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Mini Paddy Harvester

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ABSTRACT: In developing country like India, farmers play avital role in it whenever the word "farming" comes it is followed by the word "hard work"in this occupation different processes are involved in order to get the desired crop. In order to complete this different process, we had seen many techniques have been developed. But these evolutions were happing more, in other foreign countries as compared to India. But, since last 2 decades, India is also approaching to develop such equipment, special purpose machines, new techniques and healthy research and development in the field of farm machinery and equipment, by which farmers are able to increase their overall productivity with reduced human efforts. we will be glad, if output of our project helps to reduce some of the efforts of our farmers related to harvesting of paddy/rice. This crop (rice) has been effectively taken in different parts of Maharashtra, infact many of the rice species have become identity of some districts. The main purpose of our Project is to help small scale farmers who are having land of one acres or less and which are located on hilly mountainous terrains, by designing robust, self propelled machine in which harvesting and threshing operations will be carried out simultaneously on a single machine.

Keywords: Harvesting process, Threshing process, Cutting blades, Design, Belt and Chain Drive.

I. INTRODUCTION

Recently Maharashtra has seen a shortage of skilled labour available for agriculture. Because of this shortage, the farmers have transitioned to using harvesters. These harvesters are available for purchase but they are not affordable, because of their high costs. However, agriculture groups make these available for rent on an hourly basis. But the small holding farm owners generally do not require the full-featured combine harvesters. Also, these combine harvesters are not available in all parts of rural Maharashtra due to financial or transportation reasons. Thus, there is a requirement of a compact and efficient combine harvester that would be more accessible and also considerably cheaper. The mission is to create a portable, user-friendly and low cost mini harvester. The idea is to create a machine which is cheap and will reduce the labour required to harvest crops for fulfilling the needs of farmers who has small land holdings.

Conventional harvesting process: In conventional harvesting process, the crop is cut manually by labour. It takes time and it is not effective as they can work only 5-6 hours in a day. Even though the smallscale farmers who having land less than 5 acres, it takes two to three days to cut and harvest the crops. After plantation of crops, if proper care is not taken then non-required plants also grows with crop. So, to separate this unwanted plant while harvesting is tedious work.

Conventional threshing process: The common method for threshing by hand is separating the grain from the panicle by impact. This can be done by hand beating, treading, or by holding the crop against a rotating drum with spikes or rasp bars. Hand beating methods are normally used for threshing rice that easily shatters.

Research Findings

According to "power requirement estimation for cutting paddy crop using a standard cutter bar" published by Arjya U. Sahoo (IIT kharagpur), the knife velocity/cutting speed must be a minimum of 1.8 m/s while the forward velocity should be less than 1.1 kmph (0.3065 m/s).

According to "Design and fabrication of crop cutting machine" by charwak depending upon length of the conveyor the peripheral velocity must be in between 2-3 m/s.

Accordingto Nuredin Nemo the rotational speed of threshing cylinder must be between 600 to 1100rpm.

From the data book the minmum power required for threshing drum is 2KW and the threshing capcity should always be greater than 90kg /kW.

According to Nuredin Nemo, the rpm of the conveyor must be around 50-70% of that of the rpm of thresher.

Methodology

As per the growing population and increasing demand for food, farmers are developing various processes to cultivate the crops faster, and because oflabour shortage and more money and time spent on conventional harvesting, there is a need,and aim to create a harvesting machine that is efficient and cost-effective, in which all operations are carried out simultaneously.

To achieve the aim, the following measures are considered.

- To interview the farmers and know the process and problems occurringat the time of harvesting.
- Surveying the farms for proper understandingof how the harvester should be.
- Designing the harvester as per the need of farmers.

Components of Harvester:

1. Reaper
2. Front Reel
3. Conveyor
4. Thresher
5. Engine

1. Reaper:The assembly consists of two blades one is stationary and another is moving and the length blade is 720mm.

Working principle: In this mechanism, the rotary motion of the rod is converted into linear reciprocating motion. When the rod is driven by the engine, the disc-shaped crank rotates. The crankpin on the disc which is engaged in the slotted yoke also rotates resulting in linear motion of the slider connected to the yoke.

