Design and Development of Weed Removing Machine

Abstract

Agriculture is the most important sector of the Indian economy. It is the most important source of employment for most of the workforce in the country. As the large workforce is employed in this area, traditional methods used in agriculture is time consuming and ineffective. A major issue faced by farmers in recent times is the infestation of weeds in their agriculture land. A weed is a plant considered undesirable in a particular situation .The term *weed* also is applied to any plant that grows or reproduces aggressively, or is invasive outside its native habitat. Weed control is important in agriculture. Conventional Methods include hand removal with hoes and sickle while modern methods include powered removal with machines, smothering with mulch, or chemical attack with herbicides. This project is focused on designing an innovative mechanism to remove weeds from its roots in an effective and cost effective manner for small scale farmers. The main objectives of this device are to increase the efficiency with minimum labor and to reduce its cost. The weed remover consists of blades that are powered by an engine and transmission system. The blades perform shallow ploughing of the land at 10cm depth of soil and will till the soil while removing the weeds simultaneously. The machine can be maneuvered by the farmer using the handle and specially designed castor wheels to provide traction to the ground while being easily maneuverable. The complete CAD design of the model has been designed in Solid Works 2017

The **Keywords:** Weed Remover, Design, Cost minimization, CAD model.

Contents:

1.Introduction

1.1 Motivation

In the tremendous world of Agriculture, the presence of weeds, prove to be catastrophic to the growth of crops. There arises an exigency for the removal of these harmful and unnecessary parasites. It is estimated that India inculcates a loss of around 16250 crore per annum in weed controlling activities. On an average, weeds removed per field during khariff seasons vary from 46.6kg/ha to 73.3 kg/ha.
We thrive to design and develop a revolutionary weed remover for the same while proving to be efficient and cost effective after analyzing various existing designs of weed removers such that it combines their advantages and overcomes their shortcomings.

1.2 Existing Models

There are various existing models for weed cutters in the market. STIHL and OLEOMAC are the leading producers of weed removing machines. But there are certain shortcomings in the current models.

- The brush cutter only removes the weeds at the stem level and allows it to grow back
- The Conoweeder requires intense manual labor and is very difficult to maneuver due to its shape
- The user has to carry the entire weight of the brush cutter while using it
- Lawn mowers are very expensive and cannot be used in farmlands.



