Computer Aided Design and Force Analysis of Rotor shaft of Rotavator

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Abstract **- The intent of this paper is to study the various forces and stress acting on a rotor shaft of a standard rotavator which is subjected to transient loading. The standard models of rotavator, having a progressive cutting sequence was considered for the study and analysis. The study was extended to various available models having different cutting blade arrangement. The study was carried on different papers and identifies the various forces acting on a Rotor shaft of a rotavator. The positions of the torque and forces applied are varied according to the model considered. The response was obtained by considering the angle of twist and equivalent stress on the rotor shaft. This paper presented a methodology for conducting transient analysis of rotor shaft of a rotavator.**

Keywords—Rotor shaft, Blades, Torsional stresses, flange

I. INTRODUCTION

Rotavator is agricultural machinery, used to perform primary and the secondary tillage operations in farm. It is used to agitate the soil as well as to produce a good seed bed for crops. In the process it increases the Porosity and aeration of the soil which enhances the germination and growth of the crops. One of the added advantages of using rotavator is that it provides some forward thrust there by reducing the traction demand of the tractor [1]. When compared to conventional plough the total power requirement is lower. It is the most efficient means of transmitting engine power directly to the soil when compared to conventional tillage operations [2]. In comparison with that of the plough type rotavator, the rotary type consumes 25% less power [3]. Usually the power from the engine is given to the rotavator through the tractor PTO shaft. Rotary motion is then transferred to the rotor through gearbox and transmission system. Flanges are mounted in the rotor on which cutting blades are attached.

II. PROBLEM IDENTIFICATION

It has been observed that the rotavator assembly gets failed during the operation if proper speed is not maintained. it is also observed that the rotor shaft is not designed or selected by the manufacturer by applying any scientific tools like modeling & FEM analysis. Also they do not considered working conditions under which rotavator is going to used. Therefore in this paper the author is trying to find out what are the various critical parameters shell be considered for proper designing of a rotavator so that it will not get failed during the operation.

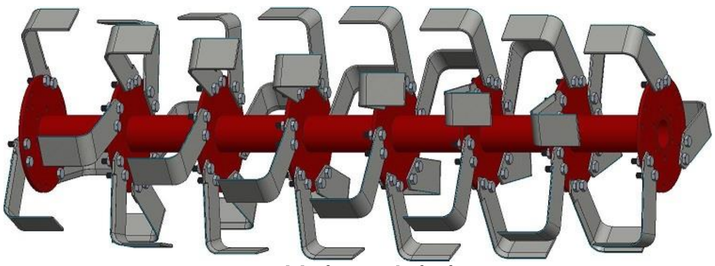


Figure: CAD model of Rotar shaft of rotavator

III. MAIN PARTS OF ROTAVATOR

Figure: Rotavator Parts

1. Independent Top Mast: one end of shaft will be connected to tractor P.T.O. and another end to rotavator.
2. Single / Multi Speed Gear Box: A gear box with bevel gears, main shaft, pinion shaft, heavy duty roller bearings combine form a unit to reduce standard P.T.O. rpm 540 rpm to 204 rpm. It enables the rotor shaft to rotate in the direction of travel.
3. Chain / Gear Cover Part Flange: A chain and gear cover part flange is a supporting element on which chain and gears are mounted.
4. Blades: The L shaped will be most common due to L shape is usually superior to others in heavy trash.
5. Chain / Gear Cover Part: A chain and gear cover part is a covering element in which chain and gears are safely protected from outside.
6. Frame and Cover: By adjusting the position of rear cover; the degree of pulverization of soil will be controlled.
7. Adjustable depth skids: It is fixed on adjustable frame to fix up a distance a gap between soil and Blade contact i.e. depth skid.

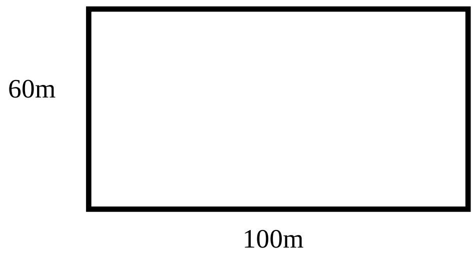
8. Offset adjustable frame: There is fixed rigid support to side parts mounted on rotary blade mounted shaft.

IV. LITERATURE REVIEW:

Literature review is carried out to find out what are the earlier work has carried out related with design of Rotavator

