

# History of Human Powered Threshing Machines: A Literature Review

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**Abstract.** The objective of this paper is to present the recent developments in the field of agricultural technology with respect to human powered threshing machines. This paper covers the form and existence of human powered threshing machines as well as manual methods from last decades. The different types of designs and progressive developments with operating parameters and mechanisms used can be overviewed from the literature review to find out the scope for further developments in human powered threshing machines.

## 1 Introduction

Area of agriculture is leading towards the commercialization in economic point of view. Emphasis is on the mechanization of pre- harvesting and post- harvesting equipment's. Post harvesting equipment's including threshing, have promising future towards the industrialization and local employment if the equipment is available at low cost and with the ease of operation. Then the recommendation will be given to human powered threshing machine which is eco friendly as well as operated with the human power which is recognized as a renewable source of energy.

The early methods of threshing includes hand threshing, bullock threshing, human powered thresher and the modern one of using a power operated thresher or tractor, and intermediate one where part of the output is threshed by bullocks and part by a thresher or a tractor. The paper focus on human powered threshing machine so taking a brief history with the traditional methods of threshing.

## 2 Materials and Methods

This study was designed on the basis of Investigative Survey Research Approach (ISRA) as developed by Anazodo (1975, 1983). The investigative survey research approach for operating data entails the history and forms of the human powered

threshing machines worldwide. The kind of data sought for year wise available. The data collected and sought for is in the same form available in the literature as it is meaningless to change the composition of the valuable history and research.

### 3 Discussion

#### Definition of Threshing:

Threshing or thrashing is the process of separation of grain from the stalk on which it grows and from the chaff or pod that covers it (answers.encyclopedia.com/question/threshing-410357.html).

#### Principle of Threshing

Grains can be separated from the panicle by a combination of stripping, rubbing and impact action on plant panicle head. This action resulted in application of tensile, compressive, bending and twisting forces and their combination on plant panicle.

#### Simple Threshing Methods (1969) (1)

Primitive threshing was done by spreading the crop on a threshing floor where it is beaten either with sticks or flails (Fig.1) or trampled by the hoofs of animals. The sheaves were made the grain in often threshed out by beating the sheaves against shielded grates.



**Fig. 1.** Simple threshing devices Chinese threshing flail

#### Threshing Sleds (1969) (1)

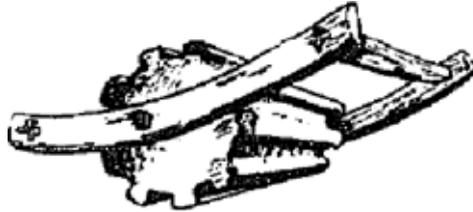
Threshing sled is an animal-drawn implement consisting of two wooden boards, slightly raised in front which are fitted with short pegs, serrated knives or hard stones, inserted into holes on the underside of the boards. The operator stands on the implement, to add weight, and it is dragged over the crop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

#### Threshing Rollers (1969) (1)

Another way of threshing was to pass ribbed rollers (Fig.2) or two or three parallel sets of discs mounted on a frame over the laid out crop (Fig.3). The disc thresher, known as the *norag* in the near East, and *Olpad* thresher in India, had serrated iron discs about 45 cm in diameter and about 15 cm apart, with a seat, and it is drawn by a

pair of animals. The crop is spread in layers 30 to 50 cm deep and turned over with wooden forks while being threshed.

The grain obtained is not clean and had to be separated not only from chaff but also from dust and dirt. Grain is also likely to be broken and some not threshed, or eaten by the draught animals. The whole process was rather slow, but it had the advantage that the straw was bruised. Threshing rollers were used through-out the Near East and in parts of Spain and Portugal.



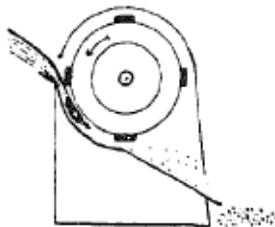
**Fig. 2.** Simple threshing devices Stone Threshing Cylinder



**Fig. 3.** Olpad Thresher, made in India on the pattern of thresher; diameter of discs about 15 cm, number of discs 20.

#### Hand-operated drum threshers (1969) (1)

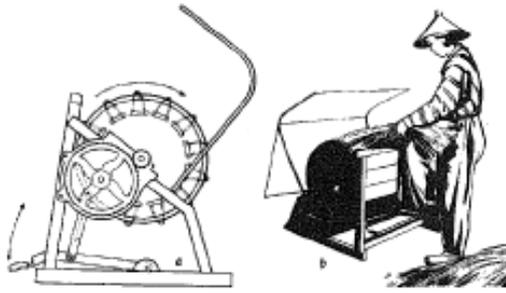
The hand-operated thresher shown in sectional view in Fig.4 is a type in which the whole sheaf is passed through the machine. The output is 200 to 300 kg of grain per hour according to the proportion of grain to straw. This low output, with two men needed at the drive wheels, makes the machine uneconomical; therefore its manufacture has been discontinued in Europe.