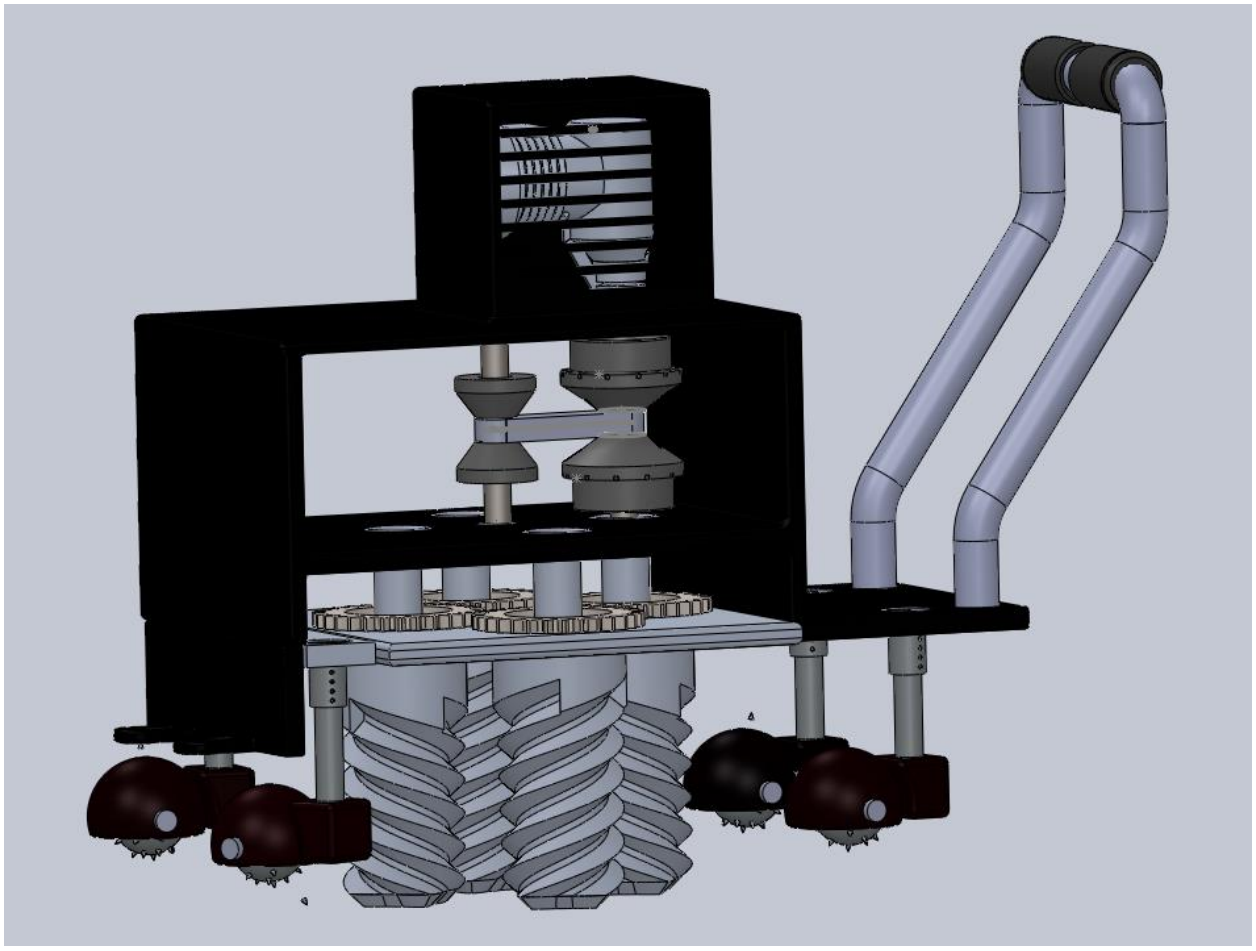
2. Literature Survey

2.1 Weeder T6 360:

The basic mechanism consists of four cutting blades that are driven by a single engine. The engine gives direct transmission to one of the four blades. The torque is transmitted and divided equally among the four cutting blades by means of four meshed spur gears. The final result is the equal rotation of all the blades. The blades are initially placed at a depth of 10cm below the soil (shallow ploughing). The machine is pushed manually against the soil while the rotating blades cuts the soil and removes the weeds from their roots

The spherical castor wheels have spikes with an axle. The axle is attached to a ball bearing to act like a castor wheel. This provides enough traction with the soil which enables it to be maneuvered in any direction on the ground. The spikes are designed in such a way that they will not inhibit the motion of the wheel while providing the necessary traction. These castor wheels are attached to a telescopic link to adjust the height of the machine.

The product will have a frame wherein the entire setup, including the engine, transmission and cutting blades will be placed to make it more compact and ergonomically efficient. A handle bar is attached to the frame to facilitate maneuvering of the device.



3. Design of the Weeder T6 360:

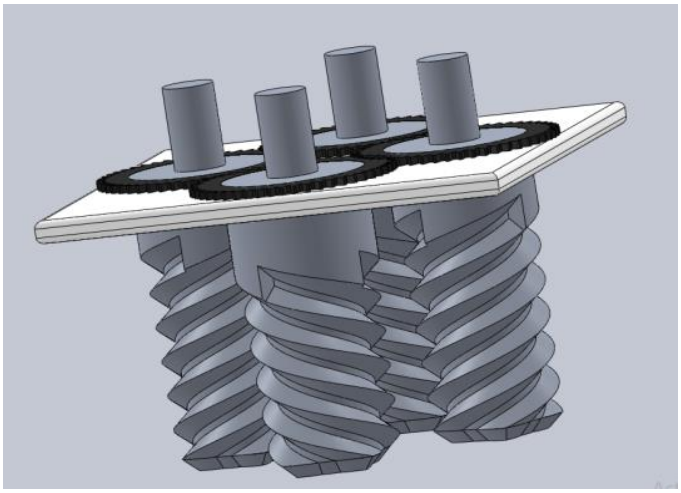
Assembly of the Weed Remover

- The assembly of the weed remover consist of
- Cutting blades with meshed gears
- Engine and transmission
- Support structure
- Specially designed telescopic Castor wheels
- Handle bar

The primary objective is to integrate the feature of weed removing and tilling of soil.

