

Design and Performance evaluation of Wheat Crop Cutting Machine

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Abstract - This machine targets the small scale farmer who are not affordable the high cost machine or on the rented bases, so that the idea is to prepare a machine which work like similar operation as actual machine but in modification of their system. This work describes the constructions of a crop cutting machine. The machine consists of four main parts, name as cutter blades, slider crank mechanism, Rack and pinion, and Crop reel system. The machine run on motor of 24VDC motor, this power from motor is provided to the slider crank mechanism through cutter. A collecting mechanism are provided which bend the crops and easily allow the crop to cut, after cutting these crops fall into the rack and pinion mechanism which collect and force the crops at one side. The design of reel includes determination of the rotational speed of reel. On the basis of their design is to determine minimum grain losses. The test was conducted to study the performance of our machine for that, testing was done at farm. After the testing machine performance was evaluated on the basis of their parameter like the forward speed (km/hr) field capacity (ha/hr), field efficiency (%).

Key Words: Slider Crank Mechanism, Collecting system, Performance testing

1. INTRODUCTION

The Farming is most widely followed profession in India. Agricultural products contribute a major portion to our economy. The crop cutting is important stage in agriculture field. Crop harvesting is the last stage in farming which takes maximum time of farmer among all farming process. Crop harvesting is a process of cutting the crops closed to the ground or pulling the plants when they are ripped out. It includes cutting the stems of coral crops like wheat and rice etc, closed to the ground. In our country it is done by sharp sickle. Engineering science has brought tremendous changes in traditional crop cutting methods. Farming in India is not only limited to growing of crops but is also associated with the economic growth of farmers and labor. Farmers in Vidarbha have been experiencing a problem of lack of skilled and cheap labor which has ultimately forced them to adopt the use of machine.

The status of mechanization in agriculture varies for different activities, although the overall level of mechanization is still less than 50%, as compared to 90% in developed countries.⁶² The highest level of mechanization (60%-70%) is observed in harvesting and threshing activities and irrigation (37%). To increase productivity, farm equipment which is durable, light-weight and low cost, and

also specific to different crops and regions should be made available for small and marginal farmers. Some challenges faced by farm mechanization include different soil and climatic zones which require customized farm machinery, and small land holdings with lack of access to resources. Mechanization should aim to increase agricultural efficiency by reducing the time and labor requirement, minimizing wastage and reducing costs of labor.

The alarming rate of growth in population has now made it necessary to fasten the rate of production of agricultural products using mechanized system. These machines are available in market for purchase or are made available on hourly basis on rent by agricultural organizations but small scale farmers do not require such full/extra featured combined harvesters. Thus there is a need for the development of a compact and a comparatively cheap machine which will be affordable to the small scale farmers. The focus of the project is to create a portable, compact and user friendly low cost and mini collector machine which will simultaneously perform both jobs of cutting and collecting the crops. This machine is cost effective, easy to maintain and can be simply manufactured as it comprises of locally available spare parts.

The low productivity in India is a result of the following factors:

- Adoption of modern agricultural practices and use of technology is inadequate, hampered by ignorance of such practices, high costs and impracticality in the case of small land holdings.
- Small size and scattered holdings of the farmers stand in the way of mechanization. As a result of this, farm machinery generally remains underutilized.
- Majority of small cultivators are poor who are not in a position to purchase the costly machinery like tractors, combine harvesters etc.
- Lack of proper knowledge of farmer to purchase farm machinery, operate and maintain it properly leads to wrong choice, makes it uneconomical and risky too.
- There is great shortage of diesel in the country as a whole. Thus, to use so extensive oil based farm machinery is not desirable.

- The lack of repair and replacement facilities especially in the remote rural areas is another hindrance in efficient small farm mechanization.
- Illiteracy, general socio-economic backwardness, slow progress in implementing land reforms and inadequate or inefficient finance and marketing services for farm produce.

2. METHODOLOGY AND STUDY OF DIFFERENT MECHANISM

As being stated in the statement of the problem in order to develop the machine which solve the specified problem, So that the theoretical analysis of the method applied to a study. The aim was to fabricate affordable machine with locally available parts for economy growth of farmers. To achieve this aim, it was decided following steps.

- Interact with local small scale farmers to obtain a basic idea of traditional techniques used for harvesting.
- Studying the present mechanisms.
- Consulting agricultural machines manufacturers. To get information about different operation.
- Reviewing different literature review and Gathering raw data and interpreting it.
- Design of crop cutting machine Cero model.
- Calculation
- Performance Evaluation
- Result and conclusion

2.1 Studying Different types of mechanism

- **Concept 1:** (Single Circular Rotating Cutter)

This mechanism works on the single circular blade which is rotate in one direction. The power is directly given by shaft to bevel gear agreements to the cutter. The reason for dropping this concept because of less cutting surface area and second is crops may fall on either side of machine.

