

Design and Analysis of Cutter Drum by using Analytical Approach

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Abstract— In this paper, Chains are used for transmission of power, when the distance between the centers of shafts is short. These chains have provision for efficient lubrication. Considering the system, forces, torque acting on a chain is used to calculate the stresses induced. Stress analysis also carried out by using FEA software and the results are compared with the calculated values. The chains may also be used for long center distance of up to 8 meters. This paper illustrates how the chain drives are very important to carry forwards the power. These wheels have projecting teeth of special profile and fit into the corresponding recesses in the links of the chain. The toothed wheels are known as *sprocket wheels or simply sprockets. A cable laying machine for underground placement of cable incorporating a basic frame and power unit incorporating a rear warred attractive component with the front and rear components being articulately interconnected for steering control of the machine and the rear component including cable laying plough associated there with the rear component may be provided with cable reels and guide structures for guiding the cable plough. The cable laying machine has a cutter drum at its front end which digs up the soil along linear channels rolls down the cable mounted on the roller behind. The proposed machine eliminates hazards faced by commuters solving three purposes simultaneously of digging, Cable laying and then covering the soil.

Key words: Cable, Soil condition, Creo, Sprockets

I. INTRODUCTION

The cable laying work as seen in day to day lives employs labourers who dig up the soil along the predefined paths, clears the channel and lays the cable. This entire process takes 3 to 4 days and causes lots of hurdles to the commuter. To reduce the stress and fatigue level of labourers, the cable laying machine has been designed. The machine is run by a 1 hp motor which performs 4 functions.

- Digs up the soil (with the help of cutter drum)
- Clears the channel (by means of flapper)
- Lays the cable (through the cable roller drum)
- Cover up the soil (by means of flapper)

The machine has the cutter drum mounted on the front section and the cable which is to be laid is anchored on the cable drum on back of the machine. The Machine is mounted on four wheels as it moves the cutter drum impinges on the soil and digs up earth along the linear channels. The accumulated soil is removed by the flapper and the cables are laid on the channels.

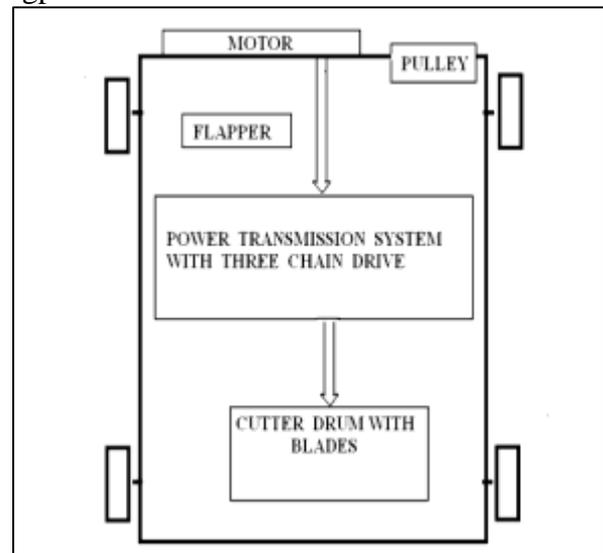


Fig. 1: Block diagram of cable laying machine

II. DESCRIPTION

A. Frames:

In the cable laying machine, the frame is the supporting membrane of the machine. It acts as a skeleton to the machine. It holds the overall weight of the machine. It carries the motor, pulley, sprockets, chains which move over the sprockets, the cutter drum, the cable drum and the shafts. Thus, the frame should have the enough strength and rigidity to withstand the load of the various parts of the machine. The frame is made up of the cast iron (C.I) as it is ductile and has enough strength and rigidity to carry the above mentioned load.

B. Bush Bearing:

Bush bearing is provided to support the shaft. The shaft is attached at the end of the frame horizontally by means of the socket. Inside the socket is placed the bush bearing, at which the shaft is held to revolve freely. The main reason to provide the bearing along with shaft is to reduce the friction considerably and allow the free rotation of the shaft to which the socket is attached. Thus, it plays a vital role to reduce the friction during the rotation of the shaft and increase the efficiency of the machine.