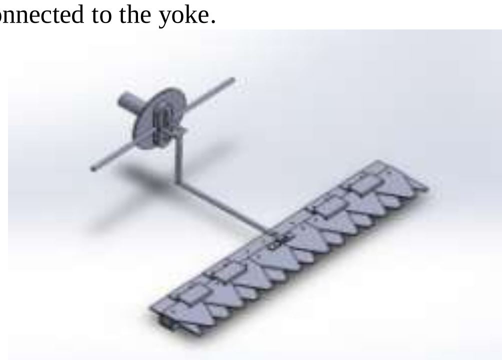

Fig 1. Reaper

2. Front Reel:It is a rotating unit above the reaper where paddy is guided to the reaper in which strawsare cut and further transfers to the conveyor belt.

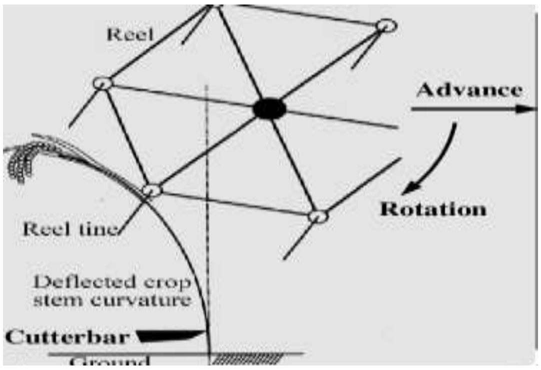

Fig 2.Reel

3. Conveyor: It consists of three parts upper roller, lower roller, and belt after transferring the paddy to the conveyor, the conveyor takes the paddy further to the threshing unit.

Fig 3. Conveyor Fig 4. Roller

4. Thresher:This is the most important component of mini paddy harvester in which threshing process takes place where grains are separated from the stalk and then the grain flow downward in the storage unit.

Fig 5. Upper Casing

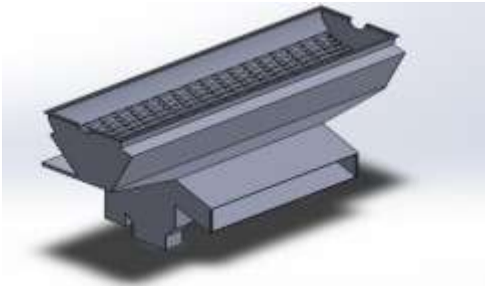

Fig 6. Lower Casing

5. Engine:As the total power required for operating of the machine is 6.174 HP. Therefore, we decided to select the Honda GX270LH 4 stroke petrol engine with fuel tank capacity of 5.3 liters and 8.4 HP of net power.

Fig 7.Honda GX270LH Engine

3 D Model:

Overall dimensions: length = 1530 mm, width = 720, height=1120

Fig 8. Mini Paddy Harvester

Components Used for Transmission:

Sr. No.	Type of transmission devices	Nos
1	Chain sprocket pairs	04
2	Belt drive pairs	05
3	Bevel gear	01
4	Shafts	03
5	Bearings	16

Design Calculations:

1. Design for Reaper:

As mentioned in the theory, the cutting velocity must not be less than 1.8 m/s.

Therefore, let us keep the cutting velocity as 2.24m/s i.e V = 2.24 m/s

Now, we know that $v = r \times \omega$

Here,

V = cutting velocity; r = radius of disc shaped crank = 45 mm = 0.045 m

Therefore,

$\omega = v / r$

$\omega = 2.24 / 0.045$

$= 49.77$

But,

$N = \omega/2\pi = 49.77/2\pi = 7.296$ rps

$= 7.296 \times 60$ rpm

$= 475.58$ i.e. 475 rpm

Torque = (shear force to calculate one crop) × (no. of input crop for each stroke) × (radius of crank)

Torque = $34.5492 \times 21 \times 0.045$

= 34.54 Nm

So,

Power = ($2 \pi NT \div 60$) + Power consumed due to friction

= 1717.67 + 58.41

= 17.76 watt

= 2.384 hp

2. Design of Reel:

Centrifugal force created by the reel = mr2

Now ,

N = 40rpm…..(from Data book for agricultural Machinery design)

