

Design and Fabrication of Manually Operated Paddy Transplanter

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Abstract— Agriculture is the most important sector of the Indian economy. It is the most important source of employment for the majority of the work force in the country. Approximately 49 percent of the total labor force was engaged in agriculture in 2012. Among that highest percentage was in paddy sector. Rice is the major staple food of the country. Releasing of work force to sectors other than Agriculture is important to develop the country. To release the work force in paddy sector mechanization plays a big role. To feed growing population is a huge challenge. Importation of rice will lead to drain out the economy of the country. Mechanization of paddy sector will lead to higher productivity with releasing of work force to other sectors. The objective of this project is to design a paddy transplanting mechanism to transplant paddy seedlings by small scale farmers in the country. In world the usage of agriculture equipments are increasing. In the usage of agriculture equipments, India contributes only 10%. Due to the scarcity of manpower and more time taken for transplant to reduce this problem we have decided to do project related to agriculture. For more information about today's agriculture equipments and methods we searched and studied some papers and also visited to agriculture equipments manufacturing companies.

Key words: Paddy Transplanter, Fabrication

I. RESEARCH PROBLEM

Mechanical transplanting of paddy seedlings is a solution to the prevailing situation in the India to release the work force and to reduce the cost of paddy production. Farmers are aware of the advantages associated with transplanting of paddy over the broadcasting. But they are unable to practice it for high scarcity of labor. Still the transplanting machines available for the country are imported. Engine driven transplanters are high in cost and the inter-row, intra-row spacing are fixed which are not suitable for the Indian condition. Existing manually operated transplanters are inefficient. The main reason for the poor acceptance was the low capacity of the machine. A simple engine operated transplanter or manually operated transplanter having an average capacity of one hectare per day would be a better solution.

A. Objectives

Main objectives in this project were to:

- Design a mechanism for transplanting paddy seedlings
- Test the performance of the transplanting mechanism

II. METHODOLOGY

Methodology is the systematic, theoretical analysis of the methods applied to a field of study. It comprises the theoretical analysis of the body of methods and principles associated with a branch of knowledge. Typically, it

encompasses concepts such as paradigm, theoretical model, phases and quantitative or qualitative techniques.

A. Design

1) Method of Design

This included designing of

- Planting unit
- Paddy seedling tray
- Power transmission system and attachments

2) Designing of Planting Unit

The planting unit consists of various types of moving parts and mechanisms. They are as follows:

- 1) Shaft
- 2) Fork
- 3) Four bar linkage

III. PROPOSED MODEL

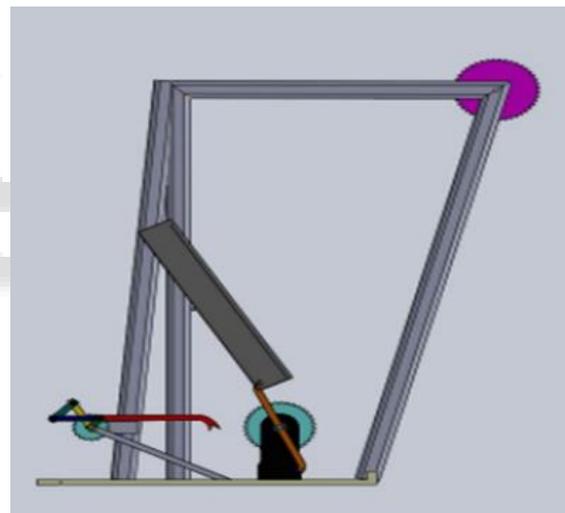


Fig. 1: Proposed Model

A. Design of Shaft

The shaft is revolving rod and it is used to transmit the motion or power. There are two shafts are used to transmit the motion.

Here, the shaft contains forks and another contains four bar linkage. The power is transmitted to these shafts from the hand driven wheel by using the chain and sprocket.

1) Dimensions of Shaft

Generally the distance between the two rows of rice transplanting is to be maintained of 9 Inches (22.86cm). Length of shaft = 30 cm.

