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# Design and Development of Semi-Automatic Weeder

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## Abstract

Weeds in the wet paddy field were plucked by manually with use of hand tools and collectively taken away during some years ago. Now-a-days weeds are being utilized as fertilizer. Manual weeder is a device which is having two cylindrical rollers is mounted on the metallic frame structure with handle. It's a push and pull type of operation where a person pushes the device in forward direction for about 3 feet and then pulls back for the same distance and the operation repeats accordingly. While pushing action, weeds are uprooted. While pulling action, those uprooted weeds are buried there itself.

To overcome from push and pull operation, this project provides a Semi automatic weeder which operable in only in forward direction. Semi automatic weeding device is same as manual weeder with implementation of a petrol engine, spur gears, chain and sprockets arrangements. The device is developed in such a way that, the front roller rotates clockwise and uproots the weeds and soil gets loose. The rear roller automatically rotates anti-clockwise and buries those roots simultaneously. One of the major challenges in this project will be pushing the device in forward direction which reduces human fatigue and increases productivity. The design will be considered for easy handling and to not to increase the weight of the device.

***Key words:*** *Weeding Device, Petrol engine, Spur gear*

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# 1. Introduction

Weed is a plant which is judged by man to be not of use and undesirable at a place where it flourishes. The weeds that grow along with paddy crop results in low agricultural output. They are the major barriers to rice production because of their ability to compete for CO2, space, moisture, sunlight and nutrients. Weedy crop sometimes leads to complete failure. Out of total losses due to various biotic factors weeds are known to account for one third.

In the proposed project work an attempt has been made to develop a Semi Automatic weeding device by which a person can push the device in the forward direction to achieve more output. The device is assembled a petrol engine on the mainframe which is modified to accommodate the engine and Bearing Housing Block. Bearing housing block assembled with driven shafts, sprockets and spur gear train etc. Proper safety precautions are identified and provided to take care of chain, sprockets, gears etc. Two similar rollers are mounted under the main frame. Rollers are fabricated with blades. Petrol engine starts by pulling the thread and knob arrangement. There is a throttle lever, electrical cut-off switch and petrol tank which are mounted on the handle to operate easily. The device can keep in the right position on the field. The engine starts by pulling the thread by keeping the throttle in zero position. Operator can operate the throttle by which the front roller rotates anticlockwise and the rear roller rotates in the opposite direction. While pushing action, weeds are uprooted by the front roller and the soil gets loosen and rear roller does the burying action simultaneously.

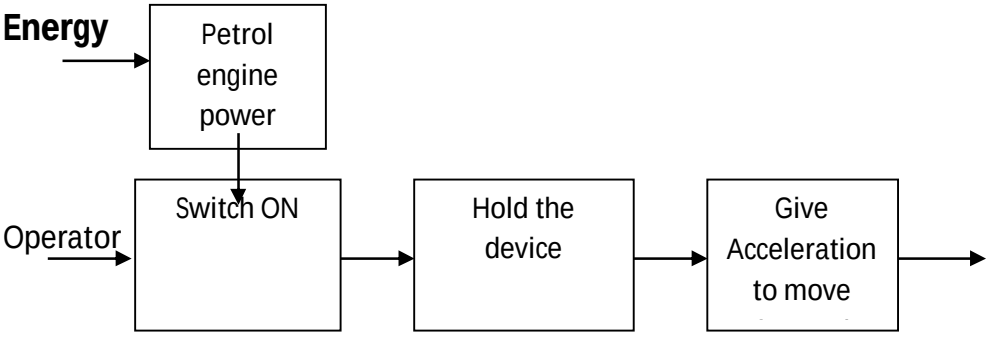


Figure 1.1 Block diagram of the device

## 2. Product development methodology:

Product development methodology (1) is used to develop a new product. It is very important to know the needs of the customers. For this purpose numbers of customers (farmers) are selected from different locations as shown in the customer selection matrix.

