TESTING AND PERFORMANCE EVALUATION OF HOLD-ON TYPE POWER PADDY THRESHER

By

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PROJECT REPORT

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DECLARATION

I hereby declare that this Project report entitled **"Testing and performance evaluation of hold-on type power paddy thresher"** is a bonafide record of project work done by me and that this work has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title to me of any other University or Society.

Tavanur,

10-06-1992.

O. Basudev Singh

CERTIFICATE

Certified that this project report entitled **"Testing and performance evaluation of hold-on type power paddy thresher"** is a bonafide record of project work done by **Sri. O. Basudev Singh** under my guidance and supervision and that it has not formed the basis for the award of any degree, diploma, fellowship, associateship or other similar title to him, of any other University or Society.

Tavanur,
10-06-1992.

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SYMBOLS AND ABBREVIATIONS USED

Agric.	Agriculture
ASAE	American Society of Agricultural Engineering
cm	centimetre(s)
Dept.	Department
et al.	and other people
etc.	et cetera
Engg.	Engineering
Fig.	Figure
GI	Galvanized iron
h	hour(s)
ha	hectare(s)
hp	horse power
ICAR	Indian Council of Agricultural Research
i.e.	that is
IRRI	International Rice Research Institute
ISAE	Indian Society of Agricultural Engineers
ISI	Indian Standard Institution
J	Journal
kg	kilogram(s)
kg/h	kilogram(s) per hour
kg/min	kilogram(s) per minute
kg/s	kilogram(s) per second
kg cm	kilogram centimetre
Ltd.	Limited
m	metre(s)

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
p.	pages
q	quintal
q/h	quintal per hour
Res.	Research
rpm	revolution per minute
Rs.	Rupees
s	second(s)
viz.	namely
/	per
%	percentage
°	degree (angle)
PAU	Punjab Agricultural University

INTRODUCTION

India is a vast country characterized with high population density and generally small farm holdings. According to 1991 census, Indian population is 84,39,30,861 and it is increasing at an alarming growth rate of 23.5 per cent. Per capita consumption of rice is 74 kg. So with the explosion of population, the demand for food grain is increasing day by day. However, the per capita consumption of rice has been almost stagnant or rising very slowly. To meet the increasing demands, it is high time for Scientists and Engineers to take necessary steps for the resurrection of rice cultivations in India.

Rice is predominantly produced with labour intensive cultivation practices and its production and processing requires nearly half of the labour force. There is little doubt that human and animal will continue to be major source of power in rice production for many years. Agricultural mechanization is however, starting to gain importance in our country as it helps in improving land and labour productivity by reducing turn around time, improving timeliness of operations and increasing cropping intensities. Mechanization also helps in reducing the drudgery from farm production operations.

There are essentially two types of rice mechanization technologies available from the industrialized world.

(a) Japanese approach: The main focus of the Japanese mechanization technology is on more efficient utilization of available labour and other agricultural inputs.

(b) Western approach: The main focus of the western mechanization technology is towards minimization of labour from farming.

The traditional methods of manual threshing contributes to high losses from poor threshing, shattering, and deterioration of harvested paddy. Manual threshing is labour intensive and involves considerable human drudgery. Moreover adoption of improper threshing methods 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. Moreover oftenly the scarcity of labour during the peak reason and unfavourable weather changes the loss unpredictably.

Efforts are also being made at different places in India to develop/identify a suitable paddy thresher for medium farmers. Most of the threshers available in India have complicated important designs and their performance characteristics does not suit to local crop conditions. They are very expensive and power requirement is very high. So farmers of small/medium holdings cannot easily afford. Hence a simple low cost hold on type power thresher having medium capacity and good threshing efficiency is needed. It is in this context a "Low cost hold-on-type power paddy thresher" was developed in the Department of Farm Power Machinery and Energy, K.C.A.T, Tavanur. And a project for the testing and evaluation of the thresher with the following objectives was undertaken.

(i) to find out the optimum peripheral velocity of threshing cylinder for a maximum threshing capacity of above 250 kg/hr.

(ii) to evaluate the performance of the prototype.

(iii) to assess the economic viability of the model.

(iv) to introduce and popularise the machine to local farmers.

REVIEW OF LITERATURE

A brief review of research works conducted in this field is discussed here under the following heads:

1. Threshing and methods of threshing
2. Paddy threshers
3. Performance evaluation
4. Recent development of threshers

Threshing involves the detachment of paddy kernels from the panicle and can be achieved by three methods. (1) Rubbing action, (2) Impact and (3) Stripping.

Rubbing action occurs when paddy is threshed by trampling by manual, animals, or tractors. It is not efficient method for threshing.

The impact method is the most popular method of threshing paddy. Most mechanical threshers primarily utilize the impact principle of threshing, although some stripping action also involved.

Stripping method has been used in paddy threshing. Some impulsive stripping occurs ordinarily with impact threshing in conventional threshing cylinder. Non-impulsive type of stripping has been tried experimentally in centrifugal threshers and strippers but no commercial machine has so far been successfully developed.

2.1 Methods of threshing

Depending upon the type power source used, threshing can be classified as, (1) Manual threshing, (2) Animal threshing and (3) Mechanical threshing.

2.1.1 Manual threshing

The methods used for threshing paddy by manual labour are: treading by feet; flail threshing; and beating on tubs, threshing boards, or racks. By this methods a man can thresh from 15 to 40 kg of brown rice per hour. Manual threshing is a slow and labour consuming process. Sahay (1977) reported that output of hand beating is about 17-20 kg/hr.

2.1.2 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 a 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. One man drives the bullocks from the back. Sahay (1977) reported that the output of this traditional method of treading with bullocks is 140 kg/hr.

Tree branch threshing

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

Punched sheet threshing

Corrugated metal sheet with punched holes has been used for threshing. The jaggered edges formed by punching hole 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.

Olpad threshing

It is a machine driven by a pair of bullocks. Olpad thresher is said to have its origin at a small place named Olpad in Gujarat State. This thresher consists of 20 circular disks each of 45 cm diameter and 3 mm thickness placed 15 cm apart in three rows. An angle iron frame supports the disk shafts. A wooden platform supported on the frame is provided as the operator's seat. Steel mesh is also fixed on the machine to guard against the serrated edges of these desks. All the disks are mounted staggered to give more effective cutting of straw. A pair of bullocks pull over the spread crop with driver sitting over it. Loading the thresher with weights increases its efficiencyl. Michael (1966) reported that the capacity by a pair of bullock is 35 kg/hr.

Disk harrow threshing

The use of bullock drawn disk harrow for threshing has been demonstrated successfully. A single action disk harrow with six or eight disks compare favourably with the Olpad thresher in work output. The disk harrow has an added advantage that the churning effect due to angling of the gangs helps in allowing the grain to shift down to the bottom, thereby reducing the labour of shaking the crop.

2.1.3 Mechanical threshing

Trading under tractor tyres: This method of threshing has been used in some Asian countries. It is quite popular in Sree Lanka for custom threshing. The popularity of this method can be attributed only to a lack of suitable tractor PTO-driven threshers. A theshing capacity of 640 kg/hr has been reported from Sree Lanka when two threshing floors are alternately worked with one tractor (Araullo et al., 1976).

Power Threshing

The mechanical threshers were introduced to do the threshing efficiently and quickly. The capacity of these threshers ranges from 200 kg/hr to 1500 kg/hr. These mechanical threshers not only thresh the crop but also clean the grain and thus the quality of the grain is considerably improved as compared to the traditional threshing are listed below (Pradhan, 1968 and Johnson, 1969).

1. The efficiency of threshing is high.
2. The threshing is quick and time saving.
3. The labour charges can be reduced considerably.
4. Timeliness of operation reduces various losses.
5. Minimise the grain losses irrespective of threshable character of the variety.
6. Studies shows that crack ratio is higher in paddy sample threshed by beating.
7. Most of the improved variety of paddy are weakly dormant and there is greater possibility of germination in field.
8. Even the small quantity of crop can be threshed separately without deterioration in the quality.
9. Cleaning of grain is efficient.
10. It produced good quality chaff.

Power paddy threshers can be classified based on the feeding method as: (1) Hold-on-type, (2) Throw-in type.

In hold-on type of threshing, paddy stalk is held stationary while threshing is done by the impact on the panicle from the cylinder bars, spikes or wire loops.

In throw-in type of machine whole paddy plants are fed into the machine and a major portion of the grain is threshed by the initial impact of the bars or spikes on the cylinder. The initial impact also accelerates the straw and further threshing is accomplished as the moving panicles hit the spikes or bars of concave.

2.2 Paddy threshers

2.2.1 Manually operated paddy threshers

The mechanical equipment used for manual threshing is the pedal thresher that originated in Japan during the early stage of mechanization. This thresher is also popular in Taiwan where a threshing team of 6-7 men work with each machine. The crew moves in a circle while one or two men are threshing the others collect and bring new paddy bundles. The cylinder rotates at about 300 rpm and the inertia of the cylinder keep the drum rotating as men take turns at pedalling the machine. There is no cleaner with threshers. Tests at IRRI with this thresher indicates an output of about 30-70 kg of paddy per hour. In Taiwan, 60-65 man-h/ha are required for threshing with a pedal thresher which gives an approximate output of about 50-80 kg/hr (Michael Graham et al., 1976).

The threshers which can be operated with the help of bicycle is also available. It has a capacity of 91 kg/hr (Kherdekar, 1967).

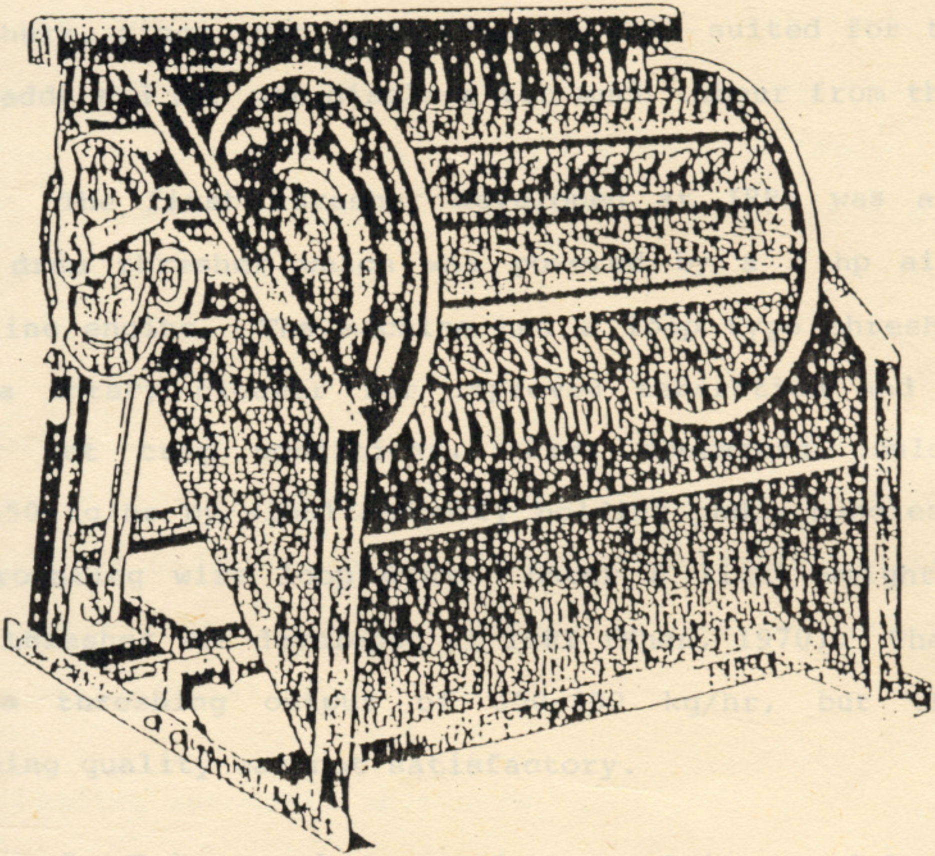


Fig.1 Japanese Pedal Paddy Thresher

2.2.2 Power operated paddy threshers

Hold-on type

Work on the development of paddy threshers were started at IRRI in the year 1967 (Khan _et al._, 1967). The early attempts were focussed on developing hold-on type threshers, since such machines were well suited for threshing wet paddy and did not displace too much labour from threshing.