- **Concept 2:** (Using two Circular Blades)

This mechanism of crop cutting work on the two same circular saw cutter which is rotates in opposite directions. Reason for dropping this concept, collection mechanism was absent, making the crop to fall on either sides creating problem for farmer to collect the cut crop.

- **Concept 3:** (Scotch yoke mechanism)

It is the one of the good alternative to the above two concepts. This mechanism converts the rotating

motion to the reciprocating motion which gives the cutting active to the cutter. Reason to dropping this concept due to low transmission of cutting force, friction on rotating yoke and this mechanism may fail when the bunch of crops gathers on the reciprocating cutter. Because of this critical mechanism it may creates a problem during the cutting of crops.

2.3 Final Proposed Design

In this concept it is a thought of making some changes in the existing machine, keeping in mind to design a machine with more effective as well as cost effective. The motor power of this machine is 250W, which transmitted to the cutter with the help of slider crank mechanism. This mechanism converts the rotary motion of disc into reciprocating motion. A cutter assembly consists of two sets of cutter one set of cutter attached with the slider crank mechanism. And another cutter is fixed with chassis. The cutters used are of straight shape. This sliding motion of cutter gives the scissoring action responsible for cutting the crops.

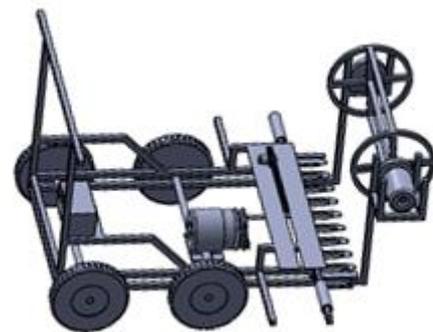


Fig-1: Model of machine

Collecting mechanism consist of the cylindrical section which consist of three blades, the crops are guided towards backside by means of the cylindrical collecting mechanism system. The purpose of this system to hold the crop against the cutting mechanism, to clear the cut stalks from the cutter and to deliver cut material to other units of the machine. Its effectiveness is dependent upon how closer they pass to the cutter, better the clearing of cut material and the more constant the feed rate. The optimum position of this system is determined by the crop height, amount of straw cut and condition of the straw. Note (Peripheral rotating collecting speed should be slightly faster than ground speed for good result.

3. DESIGN CALCULATION

3.1 Collecting Systems

A_0 - Initial Position

H_r - Height of the cylinder

R - Radius of the cylinder

T - Time

V_m - Forward speed of the machine

X_n, Y_n - Reference Co-ordinates of

Crops Stalks

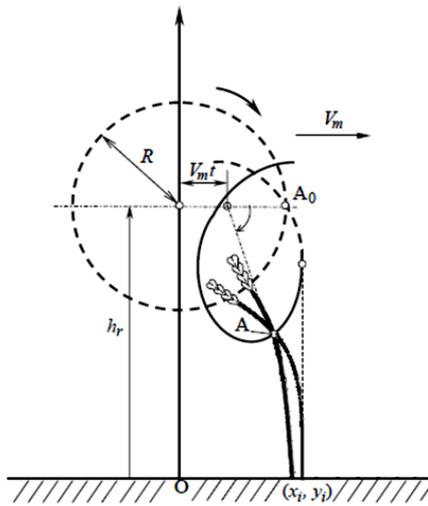


Fig-2: Collecting system drawing

Radius of Cylinder = 24cm = 0.24m

$N = 40$ r.p.m

1. Rotational velocity of the cylinder

$$w = \frac{2 \times \pi \times N}{60} = \frac{2 \times \pi \times 40}{60} = 4.18 \text{ rad/s}$$

• Peripheral Speed of the cylinder

$$v = w \times r$$

$$v = 4.18 \times 0.25$$

$$v = 1.02 \text{ m/s}$$

• Forward Speed of the machine:

$$V_m = \frac{v}{1.25} = \frac{1.02}{1.25} = 0.81 \text{ m/s}$$

3.2 Slider Crank Mechanism

• Method for Calculating the Displacement, Velocity and Acceleration of the Cutter.

• In fig, OC is the Crank and PC is the connecting rod.

• X is the displacement of a reciprocating body.

• L is the length of connecting Rod, r is radius of crank

• Crank rotates with angular velocity of w rad/s.