Table 2.1: Customer selection matrix for Semi Automatic Weeding device

| Market | Lead users | Users |
|---|---|---|
| Farmers (owners) | 2 | 5 |
| Operators (Frequent user) | 1 | 8 |

For my interview total of 16 customers are selected so that needs can be gathered in a more effective way and a better product can be generated. The customers include owners as well as operators, shop people and teaching experts. Based on their opinion metrics are developed and target values are set as shown in the table 2.2

Table 2.2 Target specification for Semi Automatic weeder

| Sl No. | Metric | unit | Specification | |
|---|---|---|---|---|
| | | | Minimum value | Maximum value |
| 1 | Total weight | Newton | 118 | 127 |
| 2 | Action (Movement) | Mtr / min | 20 | 22 |
| 3 | Unit product cost | INR | 6,000 | 7,000 |
| 4 | Materials | MS / SS / Plastic | | |
| 5 | Safety | Subjective | | |
| 6 | Type | Semi Automatic | | |
| 7 | Size (1.6 x 0.8 x 0.5) | Cu. Mtr | 0.64 | |
| 8 | Ergonomically Considerations | Subjective | | |

## 2.1 Concept generation:

Considering the targeted values and the metrics, different concepts were created and a best concept is selected which satisfies maximum needs of the customer. The selected concept has better output, ergonomic features and simple in construction, easy to use. It can be handled by a single person easily in the field. Parts can be easily assembled and dis assembled.

# 3 Design of Semi-Automatic Weeder

## 3.1 Petrol engine specification

Table 3.1: Petrol engine specification

| | |
|---|---|
| Engine type | 2 stroke |
| Capacity | 26 CC |
| Maximum output | 0.8 HP |
| Continuous output | 3000 RPM |
| Fuel | Petroil |
| Dry weight | 2 Kg |
| Direction of rotation | Anticlockwise looking at driving end |
| Engine starting | Rope with handle |
| Engine stopping | Electrical cut-off |
| Electrical | Magneto type |
| Cooling system | Air cooled |
| Power transmission | Centrifugal clutch (Drum type) |
| Fuel capacity | 0.75 Ltrs |

## 3.2 Impeller Design

Roller size: Dia 120 x 125 mm long and Fins: Width 25 x 105 mm long

Impellers are designed in such a way that the impeller blades should have sufficient strength in order to poke the field which is in semi solid condition and it should be sharp enough to uproot the weeds.

Material selected is Carbon steel (CS) and its Tensile strength = 250 Mpa

## Force analyzation of soil on Impeller

Pressure on semi-solid condition of the field is considered as 4,000 kg/mtr.sq.
(Pressure on solid is 15,000 kg/mtr.sq)
Scooping area by individual impeller = 2.5 cm. x 10.5 cm = 26.25cm.sq.
i.e. 0.002625 mtr.sq.
Force = Pressure x Area

Hence, the force on the impeller will be 4,000 x 0.002625 = 10.5 Kgs = 103 N.

A consideration will show that there will be 3 impeller blades in action at any instant and 2 nos. will be partially loaded while the center one is fully loaded.

Hence, the total load (Force) on the impeller will be 10.5 x 2 = 21 Kgs = 206 N.

## 3.3 Sprocket Selection on Impeller

- Due to the selection criteria depending on the dia. of the roller, the preliminary selection of a simplex chain sprocket of 14 teeth with ½" pitch is selected to mount over the first impeller.

- The similar roller is placed at the rear as front driving roller, but the rotation of the impeller in reverse direction in order to create the easy movement while burying action of weeds.

- Simplex ½" chain is considered for adequate length

- Since the concept of these rollers has to rotate in opposite direction, a gear transmission of spur gear train is selected.

## 3.4 Spur gear details

Table 3.2: Petrol engine specification

| | | |
|---|---|---|
| 1 | Module | 2.5 |
| 2 | No of Teeth | 40 |

| | | |
|---|---|---|
| 3 | Pressure Angle | 20 deg inv.spur |
| 4 | Outer dia | 105 mm |
| 5 | Pitch Circle dia | 100 |
| 6 | Root dia | 93.75 |
| 7 | Material | Nylon |
| 8 | Quantity | 2 Nos |
| 9 | Mating pinion | Module – 2.5 and 40 Teeth |
| 10 | Centre distance | 100 mm |

## 3.4 Power requirement at the impeller

**Torque (T) at the impeller:**

Torque (T) = Force on the impeller blade x radius of the impeller

Radius (R) of the impeller = 7.25 cm = 0.0725 mtr.

T = 21 kgs x 0.0725 = 1.5225 kg-mtr

The engine speed has been kept at 750 RPM at full throttle for safer working environment and also considering maneuverability.

A reduction ratio of 1:3 is considered to drive the impeller drive sprocket i.e. the RPM of the drive impeller will be 250 RPM (N).