The first thresher developed at IRRI was a hold-on type drum thresher which was powered by a 4 hp air cooled gasoline engine. The machine had a loop type threshing drum and a rotary cleaner for improved separation and cleaning under wet crop conditions. Five operators could thresh 300-450 kg/hr by simultaneously holding paddy bundles against the rotating wire loop drum. Later a light weight hold-on type thresher was developed at IRRI (Khan, 1970). The machine had a threshing output of 350-400 kg/hr, but the grain cleaning quality was not satisfactory.

In Taiwan and some other countries, pedal threshers have been converted for power operation by using small air cooled engines.

These machine have no grain separators or winnowers. Cleaning is a time consuming problem and the output is relatively low. These threshers are however, simple and can be manufactured in most Asian countries. Attempts are being made in many Asian countries to incorporate simple separating and winnowing mechanism in such threshers.

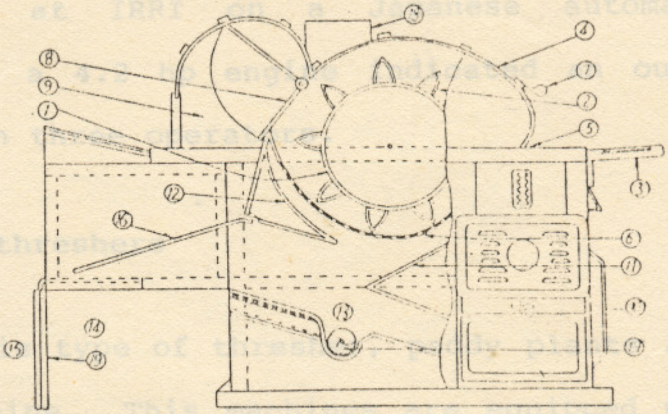
Japan power threshers

These machines are equipped with a wire loop threshing drum and regular cleaning and winnowing mechanisms. Due to hold-on method of finding, output is not too high, but the machine can do a good job of grain cleaning. Relatively high labour is required because the paddy bundles have to be held by the operator until threshed.

Both single-drum and double-drum threshers are offered by Japanese manufacturers. These machines can be operated either as a hold-on or throw-in thresher. Experience with double-drum thresher in the Phillippines indicates that it is quite well suited for threshing both wet and dry paddy and other agricultural crops.

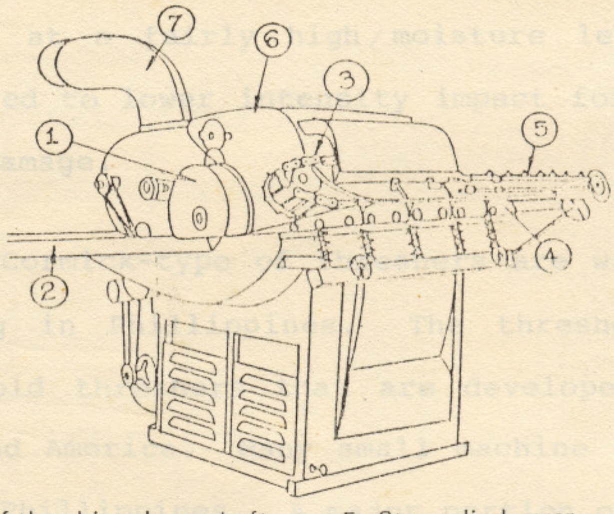
Self feeding automatic threshers

These machines are similar to the non-automatic thresher except that these machines are equipped with paddy gripping feed chains that automatically feed the paddy in a continuous layer. The threshing output is high and the machine requires less labour.



1. Threshing drum
2. Threshing teeth
3. Feeding table
4. Concave
5. Fan (inside)
6. Main grain outlet
7. Immature grain outlet
8. Chaff outlet
9. Cover

Fig. 2. THRESHER (HOLD-ON TYPE)



1. Pulley of threshing drum shaft
2. Feeding table
3. Feeding chain
4. Feeding rail
5. Straw discharger
6. Cover
7. Drum for discharge of chaff

Fig.3 Self feeding automatic thresher

Tests at IRRI on a Japanese automatic thresher equipped with a 4.2 hp engine indicated an output of about 200 kg/hr with three operators.

.

Through-flow threshers

In this type of thresher, paddy plants are completely fed into machine. This machines are equipped with threshing cylinder and concave and have some separating and cleaning mechanisms. The rasp-bar cylinder was previously considered suitable for rice, however, all of the new rice threshers and combines are equipped with spike-tooth cylinder. The spike tooth cylinder can operate without clogging even with large amount of straw at a fairly high moisture levels, and the grain is subjected to lower intensity impact forces resulting in lower grain damage.

Large McCormick-type of threshers are widely used for custom threshing in Phillippines. The threshers are exact copies of the old threshers that are developed 50-70 years ago in Europe and America. Many small machine shop fabricate this machine in Phillippines. A major portion of paddy in the Philippines is custom threshed with this threshers. These threshers are belt driven from 45000 W (60 hp) tractor PTO pulley. Usually a crew of 8-12 men operates these machines which thresh about 20-30 tonnes of paddy per day. Because of high threshing capacity this machine is moved often which results in substantial down time.

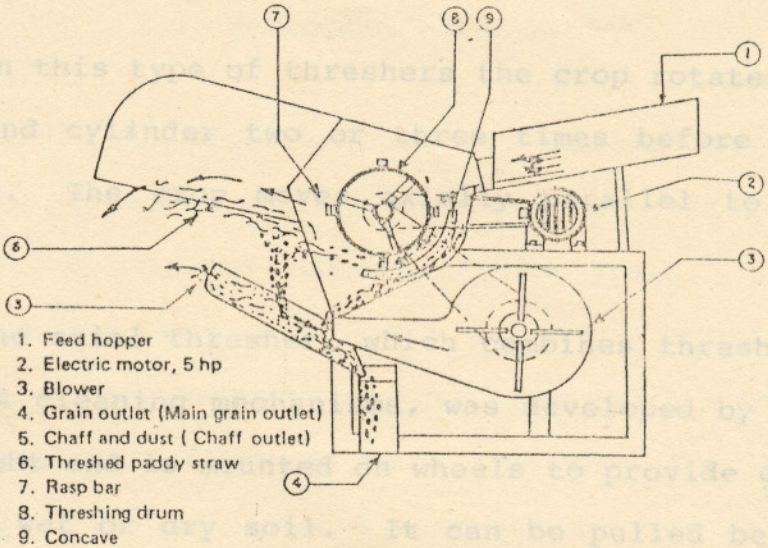


Fig. 4 PADDY THRESHER (THROW-IN TYPE)

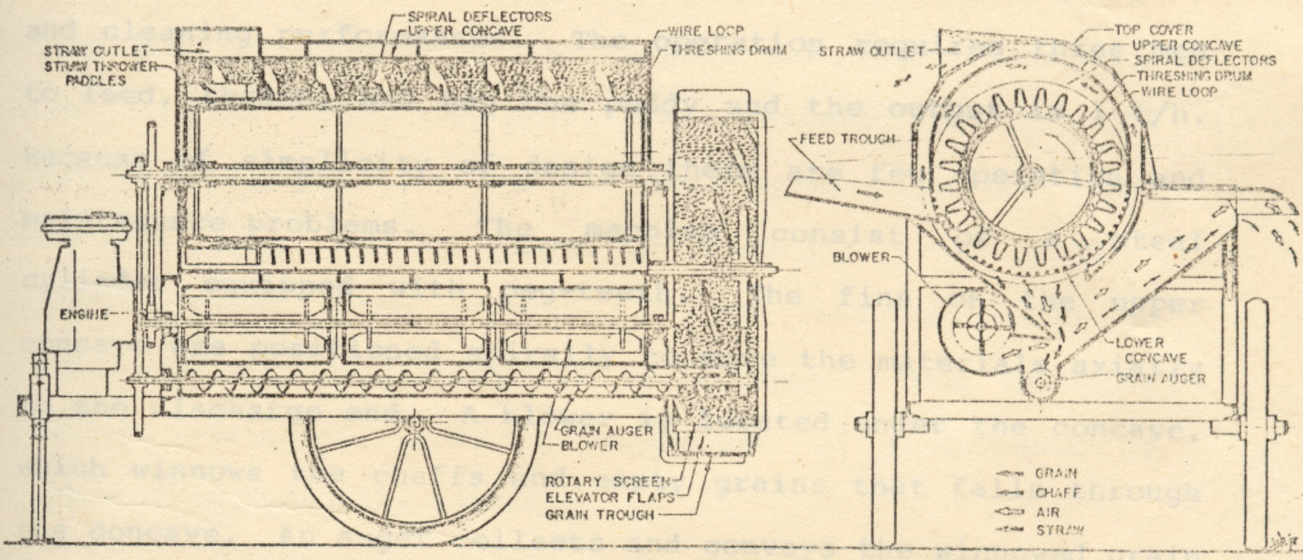


Fig.5 Schematic drawing of IRRI axial-flow thresher

Axial flow threshers

In this type of threshers the crop rotates between the concave and cylinder two or three times before throwing out the straw. The crop moves axially parallel to the axis of cylinder.

The axial thresher, which combines threshing with air and screen cleaning mechanisms, was developed by IRRI. It is light weight and is mounted on wheels to provide good mobility in either wet or dry soil. It can be pulled behind a small hand tractor, a jeep, or a truck.

This thresher is powered by a 7 hp air cooled engine and can handle freshly harvested paddy with good separation and cleaning performances. The operation requires three men to feed, thresh, and bag the paddy and the output is 1 t/h. Because of simplicity of design there are few operation and maintenance problems. The machine consist of a steel cylinder equipped with peg-teeth. The fins on the upper concave are positioned spirally to move the materials axially to the discharge end. A blower is located under the concave, which winnows the chaffs and empty grains that falls through the concave. An auger collects and conveys the winnowed grain to a rotary sieve. This sieve separates pieces of straw that passes through the perforated concave and that are not blown by air from the full grain. The grain from the sieve drops to a trough and is then conveyed by elevator flaps to the bags.

2.3 Performance evaluation

Amir-U-Khan reported that one of the most important variables to consider while evaluating the performance of a machine is the moisture content of the grain. Because the same machine may have an entirely different capacity for wet and dry grains, the moisutre content of grain should always be recorded when evaluating the rated capacity. The capacity of the machine should be stated either raw and wet paddy with a moisture content greater than 15 per cent, or for precleaned and dried paddy with a moisture content equals to 15 per cent.

Other factors that should be considered when evaluating the performance of the machine are fuel consumption (l/kg), labour supply (man h/kg), and investment cost (per kg). Although standards have not yet been established for these variables they should always be recorded. It is also important that rated capacity of the machine should be determined when evaluating its performance. Thus by using standard variables, accurate comparison of performance of different machines are possible.

But Kepner <u>et al</u>. (1978) reported that the primary performance parameters of a threshing unit are the per cent of seed detached from the non-grained parts of the plant and per cent of seed that is damaged. Two additional parameters that are important because they affect the performance of the separating and cleaning units are the per cent of seed separated through the concave grate and the degree of break up of straw.

Most of seed damaged occurs in the threshing unit, primarily because of impact blows received during the threshing process. Seed damaged may viable or it may be internal, the latter type being determinable only by germination tests or with special instruments. The significance of seed damaged depends upon the intended use for the seed or grain.