**Fig. 4.** Sectional View of drum thresher

Pedal-operated drum thresher (1969) (1)

The pedal-operated drum thresher is common in rice growing countries. A revolving threshing drum fitted with wire teeth and driven by a pedal, connecting rod and a crank is mounted in a framework. The sheaf is held at the butt end with the head against the revolving drum until all the grain is beaten out (Fig. 5). The drum has a speed of approximately 300 to 400 revolutions per minute, and the output is about 150 kg of grain per hour. Two man treadle machines with a considerably higher output are also available. These machines are inexpensive and portable, averaging 35 to 70 kg in weight, but are satisfactory only when the grain is easily detachable from the stalks, such as rice, but not wheat or barley.



**Fig. 5.** Japanese Rice Thresher (a) Sectional View of Rice Thresher (b) Rice Threshing with a Pedal Operated Machine

Manual Thresher (1972) (19)

C.C. Lee stated that the manual thresher worked by two persons in which one keeps the drum turning and the other feed the grain is the most usual type of thresher in Korea.

Pedal Driven Thresher by Dynapod (1976) (2)

It was found suitable to operate the pedal driven thresher by Dynapod. Dynapod comprises a frame comprising pedal cranks, saddle, handlebars and power take-off to be clamped to machine. It is a universal device to operate the pedal driven machinery.

Pedal Threshers(1981) (3)

In 1950 Japan a agriculture was just entering the early stages of mechanization with many small pedal threshers, some 13,000 power tillers and an equal number of power sprayers, but essentially no other machinery. Early data on threshers is not available, but in 1955 there was one thresher for every 3 hectares and in 1960s there was one thresher for every 2.5 hectares.

Bicycle Thresher (1985) (22)

A quite efficient manual threshing method is employed by machines based on the bicycle. One or two operators are required to feed the hopper while providing the



Fig. 6. Bicycle Thresher

power via v-pulley to the threshing mechanism. This thresher is suitable for rice and most other cereals. The unit is operated by two men. A sloping sieve at the discharge point helps to separate the straw from the grain which can be collected in a shallow skip or a sheet. The thresher is equipped with twin wheels and has an output of up to 200 kg/h. (See Fig. 6)

#### Pedal Powered Thresher(1999) (4)

The paper confirmed the existence of pedal powered wheat threshers in Bangladesh. It had some problems with the gear slipping but it was seemed to work well with smallish sheaves. It was by the visited to Bangladesh and desired to get a copy of it for Nepal.

#### Pedal paddy thresher (2001) (5)

In Tarai(Nepal), there is a trend towards the use of improved manual tools, e.g. corn sheller, pedal thresher etc. Pedal paddy threshers are becoming popular in the Kathmandu valley. It is estimated that about 3000 pedal threshers are currently in use. The mechanization related ongoing R&D activities of AED are to study the relationship between cylinders speed and moisture content of wheat for better performance of the pedal rice thresher. Paddy Pedal Thresher (2004) (6)

In manual threshing by beating, one can separate about 100 kg of grain/h, whereas by using a pedal thresher (oscillating or rotary mode) one can separate about 150 kg of grain/h from medium sized paddy/wheat plants. However, the pedal threshing is a strenuous activity with high muscular strain due to speedy pedalling and holding of paddy plants on the rolling drum. The ergonomics improvement in the pedal thresher might allow a rhythmic legwork in sit stand position; in addition, the weight of the rolling drum at about 8 kg might be comfortable to the user. (See Fig. 7.)



**Fig. 7.** Paddy Pedal Thresher in Operation

Pedal Thresher or Treadle Thresher (2005) (20)

The pedal thresher or treadle thresher consists of threshing drum, base, transmission unit and a foot crank. When pedaled, the threshing drum rotates and rice can be threshed when panicles are applied against the threshing drum. Because small straws, chaff, and foreign matter drop along with the threshed grain, whole grains must be separated using a flail, sieve or by winnowing. (See Fig. 8.)