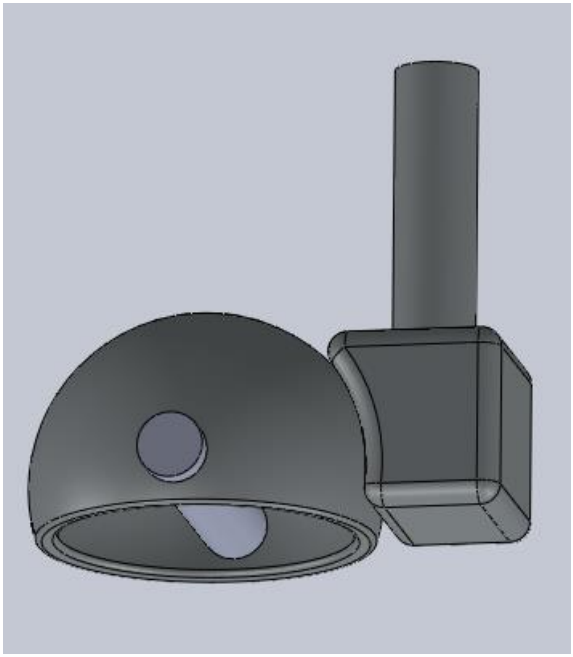
3.1 Design of cutting blades

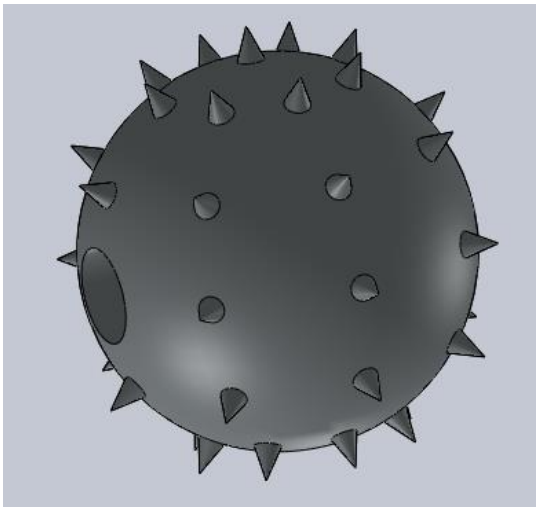
The cutting blades form the primary action of removing the weeds from the soil. The blades have been designed in such a way that the main cutting edges facilitate the blades' movement in any direction along the horizontal plane on the soil. These blades will first be placed at a fixed depth into the soil, and is then allowed to rotate to perform the cutting action. The blades are mounted on the machine and it is moved around manually. The stress has been calculated using penetration resistance of soil. Aluminum alloy grade 2014 t6 is used because of its machinability and ability to handle stress. The material is hard and can undergo cutting motion easily.



3.2 Design of wheel and movement

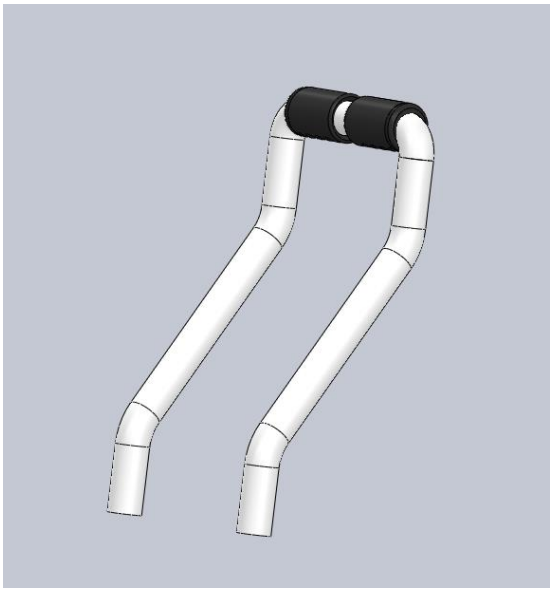
The product is supported by means of 2 spherical wheels with spokes which revolves around an axle and moves on the soil in any direction. The sphere has small spokes on it, to ensure proper traction with the soil and enable the entire device to move freely on the ground. The device is pushed around manually using a handle. The wheel is designed such that there are enough number of spikes inside the soil at all points of time to provide traction and also facilitates motion along all directions.