2.3.1 Effect of operating conditions upon cyliner losses and seed damage

The threshing effectiveness is related to the following parameters:

a. The peripheral velocity of the cylinder.

b. The type of crop.

c. The conditions of the crop in term of moisture content, grain ratio, maturity of crop etc.

d. Method and rate of feeding the material into the machine.

e. The number of times the material passes the concave.

f. Cylinder and concave clearance.

g. The number of rows of concave teeth used with spike-tooth cylinder

Cylinder speed is the most important operating parameter in regard to threshing efficiency,cylinder loss and seed damage. Increasing the speed reduces the cylinder loss

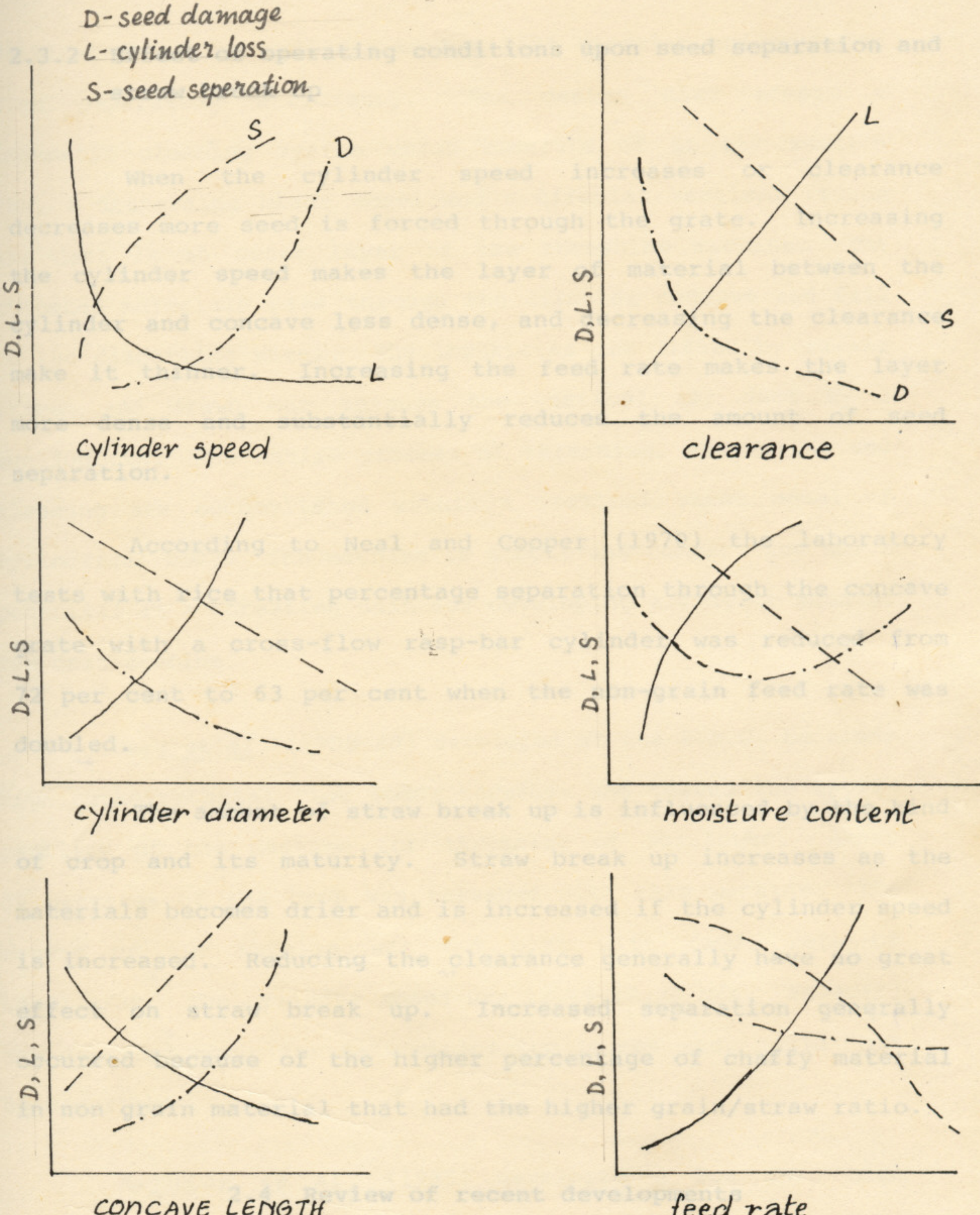


Fig.6 Factors affecting seed separation, damage and grain loss

2.3.2 Effect of operating conditions upon seed separation and straw break up

When the cylinder speed increases or clearance decreases more seed is forced through the grate. Increasing the cylinder speed makes the layer of material between the cylinder and concave less dense, and decreasing the clearance make it thinner. Increasing the feed rate makes the layer more dense and substantially reduces the amount of seed separation.

According to Neal and Cooper (1970) the laboratory tests with rice that percentage separation through the concave grate with a cross-flow rasp-bar cylinder was reduced from 72 per cent to 63 per cent when the non-grain feed rate was doubled.

The amount of straw break up is influenced by the kind of crop and its maturity. Straw break up increases as the materials becomes drier and is increased if the cylinder speed is increased. Reducing the clearance generally have no great effect on straw break up. Increased separation generally occurred because of the higher percentage of chaffy material in non grain material that had the higher grain/straw ratio.

2.4 Review of recent developments

James Ma (1991) reported about a new vertical axial-blow threshing machine which was developed in China. It has a woven wire mesh concave at the bottom of the cylinder. Deflection louvers, were provided on upper concave to move crop from one end to the other end of cylinder while threshing. The long straws are thrown out of the cylinder by a straw thrower and grain with little chaffs fall through the concave and directed towards the air blast by a blower mounted under the threshing drum. The machine operated by a 5 hp electric motor. The test results shows capacity of thresher to be 434 kg/hr clean grain at cylinder speed of 480 rpm and grain - straw ratio of 1.2:3. The threshing efficiency was 99.99 per cent and grain damage was negligible. The grain loss in the straw was 1.3 per cent. The cleaning efficiency was 85 per cent.

IRRI (1985) developed a portable thresher at the Agricultural Engineering Department, which is simple, easy to manufacture and operate, light weight and portable for easy movement to the field on existing pathways. This machine is a smaller version of the IRRI axial flow thresher. it retains the throw-in and hold on features and axial movement of the materials inside the thresher which provides high threshing efficiency over a wide range of moisture levels. It is driven by a 5 hp gasoline engine and has a capacity of 300 to 600 kg/h depending on crop conditions.

A dual mode all crop thresher has been developed in Egypt in 1989 which can be operated as a beater or an axial flow type machine. This machine can thresh all the popular

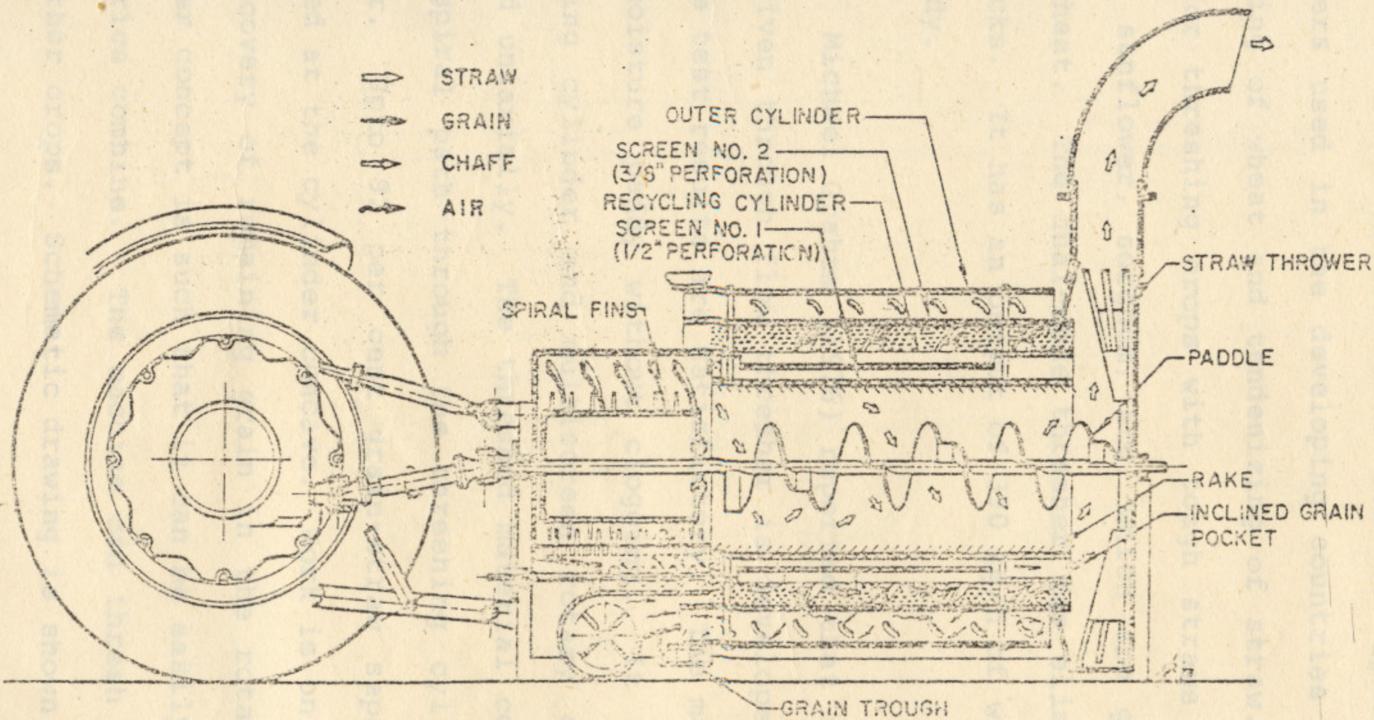
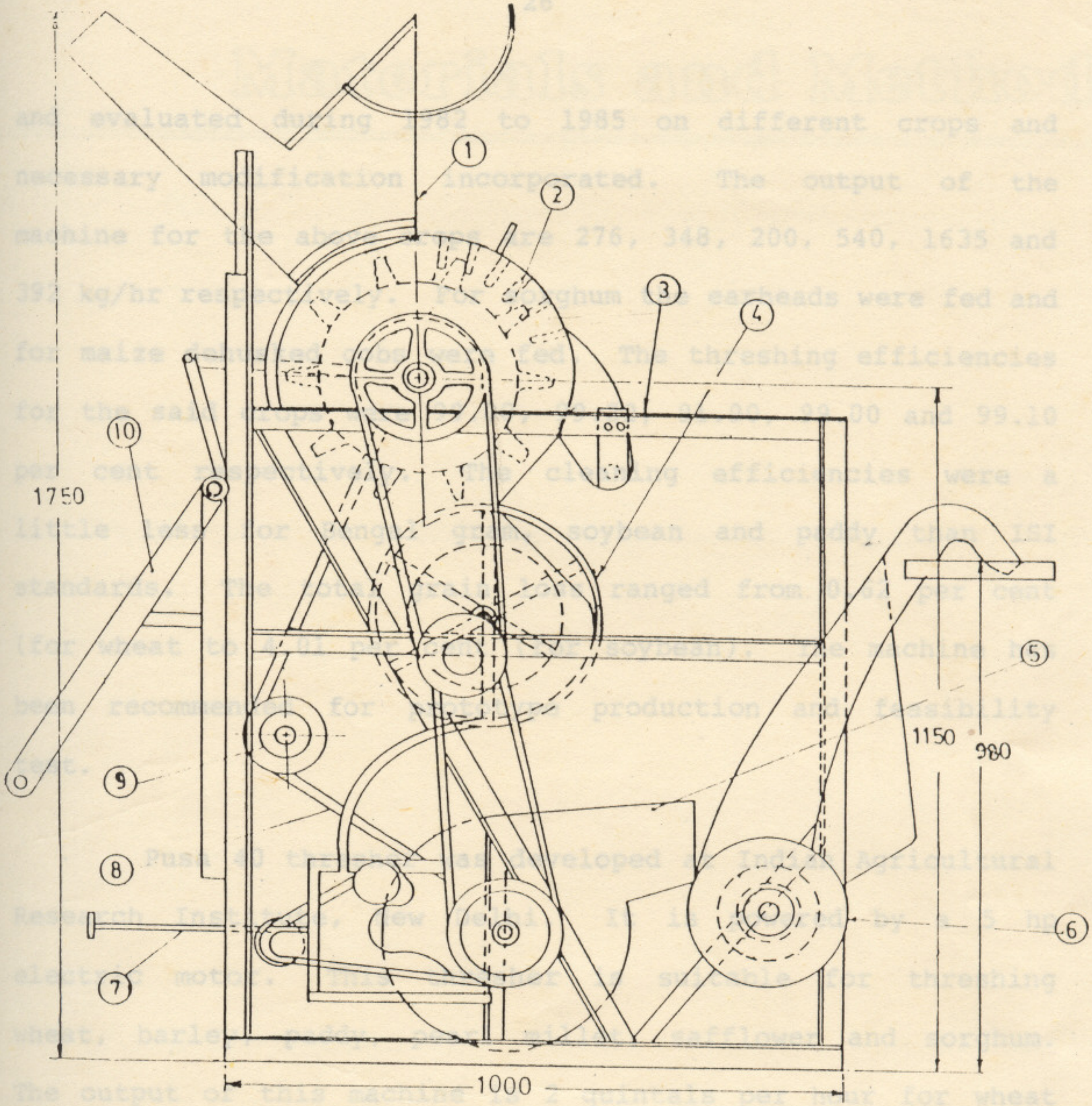