**Fig. 8.** Pedal or Treadle Thresher

Hand and Pedal Operated Sunflower Thresher (2007) (7)

Manual threshing of sunflower found tedious, time consuming and labour intensive work. It was decided to mechanize the threshing of safflower trial plots by developing a mini plot thresher. Earlier, a hand-operated single plant thresher was designed and built to see its suitability for threshing safflower trial plots and later on a pedal-operated system was incorporated in the thresher for reducing the human effort required to run it.

However, since the machine was expected to be operated continuously for 7-8 hours daily, hand or pedal-operated threshers could prove to be very strenuous for a labour. Also there were practical limitations to a frequent replacement of the labours, so it was decided to design a mini plot thresher running on a battery-powered motor.

#### Manual Pedal Thresher (2007) (8)

Beside the existence of power tillers and power driven pumps more than about 350,000 about 200,000 manually operated pedal threshers were also being practiced in different districts of Bangladesh (Anon, 2004). Farmers in Dhaka and Jessore are not interested in this expensive power operated closed drum thresher because they are habituated with less expensive pedal thresher. Due to low cost pedal threshers were excluded from the economical analysis in Bangladesh.

#### Pedal Threshers used in the Region North-Western Himalayan region (NWHR) of India (2008) (9)

The traditional pedal paddy thresher, shown in Fig. 8, is used very rarely in hills. A mild steel sheet has been used as the covering material in this thresher, but this increases the total weight of the machine to around 50 kg.



**Fig. 9.** Traditional Paddy thresher

#### Developed VL paddy thresher (2008) (9)

The seat and hand rest of the VL paddy thresher was designed in such a way that the spinal column (15751 from the vertical plane) and arms (angle between the upper and lower arm 1351) of the operator remain in a comfortable position (Fig. 10) during operation. The height of the hand rest and seat can be adjusted according to the need of the operator. The power was transmitted from the pedal to the threshing cylinder through a chain and sprocket system having a speed ratio of 1:7. The threshing drum diameter was 350mm at the tip of wire loops. A safety cover was also provided in the thresher to protect the operator as per norms (IS: 9020, 1979) and to save the grain losses during operation. The MS sheet in the body of the pedal thresher was replaced by a polycarbonate sheet of 1mm thickness to reduce the total weight. The machine was designed adhering to the National Standards and guidelines on working posture (Hunang and Suggs, 1967). The material used for the threshing drum was as per the Indian Standard Institute (IS: 3327, 1962). The frame of the machine was made using the combination of a standard MS angle (40\_40\_5mm) and an MS pipe (40/38mm diameter). The machine was manually operated by a single person. A chain and sprocket system was used for transmitting power from the

pedals to the threshing drum. The drum of the thresher was made of MS flat (40\_5mm), MS sheet (1mm) and MS angle (30\_30\_5mm). For beating action, V-shaped wire loops made of 5mm MS round bars were welded in a staggered manner on the MS angle. These angles with wire loops were fitted on the periphery of the threshing drum with the help of a nut and a bolt.



**Fig. 10.** Developed VL Paddy Thresher

Pedal Operated Sunflower Thresher (2009) (10)

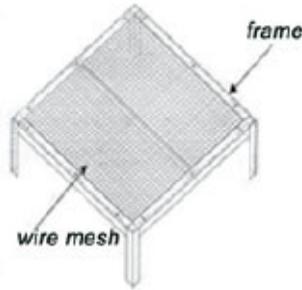
It is a hold on type thresher operated by one person. It consists of a threshing wheel of 660 mm dia., which is placed horizontally over a main shaft. The power transmission system includes a bevel gear unit, which gets power through a chain and sprocket arrangement attached to the pedal assembly. It has a blower to clean the threshed seeds. Two persons excluding the operator hold the cubs over the rotating wheel through its feeding chutes. The seeds detached from the cubs due to impact force of the threshing wheel and are cleaned by a blower unit and collected at the outlet (Fig. 11).



**Fig. 11.** Hold on Type Thresher

#### Wire mesh type Sunflower thresher (2009) (10)

It consists of a square frame having each side of 600 mm and a height of 200 mm and is made up of 30 x 30 x 3 mm MS angle. Wire mesh with mesh size of 10 x 10 mm is welded with the main frame and serves as the threshing surface (Fig.12). The workers rub the cubs over the wire mesh and the seeds are dropped at the ground, which is collected later and cleaned manually.