According to ASME code permissible shear stress τ_{max} for the shaft without key is taken as

- 30% of yield strength in tension
- 18% of ultimate strength in tension

Max Shear stress theory,

$$\tau_{max} = \frac{16}{\pi d^3} \sqrt{\{(K_b \times M_b)^2 + (K_t \times M_t)^2\}}$$

Where,

K_b = Combined shock and fatigue factor applied to bending moment

K_t = Combined shock and fatigue factor applied to torsional moment

In this case,

$K_b = 1.5$

$K_t = 1$

Weight of the each fork is 500gm = 4.90N

R_a, R_b = Bearing support

C, D = Load applied by forks

$-4.90 \times 51 - R_b \times 152 + 4.90 \times 203 = 0$

$-249.90 - 152R_b + 994.7 = 0$

$R_b = 4.9$

$R_a + R_b = 9.8$

$R_a = 4.9$

Selected material for shaft is Cn55Mn75 (mild steel)

From design data book

$S_{yt} = 460 \text{ N/mm}^2$

$\tau_{max} = 0.3 \times S_{yt}$

$= 0.3 \times 460$

$= 138 \text{ N/mm}^2$

Force applied by human hand is taken as 100N

Torque on handle is

$T = r \times F$

$= 180 \times 100$

$T = 18000 \text{ N-mm}$

Power transmitted by shaft is

$P = \frac{2\pi NT}{60}$

$= 2 \times \pi \times 25 \times \frac{18000}{60}$

$P = 2619.9 \text{ Watt}$

Torsional moment of shaft is

$M_t = \frac{60 \times 10^6 (Kw)}{2\pi n}$

$= \frac{60 \times 10^6 (2.61)}{2\pi \times 61}$

$M_t = 407019.19 \text{ N-mm}$

$\tau_{max} = \frac{16}{\pi d^3} \sqrt{\{(K_b \times M_b)^2 + (K_t \times M_t)^2\}}$

$138 = \frac{16}{\pi d^3} \sqrt{\{(1.5 \times 249.9)^2 + (1 \times 407019.19)^2\}}$

$d^3 = 15014.38$

$d = 24.67$

$d \approx 25 \text{ mm}$

Length of shaft = 300 mm Diameter of shaft = 25 mm

B. Design of Fork

The paddy seedling is kept in the tray. It is required to pick the paddy seedling from the tray and put on the skid. Here, the forks are used to pick up the paddy seedling from the tray and to keep it on the skid.

There are two forks are attached to shaft. The spacing between the two rows is standard of 9 Inches (22.86 cm). Hence the distance between the two forks is 22.86 cm. The motion from the first shaft is given to these forks. The total length of forks is adjusted according to the comfort and distance between the bottom side of the tray and skid.

The length of the fork is taken approximately 29 cm.

C. Design of Four Bar Linkage

The four bar linkage mechanism is used for transplant the paddy. The power from hand wheel is given to the fork

attached shaft by using the chain and sprocket. From this shaft the motion is transfer to the linkage attached shaft and finally the motion is transfer to the four bar linkage.

Dimensions of Four Bar Linkages

Length of crank= 3.5 cm

Length of lever= 6 cm

Length of connecting rod= 10 cm

Length of fixed frame = 8 cm

1) *Grashof Condition*

$S+L \leq P+Q$

$3.5 + 10 \leq 6+8$

$3.5 \leq 14$

Hence Grashof condition is satisfied.

– Crank – It will be rotate in a full 360 degree.

– Lever – It will be rotate through a limited range of angles.

– Connecting rod – It is used to connect the crank & lever.

– Fixed frame – This is the fixed part of the linkage.

2) *Transplanter*

It is nothing but the extended length of the connecting rod. It is used to collect the paddy from the fork and transplant it into the ground. The length of the transplanter is 25 cm.

