 679.20 | | 3.640 | 0.240 | 6.000 | 3.880 | 93.81 | | 247.25 | |
| 15 | 5 | | 10 | 52 | 692.30 | | 3.590 | 0.240 | 6.050 | 3.830 | 93.73 | | 248.54 | |
| 16 | 1 | | 10 | 51 | 705.88 | | 3.380 | 0.290 | 6.150 | 3.670 | 92.09 | | 238.59 | |
| 17 | 2 | 848.23 | 10 | 50 | 720.00 | | 3.500 | 0.350 | 6.050 | 3.850 | 90.91 | | 252.00 | |
| 18 | 3 | (rpm 600) | 10. | 49 | 734.69 | 717.29 | 3.420 | 0.300 | 6.150 | 3.720 | 91.94 | 91.82 | 251.27 | 246.28 |
| 19 | 4 | | 10 | 51 | 705.88 | | 3.420 | 0.290 | 6.180 | 3.710 | 92.18 | | 241.14 | |
| 20 | 5 | | 10 | 50 | 720.00 | | 3.450 | 0.300 | 6.100 | 3.750 | 92.00 | | 248.40 | |

Table No: 2 Threshing efficiency and Capacity at 16.0 % (w.b.) M C

| Sl. No. | Test No. | Peripheral velocity (m/min) | Weight of crop (kg) | Threshing Time (s) | Feed rate (kg/h) | Feed rate Ave. | Threshed grain (kg) | Un threshed grain (kg) | Weight of straw (kg) | Grain input (kg) | Threshing Efficiency % | Threshing Efficiency Ave % | Capacity (kg/h) | Capacity Ave. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | | 10 | 52 | 692.30 | | 3.850 | 0.150 | 5.900 | 4.000 | 96.25 | | 266.54 | |
| 2 | 2 | 508.93 | 10 | 51 | 705.88 | | 3.800 | 0.100 | 6.000 | 3.900 | 97.43 | | 268.24 | |
| 3 | 3 | (rpm 360) | 10 | 52 | 692.30 | 700.42 | 3.900 | 0.100 | 5.900 | 4.000 | 97.50 | 96.97 | 270.00 | 268.96 |
| 4 | 4 | | 10 | 51 | 705.80 | | 3.850 | 0.100 | 5.900 | 3.950 | 97.47 | | 271.76 | |
| 5 | 5 | | 10 | 51 | 705.80 | | 3.800 | 0.150 | 6.000 | 3.950 | 96.20 | | 268.24 | |
| 6 | 1 | | 10 | 48 | 750.00 | | 3.950 | 0.030 | 5.980 | 3.980 | 99.25 | | 296.25 | |
| 7 | 2 | 565.49 | 10 | 47 | 765.95 | | 4.000 | 0.020 | 5.950 | 4.020 | 99.50 | | 306.38 | |
| 8 | 3 | (rpm 400) | 10 | 48 | 750.00 | 733.31 | 3.960 | 0.040 | 5.950 | 4.000 | 99.00 | 99.25 | 297.00 | 300.27 |
| 9 | 4 | | 10 | 49 | 734.69 | | 4.020 | 0.030 | 5.920 | 4.050 | 99.26 | | 295.35 | |
| 10 | 5 | | 10 | 47 | 765.95 | | 4.000 | 0.030 | 5.930 | 4.030 | 99.26 | | 306.38 | |
| 11 | 1 | | 10 | 46 | 782.60 | | 3.780 | 0.160 | 5.960 | 3.940 | 95.94 | | 295.83 | |
| 12 | 2 | 720.99 | 10 | 45 | 800.00 | | 3.650 | 0.140 | 6.060 | 3.790 | 96.30 | | 292.00 | |
| 13 | 3 | (rpm 510) | 10 | 45 | 800.00 | 793.04 | 3.700 | 0.150 | 5.980 | 3.850 | 96.10 | 96.14 | 296.00 | 292.62 |
| 14 | 4 | | 10 | 45 | 800.00 | | 3.670 | 0.150 | 6.020 | 3.820 | 96.07 | | 293.60 | |
| 15 | 5 | | 10 | 46 | 782.60 | | 3.650 | 0.140 | 6.010 | 3.790 | 96.30 | | 285.65 | |
| 16 | 1 | | 10 | 43 | 837.20 | | 3.600 | 0.230 | 6.020 | 3.830 | 93.99 | | 301.39 | |
| 17 | 2 | 848.23 | 10 | 42 | 857.14 | | 3.560 | 0.250 | 5.990 | 3.810 | 93.44 | | 305.14 | |
| 18 | 3 | (rpm 600) | 10 | 42 | 857.14 | 849.16 | 3.580 | 0.260 | 6.000 | 3.840 | 93.23 | 93.61 | 306.86 | 303.64 |
| 19 | 4 | | 10 | 43 | 837.20 | | 3.600 | 0.240 | 5.970 | 3.840 | 93.75 | | 301.40 | |
| 20 | 5 | | 10 | 42 | 857.14 | | 3.540 | 0.240 | 6.010 | 3.780 | 93.65 | | 303.43 | |

Table No: 3 Threshing efficiency and Capacity at 14.0 % (w.b.) M C

| Sl. No. | Test No. | Peripheral Velocity (m/min) | Weight of crop (kg) | Threshing Time (s) | Feed rate (kg/h) | Feed rate Ave. | Threshed grain (kg) | Un threshed grain (kg) | Weight of straw (kg) | Grain input (kg) | Threshing Efficiency % | Threshing Efficiency Ave % | Capacity (kg/h) | Capacity Ave. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | | 10 | 55 | 654.55 | | 3.630 | 0.270 | 5.750 | 3.900 | 93.07 | | 237.60 | |
| 2 | 2 | 508.93 | 10 | 56 | 642.86 | | 3.640 | 0.300 | 5.800 | 3.940 | 92.39 | | 234.00 | |
| 3 | 3 | (rpm 360) | 10 | 54 | 666.67 | 649.96 | 3.630 | 0.290 | 5.800 | 3.920 | 92.60 | 92.57 | 242.00 | 236.45 |
| 4 | 4 | | 10 | 56 | 642.86 | | 3.650 | 0.320 | 5.850 | 3.970 | 91.94 | | 234.64 | |
| 5 | 5 | | 10 | 56 | 642.86 | | 3.640 | 0.280 | 5.750 | 3.920 | 92.86 | | 234.00 | |
| 6 | 1 | | 10 | 51 | 705.88 | | 3.950 | 0.200 | 5.700 | 4.150 | 95.18 | | 278.82 | |
| 7 | 2 | 565.49 | 10 | 52 | 692.31 | | 3.850 | 0.210 | 5.750 | 4.060 | 94.83 | | 266.54 | |
| 8 | 3 | (rpm 400) | 10 | 53 | 679.25 | 692.41 | 3.860 | 0.220 | 5.750 | 4.080 | 94.61 | 94.81 | 262.19 | 267.99 |
| 9 | 4 | | 10 | 52 | 692.31 | | 3.870 | 0.220 | 5.800 | 4.090 | 94.62 | | 267.92 | |
| 10 | 5 | | 10 | 52 | 692.31 | | 3.820 | 0.210 | 5.800 | 4.030 | 94.79 | | 264.46 | |
| 11 | 1 | | 10 | 47 | 765.96 | | 3.750 | 0.350 | 5.700 | 4.100 | 91.46 | | 287.23 | |
| 12 | 2 | 720.99 | 10 | 48 | 750.00 | | 3.700 | 0.340 | 5.750 | 4.040 | 91.58 | | 277.50 | |
| 13 | 3 | (rpm 510) | 10 | 47 | 765.96 | 759.58 | 3.870 | 0.350 | 5.650 | 4.220 | 91.70 | 91.55 | 296.42 | 288.50 |
| 14 | 4 | | 10 | 47 | 765.96 | | 3.820 | 0.360 | 5.700 | 4.180 | 91.39 | | 292.60 | |
| 15 | 5 | | 10 | 48 | 750.00 | | 3.850 | 0.350 | 5.750 | 4.200 | 91.66 | | 288.75 | |
| 16 | 1 | | 10 | 45 | 800.00 | | 3.750 | 0.400 | 5.650 | 4.150 | 90.36 | | 300.00 | |
| 17 | 2 | 848.23 | 10 | 46 | 782.61 | | 3.670 | 0.400 | 5.700 | 4.070 | 90.17 | | 287.22 | |
| 18 | 3 | (rpm 600) | 10 | 44 | 818.18 | 796.68 | 3.620 | 0.390 | 5.600 | 4.010 | 90.27 | 90.20 | 296.18 | 293.47 |
| 19 | 4 | | 10 | 45 | 800.00 | | 3.680 | 0.400 | 5.650 | 4.080 | 90.19 | | 294.40 | |
| 20 | 5 | | 10 | 46 | 782.61 | | 3.700 | 0.410 | 5.700 | 4.110 | 90.02 | | 289.57 | |

