Design and Modelling of Shaft of Two Furrow Reversible Plough

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***Abstract*- In the field of agriculture there is a remarkable development, the farmers are using plough, harvester, tractors and advance farm equipment's. Plough is one of the very important agricultural equipment and thus the various parts of plough such as frame, shaft, tilting mechanism, mould board should be reliable and strong. In this paper, various parameters are identified for optimum design of two furrow reversible plough. The author has done the design of existing shaft and checked the existing design of shaft. Also the modeling of shaft is done for further analysis**.

***Keywords*- Plough, Shaft, Design, Modeling**

I. INTRODUCTION

In last few decades we all are witnessing the development in each and every field of life. In the field of agricultural also we had seen remarkable development, farmers of developed nations are now a day's using harvester, tractor, advance machine tools and advance farm equipment's but country like India most of the farmers are still using traditional method of farming may be because of poor financial conditions or unavailability of cheap and reliable farm equipment's. Farmers are facing the various problems with the agricultural equipment's viz. High cost, heavier in weight, less reliable, etc, it's also observed that the agricultural equipment's are mostly manufactured by local manufacturing companies and they do not having any R & D facilities also they manufactured the equipment without applying any type of scientific tools, techniques and methods. Therefore there is a need of improved agricultural tools so that it does not get failed at the time of uses.

II. PLOUGH

Plough is used to turn the heavy growth of green manure to help proper decay and addition of humus to soil. It is generally done to create a favorable condition for seed placement and plant growth. It is the mechanical manipulation of soil which is used to maintain, modify or promote changes in soil environment for plant growth. The mould board plough is one of the oldest of all agricultural implements. In general, this plough is used in the areas where there is sufficient rainfall to produce a good crop. Of all the types of mould board plough, the one with single bottom and animal drawn and walking type is the most common among the farmers. However, some farmers who own tractors drawn multi bottom mould board plough. They are classified further as –

A. Reversible type of plough

The reversible plough has two mouldboard ploughs mounted back-to-back, one turning to the right and other to the left. While one is working the land, the other is carried upside down in the air. At the end of each row, the paired ploughs are turned over, so the other can be used. This returns the next furrow, again working the field in a consistent direction.
A reversible plough can be turned over by the tractor's hydraulics or manually at the end of the furrow and the next pass made against the previous strip. The ploughman drives backwards and forwards across the field untilall is done.

B. Non Reversible type of plough

Non reversible plough can only turn the soil one way. If the ploughman were to run back alongside the previous furrow the soil would pile up in the middle. Instead the field is divided into lands. A land is an arbitrary area around which the ploughman drives in an elongated spiral. All the soil is turned the same way and there is only one slight ridge in the middle where the soil was turned together. As each land is finished and the next started there is a shallow trench left between the adjacent lands.

III. LITERATURE REVIEW

The literature review has been carried out for finding various important parameters which are required to be considered while optimum designing. By field survey and literature review it has been observed that following are the failures generally occurs in the shaft –
1. Bending of shaft
2. Breakage of shaft

According to V. Jankauskas et al. (2008) the welding of different parts of plough is very important for reliable application of plough. Anil R. Sahu et al. (2011) has focused on tilting mechanism of plough and they identified the proper spring diameter and weld thickness is important parameter for reliable reversible mechanism. Sneha S. Wasu et al. (2015) has done design and modeling of two furrow reversible plough and they identified that shear plate is important component of reversible plough and they suggested that the boron steel is suitable material for shear plate. Pooja M. Raut et al. (2014) has done FEM analysis of nine type duty cultivator and they optimize the life of shovel and they have changed the material of shovel to boron steel.

From the above literature review it has been observed that most of the authors optimize the design of different components of mould board like shovel, shear plate, tilting mechanism and welding of different components. But nobody has done the optimization of shaft. Therefore in this paper we are suggesting the various important parameters which have to be considered while designing shaft and checking the existing design of shaft so that the reversible plough work efficiently without fail at the time of use.