Fig.7 Schematic drawing of the IRRI PTO-driven thresher

cereal crops that are grown in the developing countries and can also make fodder from straw. Special beater type threshers used in the developing countries for simultaneous threshing of wheat and tendenizing of straw. This cannot be used for threshing crops with tough straws or cobs such as paddy, sunflower, sorghum, etc. which are grown in rotation with wheat. The dual-mode thresher has eliminated all these drawbacks. It has an output of 390 kg/h of wheat and 634 kg/h of paddy.

Michael Graham (1976) reported that a tractor mounted PTO driven through flow thresher is developed at IRRI and so far the test results are satisfactory. The machine can thresh high moisture paddy without clogging. It uses spike tooth threshing cylinder and multiscreen rotary cleaner that are mounted uniaxially. The threshed material continuously moves in a spiral path through the threshing cylinder and rotary cleaner. Upto 92 per cent grain-straw separation has been achieved at the cylinder concave. Work is on hand to optimize the recovery of remaining grain in the rotary cleaner. The thresher concept is such that it can be easily adapted for low cost price combine. The machine can thresh paddy, wheat and many other crops. Schematic drawing is shown in Fig. .

Majundar (1985) reported that a multicrop thresher was designed and developed for threshing wheat, Bengal gram, sorghum, maize and paddy. The prototype was developed in 1982



1. Feed hopper
2. Threshing drum
3. Angle iron frame
4. Beater drum
5. Blower fan
6. Elevator grain chute
7. Air blast regulator
8. V-belt drive
9. Shaker
10. Hitch

ALL DIMENSIONS IN MM

Fig.8 Pusa 40 thresher

and evaluated during 1982 to 1985 on different crops and necessary modification incorporated. The output of the machine for the above crops are 276, 348, 200, 540, 1635 and 392 kg/hr respectively. For sorghum the earheads were fed and for maize dehusked cobs were fed. The threshing efficiencies for the said crops were 99.00, 99.22, 91.90, 99.00 and 99.10 per cent respectively. The cleaning efficiencies were a little less for Bengal gram, soybean and paddy than ISI standards. The total grain loss ranged from 0.62 per cent (for wheat to 4.01 per cent (for soybean). The machine has been recommended for prototype production and feasibility test.

Pusa 40 thresher was developed at Indian Agricultural Research Institute, New Delhi. It is powered by a 5 hp electric motor. This thresher is suitable for threshing wheat, barley, paddy, pearl millet, safflower and sorghum. The output of this machine is 2 quintals per hour for wheat threshing. The working parts and functions are shown in Fig. .

MATERIALS AND METHODS

The details of the Hold-on type power paddy thresher which was used for testing and evaluation and experimental procedures are presented in this chapter.

3.1 Details of threshing machine

The Hold-on type power paddy thresher has the following units.

1. Threshing drum (cylinder)
2. Cylinder cover
3. Blower
4. Feeding tray
5. Frame
6. Prime mover
7. Power transmission system

3.1.1 Threshing cylinder

The diameter of the cylinder is 450 mm at the tip of the wire loop. The threshing cylinder is made up of twelve equally spaced wooden slates fixed around the two end disks of MS plates of 6 mm thick and 310 mm dia. each. The slates are 70 mm wide, 18 mm thick and 750 mm length. The threshing teeths of 4 mm dia. G.I. wires are projected 50 mm above the surface of the slates. The distance between the bottom ends of each tooth is 35 mm on the slates. The length of the cylinder is 750 mm. This facilitates for feeding the paddy sheaves against the cylinder by two persons at a time. The length of shaft between the two bearing is 880 mm.

3.1.2 Cylinder shaft

The cylinder shaft is made of MS rod of dia. 25 mm and has a length of 1080 mm. The cylinder is fixed on this shaft. Two V-belt pulleys are fixed at both ends of shaft. One pulley is to take power from motor to the cylinder shaft and other to take power from cylinder to the blower. The shaft is fixed to frame through ball bearings.

3.1.3 Cylinder cover

The front and sides of the cylinder are covered with GI sheet of 22 gauge. The length of the cover is 845 mm and has a width of 580 mm.

At the bottom of the cylinder a GI plate of 22 gauge is provided at an angle of 30° to the horizontal which is greater than the angle of repose of paddy. The bottom plate is converged to get 500 mm width at the front by bending the sides of the plate.

A feeding tray, having a length of 925 mm and width of 295 mm is provided at the back side of cylinder and attached to the bottom plate. It is made of MS sheet of 20 gauge.

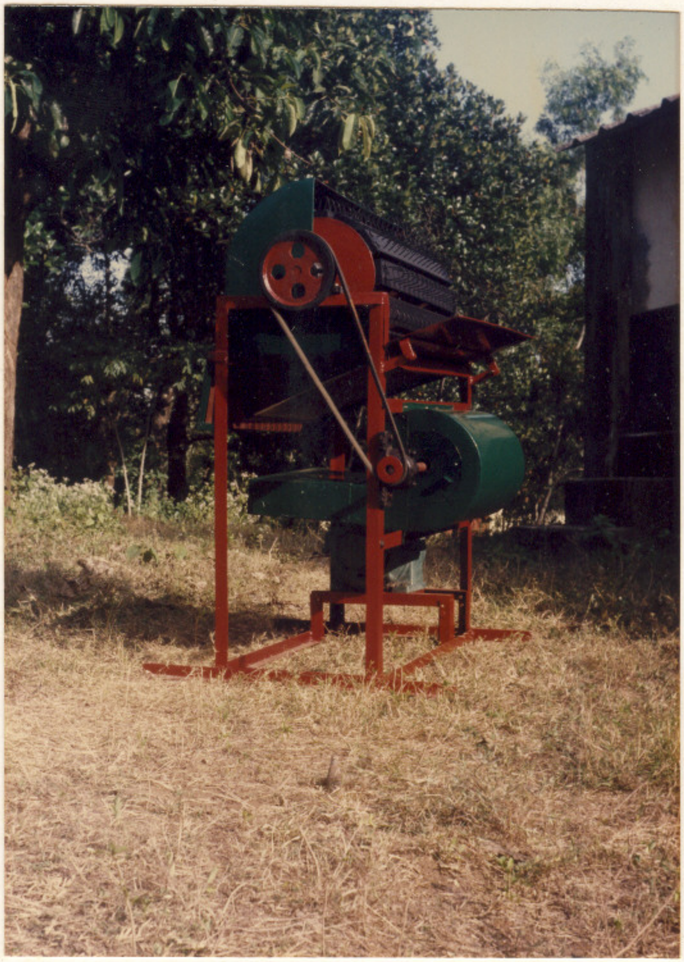


Plate I Hold on type Power Paddy thresher

Provisions were made to adjust lthe clearance between the feeding tray and cylinder. A grain stopper of length 915 mm and width of 200 mm is provided at the front of the frame in order to prevent the throwing out of paddy grains.

3.1.4 Blower

A blower is provided below the cylinder at a distance of 495 mm from the cylinder shaft and has four blades of MS sheet of 405 mm length and 100 mm width. The blower casing is made of GI sheet of 22 gauge and has a diameter of 328 mm. It has a length of 520 mm. The shaft of the blower is made of MS rod of 1000 mm length and 25 mm diameter. Two ball bearings are provided at the end of the shaft. Two air inlets are provided at the side of the blower casing and has two slide covers to control the air inlet. The air outlet is extended to the front of the frame and has a length of 455 mm.

3.1.5 Frame

The whole frame is made of MS angle of 35 x 35 x 2 mm size. The frame is rectangular in shape when looked from all sides. The frame has a height of 1008 mm, width of 455 mm and length of 910 mm. At the base of the frame two 860 mm long 37 x 37 x 5 mm size MS angle pieces are fixed parallel to the ground, to get stability. The threshing cylinder is mounted at the centre on the top of the frame and the motor is fixed on the stand made at the bottom of the frame.

