Design and Development of Power Transmission System for Tractor Operated Hybrid bio-composite mulch sheet laying machine

ABSTRACT :

Tractor 3 point hitch drawn hybrid bio-composite bio degradable mulch laying machine was designed and developed based on the formulation of the hybrid bio-composite mulch sheets with a intension of the integrate the field operations at easy pace and conserve the time and labour. The prototype was fabricated and tested in the fields in order to perform the operations such as hybrid bio-composite mulch sheet laying, Mulch sheet pressing and guiding and soil covering on the edges of the mulch sheets in one forward movement of the machine. The machine was fabricated with design of many components but the power transmission system was plays a major role in this machine as the entire forward movement of machine and performance of the mulch sheet laying unit was depends on the power transmission system only. Various components of power transmission system was designed such as shafts, chain, bearings and sprockets etc. The shaft design was done considering the two conditions of fields while in operation like considering twisting and bending moments of the shaft as well as sudden applied shocks and fluctuated loads. Considering the two conditions ,the main shaft, counter shaft and rear wheel shafts diameters were designed based on this two conditions and obtained results were 30 mm, 40 mm and 25 mm respectively The chain and sprocket will be used for the transmitting the power from one shaft to other one. The length of the chain was calculated 162.56 cm and the HP transmitted by the selected chain and HP of chain drive system were calculated as 2.05 hp and 0.339 hp respectively. Based on the results, the calculated horse power was less than the horse power of selected chain that means required horse power was 0.339 hp but we have got 2.05 hp , hence the design was safe and machine will be operate without any hassles.

Keywords: Mulch machine, Mulch machine design, Power transmission system, biodegradable mulch laying machine, Design of chain and sprocket.

1. INTRODUCTION:

The agricultural operations in India play a major and vital role in India's GDP. The agricultural operations and allied activities contributes almost 17% India's GDP with the population involved of 54.6% [1], for the year 2018-2020. This may be happened due to the practicing the improved methods of increasing the soil fertility, Irrigation, farm mechanization and protected cultivation which includes plasticullture [2]. More over green

revolution emphasises on high yielding variety of seeds, fertilizers, pesticides and adopted best methods of the farming, hence this methods turns the society from the deficient in food grains to being self-sufficient [3]. But in the increase in the agricultural yield has to keep the same pace with the growing population, this can be attained by the mechanization in agriculture. Mechanization in agriculture has enhanced production and productivity of agricultural commodities through timeliness of operation, better management of inputs and reduction of post harvest losses [5] in the country. Indian farms are irrigated primarily by monsoons as three-fifth of the land is irrigated directly by rainfall. To irrigate these lands, India receives three fourth of its rains, in just four months of the year [6]. As per estimates by the year 2025 about onethird of India would be under absolute water scarce condition [2].

The mulching operations have been done with the mechanized way. The fundamental elements of modern plastics, including carbon, silicon, hydrogen, nitrogen, oxygen, and chloride, are both inorganic and organic. Oil, coal, and natural gas are the sources of the raw resources used to make plastics (9). The American Society for Plasticulture defines plasticulture as "the use of plastic in agriculture," which includes plastic mulch films, drip irrigation tape, row covers, low tunnels, high tunnels, silage bags, hay bale wraps, and plastic trays and pots used in the production of transplant and bedding plants (10). The issue with removing mulching sheets from the fields is that it is a labor-intensive and time-consuming procedure, which is why biodegradable sheets were created. By the action of the microorganisms in the soil, these sheets may self-degrade. This biodegradable sheets were created using a machine.

Hence there is a need of the developing the technique of creating the micro-environment for the plants in agriculture has sufficient demand to increase the form produce t the reducing cost of utilizing lesser amount of resources. This concept can be preliminarily achieved by the mulching operations in agricultural fields [7]. The mulching used to protect seedlings and shoots through insulation and prevent evaporation, thus maintaining or slightly increasing soil temperature and humidity [8]. The plastic mulching has introduced in india since 4-5 decades but the problem involved in the plastic mulching was the removal of plastic mulch from the fields was exhaustive process and more labour and time consuming process. Hence, we have designed a hybrid bio-composite and bio-degradable sheets using in the mulching operations and easily they can degrade over a period of time and mix with the soil. For this purpose a tractor drawn machine was developed and tested in the fields that is called hybrid bio-composite bio-degradable mulch sheet laying machine.