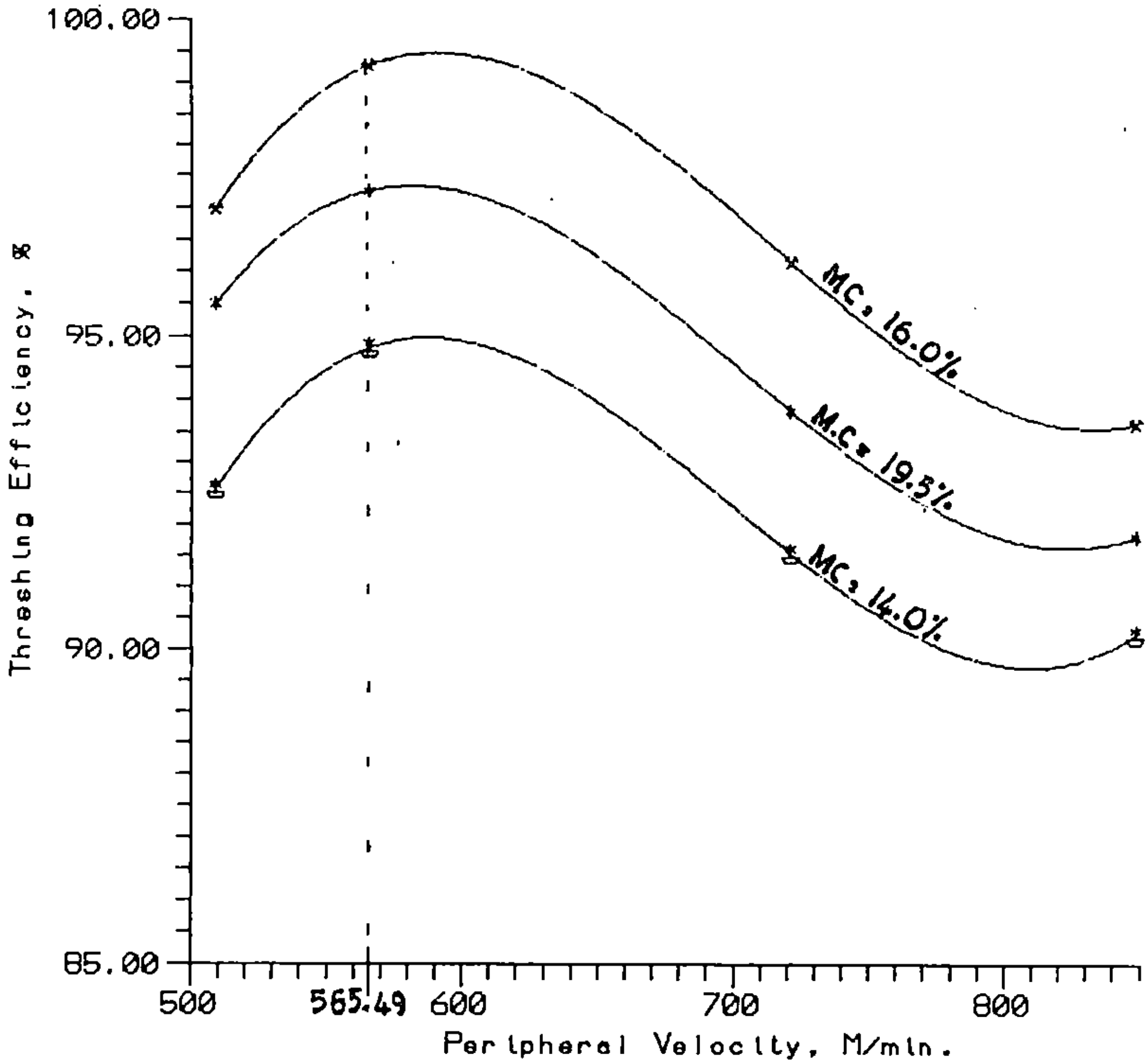


Fig. 4.1 Threshing efficiency Vs peripheral velocity.

upto 565.49 m/min (400 rpm). After that the threshing efficiency is found to be decreasing.

When the peripheral velocity is lower than 565.49 m/min, the number of hittings of the cylinder loops on paddy sheaves are less and when the peripheral velocity is higher than 565.49 m/min, the breakage of earheads is more. Moreover, there is a tendency for the paddy sheaves to float over the rotating cylinder in higher peripheral velocities. Proper combing action between the grains and the cylinder loops in higher velocities were found not as good as in lower velocities. Hence, the decrease in threshing efficiency at higher peripheral velocities than that of 565.49 m/min is justified. The optimum peripheral velocity of the cylinder for maximum threshing efficiency is thus identified as 565.49 m/min, and the corresponding speed of the shaft is 400 rpm which simulates with the optimum rpm of hold-on type threshers identified in earlier studies.

From the graph (Fig. 4.2), it is clear that the capacity of the machine increased as the peripheral velocity increased for all the levels of moisture contents of the crop. But, the increase in the capacity is not very significant after the peripheral velocity of 565.49 m/min. After the peripheral velocity of 720.99 m/min, the increase is negligible.

Even though the capacity of the machine is increasing beyond the limit of 565.49 m/min, the threshing efficiency is decreasing. That is, after the limit of 565.49 m/min, the increase in

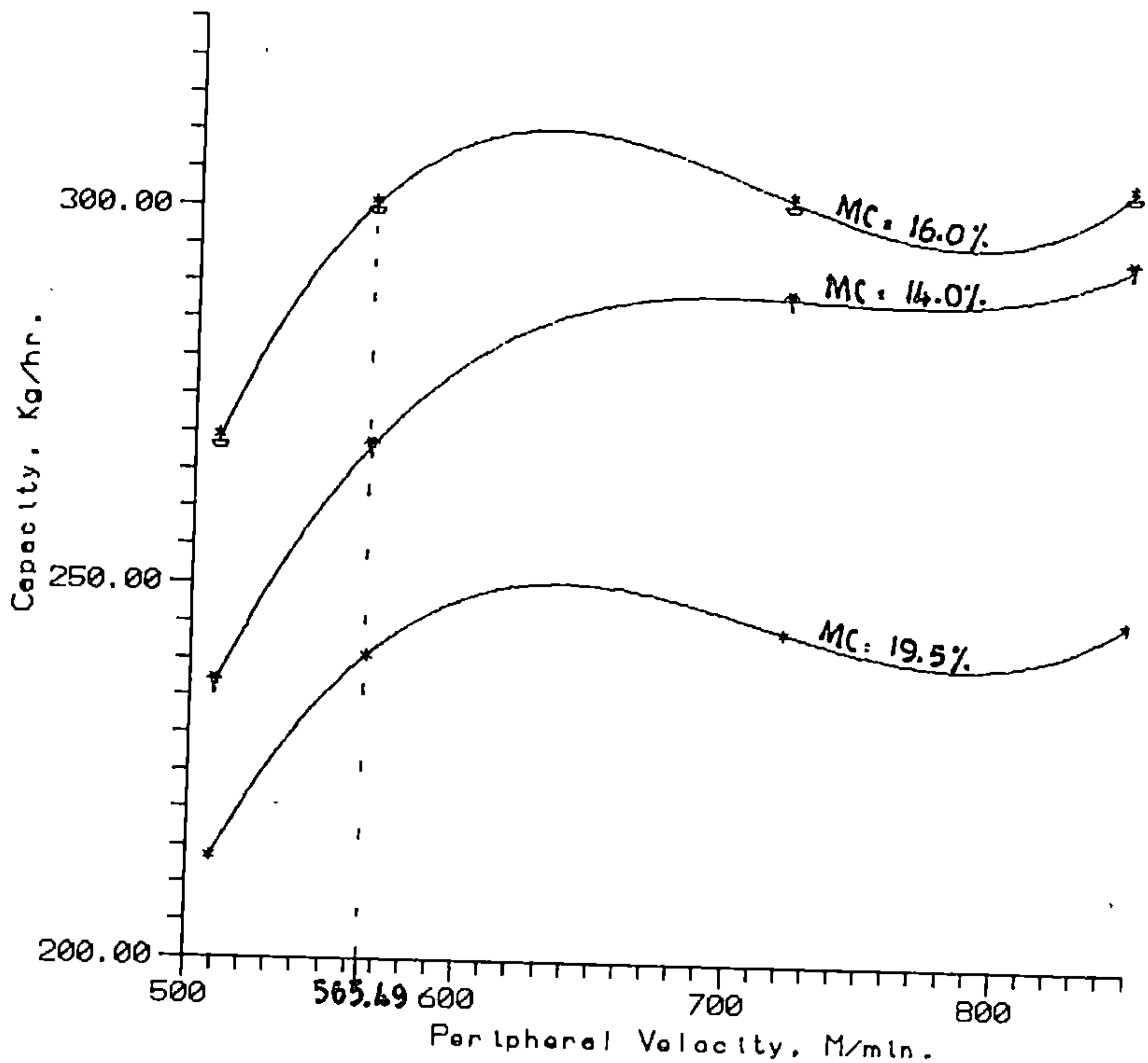


Fig. 4.2 Capacity Vs peripheral velocity.

capacity is due to the increase in feed rate, but the threshing efficiency is decreasing. This is not economical. So, the recommended peripheral velocity is 565.49 m/min (400 rpm).