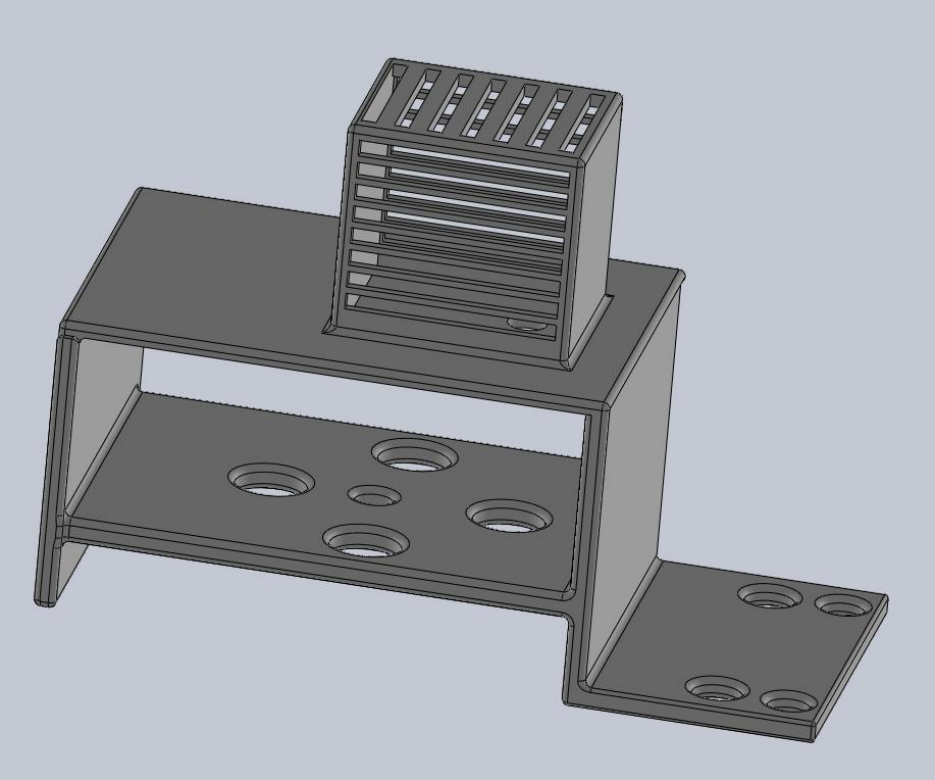
3.3 Design of handle

The handle is designed ergonomically to push the machine to remove weeds. The handles are provided at a height of 1m from the ground for the user to provide pushing angle of 20 degrees of 600N. The handle has been designed using carbon-fiber for this purpose.



3.4 Design of platform

The platform has been designed to carry the load of the engine, transmission system and cutting blades. The platform has been designed using aluminum alloy grade 6061 t6 to handle stress. It is used for structural properties and is also light weight. The material cost drastically reduces due to availability and easy machinability.



4. Dimensions

- The body has a dimension of 0.8m x 0.4m x 1m.
- The cutting blades have a radius of 0.06m
- The blade is penetrated into the ground at 0.1m
- The spherical balls are at diameter of 0.15m
- The handles are at a height of 1m from the ground

5. Why is this model more efficient than existing models

i) **Mode of Operation**:
It is a semi-automatic machine where the farmers only have to provide the forward push and its direction. Since it is multidirectional they can move it in any direction as per their convenience. The blades are powered by an engine and can remove the weeds along every direction. The multi directional feature is facilitated by spherical wheels with spokes to provide traction and hence reduces human effort

ii) **Cost**:
The cost of our model has been drastically reduced by optimizing its design and material. It varies from 12k to 18k based on its versions. This is one of the cheapest weed removers that is semi automatically run with such efficiency and coverage area in the market.

iii) **Efficiency**:
The main reason for efficiency decrease in case of weed removers is because of friction between the machine and soil. Our blades and wheels have been designed to reduce this friction while being able to move around in all directions easily. The blades are driven using a single engine and the torque is equally distributed amongst them

iv) **Versatility**:
This unique design permits the cutting of weeds from the stem and simultaneously removes the weeds from the soil, both in one motion of the device. Any type of weed can be cut and removed from the soil with the help of this device.