IV. DESIGN OF SHAFT AND FORCE CALCULATION

The power required to pull a two bottom 33.5 cm plough, working to a depth of 25 cm. the power unit (Tractor) is operating at a speed of 4.5 km/hr. The type of soil is medium having soil resistance is 0.65 kg/cm2

Total width of ploughing = 33.5 × 2 = 67 cm

Furrow cross section = Total width of ploughing × working depth

= 67 × 25

= 1675 cm2

Total Draft = Soil resistance × Furrow cross section

= 0.65 × 1675

= 1089 Kg = 10683 N (1 Kg = 9.81 N)

Line of pull of a moldboard plough is 20 deg. horizontal with the direction of travel.

Total Draft = Required Pull × cos 20

.:. Required Pull = Total Draft / cos 20

= 10683 / cos 20

Required Pull = 11369 N

The required pull acting on the shaft is 11369 N.

The power required to pull a two furrow bottom plough is (W),

P = Total Draft (N) × Speed (m/s)

= 10683 N × (4.5×1000/ 60 × 60)

= 13354 W = 13.3 kW

The weight of two furrow mouldboard or rear assembly is assumed to be 380 Kg i.e. 3728 N

Consider uniformly distributed load on the shaft for the portion of .300 m

= 3728/.300 = 12426 N/m

Total force required to pull the tillage is 11369 N, acted by the power source through the shaft. Therefore, the force required to pull the each mouldboard is 11369 / 2 = 5685 N.