### 4.2.2 Effect of moisture content on threshing efficiency and capacity

The graphs (Fig. 4.3 and 4.4) show the effect of moisture content on threshing efficiency and capacity respectively, for different levels of peripheral velocities of the cylinder.

From the graphs, it is clear that the threshing efficiency is increasing on increase in moisture content from 14% to 16% and then decreasing, for all levels of peripheral velocities. This is due to the fact that at higher moisture contents, the separation of seeds from the earheads will be difficult and at lower moisture contents, the breakage of earheads will be more. In both the cases the threshing efficiency decreases. So, the optimum moisture contents of the crop for maximum threshing efficiency is 16% (w.b.).

The capacity varies similar to the variation in threshing efficiency at all levels of peripheral velocities and for different moisture contents of the crop.

Considering all the above factors, the optimum peripheral velocity of the machine and the moisture content of the crop is

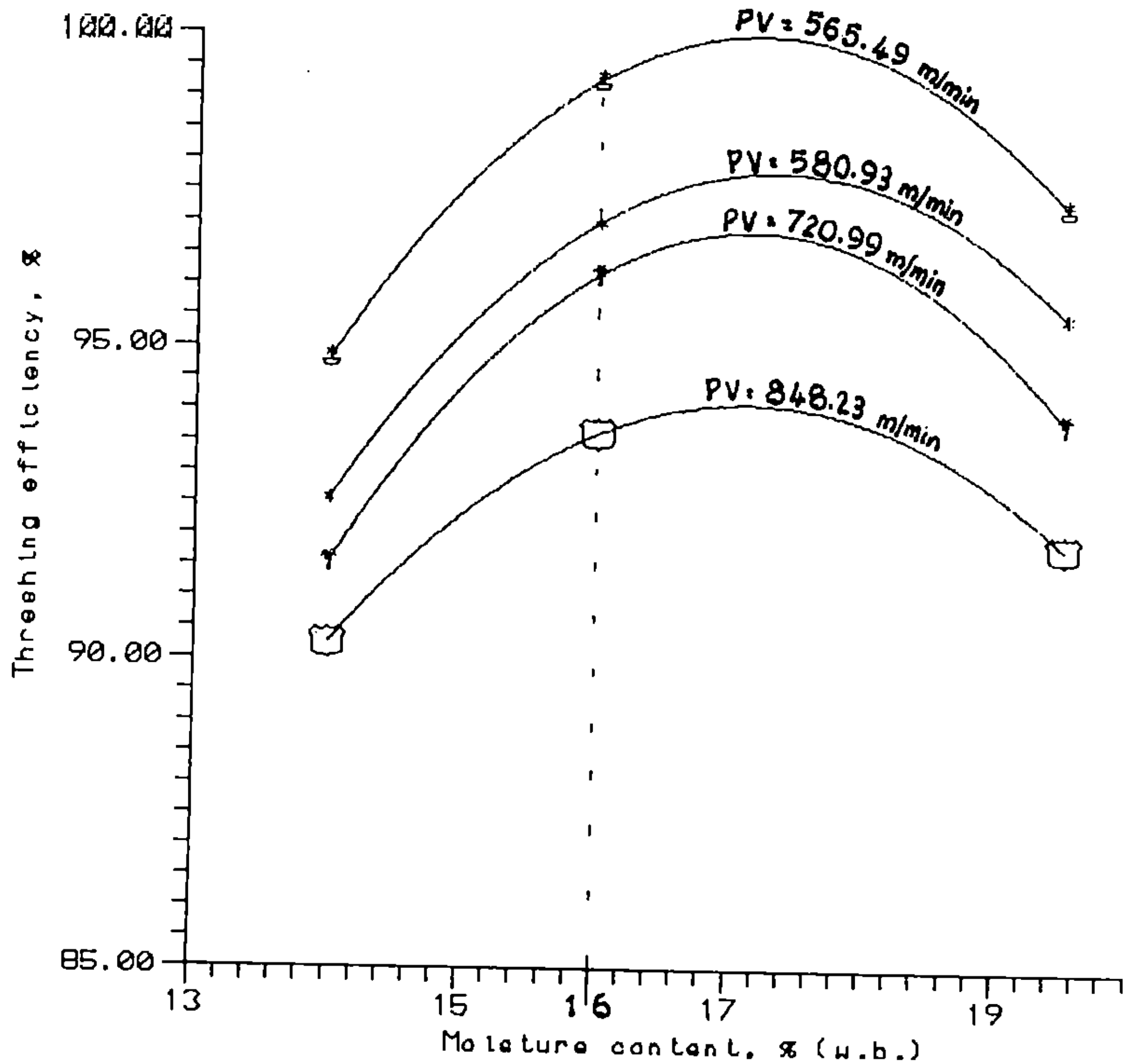


Fig. 4.3 Threshing efficiency Vs moisture content.

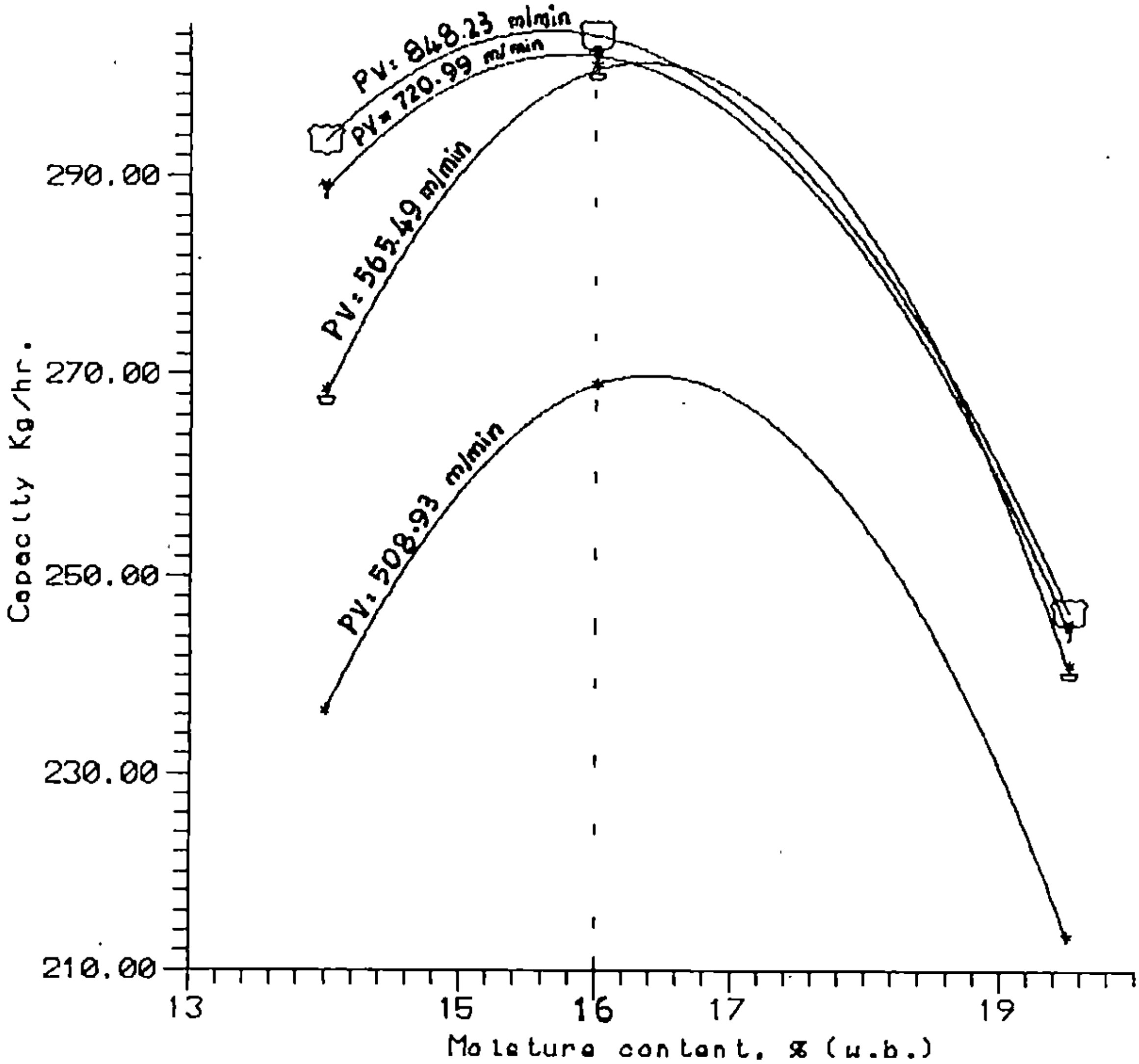


Fig. 4.4 Capacity Vs moisture content.

