# DESIGN, FABRICATION AND PERFORMANCE OF DRUDGERY FREE PADDY THRESHER FOR FARMERS OF HILLS OF HIMALAYAS

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**ABSTRACT**

*Paddy threshing by manually operated paddy thresher is popular among the farmers since more than 60 percent of the cultivated land in hill area is under the category of small and marginal farmers in India. In manual beating operation the operator had to sit in a bent position, which was ergonomically not appropriate for long-time operation, since wrong posture may cause serious injury. Hence need was felt to design and develop a small motorized thresher especially for hill region which should be user friendly and more efficient New developed thresher was a low cost motorized machine for threshing paddy crops. The machine runs on ½ hp and operated by an electric motor. Due to the mechanical process, drum speed increased and it reduced the energy expenditure and threshing time of the users. Optimization process was carried out using design software. On this basis, a new motorized paddy threshing unit, having a height 755 mm, time 5.1 minutes and load density 1 ½ kg gives production.i.e. 16.69 kg with 9.6 kj/min energy expenditure, and 299 beats Tccw, 127 beats/ min. heart rate, 20.94 per cent MSD and 20.86 per cent RPE and overall desirabillty were found to be .73 percent.*

## INTRODUCTION

Agriculture is the only source of livelihood for most of the population resided in our 638000 Indian villages. Drudgery is generally conceived as physical & mental strain, agony, fatigue, monotony & hardship experienced by human beings, while all these results in the declining performance of men and women alike. The main reasons for drudgery perception were monotone. Tiring, laborious, repetitive & time consuming tasks. Human beings play a great importance in Agriculture since agrarian, hence is the design of farm tools & equipment, everything known about the operator is very important as they have to work with the designed/developed equipment (Singh 2012).

Agriculture has change significantly with advances in science and technology. Traditional agriculture was mostly dependent on human labour and draught animal. Modern agriculture practices are mainly based on machines especially high speed and powerful machines. Agriculture mechanization has not only changed the characteristics of labour in agriculture but also influenced the workload. The timeliness of operation and increased capacity of production resulted in the need for higher speeds.

Manual beating is common in all paddy-growing areas across the country, but particularly in cases of marginal land holdings. In the hills, threshing of paddy is normally carried out manually, either by beating out the grains with sticks or by rubbing out under feet, both of which are time- and labour intensive. Threshing consumes 25 per cent of the total energy utilized in paddy cultivation (Kathrival and Shivakumar 2003) Manual beating is common in all paddy-growing areas across the country (Datt, 2003), but particularly in cases of marginal land holdings.

Drudgery is farm operations can be reduced by introducing user friendly improved farm tools & equipment. The purpose of user friendly improved farm tools & implements is to help in reducing drudgery, increasing utilization efficiency of inputs, ensuring timeliness in field operations, increasing productivity of women – machine system, improving work efficiency so as they can also get leisure time, conserving energy, improving quality of work & produce & enhance the quality of work life of farm farmers. The purpose can be fulfilled if one or more of the above mentioned parameters are met. considering the ergonomics, General design considerations for developing a drudgery frce paddy thresher with aim to enhance the productivity of farm workers.

**Design Consideration**

Design methodology involves the anthropometric data of the respondents/farm workers.

**Methodology for anthropometric data collection**

Anthropometric is defined as the art of measuring Herman body to a considerable accuracy. A major anthropometric concern in design & evaluation of engineering products in the statistical description of all those persons. Who may, throughout the life of the product usefulness, be involved in its operation and maintenance. This group of person is defined as the total user population. It is usually impossible or uneconomical to measure every individual in a population. Therefore a smaller group. Called a sample is selected & measurement are carried out on the individuals in that sample.