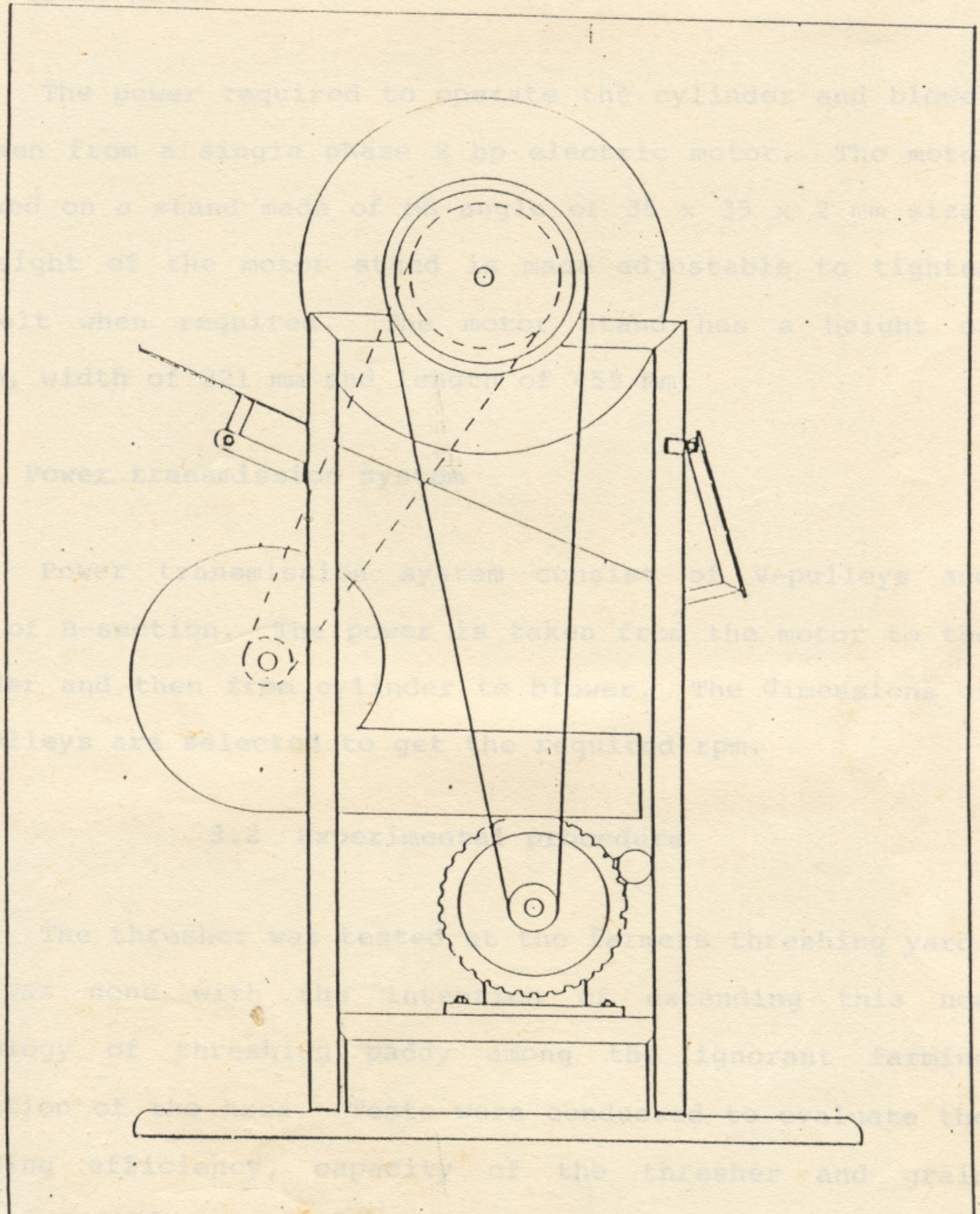


Fig.3 Power transmission system of Hold-on type power paddy thresher

3.1.6 Prime mover

The power required to operate the cylinder and blower is taken from a single phase 2 hp electric motor. The motor is fixed on a stand made of MS angle of 35 x 35 x 2 mm size. The height of the motor stand is made adjustable to tighten the belt when required. The motor stand has a height of 154 mm, width of 221 mm and length of 455 mm.

3.1.7 Power transmission system

Power transmission system consist of V-pulleys and belts of B-section. The power is taken from the motor to the cylinder and then from cylinder to blower. The dimensions of the pulleys are selected to get the required rpm.

3.2 Experimental procedure

The thresher was tested at the farmers threshing yard. This was done with the intention of extending this new technology of threshing paddy among the ignorant farming population of the area. Tests were conducted to evaluate the threshing efficiency, capacity of the thresher and grain looses at different peripheral velocities of the cylinder. The paddy variety harvested in the summer season, 'Red Triveni' was used for the test and it has grain-straw ratio of 1:1.3

Plate II Experimental set up for field test

Plate III Experimental set up for field test

The testing was done at different rpm of the threshing cylinder from 382.9 to 672 viz., 382.9, 509, 609, and 672. Pulleys of different diameter were used to obtain the different speeds. Conepulleys of diameters 76 mm, 89 mm, 102 mm, and 114 mm were fixed on the motor shaft successively for varied speeds. As the cylinder diameter at the tip of the wire loop is 450 mm, the four ranges of peripheral velocities used were 539.89 m/min, 719.99 mm/min, 860.19 m/min, and 950.46 m/min respectively.

The three levels of moisture contents of the crop used for testing were 13.4, 16.7 and 19.6 per cent (wet basis) respectively. The moisture content of the grain was determined by using the universal moisture meter and the rpm of the threshing cylinder was recorded with the help of tachometer.

The first trial was done at the rpm of 382.9 of the threshing cylinder. Approximately 20 bundles of crop was piled near the thresher before starting the operation. This much of the crop was proved enough to work for 20 minutes. Two persons were engaged to feed the bundles simultaneously to the machine. The threshing time for each test run was recorded. Threshed grains were collected from the main grain outlet. Unthreshed broken earheads were separated from the grain. The unthreshed earheads were also collected from the

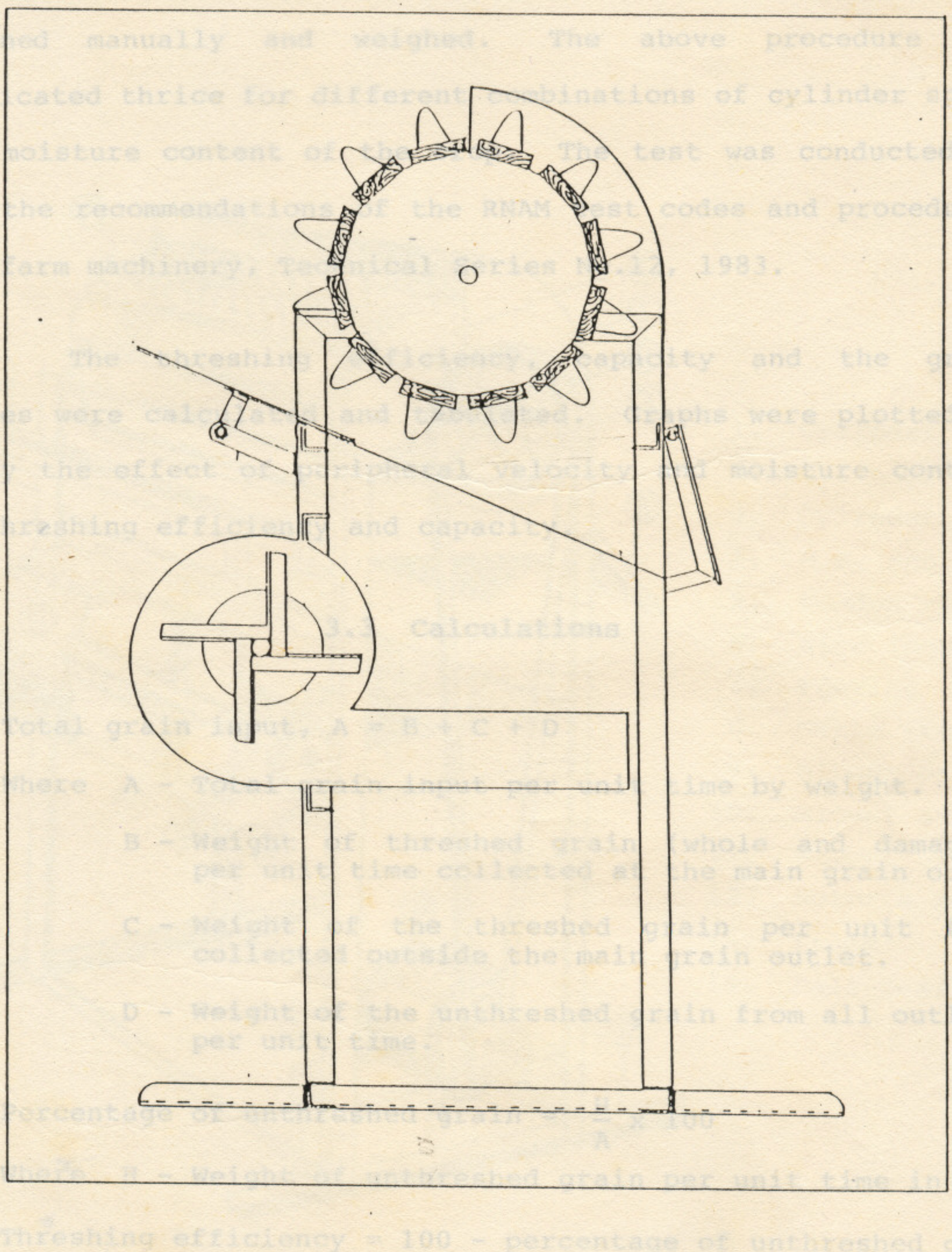


Fig.4 Sectional side view of Hold-on type power paddy thresher

threshed bundles. The cleaning operation was not done properly by the thresher. The total threshed grains were cleaned manually and weighed. The above procedure was replicated thrice for different combinations of cylinder speed and moisture content of the crop. The test was conducted as per the recommendations of the RNAM test codes and procedures for farm machinery, Technical Series No.12, 1983.

The threshing efficiency, capacity and the grain losses were calculated and tabulated. Graphs were plotted to study the effect of peripheral velocity and moisture content on threshing efficiency and capacity.

3.3 Calculations

1. Total grain input, A = B + C + D

   Where A - Total grain input per unit time by weight.

   B - Weight of threshed grain (whole and damaged) per unit time collected at the main grain outlet

   C - Weight of the threshed grain per unit time collected outside the main grain outlet.

   D - Weight of the unthreshed grain from all outlets per unit time.

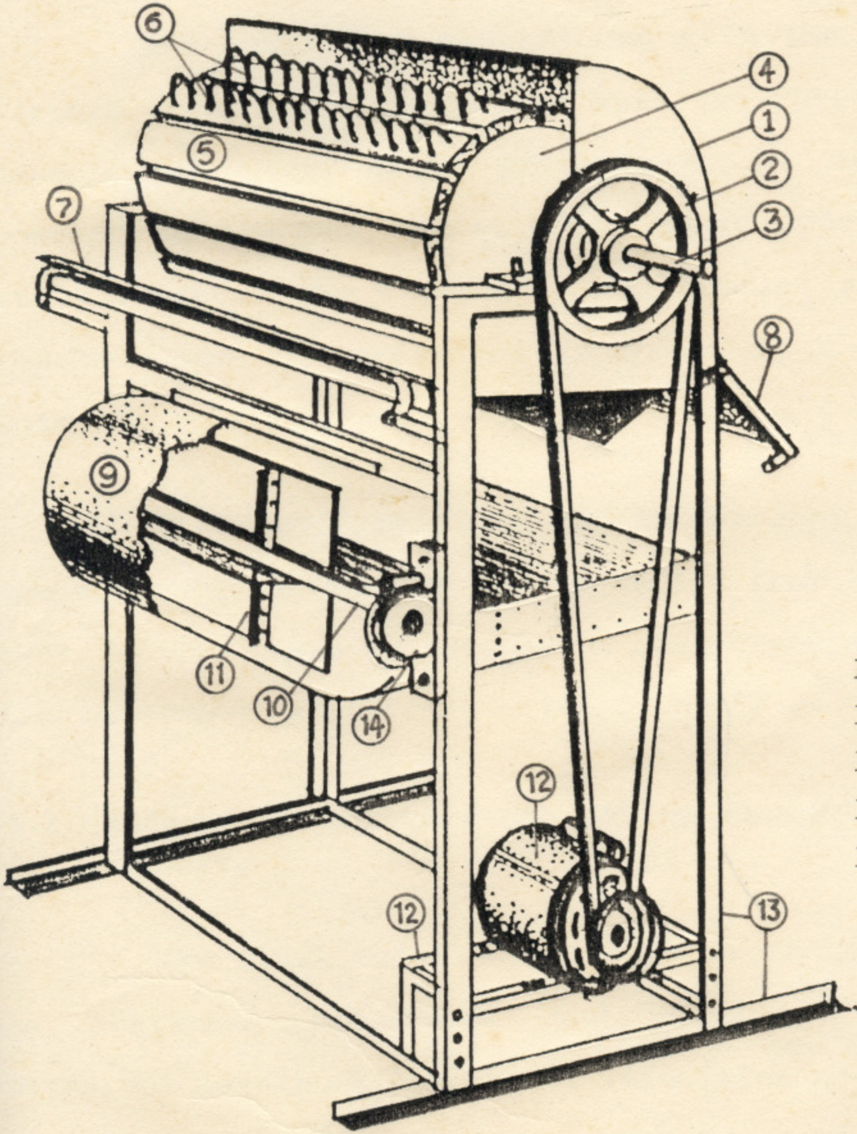
2. Percentage of unthreshed grain = $\frac{H}{A} \times 100$

   Where H - Weight of unthreshed grain per unit time in kg.