C. Sprocket: -

There are six sprockets in the cable laying machine. Three of which having the same diameter and weight while the other three of varying diameter and weight in order to meet the various requirements. The sprocket is a device which is used to carry the chain drive over it. It is firmly attached to the shaft and rotates uniformly along with the shaft. The main reason for selecting the chain drive is that it is a positive drive, reduces friction and increases the efficiency of the machine. Now, the pulley drive along with the three chain drives is used

in order to reduce the speed of the motor from 1425 rpm to 59.375 rpm. This is because the basic aim of our cable laying machine is to have maximum torque at the output and not speed.

D. Shaft: -

The Shaft is the horizontal supporting member of our cable laying machine.

There are 4 shafts in our cable laying machine. The two shafts which are of larger length support the front axle and rear axle supporting the four wheels. The shaft is attached to the frame and rotates around the bush bearing supported by the sprocket in order to reduce friction and increase efficiency. The other three shafts support the pulley and the sprockets. The pulley and the sprocket are firmly mounted on the shaft. Thus the shaft material should be of suitable strength and rigidity to support the axle sprocket and the pulley.

E. Pulley: -

The pulley is directly coupled with the motor with the help of belt drive. Thus the speed of the pulley is maximum and is further reduced by the other three chain drives. The shaft on which the pulley is mounted must rotate freely that is the bush bearing must be friction free so that the resistance produced due to the friction does not affect the pulley. The belt which is used around the pulley is provided with 2% slip to avoid any back pressure which would otherwise lead to the burning of the coil of the motor.

F. Cutter Drum: -

The cutter drum is most important element of this machine. The cutter drum consists of teeth which dig up the soil when they come in contact with the earth. There are 4 rows of teeth consisting of consecutive 4 and 5 teeth. The cutter drum is made up of hollow cylinder. The reason of drum being hollow is light weight and low price. The thickness of the cutter must be select such that it can withstand the torque generated by the motor and resistance force produced by the earth while digging the soil.

G. Flapper: -

The flapper forms the tail unit of the cable laying machine. The aim of the flapper is to remove the dug up soil along the cable laying channel. By removing the soil, it forms a pathway in which the cable can be laid which is anchored on the cable drum. The sides of the flapper are tilted at a small angle for better digging operation. The flapper can b adjusted to different lengths by nut and bolt arrangement to meet requirement and match different soil levels.

III. WORKING

The cable laying machine having a 1H.P motor mounted on the rear end is used to drive the transmission system of the machine. The machine is driven of four wheel s and the directional stability is governed by the help of lever arm. With the help of the lever the machine is pulled forward along linear channels where cable is to be laid. When the motor is supplied by alternate current supply, power is transmitted to the various chain drives and the pulley attached to the shaft. The power is transmitted from the motor having rotational speed of 1425 rpm to the cutter drum which rotates at 59.375 rpm by mean of various reduction using chain drive and

pulley. The man reasons for speed reduction are to obtain maximum torque at the cutter drum and not the speed. When the cable laying machine moves forward, the cutter drum impinges the soil to dig up the earth. The depth of cut can be adjusted by means of the maneuverator. The flapper at the rear end clears the channel in which the cable is to be laid. The cable wound on the drum or roller lays the cable on the channel. The cable drum has the advantage of the rolling action which allows the automatic laying of the cable on the channel once it is anchored at one end. The working of cable laying machine is simple and less manual assistance is required to operate it. In this way, the cable laying performs all the three functions of digging of the soil, clearing the channels and laying of the cable simultaneously.

