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Design and fabrication of pedal operated paddy thresher fitted with winnower

SWAPNIL JAIN AND S.C.MOSES[1]
Research scholar, Department of Farm Machinery and power engineering, Sam Higginbottom University of Agriculture, Technology and Sciences Allahabad, Uttar Pradesh,
Email: swapniljain247@gmail.com)

Abstract

The purpose of this project was to design and fabricate a "Pedal operated paddy thresher fitted with winnower" for threshing, separating and cleaning of paddy grains. In earlier days, threshing and winnowing operation of paddy were done individually but now in this machine both operations can be performed in same time and also needing just a person to operate. The machine is modified with winnowing kit (blower) to enhance threshing and dust removal quality. The result obtained from the performance evaluation of machine such as- threshing efficiency was 94.9 %, when cylinder speed is 220 rpm. The cleaning efficiency and grain losses (blown grain, un-threshed grain, and damage/crack grain losses) was 98.9% and 3.18%. The threshing capacity was 40-45 kg/hr. The overall results are impressive and it will help to reduce drudgery and improve threshing and dust removal challenges with small scale farmers. And also reduces the time used in threshing and winnowing operation on small farms. The concern machine is quite effective, efficient, multitasks and ergonomic consideration in design for comfortable use and easily be operated by either male or female etc.

Key Words: Winnower, pedal, fulcrum mechanism, Auto CAD software, threshing cylinder

Introduction

Rice (*Oryza sativa*) belongs to the grass family Oryzeae, and is one of the leading food crops in the world. The worldwide cultivation cereals, rice (Oryza Sativa L) is only of the leading crop in the world and is second only to wheat in turn of annual food consumption, With 140.22 lakhs ton of rice production, Uttar Pradesh rank on the fourth position in the country, West Bengal rank first, with a total rice production of 146.05lakhs tons. It is highest rice producing state in India with a yield of 2600 kg/ha. the nutrition value per 100 grams of paddy carbohydrate(27.9g) protein(2.66g), fat(0.28g), calcium(1!), fiber(0.4g), iron(7!), potassium (35mg) and energy 129 calories. Paddy is the most important kharif crop of India

Pedal operated paddy thresher with winnower is importance of post harvest operation of threshing and winnowing. It consists of wire-loop type threshing cylinder, drives, winnower, mild steel sheet body and foot pedal etc. The threshing cylinder consists of wire-loops of 'V' shape embedded in wooden bars. A shaft carries the threshing cylinder and is connected to the transmission system. The transmission system consists of meshed gears or sprocket-chain mechanism. The larger gear or sprocket is connected to foot pedal/bar with links. The foot pedal/bar is always in raised position. On pressing the pedal the threshing cylinder starts rotating. For continuous rotation of the cylinder, the pedal is lowered and raised repeatedly. For operation, paddy bundle is held in hands and ear head portion of the crop is placed on the rotating cylinder. The wire-loops hit the ear head and grain get detached from the rest of the crop. The threshed grains fall on sieves which are held in front of threshing cylinder and it is act as a cleaning unit. Also the blower/ winnower are placed at below the threshing cylinder, blower is an essential for the separation of chaff from the grains. Therefore, in UPCAR project has been planned for design and fabrication in the prevalent design of present threshers with winnower.

[1]Professor & Head, Deptt. of Farm Machinery and Power Engineering, Sam Higginbottom Univ. of Agril., Tech. and Sciences Allahabad, Uttar Pradesh, India
Email: sheen.moses@shiats.edu.in,

Materials and Method

The experiment of 'Pedal operated paddy thresher with winnower' is conducted to designing, and fabrication of machine. Conventional threshing practices of paddy is generally done by hand, bunches of panicles are beaten against it hard surface (table, wooden bar log or stones) or a flail. Through which output are obtained 10-30(kg) of grain per man-hour according to varieties of paddy and method applied. The crop is threshed by being trodden underfoot (human and animal), the output is 30 -50 kg of grains per man- hour. The same method, but using a vehicle (tractor or lorry) is also a commonly applied. The total losses induced by traditional threshing methods are estimated 5 to 15%. In new developed machine during operation, an operator lifts and holds a bundle of crop against the cylinder. He/she operate the pedal by one leg keeping the other leg on the ground in a standing posture. After threshing, the bundle is thrown away and new bundle is collected. At the end of work, grain over the ground is collected by sweeping the floor.