3. Threshing efficiency = 100 - percentage of unthreshed grain

4. Percentage of grain loss = $\frac{G}{A} \times 100$

   Where G - Weight of grains and unthreshed grains per unit time collected from outside the main grain outlet (Scattered grains per unit time)



1. Cylinder cover
2. Cylinder pulley
3. Cylinder shaft
4. M.S. end disk
5. Wooden slate
6. Wire loops
7. Feeding tray
8. Grain stopper
9. Blower casing
10. Blower shaft
11. Blower blade
12. Motor & motor stand
13. Frame
14. Ball bearing

Fig.711 Perspective view of Hold-on type power paddy thresher

RESULTS AND DISCUSSION

The results of experimental studies conducted and economics of the 'Hold-on type power paddy thresher' are presented and discussed in this chapter.

The tests were carried out with the view of studying various performance parameters viz. the threshing efficiency, capacity of thresher and grain losses at different moisture contents of the crop and at different peripheral velocities of the cylinder. The threshing efficiencies and capacities of the thresher are presented in Table 1, 2 and 3 for three moisture levels respectively.

It is observed from the tabulations and figures that the threshing efficiency mostly varied from 92.65 to 98.45 per cent, though these variations in most cases are very small and the threshing capacities varied from 193.04 to 307.16 kg/hr.

4.1 Effects of moisture content on threshing efficiency and capacity

The Fig.1 and 2 shows the effects of moisture content on threshing efficiency and capacity respectively for different levels of peripheral velocities of the cylinder.

It is apparant from the Fig.1 that the threshing efficiency increases with the increase in moisture content from 13.4 to 16.7 per cent and then decreasing for all levels

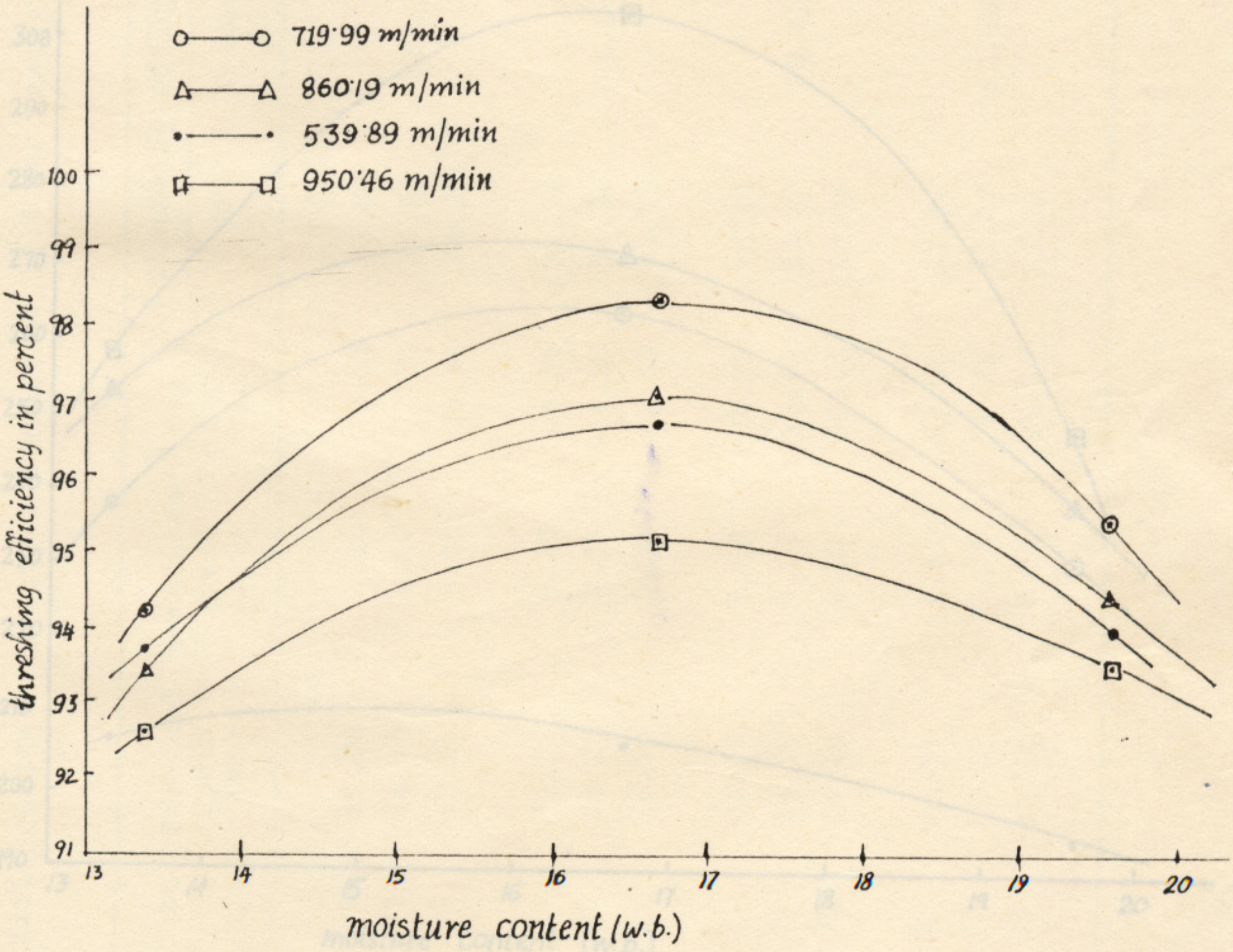


Fig.12 Effect of moisture content on threshinng efficiency

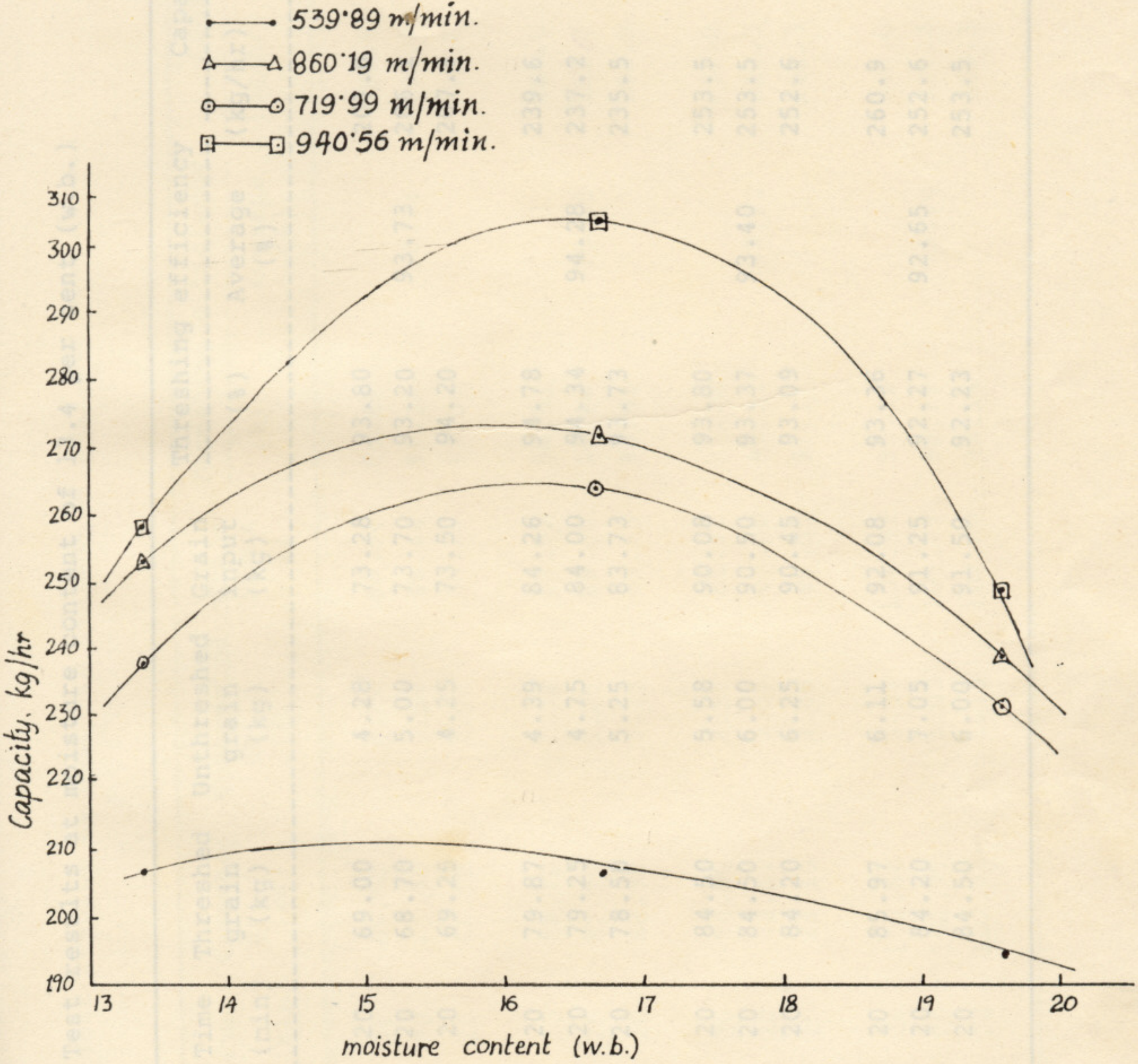


Fig.13 Effect of moisture content on capacity

Table 1. Test results at moisture content of 13.4 per cent (w.b.)

Sl. No.	Replications	Peripheral velocity (m/min)	Time (min)	Threshed grain (kg)	Unthreshed grain (kg)	Grain input (kg)	Threshing efficiency		Capacity	
							(%)	Average (%)	(kg/hr)	Average
1.	1		20	69.00	4.28	73.28	93.80		207.0	
2.	2	539.89	20	68.70	5.00	73.70	93.20	93.73	206.1	206.95
3.	3		20	69.25	4.25	73.50	94.20		207.8	
4.	1		20	79.87	4.39	84.26	94.78		239.6	
5.	2	719.99	20	79.25	4.75	84.00	94.34	94.28	237.2	237.62
6.	3		20	78.50	5.25	83.73	93.73		235.5	
7.	1		20	84.50	5.58	90.08	93.80		253.5	
8.	2	860.19	20	84.50	6.00	90.50	93.37	93.40	253.5	253.23
9.	3		20	84.20	6.25	90.45	93.09		252.6	
10.	1		20	85.97	6.11	92.08	93.36		260.9	
11.	2	950.46	20	84.20	7.05	91.25	92.27	92.65	252.6	255.67
12.	3		20	84.50	6.00	91.50	92.23		253.5	

Table 3. Test results at moisture content of 19.6 per cent (w.b.)

Sl. No.	Replications	Peripheral velocity (m/min)	Time (min)	Threshed grain (kg)	Unthreshed grain (kg)	Grain input (kg)	Threshing efficiency (%)	Threshing efficiency Average (%)	Capacity (kg/hr)	Capacity Average
1.	1		20	64.79	3.89	68.68	94.33		194.37	
2.	2	539.89	20	64.00	4.20	68.20	93.80	94.06	192.00	193.07
3.	3		20	64.25	4.05	68.30	94.07		192.75	
4.	1		20	76.97	3.46	80.43	95.69		230.90	
5.	2	719.99	20	76.50	4.25	80.75	94.74	95.40	229.50	230.22
6.	3		20	76.75	3.50	80.25	95.64		230.25	
7.	1		20	79.60	4.42	84.02	94.74		238.80	
8.	2	860.19	20	78.90	4.75	83.65	94.32	94.40	236.70	237.25
9.	3		20	78.75	4.90	83.65	94.13		236.25	
10.	1		20	83.14	5.77	88.41	93.50		249.42	
11.	2	950.46	20	83.00	5.57	88.55	93.70	93.50	249.00	249.14
12.	3		20	83.00	5.75	88.75	93.50		249.00	

of peripheral velocities. This behaviour of thresher may be due to fact that, as it is hold-on type, at high moisture content (19.6 per cent) the crop requires high threshing force in order to separate the grains. That is the earheads are tought and the grains are rigidly attached on it. But at low moisture content of 13.4 per cent (w.b) greater number of earheads broke thereby increasing the amount of unthreshed grain.