1. Vignesh. M, et. al, (2015) has studied the torsional response of a rotor shaft of a standard rotavator which is subjected to transient loading by considering the angle of twist and equivalent stress on the rotor shaft and they found that due to the shear stress and angle of twist , cyclic variation occurs . The cutting sequence does have an influence in the tensional response of the rotor. The cutting sequences have little effect on the equivalent stress. The cutting blade arrangement of the standard rotavator considered is not arranged according to an optimum sequence and the angle of twist can be reduced by the proper selection of cutting sequence. The torsional rigidity of the shaft can be increased by proper selection of cutting sequence.
2. Mr. Prasad D. Tupkari, et. al, (2014) has studied about 'Rotavator Blade' and they found that Computer Aided Design (CAD) is an effective tool for the design and development of rotavator blade. They also suggest that that L-shaped blades are better than C or J type blades in trashy conditions and at the forward rotation of the rotary tiller shaft, the tillage power consumption is decreased upto 10-15 % as compared to shaft reverse rotation because With the rotor blades cutting upwards, the tilled soil was scattered out of the seeding furrow and a seedbed was not formed.
3. C. Manivelprabhu, et.al (2015) investigated the Design of rotavator blade and design modifications are done by introducing one more cutting edge in other side of the blade. The main outcome of their study was after introducing one more cutting edge in same blade with slight modification, the new blade will withstand the same soil resistance without structural failure and same time the blade life is increased to double the times by introducing inter-changeability concept. They improved the life of blades by carrying out the design and modifications on the blade structure and this design and modifications are carried out by using CATIA R20 and HYPER MESH 12 software to simulate the stress distribution in the existing and new blades.
4. Jeevarathinam A. et.al has performs a finite Element Analysis for the investigation of Stress experienced by the blade and they found that the deformations and stresses are minimum for the developed L-type blade, they also observed that the stress in material has been reduced by applying the design change and changing the materials. The standard material used for blade is cast iron and it is producing high stress, different material compositions and dimensions are taken for analysis and the load condition is applied for existing and modified design blades. The best combination of materials and dimensions is then suggested. By changing the design of rotavator blade they increase the working hours of the blades and by using different materials increase the wear resistance of the blades.
5. J. V. Perumpral et.al, (1983) prepare A mathematical model based on limit equilibrium analysis which is useful for predicting the behaviour of slow moving narrow-tillage tools in cohesional-frictional soils. They predict the draft and vertical forces on a slow moving narrow tillage tool in soil and it can be effectively used for parametric studies to better understand the soil-tool interaction.
6. Sirisak Chertkiattipol & Tanya Niyamapa (2010) has studied the torque characteristics and the specific tilling energies of three commonly used rotary blades (Japanese C-shaped blade, the European C-shaped blade and the European L-shaped blade) were studied to develop a suitable rotary blade for seedbed preparation. They did the experiments in a laboratory soil bin at forward speed and the results in these experiments showed that the torque characteristics of the Japanese C-shaped blade, the European L-shaped blade and the European C-shaped blade during tilling were different; the varying torque was related to the blade tip positions of each rotary blade. The shape of the rotary blade influenced its torque characteristic. The specific tilling energies of all blades increased with the rotational speed. When the depth and the soil specific weight increased, the specific tilling energy also increased. The specific tilling energy decreased when the forward speed increased.

V. DESIGN CALCULATION



A Rotavator process 0.6 hector land area in 1 hour.
For processing of 0.6 hector land by using a 1.75 m Rotavator it takes 1 hour.
The width of Rotavator = 1.75 m
Therefore the time required for 0.6 hector land =1hr= 60 min.
And
The forces acting = Pulling Force + Soil Resistance
on a Rotavator
No. of turns required for a medium size Rotavator to process a land with a width of 1.75 m is = 60/1.75= 34.28 = 35 turns
Now the distance traveled in one turn = 100 m.
Therefore the total distance traveled = 35 x 100m = 3500 m.

Therefore the velocity of Rotavator = 3500 / 3600 = 0.972m/s
Now for the operation of 1.75 m width Rotavator it requires 45 Hp Tractor.
Therefore,
The power produced by tractor = 45 x 746
= 33570 W
= 33.57 Kw.

Now, in a standard 1.75 m width Rotavator there are total 42 nos of blades are used. These blades are mounted on 8 flanges. The flange are equidistant to each other in between two end bearings of rotor shaft.

The pulling force required to a tractor = Power / Velocity
= 33570 /0.972
= 36213.59 N

Now pulling force acting on each flange = 36213.59 / 8
= 4526.59 N.

The total force acting = Pulling Force + Soil Resistive Force
The Soil Resistive Pressure = 0.56 kg/ cm2.
Now
Pressure = Force / Area
Soil Resistive Pressure = 0.56 kg/cm^2
We know that
Pressure = Force / Area
Therefore, Force = Pressure x Area
The area of blade which is in contact with soil = 144 cm^2
Therefore resistive force of Soil = Pressure x Area
= 0.56 x 144
= 80.64 N

The total force acting on the shaft = Puling force on each Flange + Soil resistive Force
= 4526.59 + 80.64
= 4607.23 N

VI. CONCLUSION:

After conducting detail literature review it is observed that so many authors were studied the rotavator for optimal designing of it. they had considered the effect of depth of cut, rotational speed, forward speed and width of cut on the torque requirement, arrangement of blades etc. but lest consideration is given to torsional response& The various forces acting on the rotor shaft of rotavator under transient load conditions. The study of torsional vibration and forces is of at most importance because it can result in gear wear, gear tooth failure, shrink fit slippage and can even leads to the failure of the rotor shaft in several cases. Therefore this paper will be of great use to the designers and also for design optimization.

VII. REFERENCES:

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