**Sample Size**

The larger the sample selected, the mese likely it is be representative of the total population. However, cost & time becomes the limiting factors. The sample must be large enough to assure the accuracy & representativeness of the results while being small enough for the survey to stay within budget & time schedule constraints. For calculation of sample size, generally the following formula as given by roebuck et.al. (1975) is used.

$$n = (d \times s)$$

where : n = Sample size required
S = Estimated deviation of the data
D = The desired accuracy of the measurement (± d units)
K = A value chooses for the statistical interest, depending on the standards deviation choose.

Anthropometric Parameters

A total of 24 body dimensions have been identified as important for the design of drudgery frce paddy thresher. The anthropometric dimensions could be measured with Anthropometric (Fig. ) & anthropometric data given in table -1. These dimensions need special consideration which designing small paddy thresher to be used by operators, particularly with ryard to reach & fit requirements.

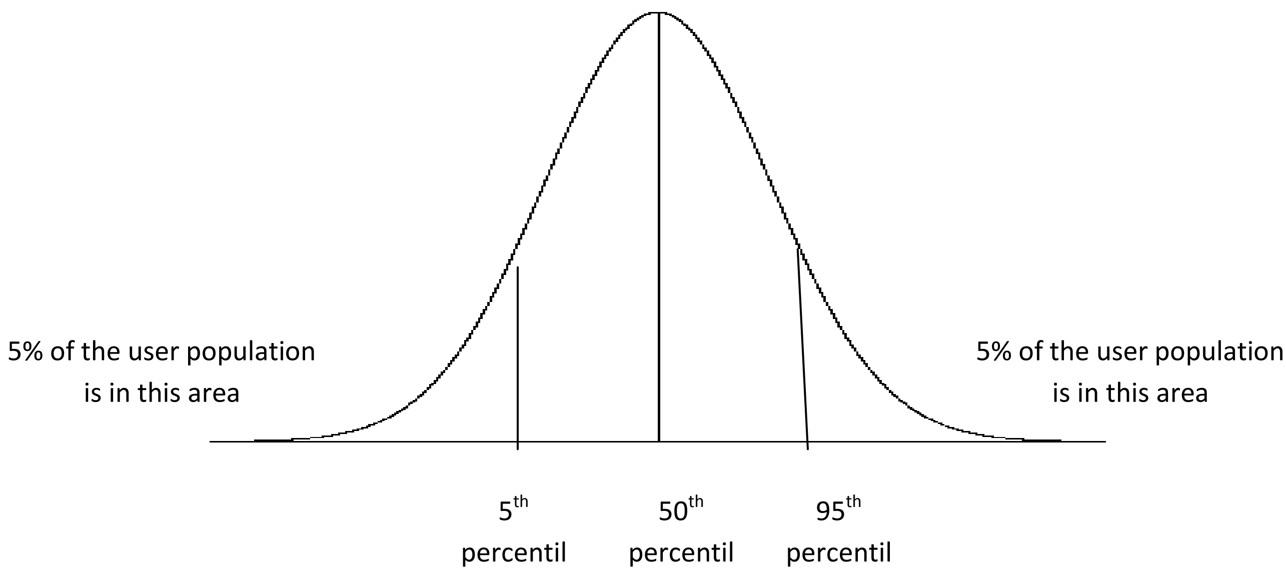
**Table -1. Anthropometric data & Agriculture workers**

| Sl. No. | Dimension | Agricultures Worker | Respondents SD |
|---|---|---|---|
| 1 | Weight, kg | 43 | 7.1 |
| 2 | Vertical reach | 190.2 | 8.0 |