$= 2\pi N/60$

=4.1866 rps

Therefore,
Force = 20 × 0.150 × 4.18662
= 52.58N
So, torque = F × r
= 52.58 × 0.150
= 7.88 N
And, power = 2пNT/60
= 2× п × 40 × 7.88
= 33.022 watt

3. Design of Conveyor:
The rpm of the conveyor must be around 50-70% of that of the rpm of thresher …… (according to Nuredin Nemo)
So, considering 50% of the thresher rpm, the rotational speed will be 300 rpm.
Now,
Linear velocity of conveyor belt
v = r × ω
= 0.05 × (300/60) × 2× п……(r=50mm)
= 1.57 m/sec
We know that mass flow rate is 0.5453 kg/sec
So, the force required for the conveyor will be equal toaddition of mass flow rate to conveyor in 1sec and weight of belt and weight of rollers
Force required =F = 0.5453 +7+10
F = 17.5661 × 9.81
= 172.32 N
Now,torque = F × r
= 172.32 × 0.05
= 8.616 Nm
Therefore,
power consumed = 2пNT/60
= 2×п×300×8.616 / 60
= 270.54 watt
= 0.3631 hp

4. Design of Thresher:
As per the theory the rotational speed of threshing cylinder must be between 600 to1100rpm……….. (According to Nuredin Nemo).
So, 600 rpm for the threshing drum is selected.
As per the data book the clearance between thresher drum and concave fixed casing must be 1025mm so, 10mm of clearance is kept.
The threshing unit has drum of radius 120mm mounted on 40mm diameter hub which is supported by two roller bearings, the toothsare of spike type with a height of 25mm and it has inbuilt fans which run at 1200rpm and also have hoppers above the storage tank
.
Calculations for mass flow rate :
The average yield rate of rice in 1 acre is 2500kg
Where,
The rice to straw ratio is 1:1.3 to 1:3
So, for 2500kg the weight of extra material for threshing will be 7500kg
So, 10000kg of paddy should be threshed by the machine in one acre.
Therefore, Mass flow rate =

$$\frac{\text{Total mass of paddy}}{\text{Time required to thresh one acre of paddy}}$$

Time required to thresh 1acre of paddy
1 hectre = 100 guntas
$=100 \times 33 \times 33\ ft^2$
$= 100 \times (10.0584)^2\ m^2$
1 acre = 40 guntas

$$Zn = 2\frac{a}{p} + \frac{Z1+Z2}{2} + \frac{Z2-Z1}{2\pi} + \frac{p}{a}$$

$$Zn = 2\frac{317}{12.7} + \frac{27+54}{2} + \left(\frac{27-54}{2\pi}\right)^2 + \frac{12.7}{317}$$

$$\underline{Zn = 89\ links}$$

$= 40 \times (10.0584)^2$
$= 4046.85\ m^2$
Now,
Area covered by machine in 1 sec =0.3065×0.720
= 0.22068 m/sec
Now ,
The time required to thresh 1 acre = 4046.85/0.22068
= 18336.77 sec
Therefore,
mass flow rate =

$$\frac{\text{Total mass of paddy}}{\text{Time required to thresh one acre of paddy}}$$

$$= \frac{10000}{18336.77}$$

= 0.54453 kg/sec

5. Design of Chain Sprocket:
For 1-1[1]
Step 1: Kw rating of Chain:
In order to reduce the polygon effect, the number of teeth on driving sprocket is selected as 27 teeth. therefore, k2=1.46) and the chain is simple roller chain with only one strand (k1=1)
Therefore,
Kw rating of chain = (kw to be transmitted) x Ks /K1 x K2.
Ks = 1.4
Therefore,
Kw rating of chain = 4.8 x 1.4 / 1 x 1.46
Kw = 4.60 Kw
Step 2: Selection of Chain:
Referring to table, the power rating of the chain number 0.8A at 1800 rpm is 6.98 Kw Therefore, The dimensions of chain
P = 12.7mm; d1 = 7.95 ; b1 = 7.85

Step 3: Pitch Circle Dia. Of Driving and driven pulleys

$$D1 = \frac{P}{\sin\left(\frac{180}{Z1}\right)}$$

D1 = 109.39mm = 109 mm

For the driven Sprocket,
Z2 = Z1(n1/n2)
= 109.39(1800/900)
Z2 = 54 teeth

$$D2 = \frac{P}{\sin\left(\frac{180}{Z1}\right)}$$

D2 = 218mm
Step 4: Number of chain Links
The distance between the sprocket wheels should be between 20p to 30p taking mean value of 25p. a=25(12.70) a =317mm

