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# Design and Development of Tractor Operated Plastic Mulch Laying Machine

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**ABSTRACT**

**In recent decade the demand for plastic mulch laying machine has been drastically increased throughout the world. The plastic laying mulch machine will benefit the farmers in controlling weed, moistening of soil, increasing of soil nutrients, reduction of insect's pests and high crop yield.In this paper, seek to design the plastic mulch laying machine that includes a sliding fit mechanism to adjust the variable size of bund making, press wheel and hoeing blade. The plastic mulch laying machine is a combination of main frame, bund making frame, drip pipe roller, mulch roller, hoeing blades, punching wheel and belt drive mechanism. This machine will perform operations like bund making, drip pipe laying, mulch laying, soil covering and punching mulch sheet in one pass. The plastic mulch laying machine will resolve the problems like laying the mulch, punching mulch sheet at explicit positions and laying the drip pipe.**

**Keywords--**Plastic mulch, hoeing blades, bund making frame, drip pipe and sliding fit mechanism.

## INTRODUCTION

Mulching is process of covering the soil round the plant root area with a view to insulate the plant and its roots from the consequences of utmost temperature fluctuation. Mulching will create a micro climate for the plant which fitted to simplest performance by regulating soil water, soil temperature, humidity, CO2 enrichment and increased microbial activity in the soil.

Mulches can be classified into organic and inorganic (plastic mulch)

A. *Organic* : Organic materials such as crop residue by-product, farm yard manure and by-product of timber industry is used for organic mulching.
B. *Inorganic* : materials such as plastic films known as inorganic mulches. Plastic mulches can be made available in different colors and thickness to obtain desired result.

Organic mulch always does not provide sufficient weed control, they may also carry weed seeds and repeatedly slow down the soil warming. Especially in spring season it will cause delay of plant growth. Weed rate cannot be controlled in organic method, by employing plastic it will reduce the weed waste on labor to clean the farm. It is documented that plastic film increases the yields of the many crops by inhibiting weeds growth and increasing soil temperature and moisture also reducing pest infestations. The use of plastic mulch has also become a standard practice for many farmers to control weeds.

Mulch laying machine consist of five operations such as bund making, drip pipe laying, mulch laying, soil covering and punching the sheet which are executed in one pass. The tractor operated machine will be beneficial for farmers to reduce the time consumption in laying the mulch sheet and punching the mulch sheet will ultimately reduce the human effort and cost of laying the mulch. Currently the mulch laying machine which are available in market are in multi operation in the mulching process. Thus, in this paper all of the operation needed for mulching process is induced in one step.

Tractor have become one of the key power sources in modern agricultural and are commonly used for most farm operation, such as irrigation, land development, sowing, threshing and transport. Tractors contribute to reducing the time required. It has now become an important part of mechanized farming. Conventional plastic mulching requires more labor, time and running costs. Taking the above information into account, this study was conducted to design plastic mulch laying equipment driven by tractor.

***Figure 1:*** *Mulching Laying Equipment Driven by Tractor.*

## OBJECTIVES

1. Bund making , drip laying, mulch laying, soil covering and punching mulch sheet will be done in one pass.
2. The design of bund making is adjustable.
3. The cost of the machine lower relative to the current machine.
4. Reduction of the time and labour demand.

## DESIGN OF MULCH LAYING MACHINE

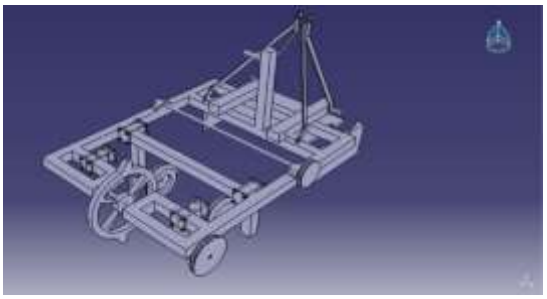

***Figure 2:*** *3D Model of Mulch Laying Machine.*

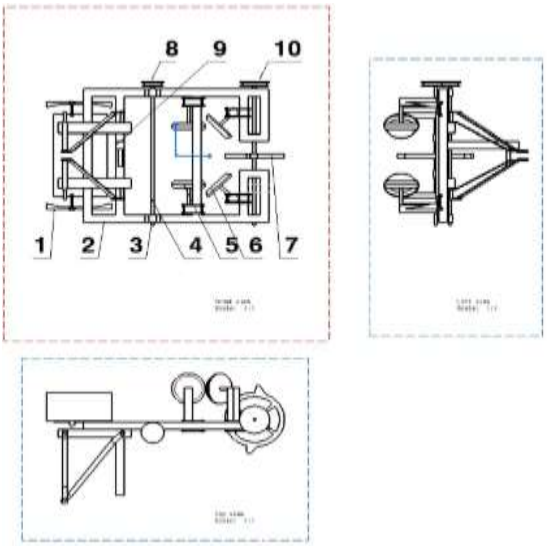


***Figure 3:*** *Components of Machine.*

***Table 1:*** *List of Components.*

| | |
|---|---|
| 1 | Bund making frame |
| 2 | Main frame |
| 3 | Pedestal bearing |
| 4 | Mulch laying shaft |
| 5 | Press wheel |
| 6 | Hoeing blade |
| 7 | Punching wheel |
| 8 | Smaller pulley |
| 9 | Drip pipe roller |
| 10 | Larger pulley |