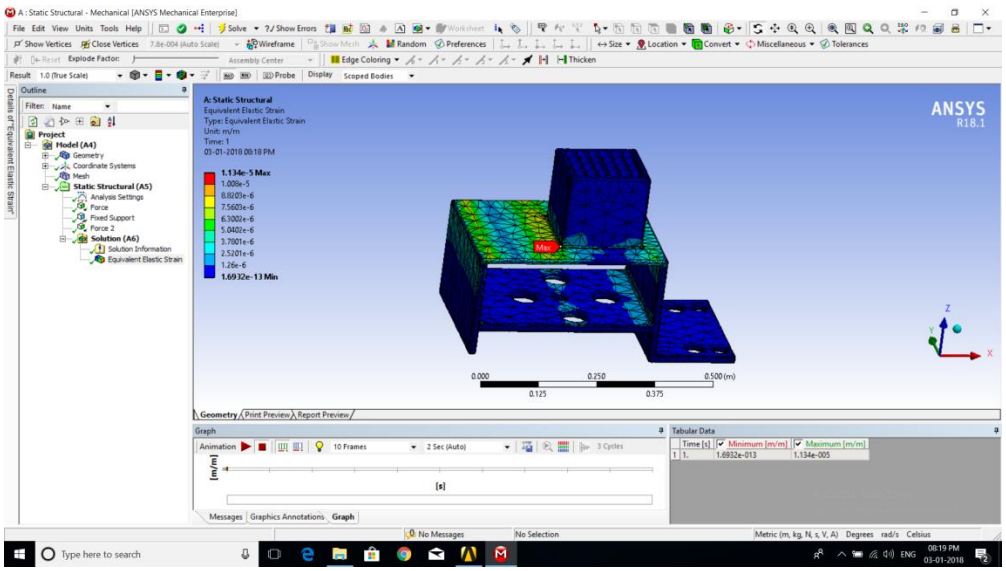
v) **Directionality and coverage area**:
Owing to the uniqueness of the design of cutting blades, motion under the soil is made much easier. The blade's design helps the tool to move in any direction along the soil. To assist this motion, a spherical wheel with spokes is held by means of an axle, and the sphere is also free to move in any direction on top of the soil with the help of a ball bearing. It works like a castor wheel. Existing machines can only move in one direction. This product enables to cover a larger area on the soil to cut the weed owing to the multiple blades arrangement, and this cuts down manual effort. The device can cover 3500 cm^2 in 1 minute.

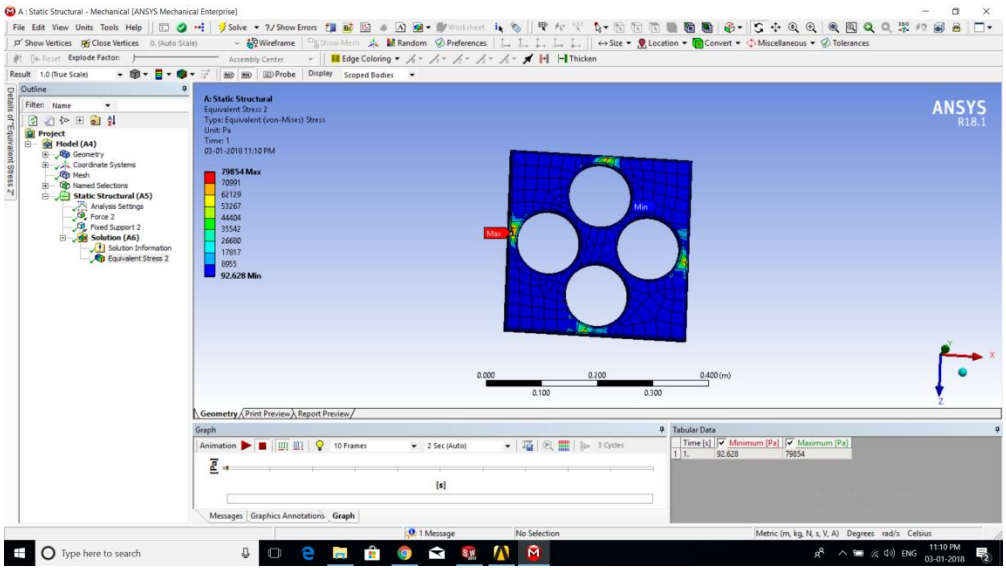
vi) **Compactness** :
Farmers need a very compact and small machine that can effectively remove the weeds from the roots so that further growth of weeds is arrested. Our design consists of only one motor. Our entire device weighs 10kg, and requires very little manual effort. The only effort that has to be invested upon is the handling of the device. The device spans an area of 80cm x 40 cm x100cm