Table No: 4 Cleaning efficiency at 19.5 % (w.b.) M C

| Sl. No. | Test No. | Peri. Velo-city | Weight of cleaned grain (kg) | | | Total Threshed Grain(kg) | Cleaning efficiency(%) | |
|---|---|---|---|---|---|---|---|---|
| | | | Fully | Partially | Total | | % | Average % |
| 1 | 1 | 508.93 | 3.20 | 0.33 | 3.53 | 3.60 | 88.88 | 88.76 |
| 2 | 2 | | 3.25 | 0.35 | 3.60 | 3.65 | 89.04 | |
| 3 | 3 | | 3.24 | 0.33 | 3.57 | 3.65 | 88.76 | |
| 4 | 4 | | 3.38 | 0.39 | 3.77 | 3.82 | 88.48 | |
| 5 | 5 | | 3.18 | 0.35 | 3.53 | 3.60 | 88.30 | |
| 6 | 1 | 565.49 | 3.50 | 0.38 | 3.88 | 3.93 | 89.05 | 89.27 |
| 7 | 2 | | 3.34 | 0.36 | 3.70 | 3.76 | 88.83 | |
| 8 | 3 | | 3.45 | 0.35 | 3.80 | 3.85 | 89.61 | |
| 9 | 4 | | 3.42 | 0.33 | 3.75 | 3.82 | 89.53 | |
| 10 | 5 | | 3.35 | 0.33 | 3.68 | 3.75 | 89.33 | |
| 11 | 1 | 720.99 | 3.25 | 0.29 | 3.54 | 3.58 | 90.78 | 90.69 |
| 12 | 2 | | 3.30 | 0.28 | 3.58 | 3.63 | 90.91 | |
| 13 | 3 | | 3.30 | 0.27 | 3.57 | 3.62 | 91.16 | |
| 14 | 4 | | 3.28 | 0.30 | 3.58 | 3.64 | 90.11 | |
| 15 | 5 | | 3.25 | 0.30 | 3.55 | 3.59 | 90.53 | |
| 16 | 1 | 848.23 | 3.12 | 0.22 | 3.34 | 3.38 | 92.31 | 92.19 |
| 17 | 2 | | 3.24 | 0.20 | 3.44 | 3.50 | 92.57 | |
| 18 | 3 | | 3.14 | 0.22 | 3.36 | 3.42 | 91.81 | |
| 19 | 4 | | 3.15 | 0.23 | 3.38 | 3.42 | 92.10 | |
| 20 | 5 | | 3.18 | 0.22 | 3.40 | 3.45 | 92.17 | |

**Table No: 5 Cleaning efficiency at 16.0 % (w.b.) M C**

| Sl. No. | Test No. | Peri. Velocity | Weight of cleaned grain (kg) | | | Total Threshed Grain(kg) | Cleaning efficiency(%) | |
|---|---|---|---|---|---|---|---|---|
| | | | Fully | Partially | Total | | % | Average % |
| 1 | 1 | 508.93 | 3.43 | 0.36 | 3.79 | 3.85 | 89.09 | 89.74 |
| 2 | 2 | | 3.45 | 0.31 | 3.76 | 3.80 | 90.78 | |
| 3 | 3 | | 3.50 | 0.35 | 3.85 | 3.90 | 89.74 | |
| 4 | 4 | | 3.45 | 0.36 | 3.81 | 3.85 | 89.61 | |
| 5 | 5 | | 3.40 | 0.35 | 3.75 | 3.80 | 89.47 | |
| 6 | 1 | 565.49 | 3.62 | 0.29 | 3.91 | 3.95 | 91.65 | 91.82 |
| 7 | 2 | | 3.68 | 0.28 | 3.96 | 4.00 | 92.00 | |
| 8 | 3 | | 3.63 | 0.28 | 3.91 | 3.96 | 91.66 | |
| 9 | 4 | | 3.71 | 0.27 | 3.98 | 4.02 | 92.28 | |
| 10 | 5 | | 3.66 | 0.29 | 3.95 | 4.00 | 91.50 | |
| 11 | 1 | 720.99 | 3.49 | 0.25 | 3.74 | 3.78 | 92.33 | 92.41 |
| 12 | 2 | | 3.37 | 0.24 | 3.61 | 3.65 | 92.33 | |
| 13 | 3 | | 3.42 | 0.25 | 3.67 | 3.70 | 92.43 | |
| 14 | 4 | | 3.39 | 0.24 | 3.63 | 3.67 | 92.37 | |
| 15 | 5 | | 3.38 | 0.24 | 3.62 | 3.65 | 92.60 | |
| 16 | 1 | 848.23 | 3.38 | 0.18 | 3.56 | 3.60 | 93.88 | 93.56 |
| 17 | 2 | | 3.33 | 0.19 | 3.52 | 3.56 | 93.54 | |
| 18 | 3 | | 3.34 | 0.19 | 3.53 | 3.58 | 93.29 | |
| 19 | 4 | | 3.37 | 0.19 | 3.56 | 3.60 | 93.61 | |
| 20 | 5 | | 3.31 | 0.20 | 3.51 | 3.54 | 93.50 | |

Table No: 6 Cleaning efficiency at 14.0 % (w.b.) M C

| Sl. No. | Test No. | Peri. Velo-city | Weight of cleaned grain (kg) | | | Total Threshed Grain(kg) | Cleaning efficiency(%) | |
|---|---|---|---|---|---|---|---|---|
| | | | Fully | Partially | Total | | % | Average % |
| 1 | 1 | 508.93 | 3.30 | 0.28 | 3.58 | 3.63 | 90.90 | 91.09 |
| 2 | 2 | | 3.32 | 0.27 | 3.59 | 3.64 | 91.21 | |
| 3 | 3 | | 3.31 | 0.28 | 3.59 | 3.63 | 91.18 | |
| 4 | 4 | | 3.33 | 0.29 | 3.62 | 3.65 | 91.23 | |
| 5 | 5 | | 3.31 | 0.28 | 3.59 | 3.64 | 90.93 | |
| 6 | 1 | 565.49 | 3.67 | 0.24 | 3.91 | 3.95 | 92.91 | 92.82 |
| 7 | 2 | | 3.57 | 0.23 | 3.80 | 3.85 | 92.73 | |
| 8 | 3 | | 3.58 | 0.23 | 3.81 | 3.86 | 92.75 | |
| 9 | 4 | | 3.59 | 0.24 | 3.83 | 3.87 | 92.76 | |
| 10 | 5 | | 3.55 | 0.23 | 3.78 | 3.82 | 92.93 | |
| 11 | 1 | 720.99 | 3.50 | 0.21 | 3.71 | 3.75 | 93.33 | 93.36 |
| 12 | 2 | | 3.45 | 0.20 | 3.65 | 3.70 | 93.24 | |
| 13 | 3 | | 3.62 | 0.21 | 3.83 | 3.87 | 93.54 | |
| 14 | 4 | | 3.56 | 0.21 | 3.77 | 3.82 | 93.19 | |
| 15 | 5 | | 3.60 | 0.21 | 3.81 | 3.85 | 93.51 | |
| 16 | 1 | 848.23 | 3.52 | 0.20 | 3.72 | 3.75 | 93.87 | 93.97 |
| 17 | 2 | | 3.45 | 0.18 | 3.63 | 3.67 | 94.00 | |
| 18 | 3 | | 3.40 | 0.19 | 3.59 | 3.62 | 93.92 | |
| 19 | 4 | | 3.46 | 0.18 | 3.64 | 3.68 | 94.02 | |
| 20 | 5 | | 3.48 | 0.18 | 3.66 | 3.70 | 94.05 | |