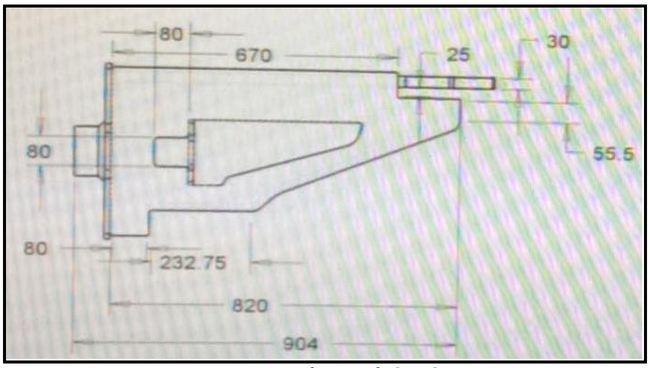


Figure 1. frame of plough

Mouldboard No. 1 = 5685 × 0.904 = 5139 N.m

Mouldboard No. 2 = 5685 × 0.280 = 1592 N.m

The total intensity of couple acted on the shaft is 5139 + 1592 = 6731 N.m

Shear Force and Bending Moment Calculations

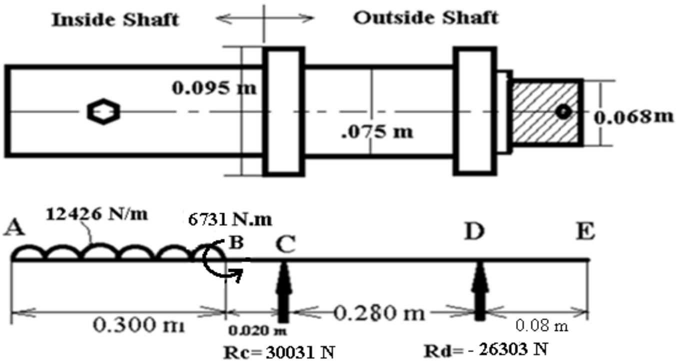


Figure 2. free body diagram

Reactions at Supports

Taking moment about point C,

Rd×0.280 + (12426 × 0.300) × 0.170 + 6731 = 0

R_D = -- 26,303 N

Taking Moment about point D,

Rc × 0.280 = 6731 + (12426 × 0.300) × 0.450

R_C = -- 30,031 N

Shear Force Calculations

Shear Force at A = 0 N

Shear Force at B

Left of B = – (12426 × 0.300) = – 3728 N

Right of B = – (12426 × 0.300) = – 3728 N

Shear Force at C

Left of C = – (12426 × 0.300) = – 3728 N

Right of C = – (12426 × 0.300) + 30031 = 26303 N

Shear Force at D

Left of D = – (12426 × 0.300) + 30031 = 26303 N

Right of D = – (12426 × 0.300) + 30031 + (--26303) = 0 N

Shear Force at E = 0 N

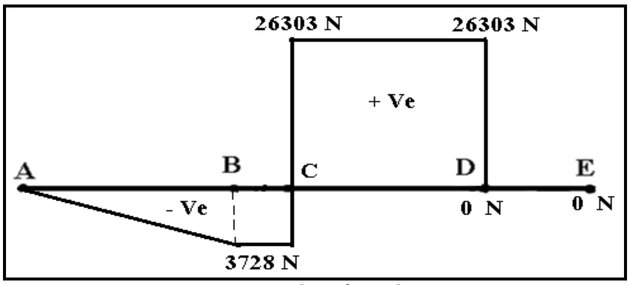


Figure 3- shear force diagram

Bending Moment Calculations
Taking moment about all points
$M_A = 0$ N.m
M_B (Left of B) = – (12426 × 0.300) × 0.150 = – 559 N.m
(Right of B) = – (12426 × 0.300) × 0.170 -- 6731 = --7290 N.m
M_C = – (12426 × 0.300) × 0.170 -- 6731 = -- 7365 N.m
M_D = – (12426 × 0.300) × 0.45 -- 6731 + (30031) × 0.280 = 0 N.m
$M_E = 0$ N.m

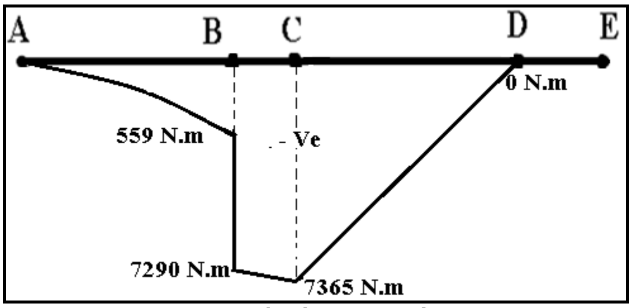


Figure 4- bending moment diagram

The maximum bending moment found to be 7365 N.m = 7,365 × 10^3 N.mm

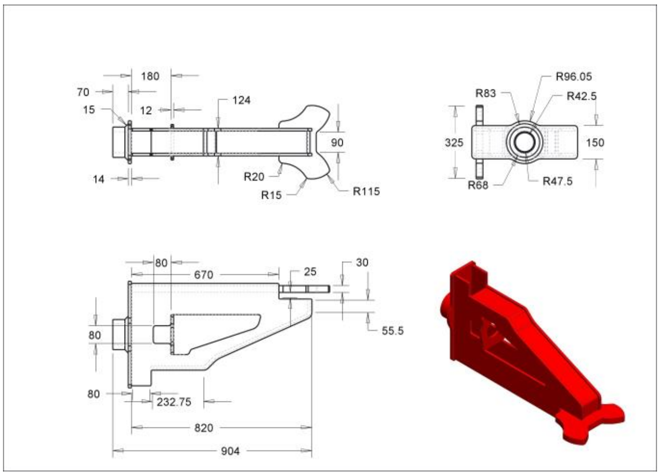
The material of shaft is EN 8 i.e. SAE 1040
The diameter of existing shaft is 75mm
.:. The yield strength in reverse bending is (Syt = 350 N/mm2)
Consider the factor of safety for the shaft material is 2.
Therefore the permissible bending stress in the shaft material is Ϭb
Ϭb = Endurance limit or Strength / Factor of safety
Ϭb = 350 / 2 = 175 N/mm2

The actual bending stress Ϭb (N/mm^2)
Ϭb = Maximum Bending Moment (N.mm) / Section Modulus (mm^3)
Ϭb = 7,365 × 10^3 / (Π × 75^3 / 32)
Ϭb = 178 N/mm2
By Calculations it was found that,
Ϭb = 178 N/mm2 > Ϭb = 175 N/mm2
From above values it is observed that the bending moment is slightly more than yield strength.