**Hence the power (HP) requirement at the impeller will be**

$$HP = \frac{2\pi NT}{4500} = \frac{2*3.14*250*1.5225}{4500} = 0.53 \text{ HP}$$

## 3.5 Chain selection

- Torque on the impeller (T) = 1.5225 kg.mtr.

- Radius (R) of the chain sprocket = 36.5 mm = 0.0365 mtr.

$$\text{Hence tooth load (F)} = \frac{T}{R} = \frac{1.5225}{0.0365} = 41.7 \text{ kgs}$$

- Factor of safety of chain = 8
- Breaking load for the chain = 41.7 x 8 = 334 kgs.
- Chain selected is ½" pitch Simplex. For this the breaking load is 1820 daN = 1892 kg (ie, 1 daN = 1.0197 kg)
- Hence the selection of chain is Safe.

## 3.6 Driven shaft selection

**Bending moment on the shaft** = load on the sprocket acting on the cantilever point from bearing block = 41.7 kg x 3.34 cm where 3.34 is the distance from bearing block to centre line of sprocket

Bending Moment on the shaft = 139.3 kg.cm.

Considering the material as MS and it's yield stress (fy) = 250Mpa, Bending stress will be 0.66 fy times = 165Mpa.

Considering factor of safety of 2.5, the bending stress will be = 165 / 2.5 = 66Mpa OR 673 kg per square centimeter.

**Section modulus (Z)** of the shaft dia = Bending moment / Bending stress

Z = 139.3 / 673 = 0.206 cu.cm.

$$Z = \frac{\pi d^3}{32} \text{ to find shaft dia.}$$

Hence the shaft dia (d) = ((0.206 x 32) / 3.142)1/3 = 1.28 cm = 12.8 mm.

Shaft dia selected is 15 mm. Hence the shaft is safe for bending moment.

**Bearing Selection**

Since the shaft dia is 15mm, the bearing selected is 6202 ZZ - Life lubricated type.

## 3.7 Driven Sprocket over Impeller driving shaft

For receiving the engine torque and in order to reduce the engine speed by 33% a ratio of 1:3 has been selected. No of teeth on the engine shaft is ½" pitch x 9 teeth.

Hence ½" pitch x 27 teeth sprocket has been selected for receiving the torque.

## 3.8 Torsion requirement of the shaft

Torque at the idler sprocket = 1.5225 kg.mtr = 152.25 kg.cm

Torsion shear stress (Ƭ) for shear of MS material will be 450 kg/sq.cm.

$$\text{Torsion shear stress } Ƭ = \frac{16\ T}{\pi d^3}, \text{ then } d = ((16*T) / (\pi*Ƭ))1/3$$

Shaft dia (d) = ((16 x 152.25) / (3.142 x 450))1/3 = 1.2 cm = 12 mm

Since the selected shaft dia (15mm) is more than 12 mm.

Hence, design is safe for torsion.

## 3.9 Engine drive power requirement

The Torque transmission from the impeller to the idler sprocket of 14 teeth is 1.5225 kg.mtr at a speed of 250 RPM.

Since the ratio of sprocket is 3, the engine RPM has been set to 750 RPM.

Assuming a transmission efficiency of 75%, the engine power requirement will be

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$$\text{Required power} = \frac{\text{Design HP}}{\text{Efficiency}} = \frac{0.53}{0.75} = 0.7 \text{ HP}$$

Since the requirement of power at the impeller was 0.53 HP, and the engine power at the driven sprocket is 0.7 HP the engine is capable of driving the equipment at the assumed soil condition.

The engine power of 26 CC engine will be 0.8 HP at the rated speed.

### 3.10 Gyroscopic effect

Gyroscopic effect is assumed during the engine rotation. Since the weight of the engine is 2 kgs and the effect of gyroscopic is expected at the diagonally opposite direction. Hence a counter weight of 2.5 kg is arranged in the opposite direction in the form of sprockets, Chain & cover etc. Weight 2.5 kgs was added to balance the CG of the device both in static and dynamic condition and comfort to the operator.

## 3.11 Assembled view of the product


Figure 3.1: Details of Semi Automatic weeder

# 4 Validation:

The prototype was taken to University of Agricultural Science, GKVK, Bengaluru for testing purpose and to validate its performance on the wet field. This project was developed based on the continuous interaction with GKVK staff Shri.H.Eshwarappa, Professor (Retd) and his team for developments based on their valuable support, suggestions with encouragement.