6. **Analysis**

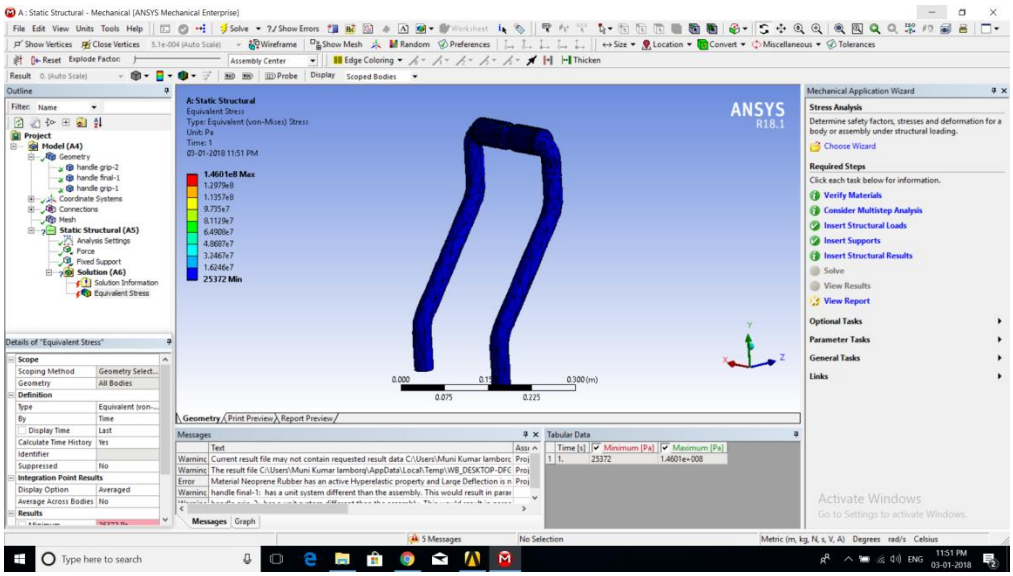
The entire model has been analyzed using Ansys 18.1.the stress distribution on various plates and nodes have been calculated while considering the material that is to be used. The materials have been chosen to optimize the weight and cost of the machine.

The stress distribution on the platform has been calculated for the weight placed on it including the engine, transmission system and the cutting blades.





The stress analysis on the handle bar has also been analyzed



7. Cost and material analysis

Material	Cost Per Unit (INR)	Total Weight	Total Cost(MRP) (INR)	Cost for Mass Production (INR)
Aluminium Alloy 2014 T6 (blade)	350/Kg	15 kg	5250	2800/-
Aluminium Alloy 6061 T6 (body)	250/Kg	20 kg	5000	2700/-
AISI 4140 Chrome-Molybdenum High Tensile Steel (castor wheel)	500/Kg	6 kg	3000	1650/-
Carbon Fibre and Bearings	650/Kg	2 kg	1300	800/-
Engine, Transmission and Shaft	8000/unit	1 unit (11 kg)	9000	5000/-
TOTAL		60 kg	23,550	12,950/-
Machining Cost	3500			16,450/-

8. Properties of Materials:

Properties of Al 2014 T6 Alloy:

Density: 2.7gm/cm^3

Rockwell Hardness Number: 83

Ultimate Tensile Strength: 490 MPa

Shear Strength: 290 MPa

Specific Heat Capacity: 870 J/kg-K

Thermal Expansion: 23 µm/m-K

Properties of Al 6061 T6 Alloy:

Density: 2.7gm/cm^3

Rockwell Hardness Number: 60

Ultimate Tensile Strength: 310 MPa

Shear Strength: 207 MPa

Used for structural purposes, and has high strength to weight ratio.