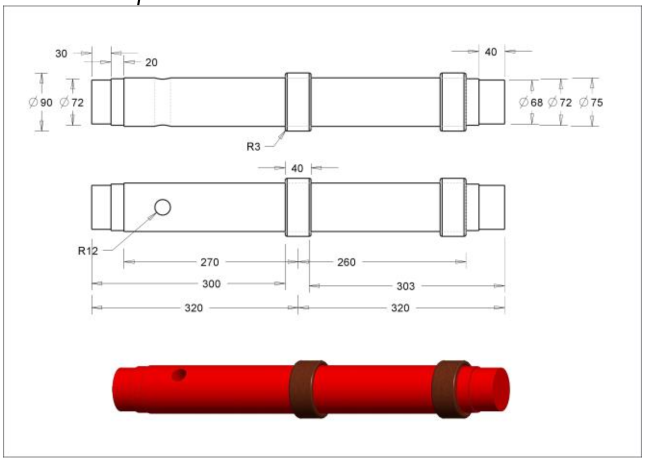
V. MODELING

The modeling of various components had been done along with the assembly of two furrow reversible plough.

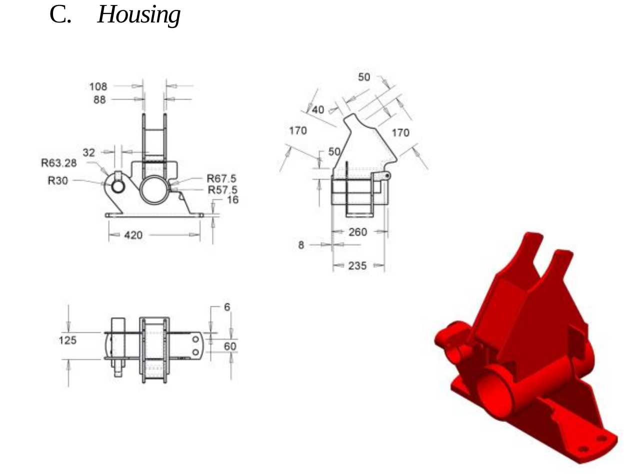
A. *Frame*



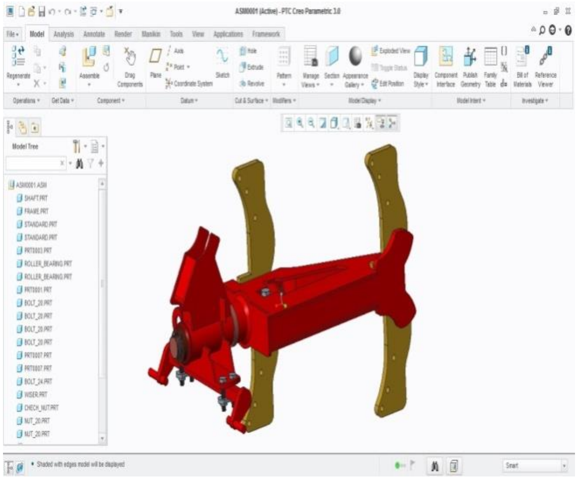
B. *Shaft*



C. *Housing*



A. *Assembly*



VI. CONCLUSION

From the above literature review the author had find out the various important parameters required for optimum design of shaft also from the above forces and analytical calculation of shaft it was found that the existing design is safe. The further modeling is done and impact forces could be calculated and analysis could be done to find the life of shaft.

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