• n is the ratio of length of connecting rod to the radius $= l/r$

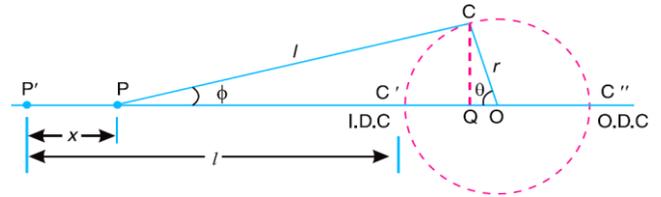


Fig-3: Slider Crank Mechanism

1. Displacement of Cutter:

$$r = 0.075 \text{ m}, l = 0.2 \text{ m}$$

(Max Displacement at angle = 90)

$$X = r \left[(1 - \cos \theta) + \frac{\sin^2 \theta}{2n} \right]$$

$$n = \frac{l}{r} = \frac{0.2}{0.075} = 2.66$$

$$X = 0.075 \times \left[1 - \cos 90 + \frac{\sin^2 90}{2 \times 2.66} \right]$$

$$X = 0.09 \text{ m}$$

2. Velocity of cutter:

$$\text{If, } r = 0.075 \text{ m}, l = 0.2 \text{ m}$$

(Velocity at any angle)

$$V_p = w \cdot r \left[\sin \theta + \frac{\sin 2\theta}{2n} \right]$$

Let taking the angle 45

$$n = \frac{l}{r} = \frac{0.2}{0.07} = 2.66$$

$$w = \frac{2\pi N}{60} = \frac{2\pi \times 300}{60} = 31.41 \text{ rad/s}$$

$$V_p = 31.41 \times 0.075 \times \left[\sin(45) + \frac{\sin(2 \times 45)}{2 \times 3.14} \right]$$

$$V_p = 1.66 \text{ m/s}$$

$$V_p = 2.35 \text{ m/s at } 90^\circ$$

3. Acceleration of the Slider

$$A_p = w^2 \times r \times \left[\cos \theta + \frac{\cos 2\theta}{n} \right]$$

$$A_p = 31.41^2 \times 0.075 \times \left[\cos 45 + \frac{\cos 2 \times 45}{2.66} \right]$$

$$A_p = 52.32 \text{ m/s}^2$$

4. TESTING THE PERFORMANCE OF MACHINE

• Forward Speed: Forward speed was measured by dividing the distance by time required to travel that distance. The forward speed was calculated as given below:

$$\frac{Disance(D)}{Time(T)}$$

Forward Speed (S) km/hr =

Where

D = distance, m

T = time, s

S = forward speed

Distance = 12 ft=3.6m , Time = 40 sec

$$S = \frac{Disance(D)}{Time(T)} = \frac{3.6}{40}$$

= 0.09 m/s = 0.32 km/hr

- Theoretical Field Capacity (TFC): Theoretical field capacity of machine is the rate of crop cutting that would be obtained if the machine were performing its function 100% of the time at rated forward speed and always covered 100% of its cutting width.

$$TFC = \frac{S \times W}{10} \text{ ha/h}$$

Where,

S = rated forward speed, m/s

w = cutting width, m

$$= \frac{0.32 \times 0.81}{10}$$

$$= 0.025 \text{ ha/hr}$$

- Effective Field Capacity or Actual Field Capacity:

The effective or actual field capacity of a farm machine is defined as the actual area covered by the machine per unite time or the area covered divided by the total time is EFC.

$$EFC = \frac{Actual \text{ cutting area}}{Total \text{ time}} \text{ ha/hr}$$

Time during the cutting = 62sec = 0.0172 hr

Width of cutter = 2.7ft = 0.82m

Actual cutting area = Distance cover * width of cutter

A= 3.6 *0.82 = 3m² = 0.0003 ha

$$= \frac{0.0003}{0.0172} = 0.0174 \text{ ha/hr}$$

- Field efficiency: The field efficiency was determined by the ratio of effective field capacity to the theoretical field capacity.

$$\frac{E.F.C}{T.F.C} \times 100$$

Field Efficiency =

Where,

EFC= Effective Field Capacity

TFC = Theoretical Field Capacity

$$= \frac{0.0174}{0.025} \times 100$$

= 68.8%

5. RESULT AND DISCUSSION

The results about peripheral reel speed indicated that when the peripheral reel speed was increased, the losses tended to decrease initially. However, as the peripheral reel speed was increased, more losses occurring ascension ally. Very low peripheral reel speed created more losses because the fingers could not collect all the crops towards the chamber. On the other hand, when the reel speed was high or moved too quickly, the fingers would beat the head violently resulting in the greater loss

The field capacity and efficiency are very important parameter which should be taken into consideration when we evaluate machine performance. The actual field capacity is affected by many factors such as machine forward speed, height of cutter bar and crop collecting system. The data collected during field evaluation trails were analyzed to determine the forward speed (km/hr) field capacity (ha/hr), field efficiency (%),

6. CONCLUSION

An experiment was conducted to study the performance of our machine for that, testing was done at 4 different farms. After the each testing machine performance war evaluated on the basis of their parameter like field capacity, cutter design and adjusting collecting system of this machine . On the bases of result suitable modification was done and rechecking their performance. The effective cutting width of the harvester was 0.82m. The average forward speed of combine was 0.32 km/hr. Theoretical field capacity and the effective field capacity were 0.025 ha/hr. and 0.0172 ha/hr and 0.91 ha/hr respectively. The field efficiencies were 68.8% for wheat.

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