The methodology adopted has been described under the following headings provided with the process flow sheet for the entire study of Design, and fabrication of pedal operated paddy thresher fitted with winnower -

- The fabrication site
- Description of threshing machinery
- Instruments/Equipment used
- Formulas/procedure followed
- Design of pedal operated paddy thresher fitted with winnower
- Fabrication of pedal operated paddy thresher fitted with winnower

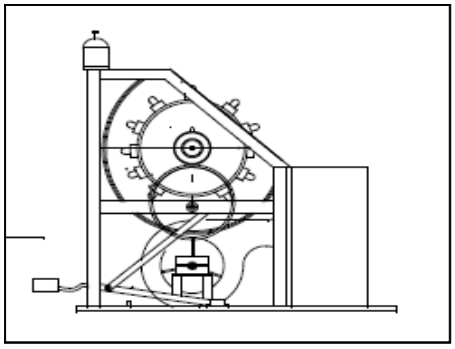


Fig. 1: Side View of pedal operated paddy Thresher with winnower

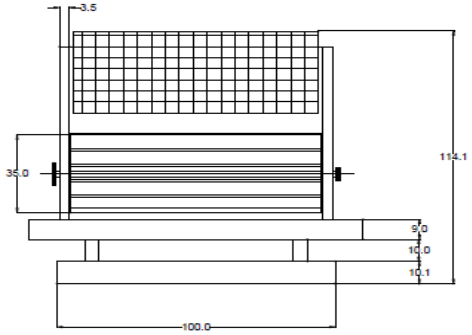


Fig. 2: Top View of pedal operated paddy Thresher with winnower

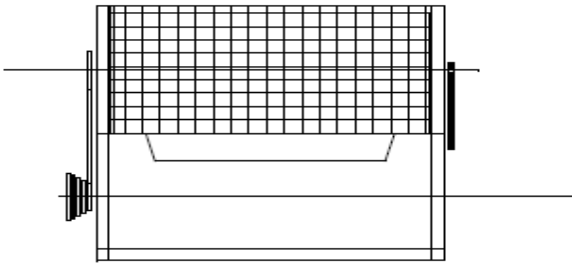


Fig. 3: Front View of pedal operated paddy Thresher with winnower

Design of Pedal Operated Paddy Thresher Fitted With Winnower

Design is the creation of plan or convention for the construction of a system. Designing often necessitates the aesthetics, functional and economic dimensions of both the design object and design process. Therefore, the following types of design were taken as for experiments. The design dimensions of various component of paddy thresher i.e. threshing drum, blower, gear box, sieve etc. were calculated and thresher was designed. The methodology is as discussed below.

Threshing Unit

The threshing cylinder shall be constructed of a series of slats supported by cylinder, the slats carry threshing loops. In case large thresher cylinder is use, so operated by two people. The thresher cylinder consists of wire loop, wooden bars, bearing, and circular rings, shaft etc. the shaft carries the threshing cylinder and is connected to the transmission system. On pressing the pedal the threshing cylinder start to rotation. It is the part where the paddy grains are beaten out of the panicles and separated from the bulk of the straw. In operation time crop is placed on the rotating cylinder and through wore loops hit the

ear heads and grain get detached from crops**.** The drum consists of 12 wooden flats arranged on 3 circular rings. Wire loops are fitted on each row of wooden flat for separating grain from the crops. The diameter of cylinder is 45cm.

The design of threshing cylinder is depending upon the type of teeth, moisture content and properties of crop to get optimal performance. The peripheral speed of at mid-point of loop of threshing cylinder for paddy is in the range of 15 to 17 m/s (Sharma and Mukesh 2010). According to (Sharma and Mukesh 2010) the following dimensional values have been established for threshing drum.