The range of output was 193.07 to 307.16 kg/hr. At moisture content of 16.7 per cent the capacity of thresher ranged from 198.57 to 307.16 kg/hr, whereas at 13.4 per cent m.c it was 206.95 to 255.67 kg/hr. This shows that a higher capacity can be achieved by threshing the paddy crop at m.c. of 16.7 per cent. At high m.c. of 19.6 per cent reduces the capacity because of requirement of more impact force and more grains remain unthreshed. At low m.c. of 13.4 per cent the capacity is reduced due to fact that more earheads break thereby increasing the losses. From this figures, it is obvious that 16.7 per cent moisture content is optimum for high capacity as well as high efficiency.

4.2 Effect of peripheral velocity on threshing efficiency and capacity

The Fig. 14 and 15 shows the effect of peripheral velocity on threshing efficiency and capacity respectively, for different moisture content of crop.

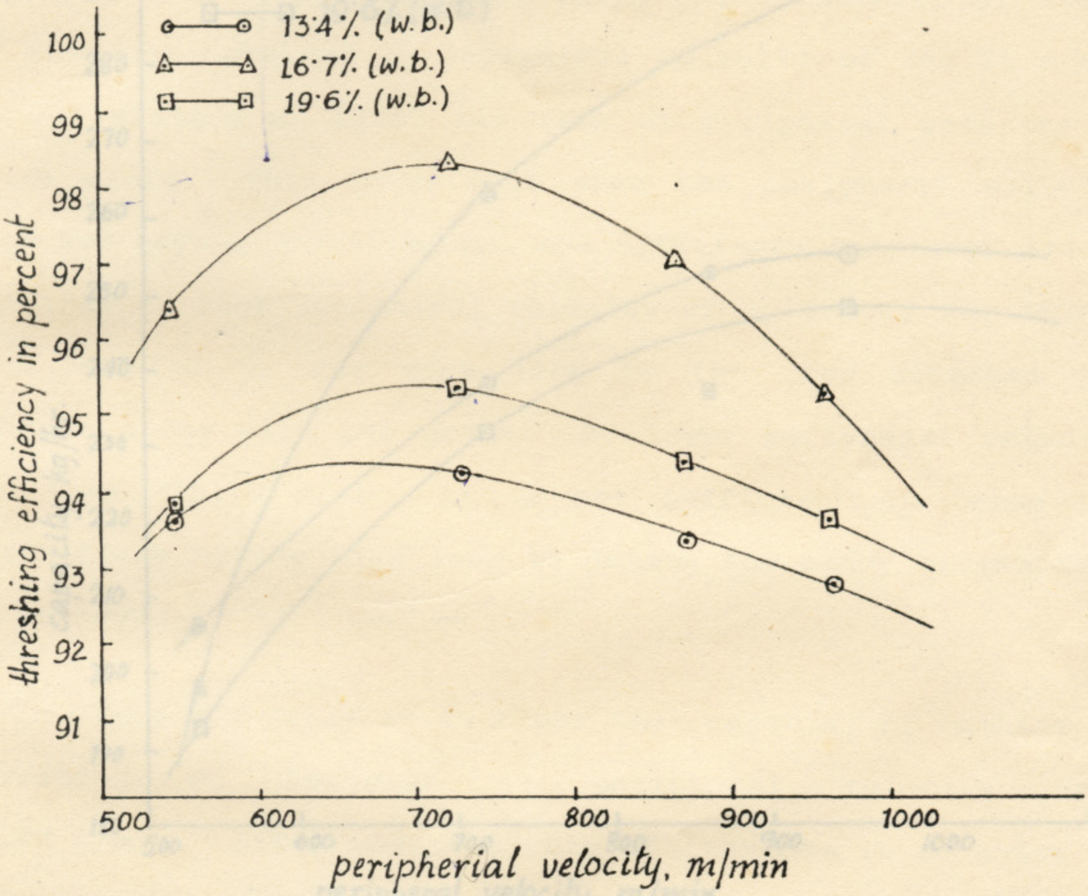


Fig.14 Effect of peripheral velocity on threshing efficiency

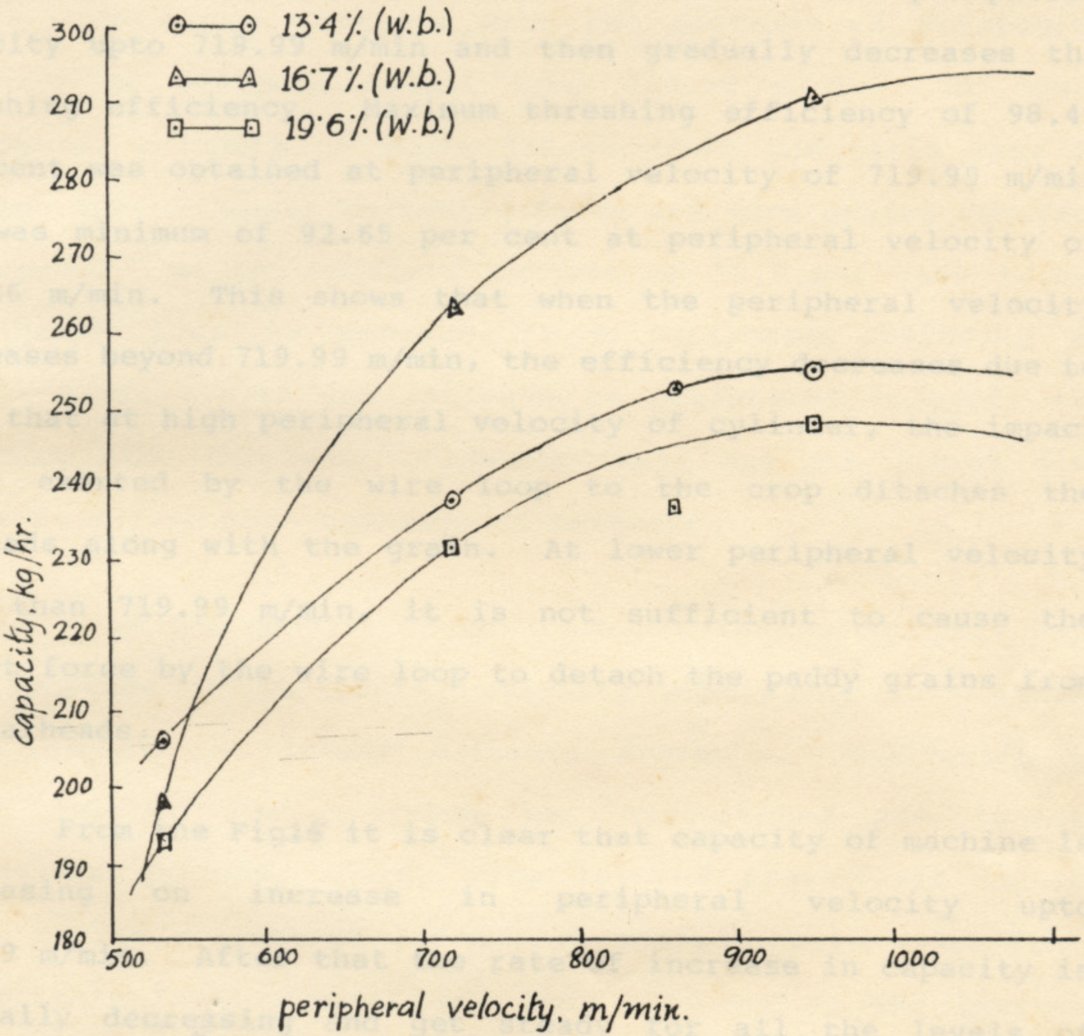


Fig.15 Effect of peripheral velocity on capacity

From the figures it is seen that the threshing efficiency is increasing with the increase in peripheral velocity upto 719.99 m/min and then gradually decreases the threshing efficiency. Maximum threshing efficiency of 98.45 per cent was obtained at peripheral velocity of 719.99 m/min and was minimum of 92.65 per cent at peripheral velocity of 950.46 m/min. This shows that when the peripheral velocity increases beyond 719.99 m/min, the efficiency decreases due to fact that at high peripheral velocity of cylinder, the impact force exerted by the wire loop to the crop ditaches the earheads along with the grain. At lower peripheral velocity less than 719.99 m/min, it is not sufficient to cause the impact force by the wire loop to detach the paddy grains from the earheads.

From the Fig.15 it is clear that capacity of machine is increasing on increase in peripheral velocity upto 719.99 m/min. After that the rate of increase in capacity is gradually decreasing and get steady for all the levels of moisture content of the crop.

Eventhough the capacity of machine is increasing beyond the limit 719.99 m/min threshing efficiency is decreasing. That is beyond 719.99 m/min, the increase in capacity will result in an increase in feed rate, but the threshing efficiency is decreasing, this will not be economical. Considering all the above factors, the optimum peripheral velocity and moisture content for the machine is recommended as 719.99 m/min and 16.7 per cent (w.b) respectively.

4.3 Effect of peripheral velocity on grain loss at different moisture level

The losses increase with the increase of peripheral velocity of cylinder higher than 719.99 m/min. At lower peripheral velocity of about 539.89 m/min the grain loss is greater due to lesser threshing force and more grains remained unthreshed. At the moisture content of 16.7 per cent (w.b.) the grain loss is minimum at a peripheral velocity of 719.99 m/min. With the increase in peripheral velocity the capacity also increases correspondingly but the losses also increase due to more breakage of earheads.

From the general observation, it is obvious that with the increase in peripheral velocity shattering loss (chaff cut) increase at lesser moisture contents. Shattering of grain towards the operator was experienced due to the inadequate cylinder cover. The feeding tray fixed to the frame having a width of 295 mm, is inadequate in width for a comfortable feeding position. This also led to the increase in grain loss. It can be suggested that the losses can be minimised by increasing the width of the feeding tray and the cylinder cover. The peculiarity of hold-on type thresher is that threshing efficiency could reach 100 per cent because threshing time can be increased until all the grains are removed. Since it is hold-on type the efficiency and output also depends on the skill of the operator.