**Fig. 12.** Wire mesh type thresher

#### Perforated GI sheet type Sunflower thresher (2009) (10)

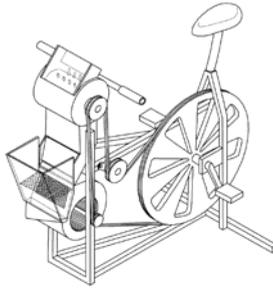
It is similar to the wire mesh type thresher but here except the wire mesh threshing surface, perforated GI sheet with perforation of 10 mm dia. was used as threshing surface. Four treatments namely pedal operated sunflower thresher (T1), wire mesh type thresher (T2), perforated GI sheet type thresher (T3) and conventional manual threshing (T4) were included in the experiment and each treatment was replicated five times. The data were analyzed in accordance with single factor ANOVA.

#### A Pedal Driven Threshing Machine (2010) (11)

The model an United State Patent Application describes a pedal driven machine and methods for processing grain using the physical exertions of a single individual feeds a panicle of grain in to a thresher, drives the thresher to thresh grain, winnows the threshed grain with a winnower, and collect the threshed grain, all concurrently. The panicle may be withdrawn from the thresher after being threshed without the panicle having passed entirely through the thresher. The machine that enables the foregoing processing by a single individual has a pedaling mechanism for driving both the thresher and winnower via a single drive member. (See Fig. 13)

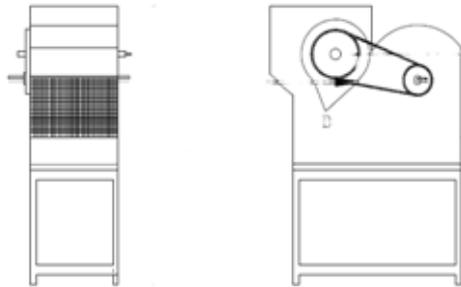
#### Manual Cowpea Thresher (2010) (12)

Design of a manual cowpea thresher has been carried out based on outcome of threshing cowpea with a conventional thresher the alvan blanch (Maunde, 2008). (Maunde et al., 2005b, 2006, 2007). The following parameters of the thresher were determined. Principal drum parameters which include drum length, drum diameter (for primary and secondary threshing), crop feed rate, drum speed and power required to rotate the drum (Bossoi et al.,1990) and (Caruthers and Rodriquez, 1992). Power transmissions for manual thresher was designed based on (Rasnikov, 1991) and (Aiyeleni, 1993). System parameters which include shaft diameter, key type, bearing



**Fig. 13.** Pedal Operated Thresher

type, width, inner and outer diameter were determined based on calculations (Maunde et al., 2008). Structural frame included the hopper design, shape, length, bottom and top width, volume and angle of inclination were designed according to (Maunde et al., 2006) and (Maunde et al., 2007). The stress on the components parts and assembly of the thresher was determined using auto desk inventor version 10 software at Cranfield University at Silsoe, UK. The software works with the principles of input data of some of the calculated parameters while some of the unknown data was automatically determined by the software. (See Fig. 14)



**Fig. 14.** Manual Cowpea Thresher

#### Pedal - Operated Paddy Thresher (As Per BIS Standard) (2010) (13)

Sealed offers were invited by 'The Madhya Pradesh State Agro Industries Development Corporation Limited Bhopal, India' with the Specification of Pedal Operated Paddy thresher according to BIS Standard IS 3327:1982 with latest amendments with a brief description such as.

1. Material to be used for various parts with applicable standard.
2. Constructional requirements included Body frame, Base, Side frames, front grain shield, rear grain shield, cylinder, slat, cylinder end discs, threshing teeth, drive, gear housing, crank, pedal frame fulcrum, pedal frame, Pedal Board, Axles.

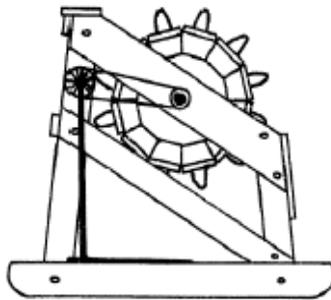
3. Other Requirements included clearance between the frame and threshing teeth, lubrication facility and safety arrangement.
4. Dimensions included with the overall height of thresher, height between the ground level and centre of cylinder, height of pedal board from ground level, and the distance between the centre of pedal board and the pedal fulcrum.
5. Workmanship and finish requirements included with the painting of metallic parts with anticorrosive rust preventive paint.

#### Pedal Operated paddy Thresher (2011) (14)

Author stated under the study of mechanization of post-harvest operations that the pedal operated paddy threshers reduces the drudgery over traditional threshing and have become popular in India.

#### Foot Powered Thresher (15)

It consisted of the plates to hold the drum firmly to the shaft (Fig.14). The shaft is in two sleeves, with a connector for ease of assembly. Inside the thresher at upper right can be seen the adjustable plate for the large sprocket shaft assembly. On top of the thresher is shown the tool for inserting wire hooks in to the drum. Undersize holes are drilled, and preformed loops are driven into holes with the tool and hammer.