| | | | |
|---|---|---|---|
| 3 | Vertical grip reach | 180.3 | 7.9 |
| 4 | Stature | 151.2 | 6.0 |
| 5 | Eye longtif | 136.2 | 6.0 |
| 6 | Acromial height | 123.1 | 5.2 |
| 7 | Elbow height | 93.1 | 4.1 |
| 8 | Ilieocrystale ht. | 92.0 | 4.2 |
| 9 | oiecranon height | 90.1 | 4.3 |
| 10 | Illiospinale height | 84.2 | 4.4 |
| 11 | Trochanteric Height | 77.9 | 4.6 |
| 12 | Metacarpal III height | 64.1 | 4.4 |
| 13 | Knee height | 40.3 | 3.0 |
| 14 | Medial Malleolus Height | 7.5 | 5.4 |
| 15 | Lateral Makeolus Height | 6.0 | 0.8 |
| 16 | Mentcn to top of head | 17.8 | 1.5 |
| 17 | waist back length | 35.6 | 4.1 |
| 18 | span | 153.7 | 7.4 |
| 19 | arm reach from wall | 77.2 | 4.4 |
| 20 | themb top reach | 67.9 | 4.1 |
| 21 | shoulder grip length | 65.3 | 4.5 |
| 22 | wall to limbo sacral jaint | 3.4 | 1.1 |
| 23 | Abdominal extension to wall | 19.8 | 3.2 |
| 24 | wall to acromion distance | 6.4 | 1.2 |

**Design Procedure**

Design of any Agricultural device/tool/Equipment or machinery should be considered in relation to both the body dimensions of the individual who are expected to use the implement and the movement that they can make without difficulty & strain. Hence the variation of individual body dimensions should be given the emphasis when a design problem is tacked. It is widely agreed that use of 5th,50th or 95th percentile value is more logical in design considerations (fig - ). However it is desirable to use the body dimensions of 95th percentile use to establish minimum equipment dimensions involving clearance so that the smaller group will not be affected.




**Design, fabrication and testing of the Motorized paddy thresher**

New developed thresher was a low cost motorized machine for threshing paddy crops. A ½ hp motor was introduced at the first stage to simplify the thresher mechanism. The power is transmitted from the prime mover to threshing drum through belts and pulleys. Motor RPM was calculated by Tachometer device. Due to the mechanical process, drum speed increased and it reduced the energy expenditure and threshing time of the users. Thresher canopy is also increased in length to protect spilling of grain during threshing. The body of the machine is made of mild steel iron to withstand maximum wear and tear. Paddy is feeded to the threshing drum, where the combs act upon each straw and separate the grain from the straw. The feeding system is safe and it retains the complete straw and does not chop it. Optimized design reduce the threshing time and give maximum output with minimum threshing time (Fig….).

**Motor selection**

The machine runs on ½ hp and operated by an electric motor. The ½ hp motor facilitate 334 RPM which is suitable for threshing of paddy.

**RPM of Drum**

$\Pi \times N1 \times D1 = \Pi \times N2 \times D2$

N1 = Number of revolution of driven pulley

N2 = Number of revolution of drum

D1 = Diameter of the driven pulley

D2 = Diameter of the drum

RPM of Drum (N2) = $\frac{\Pi \times N1 \times D1}{\Pi \times D2}$

$= \frac{540 \times 550}{890} = 334$ RPM

**Selection of pulleys and V belt**

The power is transmitted from the prime mover to threshing drum through belts and pulleys.There were two pulleys one small and one large. The large pulley was having diameter 550.0 mm , whereas small with 200.0 mm diameter

**Length of open belt**

V belt is placed at the top of both small and large pulley and it helps with the movement of pulleys.

Length of open belt was calculated by :

**Length of open belt** $= \frac{\pi}{2}(D1 + D2) + \frac{(DI - D2)^2}{4c} + 2C$

Where:

D1 – Diameter of the driving pulley

D2 – Diameter of the driven pulley

C – Distance between the centers of two pulley

$= \frac{\pi}{2}(550 + 200) + \frac{(550 - 200)^2}{4 \times 620} + 2 \times 620$

$= \frac{\pi}{2} \times 750 + \frac{(350)^2}{2480} + 1240$

= 1178 + 49.39 + 1240

= 2467.39 mm

= 246.7 cm

**Velocity ratio**

The belt transmits power virtue of difference in tension in the belt between the point at within it enters and leaves the sheave. The difference in tension was developed through friction. In these two pulley (one drive and one driven) were connected by a belt so that rotation of one cause rotation of the other.