IV. DESIGN CALCULATION TORQUE ESTIMATION OF CUTTER DRUM

A. Specifications

1) Weight of drum

$$W = 50N$$

2) Forces applied

$$F_h = 2N$$

3) Reaction

$$R = W + F_h$$

$$= 52N$$

4) Frictional force

$$F = \mu \times R$$

$$= 0.2 \times 52$$

$$= 10.4N$$

5) Effective radius

$$R_{\text{effective}} = 0.1 + 0.04$$

$$= 0.104m$$

6) Torque generated

$$T = R \times R_{\text{eff}}$$

B. Considering 4 teeth row in contact

1) For $0^\circ - 45^\circ$ of rotation

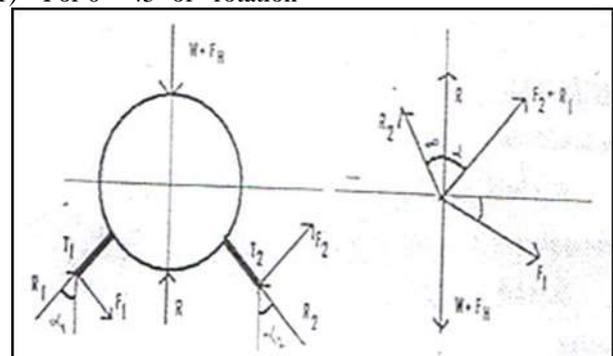


Fig. 2: Forces acting for $0^\circ - 45^\circ$

Summing horizontal forces

$$\sum F_H = 4F_1 \times \cos 45^\circ - 4R_1 \times \cos 45^\circ$$

$$= -17.66N$$

Summing vertical forces

$$\sum F_V = R + 4F_1 \times \sin 45^\circ + 4R_1 \times \sin 45^\circ - (W + F_H)$$

$$= 176.49N$$

Resultant force

$$R = \sqrt{[\sum F_H]^2 + (\sum F_V)^2}$$

$$= 51.40N$$

Torque generated

$$T = 7.19N - M$$

2. At 45°

Forces acting at 45°
Summing horizontal forces
 $\sum F_h = 4(F_1 - F_2)$
 $= 166.4\text{N}$

Summing vertical forces
 $\sum F_v = R - (W + F_h)$
 $= 0\text{N}$

Resultant force
 $R = \sqrt{[\sum F_h]^2 + [\sum F_v]^2}$
 $= 166.4\text{N}$

Torque generated
 $T = 23.296\text{N-M}$

3. For 45° - 88° rotation

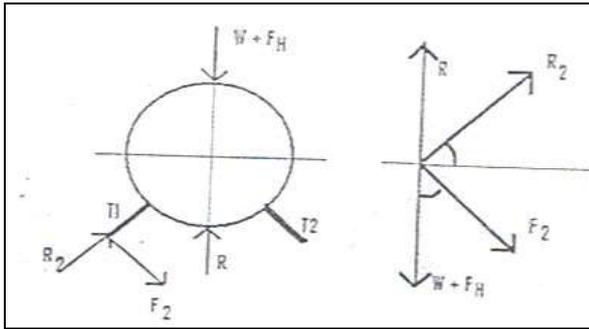


Fig. 3: Forces acting for 45° - 88°

Summing horizontal forces
 $\sum F_h = 4R_2 \times \cos 43^\circ + 4F_2 \times \sin 43^\circ$
 $= 180.49\text{N}$

Summing vertical forces
 $\sum F_v = R + 4R_2 \times \sin 43^\circ - (W + F_h) - 4F_2 \times \cos 43^\circ$
 $= 111.4\text{N}$

Resultant force
 $R = \sqrt{[\sum F_h]^2 + [\sum F_v]^2}$
 $= 297.08\text{N}$

Torque generated
 $T = 29.708\text{N-M}$

4. for 88°-90° rotation

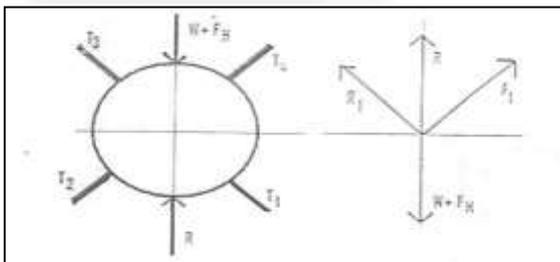


Fig. 4: Forces acting for 88°-90°

Summing horizontal forces
 $\sum F_h = (5F_2 + 4R_1) \times \cos 45^\circ - 5R_2 \times \sin 45^\circ + 4F_1 \times \cos 45^\circ$
 $= 29.4\text{N}$

Summing vertical forces
 $\sum F_v = R + (5F_2 + 4R_1) \times \cos 45^\circ + 5R_2 \times \cos 45^\circ - (W + F_h) - 4F_1 \times \sin 45^\circ$
 $= 338.27\text{N}$