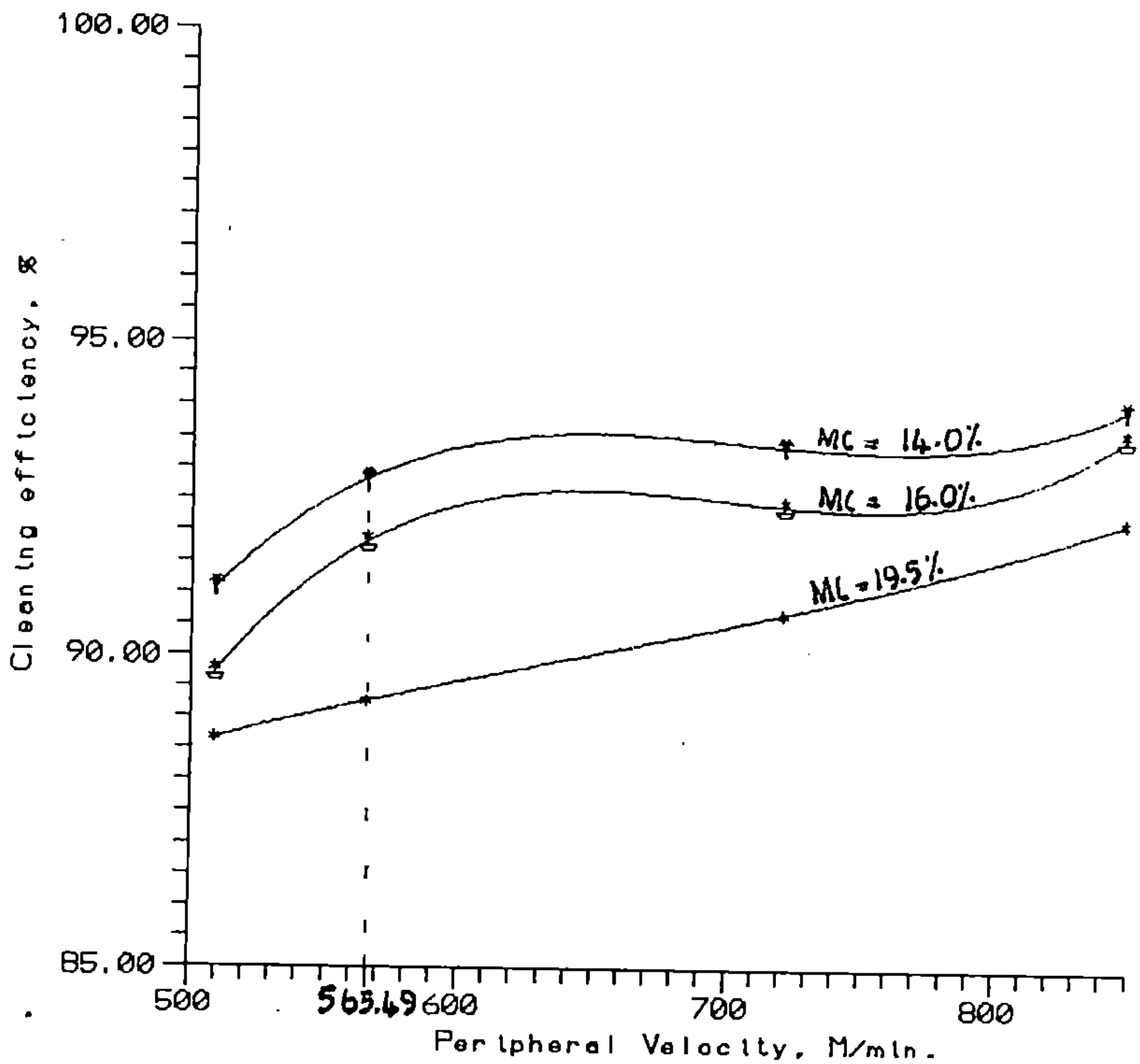


Fig. 4.5 Cleaning efficiency Vs pheripheral velocity.

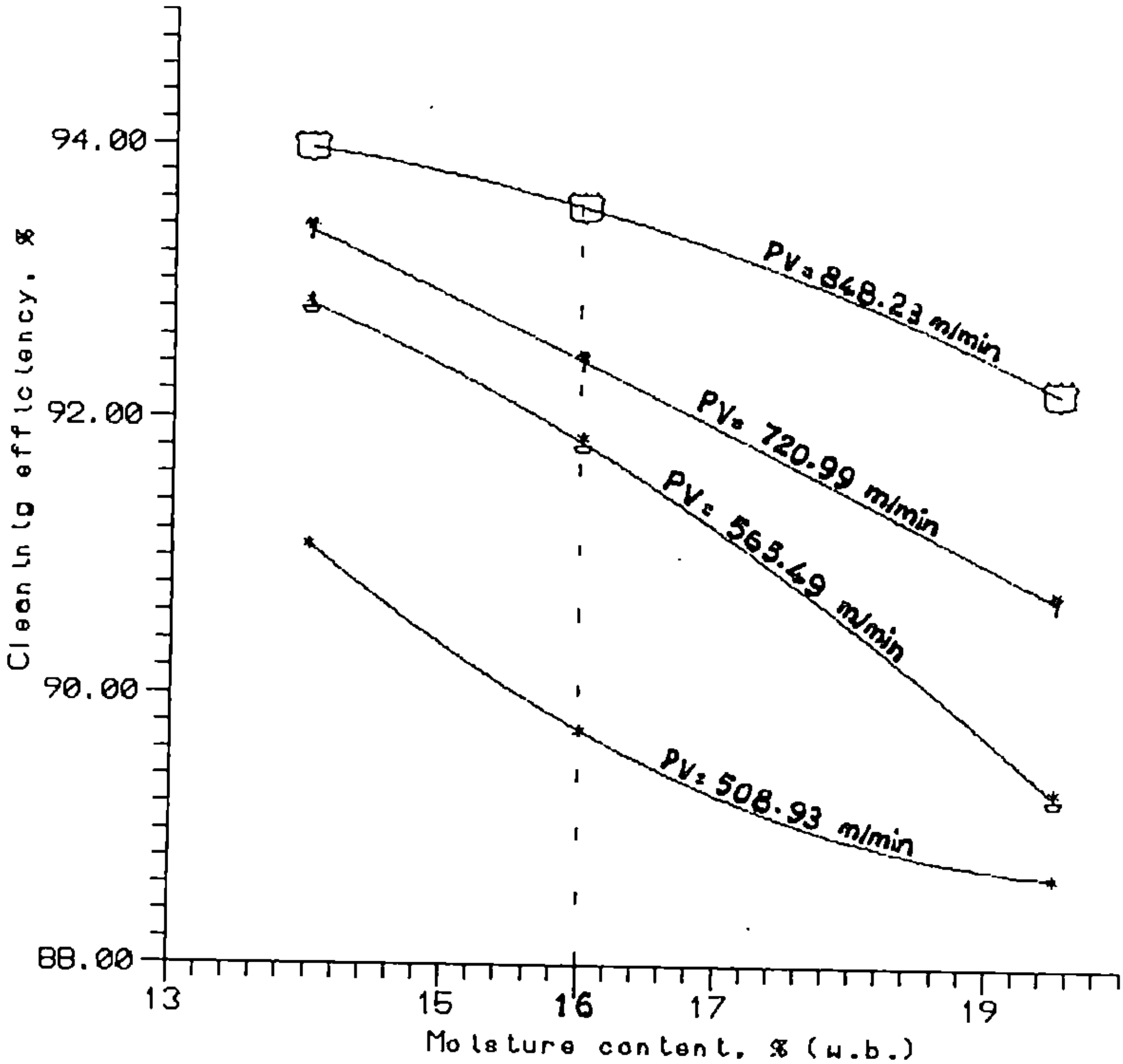


Fig. 4.6 Cleaning efficiency Vs moisture content.

recommended as 565.49 m/min and 16% (w.b.) respectively.

### 4.2.3. Effect of Peripheral Velocity and Moisture content on Cleaning Efficiency

The cleaning efficiency varies from 88.67 to 93.97% for different levels of moisture contents of the crop and peripheral velocities of the cylinder.

The cleaning efficiency is found to be increasing with increase in peripheral velocity of the cylinder and it is decreasing with increase in moisture level of the crop. As the peripheral velocity increases, the speed of the blower increases and resulted in increased air velocity. The graphs indicate that the moisture content of the crop has greater influence in the cleaning efficiency than the peripheral velocity. At lower moisture levels, the weight of the straw pieces and chaff, which is to be removed, will be less and can be removed easily by low air velocity. But, as the moisture content increases, the air velocity required to remove the chaff will be more. The average air velocity observed is 6.2 m/s (Fig. 4.5 and 4.6).

The cleaning efficiency observed at the optimum peripheral velocity of the cylinder and optimum moisture content of the crop is 91.82% which is moderate for a thresher cum winnower.

The mechanical damage to the grain is observed to be negligible.

### 4.3 Multiple Regression Analysis

Development of an empirical relation to determine the Power Requirement of the thresher with respect to the various thresher and crop parameters is done by Multiple Linear Regression Analysis using computer package MSTATC.

The data sheet and the print out of the results are presented in Appendix - D.

The regression co-efficients $b_1$, $b_2$, $b_3$ and $b_4$ corresponding to the variables $x_1$, $x_2$, $x_3$ and $x_4$ obtained from the table presented in Appendix - D are,

$$b_1 = 1.7279 \times e^{1} = 4.683 \quad \text{where, } e = 2.71$$

$$b_2 = \frac{-3.3926}{e^{2}} = -0.462$$

$$b_3 = \frac{-3.1673}{e^{1}} = -1.169$$

$$b_4 = 3.0445 \times e^{1} = 8.251$$

The Y intercept, = 931.035

The multiple linear regression equation is

$$Y = a + b_1 x_1 + b_2 x_2 + b_3 x_3 + b_4 x_4$$

Therefore, the empirical relationship between the power requirement and the different independent variables can be written as,

$$\mathbf{Y = 931.035 + 4.683\, x_1 - 0.462\, x_2 - 1.169\, x_3 + 8.251\, x_4}$$

i.e, the power requirement of the thresher = 931.035 + 4.683 (MC) - 0.462 (PV) - 1.169 (FR) + 8.251 (G/S ratio)

**4.3.1 Multiple co-efficient of determination**

The co-efficient of determination describes the relationship between the dependent and independent variables.

The multiple co-efficient of determination denoted as $R^2$ is,

$$R^2 = 0.938 \quad \text{(From Appendix - D)}$$

This means that about 93.8% of the variation in the power requirement of the thresher is explained by the independent variables.

#### 4.3.2 Test of Hypothesis

A hypothesis test has been done to determine whether there is a significant relationship among the dependent variable Y and the independent variables $x_1$, $x_2$, $x_3$ and $x_4$.