Velocity ratio was calculated by :

$\Pi \times N1 \times D1 = \Pi \times N2 \times D2$

OR

$\frac{D2}{D1} = \frac{N1}{N2}$

N1 = Number of revolution of driving pulley

N2 = Number of revolution of driven pulley

D1 = Diameter of the driving pulley

D2 = Diameter of the driven pulley

$V.R. = \frac{D2}{D1} = \frac{550}{200} = 2.7$

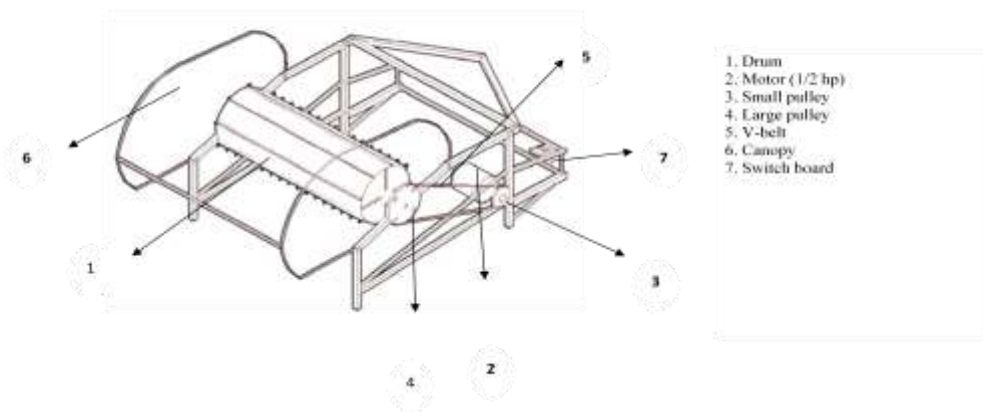
OR

$V.R. = \frac{N1}{N2} = \frac{1470}{540} = 2.7$

**Selection of canopy**

The total width of canopy is 610 mm to protect spilled grain during threshing. It was fabricatedby using good quality of plastic sheet.

**Line diagram of Paddy thresher**




## RESULTS AND DISCUSSION

### Threshing efficiency and capacity

Thresher efficiency was increased due to ½ hp electric motor. Motorized thresher gives best result in minimum time duration. The rice variety PR-113 was used for all experiments and threshing capacity was found to 200.28 kg per hour (in 5 min,16.69 kg ) with the same variety of paddy.

### Design Specification of motorized paddy thresher

After taking anthropometric measurements of the the all respondents following design specification were given:

| S. No. | Specifications | Dimension |
|---|---|---|
| 1 | **Thresher** | |
| | Length (mm) | 112.0 |
| | Width (mm) | 560.0 |
| | Height (mm) | 930.0 |
| | Weight (kg) | 55 |
| 2 | Length of the threshing drum (mm) | 445.0 |
| 3 | Diameter of the threshing drum (mm) | 890.0 |
| 4 | Spacing wire loops/slats(mm) | 39.1 |
| 5 | Height of the wire loop, (mm) | 60.5 |
| 7 | **Large pulley** | |

| | | |
|---|---|---|
| | Diameter (mm) | 550.0 |
| **8** | **Small Pulley** | |
| | Diameter (mm) | 200.0 |
| **9** | **Switch Board** | |
| | Length (mm) | 65.0 |
| | Width (mm) | 95.0 |
| | Capacity ( Ampere) | 15 |
| **10** | **Electric Motor (½ hp)** | |
| | Length (mm) | 185.0 |
| | Diameter (mm) | 510.0 |
| **11** | **Canopy** | |
| | Width (mm) | 610 |

**Optimization of parameters (height, time, crop load) for described responses**

Numerical optimization was carried out using design software. The goal was fixed to maximize the production and minimize the energy expenditure and Musculoskeletal disorder. The responses namely production, heat rate, energy expenditure, total cardiac cost of work, masculoskeletal disorder and rate of perceived exertion were taken into consideration for optimization. The goal seeking begins at a random starting point and proceeds up and down the steepest slope on the response surface for a maximum and minimum value of the response respectively. Importance to the responses and independent variables were given on the basis of the objective of the study. Maximum importance was (+++++) was given to production energy expenditure and heart rate and Total Cardiac Cost of Work (TCCW) Masculoskeletal Disorder (MSD) (++++) and Rate of Perceived Exertion (RPE) (+++) the goal was kept at in range. The goal set up for optimization of variables and responses is reported in Table 4.29. Optimum value of different parametersobtained are given in Table 4.30.