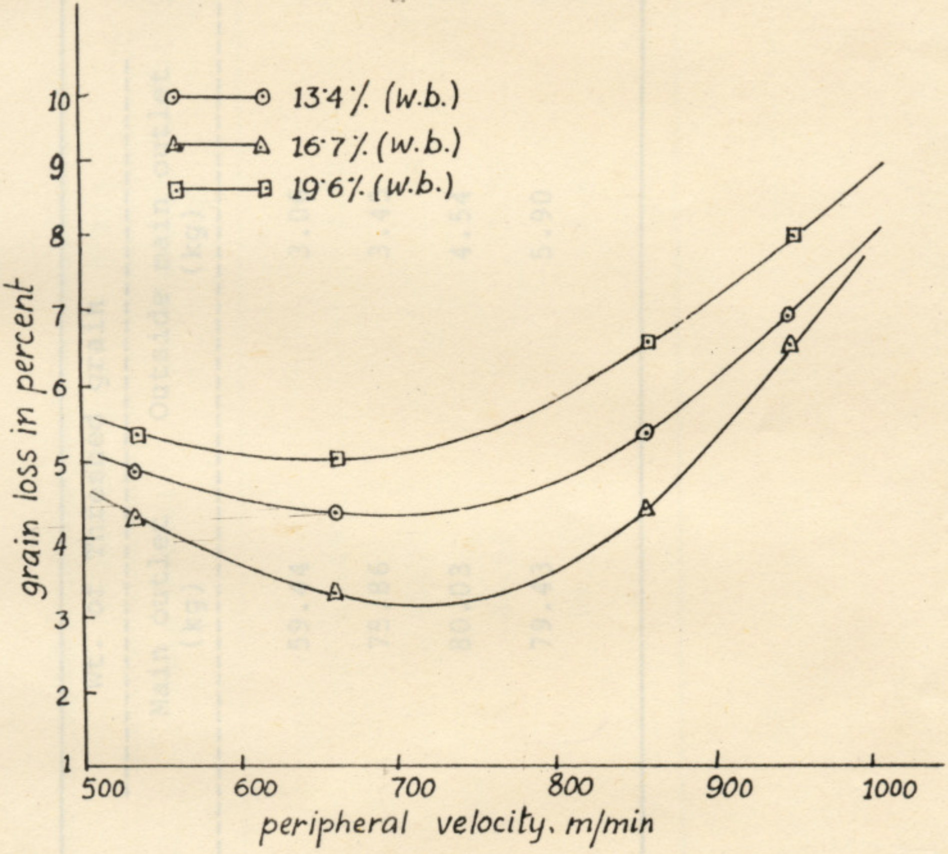


Fig. 16 Effect of peripheral velocity on grain losses

Table 4. Test results at moisture content of 13.4 per cent (w.b.)

Sl. No.	Peripheral velocity (m/min)	Time (m)	Wt. of Threshed grain: Main outlet (kg)	Wt. of Threshed grain: Outside main outlet (kg)	Grain input	% of grain loss
1.	539.89	20	59.44	3.06	62.50	4.90
2.	719.99	20	75.86	3.45	79.31	4.35
3.	860.19	20	80.03	4.54	84.57	5.37
4.	950.46	20	79.43	5.90	85.33	6.92

Table 5. Test results at moisture content of 16.7 per cent (w.b.)

Sl. No.	Peripheral velocity (m/min)	Time (min)	Weight of threshed grain		Grain input	% of grain loss
			Main outlet (kg)	Outside main outlet (kg)		
1.	539.89	20	63.49	2.82	66.31	4.25
2.	719.99	20	85.32	2.96	88.28	3.35
3.	860.19	20	80.56	3.78	84.34	4.49
4.	950.46	20	95.91	6.66	102.57	6.50

Table 6. Test results at moisture content of 19.67 per cent (w.b.)

Sl. No.	Peripheral velocity (m/min)	Time (min)	Weight of threshed grain		Grain input	% of grain loss
			Main outlet (kg)	Outside main outlet (kg)		
1.	539.99	20	60.98	3.48	64.46	5.40
2.	719.99	20	72.95	3.91	76.86	5.09
3.	860.19	20	74.02	5.19	79.21	6.55
4.	950.46	20	76.46	6.69	83.15	8.05

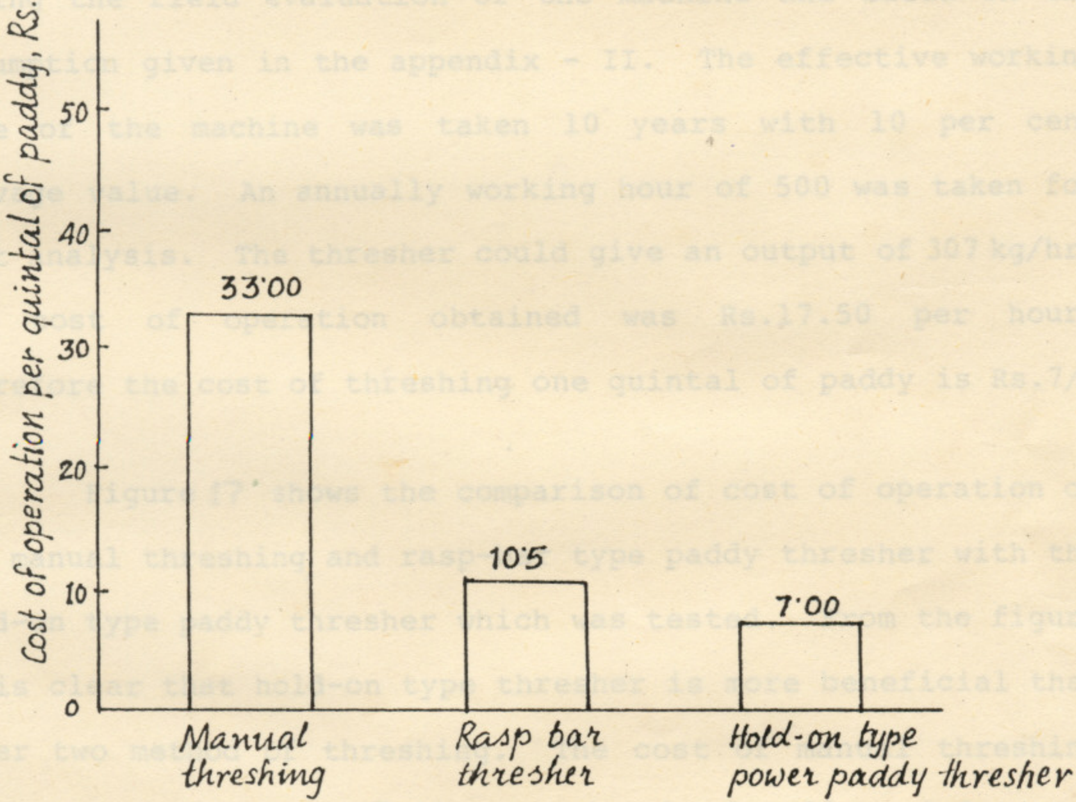


Fig.17 Comparison of cost of operation

4.4 Cost of operation of the power paddy thresher

The cost of operation is the main criteria for the acceptance of a machine by the farmers. The detailed cost of analysis of paddy thresher is based on the actual figures during the field evaluation of the machine and based on the assumption given in the appendix - II. The effective working life of the machine was taken 10 years with 10 per cent salvage value. An annually working hour of 500 was taken for cost analysis. The thresher could give an output of 307 kg/hr. The cost of operation obtained was Rs.17.50 per hour. Therefore the cost of threshing one quintal of paddy is Rs.7/-.

Figure 17 shows the comparison of cost of operation of the manual threshing and rasp-bar type paddy thresher with the hold-on type paddy thresher which was tested. From the figure it is clear that hold-on type thresher is more beneficial than other two method of threshing. The cost of manual threshing alone comes around Rs.33.00 per quintal of paddy and for rasp bar type paddy thresher, the cost of operation is Rs.10.50 per quintal (Preman et al., 1991).

SUMMARY

With the explosion of population in India, the demand for substantial increase in food grain production is increasing day by day. But the total production to meet the demand remains almost stagnant even at the farmer best efforts with chemical. So it is high time for policy maker to consider the Japanese approach of mechanisation in our agriculture.

Since rice is predominantly produced with labour intensive cultivation practices and involves considerable human drudgery, mechanisation in rice production is only means to solve the rising problem.

Threshing has been identified as one of the operation to be mechanised. But most of threshers available in India have complicated imported design and very expensive which cannot be afforded by ordinary farmers. Efforts are also being made at different places in India to develop/identify a suitable thresher for farmer having reasonable threshing efficiency, output and economic in cost. A "hold-on type power paddy thresher" was developed in consideration for the farmers need. It is important to test and evaluate the performance and study the economic feasibility of machine. In this context a project was undertaken entitled "Testing and performance evaluation of a hold-on type power paddy thresher"

The thresher is driven by a 2 hp single phase electric motor. Power transmission system consist of V-belts and pulleys. The machine is simple in operation.

The test result obtained are summarised below:

1. The optimum peripheral velocity of the cylinder is 719.99 m/min.

2. The capacity of the thresher at this peripheral velocity at 16.7 per cent moisture content is 307.16 kg of grainper hour.

3. The threshing efficiency is 98.45 per cent at the optimum peripheral velocity of the cylinder (719.99 m/min).

4. The percentage of grain loss is 8.05 per cent at the highest peripheral velocity.

5. Mechanical damage is negligible.

6. Two labourers are required for the whole operation.

7. Cost of threshing per quintal of paddy is Rs.7.00.

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Appendix - I

Safety precautions

1. First acquinted with the thresher and its operations.

2. We should never leave the thresher unattended without stopping the engine.

3. We should not wear loose fitting cloths that may be blown blown into moving parts.

4. We should never extend our hands into feed opening during operation.

5. Should not operate the thresher if loose teeth, bolts and nuts is there. Loose pig teeth can be ejected at high velocity causing injury to operator and damage to the thresher.

6. Should not attempt to operate the thresher unless one is in the operator's positions.

7. All the guards and shield should be kept in place.

8. If operated by women, long hair should be tight short to prevent it from becoming entangled in moving parts.

9. We should remember that "precaution is better than cure".

Appendix - II

Cost of operation of the hold-on type power paddy thresher

Total cost of threshing = Fixed cost + Variable cost

Approximate cost of thresher (P)

Prime mover (2 hp single phase motor)	=	Rs.3250/-
Cost of other materials (including fabrication charges)	=	Rs.4000/-
Total	=	Rs.7250/-

Other assumptions are:

a.	Working hours per year (H)	=	500 h
b.	Life of thresher (L)	=	10 years
c.	Salvage value(s) (10 per cent of the cost of the thresher)	=	Rs.725/-

I. Fixed cost

1. Depreciation

$$= \frac{P - S}{L \times H}$$

$$= \frac{7250 - 725}{10 \times 500}$$

= Rs.1.30

2. Interest per hour (12% per year on average investment)

$$= \frac{P + S}{2} \times \frac{12}{100} \times \frac{1}{H}$$

$$= \frac{7250 + 725}{2} \times \frac{12}{100} \times \frac{1}{500}$$

= Rs.0.96

3. Taxes and insurance = Nil

4. Housing charges = Nil

5. Repair and maintenance charges per hour (10% of initial cost of the thresher per year) $= \frac{P}{H} \times \frac{10}{100}$

$= \frac{7250}{500} \times \frac{10}{100}$

= Rs.1.45

Total fixed cost = Rs.3.71

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II. Variable cost (operating cost)

1. Labour charges

Number of labourers = 2

Working hours/day = 8 h

Labour charge/day per person = Rs.50.00

Labour charges per hour $= \frac{2 \times 50}{8}$

= Rs.12.50

2. Energy consumption

Energy consumption per hour of single phase motor = 1.5 electrical units

Electricity charge per unit = Rs.0.50

Electricity charges per hour = Rs.0.75

3. Lubrication charges/hr = Rs.0.50

Total operating cost = 12.50 + 0.75 + 0.50

= 13.75

Total cost of threshing/hour = I + II

= 3.71 + 13.75

= Rs.17.46

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ABSTRACT

To test and evaluate a newly developed machine and find out its economic viability is of prime importance before introduction to the farmers. In this context a project was undertaken as entitled "Testing and performance evaluation of hold-on type power paddy thresher". Two labourers are required for the whole operation. *The machine is driven by a* single phase 2 hp electric motor. The thresher gives a maximum output of 307.16 kg/hr of grain at optimum peripheral velocity of 719.99 m/min at moisture content of 16.7 per cent (w.b.). At the same peripheral velocity and moisture content, the threshing efficiency is highest, i.e. 98.45 per cent. The cost of operation is compared with that of rasp bar and manual threshing. From the study conducted and cost analysis, the operating cost of hold-on type power paddy thresher is least (Rs.7.00 per quintal) and cost of operation per hour is Rs.17.50.