Cylinder length

The length of the cylinder is one of the most important factors to be determined during the research and achieve complete threshing and separation. A length of 90 cm (0.9metre) was chosen for this thresher. The length of drum of wire loop thresher is determined by using formula which is given by

$$\mathbf{L}=\frac{4}{\pi D^2}\times \mathbf{V}$$

Where,

V = Volume of the drum (m),

D = Diameter of the cylinder (m), L = Length of the cylinder (m) Or

$$\frac{legth\ of\ cylinder}{diameter\ of\ cylinder}=\frac{Ls}{D}=1.75$$

Ls = 1.75×D

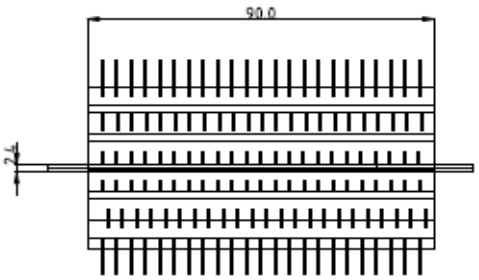


Fig. 4: View front of Threshing Cylinder

Cylinder Diameter

The cylinder diameter is also important factor to determine. The speed of cylinder is also based upon the cylinder diameter. Therefore the cylinder diameter without loop is 35 cm and with wire loop cylinder diameter is 45cm.

$$D=\sqrt{\frac{4\times V}{\pi L}}$$

Where, V = Volume of the drum (m), D = Diameter of the cylinder (m)

L= Length of the cylinder (m)

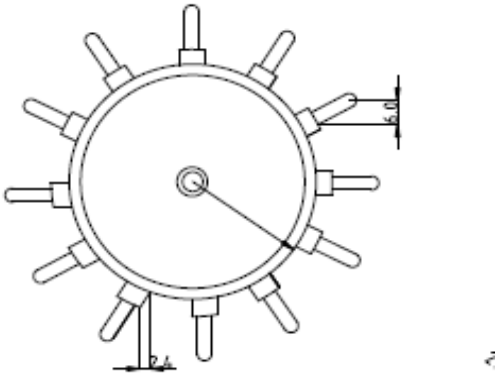


Fig. 5: Side View of Thresher Cylinder

Cylinder Speed

The optimal drum speed for the same crop may vary over a wide range, depending mainly upon such factors as the type of crop, moisture content, the size of gap between the drum and concave, the amount of straw and the feed rate. Hence in actual field conditions, the drum is selected after considering all these factors

The drum of the thresher should be rotated at proper speed for better threshing and cleaning efficiency. Threshing drum speeds (rpm) is measured by using tachometer. The speed of cylinder obtained 180-240 rpm. The Peripheral velocity of cylinder is 506 m/min. Peripheral velocity is calculated as follows:

$$V=\pi ND/60$$

Where:

V = Rotational speed (rpm),

D = Threshing drum diameter, cm.

N = Speed of threshing drum in rpm

Slate

Each slate should be 1.2cm thick and 6.0cm wide when made of wood according to test code (IS-3327). The slat should be fixed to the cylinder the distance between two slats shall be in the range of 1.2cm and 2.0cm

Wire loop on thresher

Wire-loop type threshing cylinder is specially used for paddy and threshing loop shall be at least 0.3cm diameter. The wire shall be curved and fixed to the slats in such a way that the distance between bottom ends of each loops shall be in the range of 2.5 cm and 3.2 cm. the threshing loops shall be projected

out 5.0cm above the surface of the slats. The method of fixing of the threshing loops on the slats shall be such that, when assembled, the threshing loops on the two adjacent slat come staggered to each other. The distance between the tip of the two adjacent loops shall be between 5.0 to 7.5cm (IS:3327-1982). Wire-loops are fitted on the periphery of a cylinder. Number of wire loop in each bar is 23. It is made of V shape-high tension steel. The Wire loop height is 10cm, spacing between loops 4.5 and total number of loops 276.Crop is placed on the rotating cylinder. Through The wire-loops hit the ear heads and grain get detached from the rest of the crop.

According to Pustygin (1948), No. of loop on threshing cylinder can be calculated by equation,

$$Z = Np \times \left(\frac{1}{lp} - 1 \right)$$

Where,
Z = No. of loop.
Np = No. of rows.
l = Length of threshing drum.
lp= Distance between adjacent loop, m.