Step 5: Correct Centre:
ln – (Z1 + Z2 /2) = 89 – (27 + 54 / 2) = 48.5

$$a = \frac{p}{4}\left\{\left[ln - \frac{Z1+Z2}{2}\right] + \sqrt{\left[ln - \left(\frac{Z1+Z2}{2}\right)\right]^2 - 8\left[\frac{Z1-Z1}{2\pi}\right]^2}\right\}$$

$$a = \frac{12.7}{4}\left\{48. + \sqrt{[48.5]^2 - 8\left[\frac{54-27}{2\pi}\right]^2}\right\}$$

$$\underline{a = 303\ mm}$$

Step 6 :The Chain Velocity is given by

$$V = \frac{Za\ P\ Na}{60\ X\ 10^2}$$

V= 10.28 m/s
Therefore, Chain Tension is

$$P = \frac{1000\ kw}{V}$$

P = 466.92 N

For pairs 2-2`:
- Gear ratio – 1.889:1
- N1=900rpm and N2=476rpm
- Chain link pitch – 12.7mm
- Chain links - 122
- No. of teeth on driving sprocket – 27teeth
- No. of teeth on driven sprocket – 51teeth
- PCD of driving sprocket – 109mm
- PCD of driven sprocket – 206mm
- Center distance – 525mm
- Tension – 933N
- Chain type – 08A(ANSI-40), with simple roller chain with only one strand.

For pair 3-3`:
- Gear ratio – 1.37:1
- N1=900rpm and N2=657rpm
- Chain link pitch – 12.7mm
- Chain links - 58
- No. of teeth on driving sprocket – 27teeth
- No. of teeth on driven sprocket – 37teeth
- PCD of driving sprocket – 109mm
- PCD of driven sprocket – 150mm
- Center distance – 164mm
- Tension – 933N
- Chain type – 08A(ANSI-40), with simple roller chain with only one strand.

For pair 4-4`
- Gear ratio – 1:1
- N1=11rpm and N2=11rpm
- Chain link pitch – 12.7mm
- Chain links - 69
- No. of teeth on driving sprocket – 16teeth
- No. of teeth on driven sprocket – 16teeth
- PCD of driving sprocket – 65mm
- PCD of driven sprocket – 65mm
- Center distance – 340mm
- Chain type – 08A(ANSI-40), with simple roller chain with only one strand.

6. Design of Belt Drive:
Calculations for pair 5-5`
N1 = 1800 ; N2 = 900

A = 195 …(Dist. Available for assembly without any interference)

The cross section of the belt is “V” with coefficient Of friction 0.2 and groove angle 40^0 with 0.25 Kg/m mass of the belt.
As the velocity ratio is 1:2. Let the diameter of pulley be 120 mm and 60 mm.

Step 1:Velocity of belt

$$V = \frac{\pi\, d1\, N1}{60}$$

V = 5654.86 mm/s
V = 5.654 m/s
Step 2:
αs = 180 – 2 $\sin^{-1}$(D-d/2x)
αs = 160.30^0
αs = 2.83 rad/sec
Now,

$$\frac{p1 - mv^2}{p2 - mv^2} = e^{\frac{F\alpha}{\sin\frac{\theta}{2}}}$$

$$\frac{p1 - mv^2}{p2 - mv^2} = 5.75$$

p1 – 7.98 = 5.75(p2 – 7.98)
p1= 5.75p2 – 37.90 …. (1)

Step 3:
P = (p1 – p2)V/1000
3.5X 1000 = (P1 – P2) X 5.75
P1 – P2 = 834.78 …. (2)

Now, Substituting Value of P1 in Eqn 2
5.75P2 – 37.90 – P2 = 834.78
4.75P2 = 872.68
P2 = 183 N
And,
P1 – 183 = 834.78
P1 = 1017 N
p1 = 1017 N and p2 = 183 N