## DESIGN CALCULATION

The tractor speed in the field vary from 0.41 m/s to 1.26 m/s. So considering this speed for mulch laying operation. The average speed will 0.835 m/s. Converting it into km/h will be 3.06 km/hr.

Converting km/hr to RPM
Km= d*rpm*0.001885
3.06=8*rpm*0.001885
Rpm= 203 rpm

$N_1D_1 = N_2D_2$
$N_1$ = Smaller pulley rpm
$D_1$= Smaller pulley diameter
D2= Larger pulley diameter
$N_1$= Larger pulley rpm
203*80 = N2*200
$N_2$= 81.2 rpm

*Design of Shaft*
Selecting C50 mild steel shaft
Allowable stress = 380 N/mm2 from DHB
Power calculation
Drawbar (KW) = $\frac{\text{Draft}*\text{speed}}{75}$
Drawbar = $\frac{150*0.835}{75}$ = 1.67 KW
Power = $\frac{2\pi NT}{60} = \frac{1670*60}{2*\pi*203}$
T = 78558.28 N-mm

Applying maximum shear stress theory
$d^3 = \frac{T*16}{\pi*\frac{f_s}{FOS}}$
Considering FOS = 4
Safe stress ($f_s$)= 380/4 = 95N/mm$^2$
$d^3 = \frac{78558.28*16}{\pi*\frac{95}{4}}$
d = 25 mm

***Maximum bending moment***
The shaft length 1280mm
Shaft weight 5kg = 49.05 N
M = W*L = 49.05*1280 = 62784 N-mm
Equivalent twisting moment
$TM = \sqrt{M^2 + T^2}$
$= \sqrt{62784^2 + 78558.28^2}$ = 100564.5763 N-mm

***Column design***
$P_{cr} = \frac{\pi*E*I}{L_e^2}$ (1)
Where,
$P_{cr} = \frac{\text{Total wieght}*g*FOS}{4}$
$= \frac{150*9.81*3}{4}$ = 1103.625 N (2)
$I = \frac{bt^3}{12} = \frac{27*t^4}{12}$(3)
Now, $L_e$ = effective length
$L_e$= L/2 = 390/2 = 195 mm (4)
Substituting equation (2), (3), and (4) in equation (1)
$P_{cr} = \frac{\pi*E*I}{L_e^2}$

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$1103.62 = \frac{\pi^2 * 210 * 10^3 * \frac{27 * t^4}{12}}{(\frac{390}{2})^2}$

t = 1.731mm

But standard size available is 5 mm

b = 3* 5 = 15mm , but standard size is 35mm

Hence thickness = 5mm and width = 35mm.

### *Design of belt*

P = 1.67 KW

V = 0.835 m/s

ρ = 0.95 g/cc = 950 kg/$m^3$

t = 5mm

Diameter of smaller pulley

Velocity of belt drive V = $\frac{\pi * (d+t) * n_1}{60000}$

$0.835 = \frac{\pi * (d+5) 203}{60000}$

d = 80 mm

Diameter of larger pulley

$n_1(d_1 + t) = n_2(d_2 + t)$

$203 (80+5) = 81 (d_2 + 5)$

$d_2$= 200mm

Length of open belt

Centre distance C = 2D= 2*200 = 400mm

Length of open belt L = $\sqrt{4C^2 - (D-d^2)} + \frac{(D\Theta_1 - \Theta_2 d)}{2}$

$$\theta_L = \pi + \left[2\sin^{-1}\left(\frac{D-d}{2C}\right)\right]\frac{\pi}{180}$$

$= \pi + [2\sin^{-1}(\frac{200-80}{2*400})]\frac{\pi}{180} = 3.44$ rad

$$\theta_s = \pi - \left[2\sin^{-1}\left(\frac{D-d}{2C}\right)\right]\frac{\pi}{180}$$

$= \pi - \left[2\sin^{-1}\left(\frac{200-80}{2*400}\right)\right]\frac{\pi}{180} = 2.840$ rad