Cleaning Unit

This unit is provided to separate the grain from chaff. It further uses sub unit, like aspirators or blowers, sieves etc to separate out grains from chaff. After threshing units carries out threshing, the cleaning and separation of straw from grains is required. agricultural products, often air is used as a carrier for transport or for separating the desirable product from the unwanted material. Aerodynamic properties such as, terminal velocity of paddy is important to know the air velocity for cleaning grains. An air velocity greater than terminal velocity lifts the particle. To allow gentle fall of a particle, the air velocity could be adjusted to a point just below the terminal velocity.

The various researchers have carried out studies on the aerodynamic properties of paddy for Indian varieties at different moisture content and found terminal velocity in the range of 6.85 – 7.29 m/s at 13 % moisture content. Hence the velocity of air should be less than terminal velocity, where grain will fall in to outlet and straw and chaff will be carried away (Singh *et al*. 1980). A properly functioning blower is an essential for the separation of chaff from the grains. The blower consists of 60mm diameter mild steel shaft which rests on ball bearings at the two ends on the rectangular stand. The four blades (steel plates) which are arranged and attached on the shafts periphery alternately at a 90° angle along on the shaft (rotor)which is milled square at the centre of the shaft so as to generate centrifugal force to blow the wind when in operation. When the rotor rotates it generates air which is pushed into the chamber and as the chaff are lighter in weight than the grains, they are blown away leaving the only the grains for collection. When in service, the blower forces air through the outlet vent of the thresher between 50 and 100cubic feet per minute depending on the person paddling the machine. The blower housing was fabricated with a 1mm sheet metal with a diameter of 300mm is mounted below the thresher cylinder with sectional opening chamber of blower. The separation and cleaning unit consisted of blower and sieve. The unit helps in separating grain from chaff as well as cleaning the grain. The blower rough blows the lighter material out of the machine from blower outlet. Cleaning system includes a screen, which were fitted in front of the threshing cylinder. The cleaning sieve were made of mild steel or teen sheet and hinged at the bottom of cylinder on concave hangers.

Blower Design

An aspiratory or blower is provided on a separate shaft below the threshing cylinder. The blower diameter is 32cm. The blower fan consisted of three blades of the size of 62 x 14 cm made of 2 mm thick mild steel plates. Straw and chaff from the top sieve are sucked by the blower and blown away to one side. Blown material can be collected, if required, by attaching a bag at the outlet.

The threshers have generally straight blade type blowers. Separation of the grain from the straw is done by passing an air stream through the falling grain and straw from the concave. The discharge of air required for blowing the impurities from the are aand velocity can be calculated as below. Actual air flow (QA) can be estimated as,

$$QA = A \times V \quad \ldots\ldots\ldots \text{(i)}$$

Where,
QA= Actual air flow, m3/s;
A = Area of blower which through the air, m2
V = Air velocity, m/s.

The efficiency of blower can be considered as 30%. The theoretical discharge (QT) can be estimated as (Jadhav R. T. 2009).

$$Qt = QA / 0.3$$

The theoretical discharge of a blower can be also obtained as,

$$Qt = \pi \times d1 \times b1 \times v1$$

$$= \pi \times d2 \times b2 \times v2 \ldots\ldots\ldots \text{(ii)}$$

Where, b1 and b2 are the width of blades at diameter d1 and d2 of impeller and V_1 and V_2 are tangential components of absolute velocities. V_2 can be approximate as 20% of the peripheral velocity of impeller tip for the design. Therefore

$$V_2 = 0.2 \times \pi \times d2 \times N \ldots\ldots \text{(iii)}$$

Where

N = is speed of impeller in revolutions/min.

We can obtain the impeller diameter (d2) by using equation (ii) & (iii), while the width of the impeller can be decided on the basis of the width over which air flow is required.

Power requirement for blower

Total power requirement for the blower is given by the formula (Khurmi and Gupta 2004).

$$P = 2 \pi N T / 60$$

$T = mg \times D/2$

Where,

T = Torque, N-m

P = power requirement, Watt

N = speed of shaft, rpm

m = mass of material,

kg g = gravitational acceleration,

N/m2 D = diameter, m.