During optimization 17 solution were obtained, out of which the most suitable criteria, was selected. The seleted solution was tested for the actual conditions. It was observerd that out of three independent variable. Optimum results were obtained when the Height 775 mm, time 5.1 minutes and crop load was 1.5 kilogram.

**Constraints for optimization of parameters**

| Name | Goal | Lower Limit | Upper limit |
|---|---|---|---|
| Height | Minimum | -1 | 1 |
| Time | Minimum | -1 | 1 |

| | | | |
|---|---|---|---|
| Crop Load | Minimum | -1 | 1 |
| Production | Maximum | -1 | 1 |
| Energy Expenditure | Minimum | -1 | 1 |
| Total Cardiac Cost of Work | Minimum | -1 | 1 |
| Masculoskeletal Disorder | Minimum | -1 | 1 |
| Rate of Perceived Exertion | Minimum | -1 | 1 |

**Optimum value of parameters for experimentation of paddy thresher machine**

| Value | Height (mm) | Time (minutes) | Crop Load (kilogram) | Production (kilogram) | Energy Expenditure (kJ/min) | Total Cardiac Cost of Work (Beats) | Heart Rate (Beat/min) | Masculoskeletal Disorder (Percent) | Rate of Perceived Exertion (Percent) | Desirability |
|---|---|---|---|---|---|---|---|---|---|---|
| coded | 0.43 | -1 | -1 | | | | | | | |
| Actual | 775 | 5.1 | 1.5 | 16.69 | 9.6 | 299 | 127 | 20.95 | 20.86 | 0.73 |

**Optimization of the design parameters for development of an appropriate thresher**

The numerical values and the graphical optimization investigated the independent design parameters of the machine to obtain the optimum threshing capacity and threshing efficiency. The design expert 8.06 software and surfur software 9.0 was employed for the geographical optimization.and used for simultaneous optimisation of the multiple responses. The desired goals (maximize or minimize) for each variable and response were chosen and different weights (i.e. a number between 0.1 and 1.0, which shows the importance of the desired goal) were assigned to each goal to adjust the shape of its particular desirability function. The optimised values of variables such as thresher height 755 mm, time 5.1 minutes and crop load 1 ½ kg were determined. On this basis, a new motorized paddy threshing unit, having a height 755 mm, time 5.1 minutes and load density 1 ½ kg gives production.i.e. 16.69 kg with 9.6 kj/min energy expenditure, and 299 beats Tccw, 127 beats/ min. heart rate, 20.94 per cent MSD and 20.86 per cent RPE and overall desirabillty were found to be .73 percent. Hence these combinations shows that maximum Production with minimum time, energy and Masculoskeletal disorder was obtained by Parvatiya Sugam Thresher.

## Safety Issues

Safety is the state of being safe, the condition of being protected against physical, occupational or other types or consequences of failure, damage error, accidents, harm or any other event which could be considered non-desirable safety can also be defined to be the control of recognized hazards to achieve an acceptable level of risk (Anonymous 2012). This can take the form of being protected or from exposure to situation that causes health or economical loss.

## Conclusion

Motorized Paddy thresher is low cost & user friendly. it will help to drudgery & energy expenditure during threshing activity. Small & medium farmers can make use of these technologies for production & preservation of quality of rice, these it will enhance the productivity of farm workers. it will also help in increasing rice availability as a measure of food security and additional income generation for the farm workers.

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