2. **MATERIAL AND METHODS**:

The hybrid bio-composite and bio-degradable mulch sheet laying machine was designed and developed for the laying of mulch sheets in the fields. The most crucial parts of the machine was the power transmission system as the system works smoothly the machine performance will be reaching as per the customers satisfaction. Hence, the power transmission system was designed and developed.

1. Main shaft, Counter shaft and Rear wheel shaft RPM which was connected to Ground wheel:

$$V = \frac{\Pi * D * Ng}{60} \text{ m/s} \text{ ------(1)}$$

Where , V = operating speed of equipment = 2.9kmph=0.8 m/s

D = Diameter of Ground wheel = 40 cm = 0.4m

Ng = Revelations of the Ground wheel per minute, RPM

Diameter of the Main shaft was calculated by using the two conditions

a) Twisting and bending combinations :
b) Sudden applied shocks and fluctuated loads :

We have taken the main shaft RPM is 1.3 times the Counter shaft RPM

$$\text{So, , } \frac{Nm}{Nc} = 1.3 \text{ ----- ---- - - (2)}$$

2. Speed of operation :

$$\text{Speed (kmph)} = \frac{3.6 \text{ x distance travelled (m)}}{Time\ in\ seconds} \text{--- ---- --- -- ----- -- -(3)}$$

3. The Diameters of the main shaft, counter shaft and rear wheel shaft has been calculated using the following equations

Condition 1 : Te = $[\sqrt{\boldsymbol{Mm^2 + Tm^2}}] = \frac{\boldsymbol{\Pi}}{\mathbf{16}}\boldsymbol{\tau max} * d^3 - - - - - -(4)$ and

M = $\frac{1}{2}$ $[Mm + [\sqrt{\boldsymbol{Mm^2 + Tm^2}}]]$ ------- - -- -- - -- -(5)

Condition2: $\sqrt{(\boldsymbol{Km} * \boldsymbol{Mm})^2 + (Km * \boldsymbol{Tm})^2} - - - -(6)$ = $\frac{\boldsymbol{\Pi}}{\mathbf{16}}\boldsymbol{\tau max} * d^3$ and $\sqrt{(\boldsymbol{Kmm} * \boldsymbol{Mm})^2 + (Ktm * \boldsymbol{Tm})^2} = \frac{\boldsymbol{\Pi}}{\mathbf{16}}\boldsymbol{\tau max} * d^3$ --------(7)

Design of Chain drive:

We know that $N_1T_1 = N_2T_2$ ----------(8)

Where , N_1 = RPM of Ground Wheel or main shaft = 38.2 RPM

T_1 = Number of Teeth of the Ground Wheel or main shaft = 15

N_2 = RPM of Counter shaft = 29.3 RPM

Horse Power Transmitted by the Chain at driving or main shaft:

$$HP = \frac{Pt*V}{75} \text{ ----------(9)}$$

Where HP = Horse Power of the chain transmitted, hp

Pt = Chain pulls tension side, kgf

V = Velocity of the chain at main shaft, m/s

Velocity of the chain V = N * P * RPM ------(10)

Where V = Velocity of the chain at main, m/min

N = Number of teeth of the main shaft pully, nos

P = Pitch of chain , m

RPM = RPM of the main or ground shaft

Horse Power Transmitted by the chain drive:

$$HP = \frac{2*\Pi* N*T}{4500} - - - - - (11)$$

chain load (Q) = K * Pt ------ - - -- - - - --(12)

Design of Pitch circle Diameter of sprocket of Driving shaft:

Diameter of main / driving shaft sprocket $Dm = \frac{P}{\sin(\frac{180}{Tm})}$ mm --------(13)

Where, P = pitch of chain,mm

Tm = Number of Teeth on the main driving sprocket, nos

Design of Pitch circle Diameter of sprocket of Counter shaft:

$$\text{Diameter of Counter shaft sprocket Dc} = \frac{P}{\sin(\frac{180}{Tm})} \text{ mm ---------(14)}$$