Sieve

Sieve used for separates the heavier pieces of straw from grain. During working condition Heavy straw are retain on sieve and the final threshed product passing through cylinder concave clearance is collected at the bottom outlet.

Design of drive unit

The drive shall be of eccentric type. the drive shall consist of a crank , one end of which shall be connected to the spur gear and other shall be connected suitably to the pedal frame fulcrum which shall be welded to the pedal frame shall carry the pedal board (IS:) The thresher is normally operated with a speed of 400 rev/min.

Pedal were transmitted human power to all the unit of threshers by using spur gear and chain drive as a power transmission device. A shaft carries the threshing cylinder and is connected to the transmission system. The transmission system consists of meshed gears or sprocket-chain mechanism. The larger gear or sprocket is connected to foot pedal/bar with links. The foot pedal/bar is always in raised position. On pressing the pedal the threshing cylinder starts rotating. For continuous rotation of the cylinder, the pedal is lowered and raised repeatedly. For operation, paddy bundle is held in hands and ear head portion of the crop is placed on the rotating cylinder. The wire-loops hit the ear heads and grain get detached from the rest of the crop.

Gear Housing

The gear housing consist of spur gear which shall engage the pinion. The gear ratio should not less than 3.5:1. (IS: 3327-1982). The power may be transmitted from one shaft another by means gear with high transmission efficiency. A gear drive is also providing when the distance between driver and follower is less. The bigger gear has 105 numbers of teeth and small gear has 24 numbers of teeth. The speed ratio of gear is 1: 4.3. Gear is widely used in various mechanism and device to transmit power and motion positively (without slip). Spur gear is used where transmission of power between parallel shaft. The cast iron material is used for the working condition when power, speed and torque to be transmitted.

Crank

The crank shall be mace of bar of not less than 0.9cm in diameter, this shall be preferably be ‘ U’ shaped.

Pedal -

Pedal is used in the thresher to get power through human pedalling and with the drive mechanism, convert pedalling motion to rotary motion of the thresher cylinder. A person can generate four times more power by pedalling than by hand cranking. In this machine the pedal is made by wood and its length is 102 cm, width 10 cm and thickness is 3.5 cm.

Pedal frame

The pedal frame shall be of mild steel flat of at least 0.3×0.05 cm size.

Pedal frame fulcrum

The fulcrum shall be made of mild steel bar. In case bar is used, it shall be round and square with 3 cm diameter and side respectively

Pedal board

The pedal board shall be wooden plank having minimum size of 2.5 cm× 6.5cm. Its length shall be depend on the size of the cylinder.

Chain and Sprocket

Chains are used for high transmission power. They are mostly used when distance between centres is short. The number of teeth of bigger chain sprocket

is 48 and small chain-sprocket number of teeth is 14. The distance between both chain-sprockets is 44cm. The two factors determine the selection of chain working load and rpm of smaller sprocket .they are now generally used for transmission of power in cycle, motor vehicle and agriculture machinery in workshops.

Axle

The cylinder axle and gear stub axle shall be of mild steel round bar having diameter between 1.6 and 2.0 cm. the axle shall be supported by ball and bush bearing. Shaft is a rotating and stationary member, usually of circular cross section having such as gears, pulleys, flywheel, sprocket and other power transmission element mounted on it. The diameter of shaft is 2.4 cm. The design Presented in this paper comprises of two shaft-primary and secondary shafts. The primary shaft is to be fitted to the spur gear system and other shaft is to be fitted to the blower system. 3.4.4 Side frame The side frame shall be of mild steel angle section of nominal size of at least 0.3×0.3×0.03cm and parts shall be welded or bolted .the side frame shall support be made of mild steel sheet of thickness 0.05, 1.0 or 0.8cm. And these shall be bolted to the side frame.