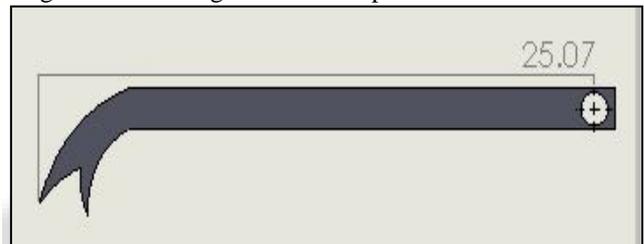


Fig. 2: Dimensions of Transplanter

3) *Four bar linkage mechanism view*

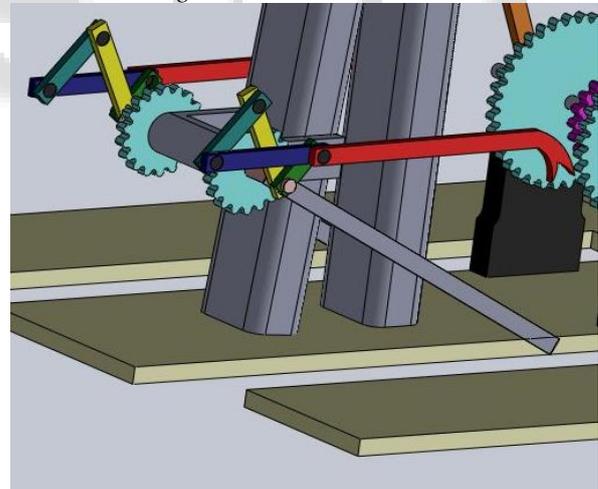


Fig. 3: Four bar linkage mechanism

D. Design of Paddy Seedling Tray

There is requirement to store the paddy seedling with machine while transplanting. Hence the tray is used to keep the paddy seedling on transplanter. The tray is only purpose of holding the paddy seedling. The sheet metal is metal formed by an industrial process into thin, flat pieces.

1) *Dimensions for Tray*

1) Length of the sheet metal – 53 cm

2) Breadth of sheet metal – 26 cm

3) Thickness of sheet metal – 0.2 cm

2) *Design of Power Transmission System and Attachments*
To transmit the power from the hand driving wheel to the shaft the chain and sprockets are used.

E. Calculation of Chain Pins

Chains are used to transmit the power from hand driving wheel to the shaft in which forks are attached and it is also to transmit the power to the four bar mechanism.

Length of chain

$$L = L_p \times P_d$$

Where,

L_p is the Length of continuous chain in multiples of pitches (i.e. approximate no. of links)

P_d = Pitch diameter

Now to find Pitch diameter P_d , $a = (30 \text{ to } 50) P_d$

Where,

a is the center distance and assumed it as 110cm

$$110 = 50P_d \quad P_d = 2.2 \text{ cm}$$

Now to find length L_p ,

$$L_p = 2a_p + (Z_1 + Z_2)/2 + (((Z_1 - Z_2)/(2 \times 3.14))^2 / a_p)$$

Where,

a_p is the approx. center distance in multiples of pitches

$$a_p = a/P$$

$$= 110/2.2$$

$$= 50 \text{ cm}$$

$$L_p = 2(50) + (62/2) + ((26/(2 \times 3.14))^2 / 50)$$

$$= 100 + 31 + 0.34$$

$$L_p = 131.34 \text{ cm}$$

Length of chain,

$$L = L_p \times P_d$$

$$= 131.34 \times 2.2$$

$$L = 289 \text{ cm}$$

Length of first chain = 289cm

Length of second chain = 85 cm

F. Selection of Sprocket

We use sprockets for hand driving wheel and in the shaft rotating the fork and four bar mechanism.

1) Calculation of Speed of Rotation

Z_1 = No. of teeth on sprocket pinion.

Z_2 = No. of teeth on sprocket wheel.

N_1 = Speed of rotation of pinion.

N_2 = Speed of rotation of wheel.

Speed of wheel driven by hand $N_2 = 25$ rpm (optimum value)

No. of teeth in sprocket wheel $Z_2 = 44$

No. of teeth in sprocket pinion $Z_1 = 18$

Transmission Ratio 'i'

$$N_1/N_2 = Z_2/Z_1$$

$$Z_2/Z_1 = 44/18$$

$$= 2.44$$

Therefore,

$$N_1 = 2.44 \times 25$$

Speed of rotation of first pinion = 61rpm.

2) Calculations for final speed

Speed of sprocket on first shaft $N_3 = 61$ rpm

No. of teeth in sprocket on final shaft $Z_4 = 18$

No. of teeth in sprocket on first shaft $Z_3 = 36$

Transmission Ratio 'i'

$$N_4/N_3 = Z_3/Z_4$$

$$Z_3/Z_4 = 36/18$$

$$= 2$$

Therefore,

$$N_4 = 2 \times 61$$

Speed of rotation of final pinion = 122 rpm.