The null and alternate hypothesis may be stated as,

$H_o$ : $\beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$

$H_a$ : All the co-efficients are not equal.

##### 4.3.2.1 The F - Test

The sum of squares, the degrees of freedom, the corresponding mean squares, and the F - ratio are summarized in the Analysis of variance table presented in Appendix - D. The critical F - value for 5% level of significance obtained from the F - table for 4 and 55 degrees of freedom is 2.54.

The computed F - value from the Analysis of variance Table presented in Appendix - D is 208.58.

So, the null hypothesis is rejected and conclude that there is a significant relationship between the power requirement of the thresher and the independent variables viz., moisture content of the crop, peripheral velocity of the cylinder, feed rate, and the grain/straw ratio. Thus, the estimated regression equation may be used for prediction and estimation within the range of values included in the sample.

#### 4.3.3.2 The t - test

The F - test is performed to determine whether there is a significant relationship between the dependent and the independent variables without specifying which variable is significant. The t - test allows us to perform a test of significance on each individual regression co-efficient.

The null and alternate hypotheses for each independent variable may be stated as,

$$H_o : \beta_i = 0$$

$$H_a : \beta_i \neq 0$$

where, i = 1, 2, 3, 4.

The critical t - value for (n - k - 1) = 55 degrees of freedom at 5% level of significance obtained from t - table is,

$$t_{0.05} = 2.398$$

The computed t - value for different independent variables from the table presented in Appendix - D are,

t - Corresponds to MC = $t_1$ = 9.669

t - " PV = $t_2$ = -1.339

$t$ - corresponds to FR = $t_3$ = -5.842

$t$ - " G/S ratio = $t_4$ = 0.358

$t_1$ = 9.669 is greater than the critical value $t_{0.05}$ = 2.398 and the null hypothesis is rejected and conclude that at 5% level of significance, the co-efficient corresponds to $x_1$ differs significantly from zero.

$t_2$ = 1.339 is less than the critical value 2.398 and the null hypothesis is accepted and it is concluded that the co-efficient corresponding to $x_2$ does not differ significantly from zero.

$t_3$ = 5.842 is greater than the critical value 2.398, and the null hypothesis is rejected and it is concluded that, at the 5% level of significance, the co-efficient corresponding to $x_3$ differs significantly from zero.

$t_4$ = 0.358 is less than the critical value 2.398 and the null hypothesis is accepted and it is concluded that the co-efficient corresponding to $x_4$ does not differ significantly from zero.

To summarise the findings, it is concluded that the moisture content of the crop and the feed rate have statistically significant effect on the power requirement of the Thresher, but peripheral velocity of the cylinder and the grain/straw ratio of the crop do not have any statistically significant effect.

### 4.4 Cost of operation

The cost of operation of the developed thresher cum winnower is calculated and presented in Appendix - E.

The cost of threshing and winnowing per quintal of paddy is Rs 8.50.

Fig. 4.7. shows a comparison of the cost operation of the developed machine with traditional manual threshing and flow-through thresher. From the graph it is clear that the cost of operation for the developed thresher cum winnower is the least.

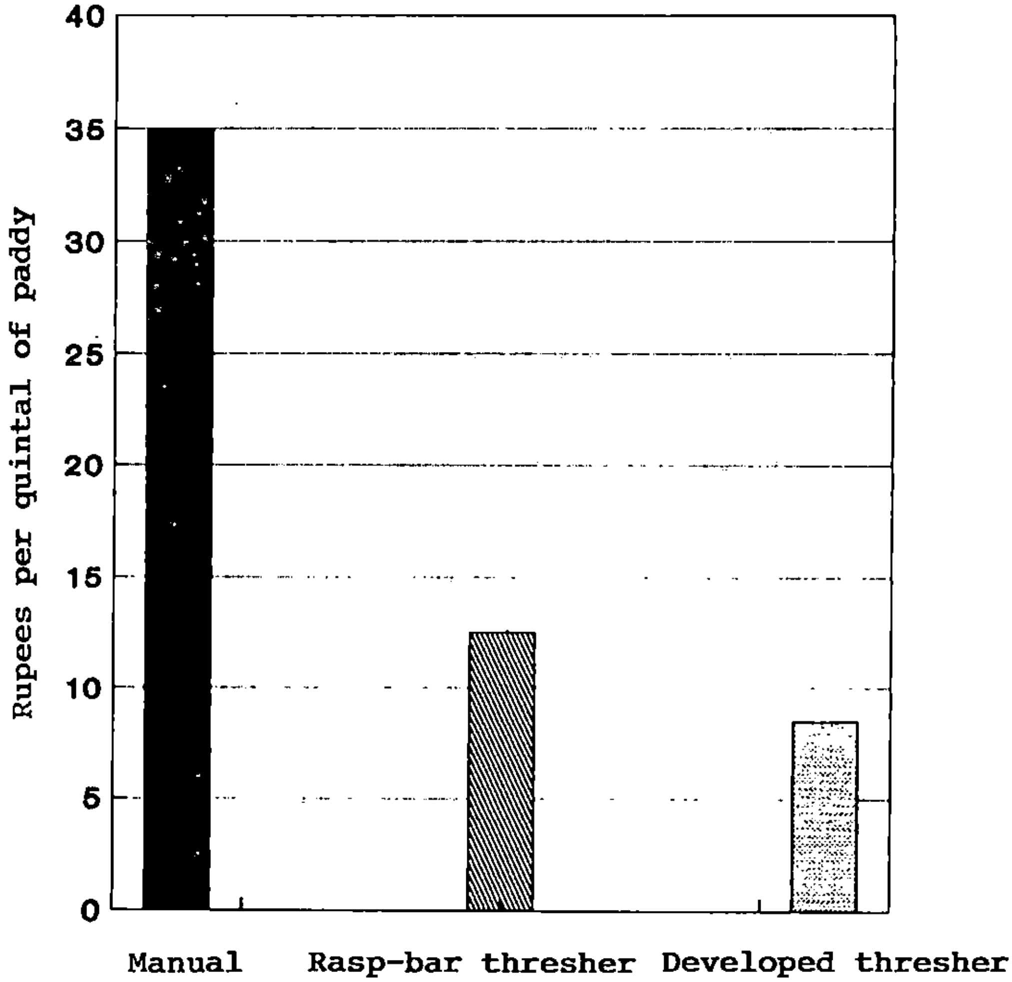


Fig. 4.7 Comparison of cost of operation for different threshing methods.

# SUMMARY

# 5. SUMMARY

Development of machinery and mechanical power to make man's efforts more effective and productive is one of the most prominent features of agricultural mechanization. Without modern and efficient farm machinery there can be no profitable agriculture.

Paddy cultivation in Kerala is confronting a crisis today. The net cultivable area is diminishing and at the same time we could not achieve substantial increase in the productivity. The main reason for this gloom over paddy cultivation is that it has become uneconomical owing to the high production cost and low productivity. Labour charges are comparatively higher in the state and labour shortage is often felt especially during the peak cultivating season. Mechanization will make paddy cultivation profitable and attractive not only by reducing the cost of production and drudgery involved but also by increasing the productivity.

Threshing is identified as the first operation now to be mechanized in paddy cultivation, since it is labour intensive and involves considerable human drudgery. Moreover, adoption of improper threshing methods results in post harvest loss and reducing the net recovery of paddy. The traditional methods of seed separation from the stalk are uneconomical, time consuming and laborious.

Most of the threshers available now have complicated designs and their performance characteristics do not match with the local crop conditions. Due to the high initial cost, power requirement and straw losses, the threshers now available are not adopted by the farmers. Therefore, a low cost power operated paddy thresher cum winnower having reasonable capacity, good threshing and cleaning efficiency operated by a low capacity electric motor has been developed and tested at the Kelappaji College of Agricultural Engineering and Technology, Tavanur.

The developed thresher cum winnower consists of (i) a threshing unit, (ii) a winnowing unit, (iii) a grain collecting tray, (iv) prime mover and power transmission system and (v) a main frame.

The threshing cylinder is made of twelve equally spaced wooden slats fixed around two end rings made of MS flat of 40 x 6 mm size and having a diameter of 310 mm. The wooden slats are of 750 x 70 x 8 mm size. Threshing teeth made of 4 mm GI wire are fixed to these slats at a spacing of 40 mm and are projected 50 mm above these slats. An overall diameter of the threshing cylinder is 450 mm at the tip of the wire loops. The length of the cylinder is kept as 750 mm so that two men can feed the crop at a time.

The cylinder shaft is made of MS rod of 25 mm diameter and is fixed to the frame using ball bearings. The whole cylinder is covered with GI sheet except the feeding portion. A feeding tray and a concave is provided with a provision of adjusting the cylinder concave clearance.

A winnowing unit consists of a sieve and a set of blowers is provided to winnow the grains. The sieve is made of MS sheet of 870 x 750 mm size with oblong holes mounted on an angle frame.

Two blower units mounted on a single shaft of 25 mm and having four blades each and spiral casings are provided below the sieve.

A collecting tray, for clean grains, made of GI sheet is provided below the blower unit so that the threshed grains can be collected easily.