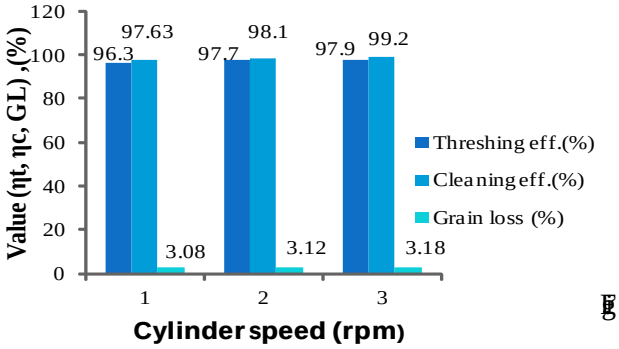
Results and discussions

Effect of cylinder speed and grain moisture on threshing efficiency, grain loss, cleaning efficiency. The harvested paddy was threshed at different grain moisture levels i.e. 13 per cent, 15 and 17 per cent and grain loss (weight of whole grain, damaged grain and un-threshed grain at chaff outlet, straw outlet and scattered grain) was measured.

During the testing of pedal operated paddy thresher with winnower was operated at different cylinder speeds i.e.180, 200 and 220 rpm and different moisture content of grain consider. Figure 6 (a) show the trend of increasing threshing efficiency, cleaning efficiency and grain loss with increasing cylinder speed but with decreasing grain moisture.

From figure 6 (a) threshing efficiency (çt), cleaning efficiency (çc) and grain loss (GL) is increased from 96.3 per cent to 97.9 per cent, 97.63 per cent to 99.2 per cent and 3.08 per cent to 3.18 per cent respectively at 180, 200 and 220 rpm. figure 7(b), it seen that threshing efficiency (çt), cleaning efficiency (çc) and grain loss (GL) is decrease from per cent 95.05 to 94.6 per cent, 98.6 per cent to 98.25 per cent and 2.06 per cent to 3.18 per cent respectively at 13 per cent, 15 and 17% grain moisture. figure 6(b), it seen that threshing efficiency (çt), cleaning efficiency (çc) and grain loss (GL) is decrease from per cent 95.05 to 94.6 per cent, 98.6 per cent to 98.25 per cent and 2.06 per cent to 3.18 per cent respectively at 13 per cent, 15 and 17 % grain moisture.

It was observed that section at cylinder speed 220 threshing efficiency, cleaning efficiency resulted highest values of 94.9 per cent, 98.9 per cent and minimum grain loss of 3.18 per centre.



6 (a): Effect on cylinder speed at threshing efficiency, cleaning efficiency and grain loss (%)

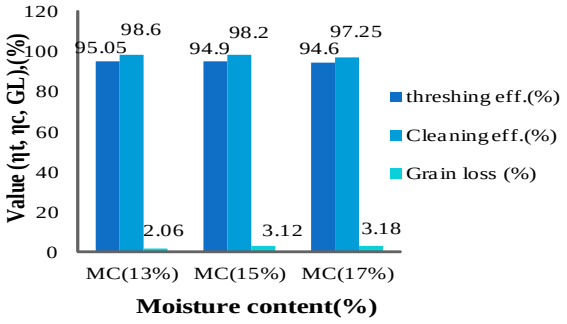


Fig. 6(b): Effect on grain moisture at different threshing efficiency, cleaning efficiency and grain loss

Hence the thresher was operated at cylinder speed 220 rpm, grain moisture 13 per cent. The thresher was operated for 30 minutes for each test and it was replicated for three times. The threshing efficiency, cleaning efficiency, grain loss and output capacity was measured.

Conclusions

From the above study undertaken following conclusions are drawn-

- The performance of pedal operated paddy thresher with winnower was satisfactory.
- On increasing moisture content from 13,15 and 17%,

the threshing efficiency, cleaning efficiency, is decrease from 95.08 to 91.6%, 98.6 to 97.25% and 3.35 to 2.8% respectively.

- On the value of threshing capacity decreased when moisture content increase from 13 to 17 per cent and 44 to 40 kg/h respectively.
- The increase the value of threshing efficiency, cleaning efficiency and grain loss of 92.3 to 94.9%, 97.61 to 98.9 % and 3.0 to 3.18% was obtained at change the cylinder speed from 180, 200 and 220 rpm.
- Comparatively better value of threshing efficiency, cleaning efficiency and grain loss obtained at 13% grain moisture.
- In order to get maximum output capacity 44 kg/h when the grain moisture 13%.

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