$L = \sqrt{4 * 400 - (200-80)^2} + \frac{(200*3.44+2.8*80)}{2}$

= 1246.94 mm

### *Width of belt*

$V = \frac{\pi * (d+t) * n_1}{60000}$

$= \frac{\pi * (80+5) * 203}{60000} = 0.903$ m/s

As co-efficient of friction is same for larger and smaller pulley

Capacity = $e^{\mu\Theta_s}$

$= e^{0.35*2.8405} = 2.702$

Cross section of belt = bt = $\frac{1000P}{v\left(\sigma_b - \frac{Wv^2}{g} * 10^{-6}\right)k}$

$b*5 = \frac{1000*1.67}{0.903\left(3.75 - \frac{950*0.903^2}{9.81} * 10^{-6}\right)0.6253}$

b = 157.77 mm

### WORKING

The main purpose of mulch laying machine is to carry out the all five operation that are bund making, drip pipe laying, mulch laying, pinching mulch sheet and soil covering through hoeing blades. It reduces cost and time on mulching laying operation. Prior to the mulch laying operation the mulch paper tip and drip pipe tip as to be placed under the press wheel(fig 4) . The machine is pulled by the drawbar of the tractor. As the machine moves forward the bund making frame (fig 5) construct the soil bed.

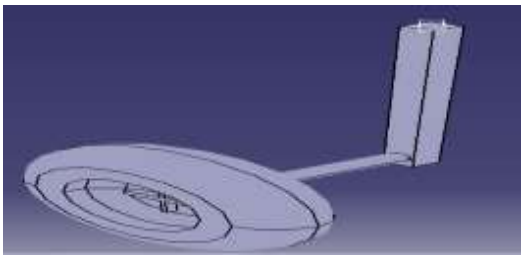

***Figure 4:*** *Press wheel.*

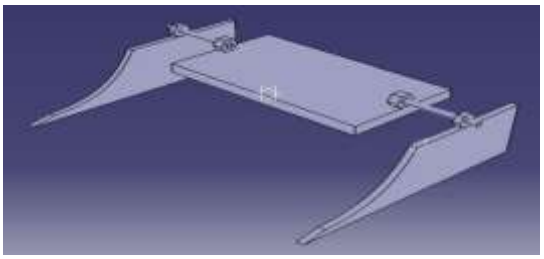

***Figure 5:*** *Bund Making Frame.*

As press wheel starts rotating the at same time mulch paper and drip pipe are been placed on soil bed. Mulch roller starts rotating, mulch roller shaft is mounted to front pulley which transmit energy through belt from front front to rear pulley. Where rear pulley is mounted to the punch wheel shaft which in-turn rotates the punch wheel hence, the holes are made at specific distance on the mulch paper.

The drip irrigation pipe is already underneath the mulching paper and is fixed at one end, due to the paper movement the drip pipe is also unwound and positioned under the mulching paper on the ground. Once the mulching paper has been laid, the hoeing blades(fig 6) come into operation, where the hoeing blades cover the edges of mulch paper with the soil to prevent paper deflection. Therefore all the five operation are completed in one pass.

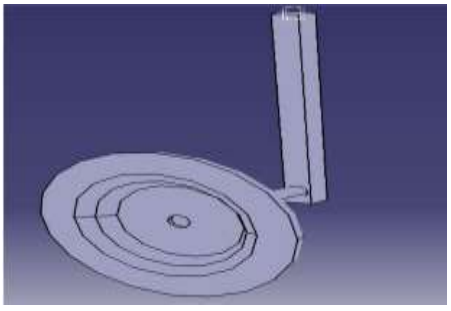

***Figure 6:*** *Hoeing Blade.*

***Table 2:*** *Gap Analysis.*

| Sl.No | Particulars | Existing solution | Our solution / Idea | Improvement |
|---|---|---|---|---|
| 1 | Object | Less efficiency<br>High cost<br>Complex operation | More efficiency<br>Low cost<br>Easy to use | Reduce cost and increase efficiency |
| 2 | Customer requirement | To mulch and reduce weed growth | Mentioned above | - |
| 3 | Principle of working | Converting fuel energy to mechanical work | Converting fuel energy to mechanical work | - |
| 4 | Operation-power supply | Fuel energy | Fuel energy | Less fuel consumption |
| 5 | Design | Complex design | Simplified design | The machine which is designed involves a slide fit mechanism to adjust the variable size |
| 6 | Advantage | The plastic laying machine has to go two passes to complete mulch laying operation | The machine will have one pass to complete mulch laying operation | - |
| 7 | Disadvantage | More fuel consumption | Comparatively low fuel consumption | - |

## CONCLUSION

In this paper, we designed the plastic mulch laying operation that includes a sliding fit mechanism to adjust the variable size of bund making, press wheel and hoeing blade. This machine has adjustable bund making frame which is well designed that it does not requires complex setup to change varying size of soil bed in the farms. This machine will be helpful for farmers of small and large scale who will focus on crops of yield varieties. The system reduces the workload on labors and time consumption.

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