The main frame is made of MS angle of 35 x 35 x 2 mm size. The frame has an overall dimensions of 1008 mm height, 455 mm width and 910 mm length.

The power required to operate the machine is taken from a 2 hp single phase electric motor. V - belts and pulleys are used for transmitting the power.

The overall weight of the equipment is 120 kg.

The developed thresher cum winnower was tested in laboratory and field to analyse the performance. An empirical relation between the energy requirement of machine and the various thresher and crop factors has been developed with the help of Multiple Linear Regression Analysing using computer package MSTATC.

The test results obtained are summerised below.

The optimum speed of the threshing cylinder is 400 rpm.

The capacity of the thresher cum winnower at this speed and at 16.0% moisture content of the crop is 300 kg/h.

The threshing efficiency is 99.25 per cent.

The cleaning efficiency is 91.82 per cent.

The mechanical damage to the grain is negligible.

Two women labourers are required for the whole operation.

Cost of threshing and winnowing per quintal of paddy is Rs 8.50.

The equation developed for the power requirement is

$$P = 931.035 + 4.683\,(MC) - 0.462(PV) - 1.169\,(FR) + 8.251\,(G/S \text{ ratio})$$

where, P - the power requirement of the thresher (Watts)

MC - Moisture content of the crop, (%)

P.V - Peripheral velocity of the cylinder (m/min)

F.R - Feed rate (kg/h)

G/S ratio - Grain/Straw ratio of the crop by weight.

To summerise the findings of the analysis, it is concluded that the Moisture Content of the crop and the Feed Rate have statistically significant effect on Power Requirement of the thresher, but Peripheral Velocity of the cylinder and Grain/Straw ratio of the crop do not have any statistically significant effect.

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# APPENDICES

# APPENDIX - A

Diameters of Pulleys, Speed of the cylinder and motor shafts, Peripheral volocity and the Length of belts used for the evaluvation of the Thresher cum Winnower.

| Sl. No. | Diameter of Pulley on motor shaft (cm) | Diameter of Pulley on cylinder shaft (cm) | Speed of Motor shaft (rpm) | Speed of Cylinder shaft (rpm) | Peripheral Velocity of the cylinder (m/min) | Length of Belt (cm) |
|---|---|---|---|---|---|---|
| 1. | 8.0 | 32 | 1440 | 360 | 508.93 | 240 |
| 2. | 8.4 | 30 | 1440 | 400 | 565.49 | 237 |
| 3. | 8.4 | 23 | 1440 | 510 | 720.99 | 227 |
| 4. | 10.0 | 24 | 1440 | 600 | 848.23 | 231 |

## APPENDIX - B

**Specifications of the developed Thresher cum Winnower**

| | | |
|---|---|---|
| Type | : | Hold - on type with wire loop cylinder and concave |
| Length of cylinder | : | 750 mm |
| Diameter of cylinder | : | 450 mm at the tip of the wire loops |
| Overall length | : | 1080 mm |
| Overall height | : | 1270 mm |
| Overall width | : | 1200 mm |
| Overall weight | : | 120 kg |
| No. of sieves | : | One |
| Shape of sieve hole | : | Oblong with 4 x 18 mm size |
| Blower type | : | Centrifugal |
| No. of blowers | : | Two |
| No. of blower blades | : | Four |
| Blade length | : | 320 mm |
| Blade width | : | 120 mm |
| Prime mover | : | 2 hp single phase electric motor |
| Labour requirement | : | Two women |
| Optimum cylinder speed | : | 400 rpm |
| Capacity | : | 300 kg/h |
| Threshing efficiency | : | 99.25 % |
| Cleaning efficiency | : | 91.82% |
| Cost of operation | : | Rs 8.50 per quintal of Paddy |
| Total cost | : | Rs 8000.00 |

APPENDIX - C

Power requirment of the thresher for different Peripheral velocities of the Cylinder at No load and load conditions.

| Sl. No. | Speed of the motor shaft (rpm) | Speed of the cylinder shaft (rpm) | Speed of blower shaft (rpm) | Air velocity at blower exit (m/min) | Supply voltage (Volts) | Current used (Amperes) | Power Requirment | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | No load (h p) | Load (h p) |
| 1. | 1440 | 360 | 675 | 5.44 | 164 | 5.0 | 0.883 | 1.5 |
| 2. | | | | | 165 | 5.0 | | |
| 3. | | | | | 164 | 5.0 | | |
| 4. | | | | | 163 | 5.1 | | |
| 5. | | | | | 164 | 5.0 | | |
| 6. | 1440 | 400 | 750 | 5.85 | 163 | 5.1 | 0.879 | 1.42 |
| 7. | | | | | 164 | 5.0 | | |
| 8. | | | | | 163 | 5.0 | | |
| 9. | | | | | 163 | 5.0 | | |
| 10. | | | | | 164 | 5.0 | | |
| 11. | 1440 | 510 | 950 | 6.45 | 164 | 5.0 | 0.882 | 1.39 |
| 12. | | | | | 163 | 5.1 | | |
| 13. | | | | | 162 | 5.1 | | |
| 14. | | | | | 164 | 5.0 | | |
| 15. | | | | | 163 | 5.0 | | |
| 16. | 1440 | 600 | 1120 | 7.02 | 163 | 5.0 | 0.881 | 1.35 |
| 17. | | | | | 164 | 5.0 | | |
| 18. | | | | | 164 | 5.0 | | |
| 19. | | | | | 162 | 5.1 | | |
| 20. | | | | | 162 | 5.1 | | |

# APPENDIX - D

## Variables used for statistical analisys

| Var | Type | Name / Description |
|---|---|---|
| 1 | NUMERIC | POWER REQUIRMEBT |
| 2 | NUMERIC | M C |
| 3 | NUMERIC | P V |
| 4 | NUMERIC | F R |
| 5 | NUMERIC | G/S RATIO |

| CASE NO. | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1120.00 | 19.50 | 508.93 | 580.60 | 0.63 |
| 2 | 1120.00 | 19.50 | 508.93 | 580.60 | 0.62 |
| 3 | 1120.00 | 19.50 | 508.93 | 590.20 | 0.64 |
| 4 | 1120.00 | 19.50 | 508.93 | 571.40 | 0.65 |
| 5 | 1120.00 | 19.50 | 508.93 | 590.40 | 0.62 |
| 6 | 1061.00 | 19.50 | 565.49 | 631.60 | 0.69 |
| 7 | 1061.00 | 19.50 | 565.49 | 642.80 | 0.64 |
| 8 | 1061.00 | 19.50 | 565.49 | 620.70 | 0.67 |
| 9 | 1061.00 | 19.50 | 565.49 | 631.60 | 0.66 |
| 10 | 1061.00 | 19.50 | 565.49 | 620.70 | 0.64 |
| 11 | 1040.00 | 19.50 | 720.99 | 679.20 | 0.64 |
| 12 | 1040.00 | 19.50 | 720.99 | 666.70 | 0.64 |
| 13 | 1040.00 | 19.50 | 720.99 | 666.70 | 0.64 |
| 14 | 1040.00 | 19.50 | 720.99 | 679.20 | 0.65 |
| 15 | 1040.00 | 19.50 | 720.99 | 692.30 | 0.63 |
| 16 | 1013.00 | 19.50 | 848.23 | 705.88 | 0.60 |
| 17 | 1013.00 | 19.50 | 848.23 | 720.00 | 0.65 |
| 18 | 1013.00 | 19.50 | 848.23 | 734.69 | 0.60 |
| 19 | 1013.00 | 19.50 | 848.23 | 705.88 | 0.60 |
| 20 | 1013.00 | 19.50 | 848.23 | 720.00 | 0.61 |
| 21 | 988.00 | 16.00 | 508.93 | 692.30 | 0.68 |
| 22 | 988.00 | 16.00 | 508.93 | 705.88 | 0.65 |
| 23 | 988.00 | 16.00 | 508.93 | 692.30 | 0.68 |
| 24 | 988.00 | 16.00 | 508.93 | 705.80 | 0.67 |
| 25 | 988.00 | 16.00 | 508.93 | 705.80 | 0.66 |
| 26 | 960.00 | 16.00 | 565.49 | 750.00 | 0.67 |
| 27 | 960.00 | 16.00 | 565.49 | 765.95 | 0.68 |
| 28 | 960.00 | 16.00 | 565.49 | 750.00 | 0.67 |
| 29 | 960.00 | 16.00 | 565.49 | 734.69 | 0.68 |
| 30 | 960.00 | 16.00 | 565.49 | 765.95 | 0.68 |
| 31 | 952.00 | 16.00 | 720.99 | 782.60 | 0.66 |
| 32 | 952.00 | 16.00 | 720.99 | 800.00 | 0.63 |
| 33 | 952.00 | 16.00 | 720.99 | 800.00 | 0.64 |
| 34 | 952.00 | 16.00 | 720.99 | 800.00 | 0.63 |
| 35 | 952.00 | 16.00 | 720.99 | 782.60 | 0.63 |
| 36 | 940.00 | 16.00 | 848.23 | 837.20 | 0.64 |
| 37 | 940.00 | 16.00 | 848.23 | 857.14 | 0.64 |
| 38 | 940.00 | 16.00 | 848.23 | 857.14 | 0.64 |
| 39 | 940.00 | 16.00 | 848.23 | 837.20 | 0.64 |
| 40 | 940.00 | 16.00 | 848.23 | 857.14 | 0.63 |
| 41 | 964.00 | 14.00 | 508.93 | 654.55 | 0.68 |
| 42 | 964.00 | 14.00 | 508.93 | 642.86 | 0.68 |
| 43 | 964.00 | 14.00 | 508.93 | 666.67 | 0.68 |
| 44 | 964.00 | 14.00 | 508.93 | 642.86 | 0.68 |
| 45 | 964.00 | 14.00 | 508.93 | 642.86 | 0.68 |
| 46 | 942.00 | 14.00 | 565.49 | 705.88 | 0.73 |
| 47 | 942.00 | 14.00 | 565.49 | 692.31 | 0.71 |
| 48 | 942.00 | 14.00 | 565.49 | 679.25 | 0.71 |
| 49 | 942.00 | 14.00 | 565.49 | 692.31 | 0.71 |
| 50 | 942.00 | 14.00 | 565.49 | 692.31 | 0.69 |
| 51 | 938.00 | 14.00 | 720.99 | 765.96 | 0.72 |
| 52 | 938.00 | 14.00 | 720.99 | 750.00 | 0.70 |
| 53 | 938.00 | 14.00 | 720.99 | 765.96 | 0.75 |
| 54 | 938.00 | 14.00 | 720.99 | 765.96 | 0.73 |
| 55 | 938.00 | 14.00 | 720.99 | 750.00 | 0.73 |
| 56 | 926.00 | 14.00 | 848.23 | 800.00 | 0.73 |
| 57 | 926.00 | 14.00 | 848.23 | 782.61 | 0.71 |
| 58 | 926.00 | 14.00 | 848.23 | 818.18 | 0.72 |
| 59 | 926.00 | 14.00 | 848.23 | 800.00 | 0.72 |
| 60 | 926.00 | 14.00 | 848.23 | 782.61 | 0.72 |