Properties of AISI 4140 Chrome Molybdenum High Tensile Steel:

Density: 8.03gm/cm^3

Rockwell Hardness Number: 92

Ultimate Tensile Strength: 655 MPa

Shear Modulus: 80

Properties of 20MnCr5 Steel Shaft Material:

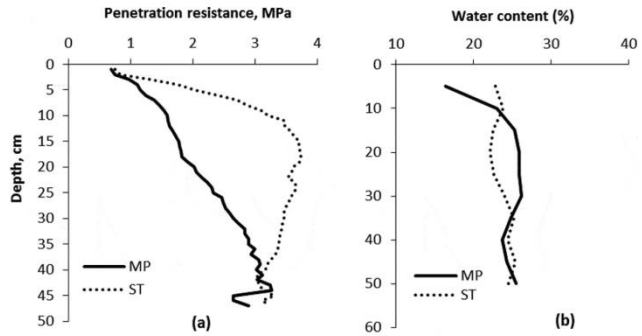
Density : 7.7gm/cm^3

Ultimate Tensile Strength: 650-880 MPa

Yield Strength: 350-550 MPa

Fatigue Strength: 275 MPa

9. Formulas and Calculations



$$R = \frac{mgH}{A\Delta Z} * \frac{M}{M + M'}$$

$$P = T\omega$$

$$T = T_1 + T_{2,1} + T_{3,1} + T_{4,1}$$

$$= I\alpha_1 + I_2\alpha_1 (\omega_2/\omega_1)^2 + I_3\alpha_1 (\omega_3/\omega_1)^2 + I_4\alpha_1 (\omega_4/\omega_1)^2$$

$R_1 \omega_1 = R_2 \omega_2 = R_3 \omega_3 = R_4 \omega_4$

$T = I\alpha$

$$\frac{\theta_1}{\theta_2} = \frac{\omega_1}{\omega_2} = \frac{\alpha_1}{\alpha_2}$$

$T_{2,1} \omega_1 = T_{2,2} \omega_2$

$\Sigma T = T_1 + T_{2,1}$

$T = r \times F$

$T_{2,1} \omega_1 = T_{2,2} \omega_2$

$T_{3,1} \omega_1 = T_{3,3} \omega_3$

$T_{4,1} \omega_1 = T_{4,4} \omega_4$

$T_{2,2} = I_2 \alpha_2$

$T_{3,3} = I_3 \alpha_3$

$T_{4,4} = I_4 \alpha_4$

$\omega_1 = \omega_2 = \omega_3 = \omega_4$

$\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4$

$I_{effective} = I_1 + I_2 + I_3 + I_4 = 4I$

$$I = \frac{1}{2}mR^2$$

m = 3.5kg , R =0.06m

I = 0.0063 kgm^2

$I_{effective}$ = 0.0252 kgm^2

Net Torque on Blades = [R x A x r x n]

= (2 x 10^3) x (3.14 x 0.06 x 0.1 x 0.06 x 4) = 9.0432 Nm

A = π*r*h r=0.06m, h=0.1m

Torque multiplying factor in CVT is 1.8

3HP engine → 3 x 747 = 2241 watts

ω_1'→angular velocity of blade

ω_2'→angular velocity of shaft of engine

$T_{eng} = T_{blade}/1.8$

T_{eng} = 5.024 Nm

5.024 ω_2' = 2241

ω_2' = 446 rad/s

N = 446 x 60/2π = **4262 rpm**

Torque multiplying factor in CVT is 1.8 to get minimum ω_1' for the blades to cut the soil.

Total resistive force on the blades is

F = R x A x n

= 2 x 1000 x 3.14 x 0.06 x 0.1 x 4 = **150.72 N**

10. Future scope for improvement

The model can further be modified in the following ways:

1. A front cutting blade can be attached to remove stems.
2. The spherical spiked wheels can be changed to slotted straight wheels
3. The shape can be altered to be more compact.

11.Conclusion

The designed model proves to be an effective and cost efficient alternative to the existing weed removing equipments available. This model is aimed at helping low scale farmers who cannot afford to purchase these expensive machines. This model contains very few moving and controllable parts and thus does not require the farmer to have a lot of prior knowledge. It will be easier and safer for the same purpose. Hence a successful alternative weed remover has been designed.