Resultant force
 $R = \sqrt{[\sum F_h]^2 + [\sum F_v]^2}$
 $= 339.57\text{N}$

Torque generated
 $T = 47.57\text{N-M}$

C. Considering 5 teeth row in contact

For 0° - 45° of rotation

Summing horizontal forces
 $\sum F_h = 5F_1 \times \cos 45^\circ - 5R_1 \times \cos 45^\circ$
 $= -158.17\text{N}$

Summing vertical forces
 $\sum F_v = R + 5F_1 \times \sin 45^\circ + 5R_1 \times \sin 45^\circ - (W + F_h)$
 $= 202.6\text{N}$

Resultant force
 $R = \sqrt{[\sum F_h]^2 + [\sum F_v]^2}$
 $= 257\text{N}$

Torque generated
 $T = 37.12\text{N-M}$

2. At 45°

Summing horizontal forces
 $\sum F_h = 5(F_1 - R_1)$
 $= -291.2\text{N}$

Summing vertical forces
 $\sum F_v = R - (W + F_h)$
 $= 0\text{N}$

Resultant force
 $R = \sqrt{[\sum F_h]^2 + [\sum F_v]^2}$
 $= 291.2\text{N}$

Torque generated
 $T = 29.12\text{N-M}$

3. For 45° - 88° of rotation

Summing horizontal forces
 $\sum F_h = 5R_2 \times \cos 43^\circ + 5F_2 \times \sin 43^\circ$
 $= 225.61\text{N}$

Summing vertical forces
 $\sum F_v = R + 5R_2 \times \sin 43^\circ - (W + F_h) - 5F_2 \times \cos 43^\circ$
 $= 139.25\text{N}$

Resultant force
 $R = \sqrt{[\sum F_h]^2 + [\sum F_v]^2}$
 $= 371.35\text{N}$

Torque generated
 $T = 37.135\text{N-M}$

4. For 88° - 90° rotation

Summing horizontal forces
 $\sum F_h = (4F_2 + 5R_1) \times \cos 45^\circ - 4R_2 \times \sin 45^\circ + 5F_1 \times \cos 45^\circ$
 $= 102.95\text{N}$

Summing vertical forces
 $\sum F_v = R + (4F_2 + 5R_1) \times \cos 45^\circ + 4R_2 \times \cos 45^\circ - (W + F_h) - 5F_1 \times \sin 45^\circ$
 $= 323.57\text{N}$

Resultant force
 $R = \sqrt{[\sum F_h]^2 + [\sum F_v]^2}$
 $= 339.57\text{N}$

Torque generated
 $T = 47.57\text{N-M}$

D. Estimation of mean torque at different instances

Since the load torque generated at various cutting position is provided by the electric motor hence the mean torque is given by the equation.

$$T_1 + J \frac{dw}{dt} = T_m,$$

Where T_L = load torque

J = polar moment of inertia of the drum.

d_w = Angular speed

d_t = time required

Hence, plotting a graph of T_w Vs time. It is found to be constant in nature Time (T)

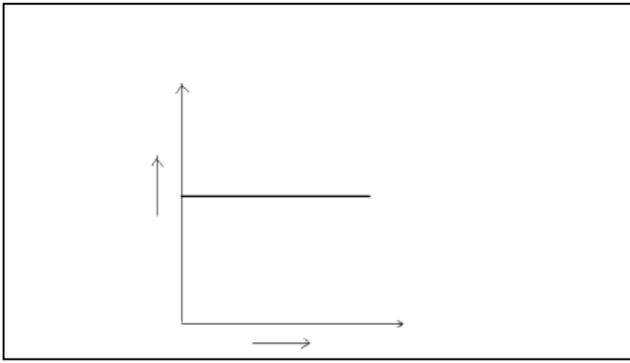


Fig. 5: Mean torque curve

V. CONCLUSION

After the working on the project we can conclude that the cable laying machine is boon to the mankind. The machine is a first of its kind which digs up the soil, lays the cable and covers the channels simultaneously. The implementation of this machine would certainly reduce the time of cable laying work and will also assist in greater precision than manual cable laying work. The cable laying machine reduces the labour cost associated with the digging up the soil and covering the channels. It also reduces the traffic snarls and hazards faced by the commuters due to cable laying work. Having seen this machine working satisfactorily on a small scale, we can conclude that with the aid of high transmission system, high capacity motors and cutter teeth of high hardness; it can be used in the large small project undertaken by the government for cable laying work.

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