- ratio – 1:2
- small pulley rpm – 900rpm
- Large pulley rpm – 1800rpm
- Smaller pulley diameter - 60mm
- Large pulley diameter – 120mm
- T1 = 1017N
- T2 = 183N
- centre distance=195mm

For pair 6-6`

- ratio – 1:1.5
- small pulley rpm – 900rpm
- Large pulley rpm – 600rpm
- Smaller pulley diameter - 80mm
- Large pulley diameter – 120mm
- T1 = 1530N
- T2 = 254N
- centre distance 843mm

For pair 7-7`

- ratio – 1:2
- small pulley rpm – 600rpm
- Large pulley rpm – 300rpm
- Smaller pulley diameter - 60mm
- Large pulley diameter – 120mm
- T1 = 500N
- T2 = 2626N
- centre distance 200mm

For pair 8-8`

- ratio – 1:1.33
- small pulley rpm – 1200rpm
- Large pulley rpm – 900rpm
- Smaller pulley diameter - 60mm
- Large pulley diameter – 80mm
- T1 = 396.39N
- T2 = 68.04N

$$\tau = \frac{16}{\pi D^3} \times \sqrt{(M_b)^2 + (M_t)^2}$$

- centre distance 443mm

For pair 9-9`

- ratio – 1:7.5
- small pulley rpm – 300rpm
- Large pulley rpm – 40rpm
- Smaller pulley diameter - 40mm
- Large pulley diameter – 300mm
- T1 = 941N
- T2 = 2692.39N
- centre distance= 221mm

7. Design of shaft :Calculations for shaft no.1

To calculate the diameter of the shaft of material 30c8 with yield strength 400N/mm2 and length 500mm

Step1 – permissible shear stress

$\tau = \frac{Syt}{Fos}$

= 0.5×400 / 3

= 66.67 N/mm2

Step 2 – Torsional Moment
MT= Force× radius of sprocket
Where, force = chain tension = 466.9….(pair 1-1`)
And
radius = 218/2 Mt = 466.92 × 109
Mt = 50894.28 Nmm

Step 3 : Support reactions at bearings
For equilibrium
Ra + Rb = 933+466+933
Ra + Rb = 2332.92 N……(1)
Now ,
Taking moment about point A
∑ Ma = 0 = RB ×365 + 933 × 40 – 933 × 325 – 466.92 × 295
Therefore,
RB ×365 + 933 × 40 = 440966.4
RB = 403646/365
RB = 1105.88 N
Substituting value of RB in equation 1
So, RA = 1227.03 N

Step 4 : ending moment calculations
1)Bending moment at A = 447855N
2)Bending moment at B = 403646N
3) Bending moment at C = (373202 + 3778652) ½ = 379703 N
4) Bending moment at D = (1377412 + 3268452)1/2 = 141565.62 N
5) Bending moment at E = (3032252 + 373202)1/2 = 305512.98 N
Therefore, max bending moment is 447855 N

Step 5: Calculation of diameter
D = 32.53 mm
D ≈ 35 mm

Shaft No.	Calculated diameter	Selected diameter	Length
1	32.53 mm	35mm	500mm
2	29.33mm	35mm	500mm
3	16.23mm	20mm	350mm

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8. Selection for Bearing:

Shaftdiameter	Type of bearing	Qty.
40	P2BE 40M-TRB-STHpillow block roller bearing	02
35	SY 35FMPillow block ball bearing unit	06
20	P 20 FM Pillow blockball bearing unit	08

Material Used in Harvester:

Sr. No.	Component	Material
1	Blades	High carbon steel
2	Cam of mechanism	Grey cast iron
3	Shafts	30c8 carbon steel
4	Sprockets	Hardened steel
5	Pulleys	Aluminum
6	Chain	Stainless steel
7	Belt	Rubber
8	Conveyor	Rubber
9	Frame	AISI 4130 steel
10	Spike tooths in thresher drum	Mild steel

II. CONCLUSION:

The Mini Paddy Harvester will be used to overcome the shortage of labour and cost of conventional harvesting process. Therefore, the farmers whose land is one or less than one acres arebenefited by this combine harvester.

The designed harvester is used to do overall process simultaneously, from cutting the straw to threshing and later storing the grain.

Considering the cost to make this machine is very low compared to harvester in the market. Hence, farmers can be able to take it for rent or buy this machine.

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