3) Design of the Skid

The all machine parts are assembled and the whole assembly is mounted on the base plate. This base plate is known as the skid.

4) Dimensions of the skid

Length = 67 cm Width = 60 cm Thickness = 3 cm

IV. FABRICATION

The fabricated and selected components are as follows:

A. Shaft

- Shaft is a revolving rod that transmits motion or power.
- There are two shafts are fabricated for this machine.
- Here, the one shaft contains forks and another shaft contains four bar linkage and power is taken from the hand driven wheel by chains and sprockets.
- There is one more shaft available which is used for mounting the hand driven sprocket.

B. Fork

Fork is used to pick up the paddy seedling from tray and to keep it on skid. There are two forks attached to shaft and distance in between two fork is 22.86cm. The motion to fork is giving by shaft. Total length of fork is 29 c.m.

C. Four bar linkages

- It contains the crank, lever, connecting rod and fixed link.
- Connecting rod is extended by another link which is known as the transplanter.
- Transplanter collects paddy from the fork and transplant it into the mud.



Fig. 4: Fabricated four bar linkage mechanism

D. Tray

- Tray is used to keep the paddy seedlings on the transplanter.
- Sheet metal is metal formed by an industrial process into thin, flat pieces.

E. Structure

- It is used to support the tray.
- It provides support to the sprocket which is rotating by hand.
- The handle which is used to pull the machine is attached to the structure.

F. Skid

- Skid is nothing but the base plate.
- The whole assembly of the machine is mounted on the skid.
- The particular shape is given to the skid to avoid the mud and water entered on the machine.

V. SELECTED COMPONENTS

A. Plumber Blocks

- They are used to support the shafts.
- There are six plumber blocks are used to provide the support.
- Two plumber blocks provide support to the first shaft, another two for second shaft and remaining two are for main sprocket shaft.



Fig. 5: Selected Plumber Blocks

B. Sprockets

- We use Sprockets for hand driving wheel and in the shaft for rotating the fork and four bar mechanism.
- The 44, 32, 18, 16 teeth sprockets are used.
- The chains are used to transmit the power from hand driving wheel to the shaft in which forks are attached and it is also to transmit the power to the four bar mechanism.

C. Assembly of the Parts



Fig. 6: Assembly on first shaft and Assembly on second shaft

VI. WORKING PRINCIPLE

Paddy seedlings are kept in the tray and allowed to flow down under gravity. The tray is mounted in angle above the fork. The fork which is attached to shaft picks up the seedlings from the tray and keeps it in horizontal position on the skid. The motion for the first shaft is given by hand using chain and sprocket arrangement. There are three sprockets and forks are attached to this shaft. Plumber blocks are used to give the support to the shaft. From the first shaft the motion is given to the next shaft where the four bar mechanism is attached. Crank is attached to the second shaft and it rotates in 360 degree. Connecting rod is used to connect the crank and lever. The remaining link is known as fixed link. The length on connecting rod is extended by using another link which is known as the transplanter. Here, Simple four bar mechanism is used to plant paddy seedlings into the land. If the hand sprocket is rotates in anti-clockwise direction then the motion is transfer to the shaft otherwise the small sprocket rotates freely due to the ratchet mechanism. Hence the four bar mechanism and shafts are stable and no any operation is done.



Fig. 7: Whole assembly of machine

A. *Advantages*

- Reduces the human effort to a maximum extent.
- Simple design compared to the existing model.
- Easy to repair by Farmers itself and maintenance is less.
- Pulling force is greatly reduced by decreasing the weight of the model.
- Cost will be reduced from Rs.18000 to Rs.5700

B. *Limitations*

- Transplanter can be operated continuously only for 4-5 hours.
- Healthy persons can only be able to pull the transplanter.

VII. FUTURE SCOPE

This project in the future can come across many changes like an automatic or semi-automatic system with motor which runs at constant speed attached to shaft instead of giving power by hand.

VIII. CONCLUSION

The paddy seedling transplanting machine worked satisfactorily. But, there were some improvements to be done before introducing to the farmers. The machine is driven by man power but engine can be coupled to enhance the performances. Machine can be developed to transplant several rows simultaneously.

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