Where, P = pitch of chain,mm

Tm = Number of Teeth on the main driving sprocket, nos

Length of the chain Lp:

$$L = m * p\text{------(15)}$$

Where , Lp = Length of the chain In pitches, mm

m = Number of Links, nos

p = pitch of the chain, mm

$$m = 2 * \frac{c}{p} + \left(\frac{Tm+Tc}{2}\right) + p\left(\frac{Tm-Tc}{2\Pi}\right)^2 ------(16)$$

3. RESULTS AND DISCUSSIONS:

1. a) Main shaft RPM : as per the equation (1),

$$0.8 \text{ m/s} = \frac{\Pi * 0.4 * Ng}{60}, \quad Ng = \frac{0.8*60}{3.14*0.4} = 38.2 \text{ RPM}$$

b) Counter shaft : As per equation (1) , $\frac{38.2}{Nc} = 1.3$, $Nc = \frac{38.2}{1.3} = 29.3$ RPM

c) Rear Wheel shaft: As per the equation (1), , $0.8 \text{ m/s} = \frac{\Pi * 0.3 * Nr}{60}$, $Nr = \frac{0.8*60}{3.14*0.3} = 50.9$ RPM

2. Speed of operation : Speed (kmph) as per equation (3) $= \frac{3.6 \times 48}{60} = 2.9$kmph $= 0.8$ m/s

3. As per the equations (4,5,6,7)

The diameters of the main shaft, counter shaft, and rear wheel shaft were computed as 20.6 mm, 21.2 mm, 24.2, 25.5 mm, 22.8 mm, 22.8 mm, 26.2 mm, and 33.8 mm, respectively; the diameters of the counter shaft were 18.8 mm, 23.8 mm, 22.2 mm, and 23.2 mm.

The maximum value of the collected diameters was taken into account for the shaft diameter requirements and stretched to a higher value.

Design of Chain drive:

As per equation (8), $\frac{38.2*15}{29.3}$ = 19.6 say 20 Teeth

Horse Power Transmitted by the Chain at driving or main shaft:

As per equation (9,10)

Horse Power Transmitted by the chain drive: As per the equation (11,12)

HP at machine wheel = $\frac{2\Pi NT}{4500}$ = $\frac{2*3.14*38.2*6.375}{4500}$ = 0.339hp

Chain pulls Pt Tension side Pt = $\frac{HP*75}{V}$ kgf

$$Pt = \frac{0.339*75}{0.239} = 106.64 \text{ kgf}$$

Q = 1.2 * 106.6 kgf = 127.97kgf

Therefore from the Chain table Roller chain 16B-1 model has been selected with Pitch of 2.54mm, and wt/m was 2.7kg/m.

Design of Pitch circle Diameter of sprocket of Driving shaft:

As per the equations (13, 14),

Dm = $\frac{25.4}{\sin(\frac{180}{15})}$ = 127mm = 12.7 cm

Dm = $\frac{25.4}{\sin(\frac{180}{20})}$ = 162 mm = 16.2cm

Length of the chain Lp:

As per equation (15,16), m = $2 * \frac{380}{25.4} + \left(\frac{15+20}{2}\right) + 25.4\left(\frac{20-15}{2*3.14}\right)^2$

m = 29.92 + (17.5) + 16.10

m = 63.5 links considered 64 links

so, Lp = m * p cm

Lp = 64 * 2.54 cm = 162.56 cm

4. CONCLUSIONS:

As per the results obtained from the design of a power transmission system, here are the conclusions made as per following table form.

Table 1 : Conclusions of the power transmission system

S.no	Component	Value with Units
1	Speed of operation	2.9 kmph
2	Diameters of Mains haft, Counter shaft, and Rear wheel shaft	Main Shaft: 30 mm was derived from the maximum diameter value of 25.5. Counter shaft: 40 mm derived from the maximum diameter of 33.8 mm. Maximum diameter of the rear wheel shaft was 23.2, which was taken as 25 mm.
3	Pitch circle diameter of the main shaft sprocket	12.7cm
4	Pitch Circle diameter of the counter shaft sprocket	16.2 cm
5	Length of the chain	162.56 cm

6	Pitch of the chain	2.54 cm

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