**Fig. 15.** Foot Operated Thresher

#### Pedal Operated Thresher (16) (M M Pandey)

It consists of wire-loop type threshing cylinder operated by foot pedal. It is suitable for threshing rice. This machine is based on IRRI design and was adopted by IIT Kharagpur during 1984-90. It costs Rs 2100/- and its cost of operation is Rs 28/q. It was extensively evaluated and adopted by the farmers of West Bengal State for threshing rice. The output capacity, threshing efficiency and labour requirement were 44 kg/h, 98.8% and 5.0 man-h/q, respectively.

#### Phule Sunflower Thresher (16) (M M Pandey)

It is a pedal operated hold on type sunflower thresher suitable for separating seeds from sunflower heads. It consists of a threshing wheel having spokes and a blower fan operated by foot pedal through chain and sprocket. Four holes are provided on the cover for holding Sunflower heads to the threshing wheel by upto four persons. This implement was developed at MPKV, Pune, during 1987-90. It costs Rs 5700/- and its

cost of operation is Rs 0.40/kg compared to Rs 0.60/kg with conventional method. The output capacity, threshing efficiency and labour requirement were 40 kg/h, 100% and 10man-h/q, respectively.

Treadle Peg-Drum Threshers (16) (M M Pandey)

Treadle operated drum threshers are widely available and are used primarily for rice but also for other crops. The threshing drum is covered in pegs, spikes or wire loops and is supported, in bearings and on a horizontal axis, by a free-standing framework. Sheaves or bundles of the crop are held against the pegs as the drum is rotated by a foot-operated treadle mechanism. Output capacity varies 70-100 kg/h.

Manual Thresher (17) (NPS Sirohi)

Under the ‘Long Term Strategies and Program for Mechanization of Agriculture in Agro Climatic Zones in India’ the paper favors introduction of manual threshers with motorized thresher on large scale to enhance the quality and output of work.

Treadle Powered Machine (23)

The most basic thresher is a treadle powered machine FT 370(Fig. 15). Threshing drum turns when operator uses one foot to pedal the machine just as early sewing machines were powered. Bundle of the crop is held with grain heads over threshing drum while teeth on drum strip grain off and drop onto ground behind machine. Technical Specification is given as

- Dimensions 31.5” x 21.6” x 34”
- Net Weight 60#
- Drum 14”diameter x 14.5” widths
- Capacity 4 bushels / hour
- Shipping 25” x 22” x 26”
- Gr. Wt. 72#
- Cube 8.28 cu ft.



**Fig. 16.** Treadle Powered Machine

## 4 Conclusion

In this paper we have concentrated on what we see as the core developments in the early history of machine and mechanism. The emphasis has been very much on human powered threshing machines development. In this paper we dealt primarily with threshing as an area of knowledge and we have not devoted much attention to the institutional level, which concerns textbook. From the literature review it is found that the human powered threshing machines are available with following mechanisms.

1. Hand Operated Threshers are found with crank and chain mechanism.
2. Foot Powered Threshers are found with crank and chain with bevel gear and some with treadle mechanism.
3. Pedal Operated Threshers are found with bicycle mechanism.

What all investigator have investigated is onload condition but we have come up with offload condition. The evolved machine system comprises of three subsystems namely (i) Energy Unit , Comprising of a suitable peddling mechanism, speed rise gear pair and Flywheel conceptualized as Human Powered Flywheel Motor (HPFM) (ii) Suitable torsionally flexible clutch and torque amplification gear pair and (iii) a process unit. The suggested machine system uses human energy achieved by peddling and stores this energy in a flywheel at an energy-input rate convenient to the peddler. After storing the maximum possible energy in the flywheel (peddling time could be 1-2 minutes) the same can be made available for the actuation of any process unit by making available the energy stored in the flywheel through a suitable clutch and torque-amplification if needed. Thus the flywheel will decelerate depending on the actual resisting torque offered by the process. It implies that the peddler does not pedal while the flywheel is supplying energy to the process-unit.

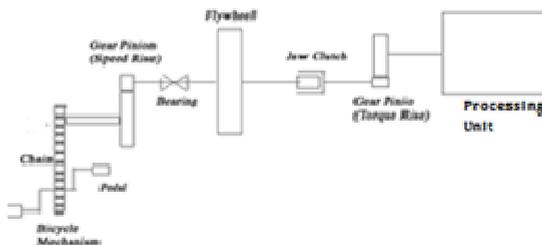


Fig. 17. Human Powered Flywheel Motor Concept

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