Figure 4.1: Interaction with GKVK staff

Wet land condition was prepared to a distance of 10 Meters on a straight path. Semi-automatic weeding device was placed at the one end and the engine was switched ON by pulling the thread. Weeding operation test conducted by pushing the device in one direction and time taken to reach 10 Meters was 28 seconds (appr).

**Straight path covered was 21.4 Meters in one minute = 21.4 Meters / min**

## 4.1 As per design calculation:

- Roller rotation is 250 RPM
- One rotation (R) = 3,14 x D, where D is roller dia = 170 mm

  = 3.14 x 170 = 533 mm
- 250 rotation in a minute = 250 x 533 = 1,33,450 mm = 133 Mt / min

Assuming direct reduction 50% in roller rotation due to its opposite rotation.

Device movement = 133/2 = 66 Mt / min

Field friction reduces further movement about 60% (appr) = 66*0.4 = **26 Mt / min**

Result achieved 21 Mt / min (appr). This is lesser than designed out put. This may be because of further friction in the wet land which also vary depends upon the land condition.

## 4.2 Comparison with existing manual weeder performance:

Field coverage by existing weeding device is 0.4 acre per day as per market survey.

1 acre = 43,560 sq ft

Hence, 0.4 acre = 43,560 x 0.4 = 17,424 sq ft

Field of 60 ft x 60 ft is considered as one segment = 3,600 sq ft

No of segments in a day = 17,424 / 3,600 = 4.84 times

1 foot = 0.3048 Meter

Width of the one row = 9" (0.75 ft)

One side of the field = 60 ft

No of rows on one side field = 60/0.75 = 80 rows

Other side of the field in Meter = 60*0.3048 = 18 Meters

Straight distance of one segment in 9" width = 18 Meters x 80 rows = 1,440 Meters

Total straight path coverage in a day = 1,440 x 4.84 times = 6,969 Meters in a day

Distance covered in one Hour = 6,969/8 = 871 Meters / Hr

Straight path distance covered in one minute = 871/60 = 14.5 Meters / min

**Semi-automatic weeding device can cover straight path distance = 21.4 Meters / min**

## 4.3 By reverse calculation on Semi-automatic device performance:

- Straight path distance covered in one Hour = 21.4 x 60 = 1,284 Meters
- Straight path distance covered in 8 Hours = 1,284 x 8 = 10,272 Meters

- Conversion of straight path distance covered in 8 Hours in to No of segments.
- One segment = 1,440 Meters = 3,600 sq ft
- No of segments = 10,272 / 1,440 = 7.13
- Total No of segments covered in 8 Hours = 3,600 x 7.13 = 25,668 sq ft
- 1 acre = 43,560 sq ft

  **Area covered in a day = 25,668 / 43,560 = 0.6 acre**

Therefore, working performance of the Semi-automatic weeding device at an average distance on the wet field is 21.4 Meters / min (appr) by which we can cover an area of **0.6 acre per day** which is higher than manual weeding device of **0.4 acre per day**.

0.6 acre in a day achieved by considering all sort of constraints during weeding operation and can expect better performance based on the good soil condition.

# 5 Conclusion:

This product was designed and developed on the existing manual weeder by implementing Petrol engine, sprockets, shaft, chain and gears with few modifications on the mainframe. Overall weight of the device is about 14 Kgs which can be easily handled by a person in the field. Handle is made such a way that, to adjust person's height. Handle grip is provided to hold the device in appropriate position and easy to operate. Throttling lever is fixed at the right side near to the handle grip so that, operator can actuate the lever very comfortably. Electrical cut-off switch is fixed at the left side of the handle to stop the engine.

The device is designed for ergonomically consideration for its operation only to push in the forward direction such a way that the front roller rotates in the anti-clockwise and the rear roller will rotate in the opposite direction. Front roller uproots weeds and loosens the soil and rear roller buries those uprooted weeds simultaneously. The device moves forward direction due to the engine shaft rotation and by manual pushing action.

- The total outcome is named as "Semi Automatic weeder".

- It is faster than the existing manual Cono-weeder.
- Human fatigue is comparatively less and thereby increases in productivity.
- The device can assemble and dismantle easily on a table.
- Spare parts can replace with the use of simple tools.
- High efficiency of uprooting & burying weeds.
- Easy to operate with minimum skill level.
- Product cost is reasonably economical for even medium size field farmers.
- Handle can be made adjustable to suit the operator's height.

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