Function : MULTIREG
Data case No. 1 to 60

M C
P V
F R
G/S RATIO
POWER REQUIREMENT

| | Minimum | Maximum | Sum | Mean | Uncorrected Sum of Squares |
|---|---|---|---|---|---|
| 2 | 14.00 | 19.50 | 990.00 | 16.500 | 16645.00 |
| 3 | 508.93 | 848.23 | 39654.60 | 660.910 | 27271639.98 |
| 4 | 571.40 | 857.14 | 43003.98 | 716.733 | 31154888.06 |
| 5 | 0.60 | 0.75 | 40.00 | 0.667 | 26.75 |
| 1 | 926.00 | 1120.00 | 59220.00 | 987.000 | 58647590.00 |

60 Cases read        0 Missing cases discarded

Determinants of matrix = 0.095555

| Variable number | Regression Coefficient | Standard error | Std. Partial regr. Coeff. | Std. Err. of Partial Coeff. | Student T Value | Prob. |
|---|---|---|---|---|---|---|
| 2 | 1.7279e+001 | 1.7871e+000 | 6.8465e-001 | 7.0809e-002 | 9.669 | 0.000 |
| 3 | -3.3926e-002 | 2.5331e-002 | -7.8736e-002 | 5.8789e-002 | -1.339 | 0.186 |
| 4 | -3.1673e-001 | 5.4213e-002 | -4.1103e-001 | 7.0353e-002 | -5.842 | 0.000 |
| 5 | 3.0455e+001 | 8.4929e+001 | 1.9850e-002 | 5.5373e-002 | 0.358 | 0.721 |

| | |
|---|---|
| Intercept | = 931.035326 |
| Coefficient of Determination (R-Square) | = 0.938 |
| Adjusted R-Square | = 0.934 |
| Multiple R | = 0.969 |
| Standard Err of Est. | = 14.900 |

ANALYSIS OF VARIANCE TABLE

| | Sum of Squares | df | Mean Square | F | Signif. |
|---|---|---|---|---|---|
| Regression | 185238.758018 | 4 | 46309.68950 | 208.58 | 0.000 |
| Residual | 12211.241982 | 55 | 222.02258 | | |
| Total | 197450.000000 | 59 | | | |

## APPENDIX - E

### Cost of operation of the Low Cost Power Paddy Thresher cum Winnower

| | | |
|---|---|---|
| Total cost of threshing & winnowing | = | Fixed cost + Variable cost |

Approximate cost of the thresher (P)

| | | | |
|---|---|---|---|
| Prime mover (2hp single phase electric motor) | = | Rs | 3,000.00 |
| Cost of other materials | = | Rs | 5,000.00 |
| Total | = | Rs | 8,000.00 |

Assumptions:

| | | | |
|---|---|---|---|
| a. Working hours per year (H) | = | 500 | |
| b. Life of the thresher (L) | = | 10 Years | |
| c. Salvage value (S) | = | Rs 800.00 | (10 %) |

**I Fixed cost :**

| | | |
|---|---|---|
| 1. Depreciation / hour | = | (P - S) / (L x H) |
| | = | (8000 - 800) / (10 x 500) |
| | = | Rs 1.44 |
| 2. Interest per hour | = | (P + S)/2 x 12/100 x 1/H |
| | = | (8000+800)/2 x 0.12 x 1/500 |
| | = | Rs 1.056 |
| 3. Taxes and insurance | = | Nil |
| 4. Housing charges | = | Nil |

| | | |
|---|---|---|
| 5. Repair and maintenance charge per hour (10 % of Total cost) | = | P/H x 10/100 |
| | = | 8000/500 x 10/100 |
| | = | Rs 1.60 |
| Total fixed cost per hour | = | 1.44 + 1.056 + 1.60 |
| | = | Rs 4.096 |

<u>II</u> <u>Variable</u> <u>cost</u> (Operating cost):

| | | |
|---|---|---|
| 1. Labour charges: | | |
| No. of labourers (Women) | = | 2 |
| Working hours per day | = | 8 |
| Labour charges per hour @ Rs 80/- person / day | = | 2 x 80 / 8 |
| | = | Rs 20.00 |
| 2. Energy consumption per hour | = | 1 Unit (1 KW) |
| Electricity charges / unit | = | Rs 0.40 |
| Electricity charges / hour | = | Rs 0.40 |
| 3. Lubrication charges per hour | = | Rs 0.05 |
| Total operating cost | = | 20 + 0.40 + 0.05 |
| | = | Rs 20.45 |
| Total cost of threshing and winnowing per hour | = | I + II |
| | = | 4.096 + 20.45 |
| | = | Rs 24.546 |

| | | | |
|---|---|---|---|
| Assume an establishment charge @ 5% of total cost of threshing and winnowing | | = | 24.546 x 5/100 |
| | | = | Rs 1.227 |
| Total cost of operation | | = | Rs 25.773 |
| | Say | | Rs 26.00 |
| Capacity of thresher | | = | 306 kg/h |
| | | = | 3.06 q/h |
| Cost of threshing and winnowing per quintal | | = | 26.00 / 3.06 |
| | | = | Rs 8.49 |
| | Say | | Rs 8.50 |

# DEVELOPMENT AND EVALUATION OF A LOW COST POWER OPERATED PADDY THRESHER-CUM-WINNOWER

By

**SURESHKUMAR, P. K.**

## ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree of

# Master of Technology in Agricultural Engineering

Faculty of Agricultural Engineering & Technology
KERALA AGRICULTURAL UNIVERSITY

Department of Farm Power Machinery and Energy
KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY
TAVANUR - 679 573
MALAPURAM

1996

**ABSTRACT**

Since threshing is labour intensive and involves considerable human drudgery and as the threshers now available are not suitable for small and marginal farmers, a Low Cost Power Operated Paddy Thresher cum Winnower has been developed and tested.

The machine consists of a threshing unit of wire loop cylinder and cover, a winnowing unit, a grain collecting tray, prime mover, power transmission system and the main frame. The power required to operate the machine is taken from a 2 hp electric motor and is transmitted to the cylinder and blower shafts by V-belt and pulley arrangement. Two labourers can hold the crop against the threshing cylinder.

The optimum cylinder speed is 400 rpm. The capacity of the thresher at 16.0 per cent moisture content of the crop is 300 kg per hour. Threshing and cleaning efficiencies are 99.25 and 91.82 per cent respectively. Mechanical damage to the grain is negligible. The labour requirement of the thresher cum winnower is two.

The cost of the thresher cum winnower was found out to be around Rs 8000.00 and the cost of operation for threshing and winnowing was Rs 8.50 per quintal.

An empirical relation between the energy requirement of the thresher and various crop and thresher parameters is

$$P = 931.035 + 4.683\ (MC) - 0.462\ (PV) - 1.169(\ FR) + 8.251\ (G/S\ ratio)$$

The moisture content of the crop and the Feed Rate have statistically significant effect on Power Requirement whereas the cylinder speed and Grain/Straw ratio do not have any statistically significant effect.

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