

Modeling and Force analysis of Rotor Shaft Assembly of 5-Foot Raj Rotavator

Shrikant M. Fulmali¹, Ujwal D. Gulhane², Shubham S. Awachat³

Assistant Professor, Department of Mechanical Engineering¹

Professor, Department of Mechanical Engineering²

PG Student/Research Scholar, Department of Mechanical Engineering³

Bapurao Deshmukh College of Engineering, Sevagram, Maharashtra, India

Abstract: The rotavator is the agricultural equipment that is used for tillage of soil to make good seedbed. The purpose of this paper to study the various forces and stress acting on the parts of the rotor shaft assembly of a 5 feet raj rotavator. The rotavator can be under various loading conditions at different velocities and intervals of time. The study was carried out on different paper to identify the various forces and stress that act on the rotor shaft assembly. Within this paper the analysis is done on rotor shaft assembly and various forces on the parts of rotor shaft assembly is find out.

Keywords: Stresses on Rotor Shaft, Dimension of Rotor Shaft, Flanges, Blades

I. INTRODUCTION

Automation in the industry gets more value because it helps to reduce costs as well over time with increased productivity and quality, automation is becoming more and more popular in the agricultural sector as well. This has led to the creation of world-class areas for growing crops from sowing to harvesting to storage.

Gone are the days when hand digging, farming, and planting were common in the agricultural sector. Farewell to all the back pain, and mental and physical burden created by manual labor on a farm, the introduction of mechanized equipment that facilitates land reform became the beginning of a transformation in the new agricultural sector; where the introduction of the rotavator is one such development. Farmers usually take two or more harvests a year. In a subsequent pruning system, the seedbed needs to be prepared in advance next harvest. Land development is a very costly issue for agriculture and agricultural machinery i.e. Rotavator it is now used for days.

A rotavator is a powerful machine that uses rotating instruments to stabilize the earth and provide the best soil conditions by preventing and controlling pest and plant diseases. This exploitation and preparation of the soil require the use of multi-functional farm equipment such as rotavator grinding, cutting, mixing, and leveling the soil in one place. The efficiency of this process effectively proves the survival and uniformity of the crop to be planted, improves soil, water, and air, and facilitates soil conservation. There are, however, a variety of rotavators that can be used depending on the power source, the type of soil, and the size of the area. Rotavator is an agricultural tool that can do tilter work, disc harrow, and leveler. Rotavator destroys weeds, paddy kernels, and sugarcane and completely digests plants. It saves 30-35% of the time and 20-25% of operating costs compared to farmer farming.



Figure 1: Rotavator

Following are the different types of rotavator

1.1 Ground Tiller

A tiller, also known by rotavator, is an instrument that breaks down soil using a set of blades. Because it mixes and loosens the soil, it is one of the best ways to create healthy soil in a flowerbed.

1.2 Heavy Duty Rotavator

This medium duty rotavator can do more than a tiller. It is best to use it in gardens and allotments. These are more durable and last longer than tillers. They also provide a better finish while reducing the amount of work required to rotavate your area.

1.3 Heavy Duty Rotavator

Heavy duty rotavators are usually more powerful and more powerful. These machines are very good at preparing large parts of the earth for cultivation. A heavy duty rotavator is best for those who work in a difficult environment

Rotary Tiller is a farm tool used for plowing also known as rototiller, rotavator, rotary hoe, power tiller, or rotary plow. The Rotary tiller is drawn as a tool on the back of a four-wheeled tractor. This rotary tiller section is hard work and is recommended for tractors with high HP. Suitable for very hard soils, rocky soils, black cotton soils and heavy soils. It breaks down and mixes the topsoil, breaks down the stems and prepares the soil for proper use.

II. PROBLEM IDENTIFICATION

It has been observed that the rotavator assembly gets failed during the operation if the correct speed isn't maintained. it is also observed that the rotor shaft is not designed or selected by the manufacturer by applying any scientific tools like modelling & FEM analysis. Also, they had not considered under which condition the rotavator is going to use. Therefore in this paper, the author is trying to seek out what are the assorted critical parameters shall be considered for the correct design of a rotavator in order that it will not get failed during the operation.

III. MODELING OF THE ROTOR SHAFT ASSEMBLY

Modeling of all the parts of the rotavator is done in CATIA Software. Within the modelling, a complete part of drawings in 3-D was completed. The essential components of the Rotor assembly (the rotating parts) are as follows:

1. BLADES – Right-Hand and Left-Hand type blades
2. HOLLOW SHAFT.
3. FLANGES – End Flanges and Middle Flanges
4. M12 NYLOC nuts

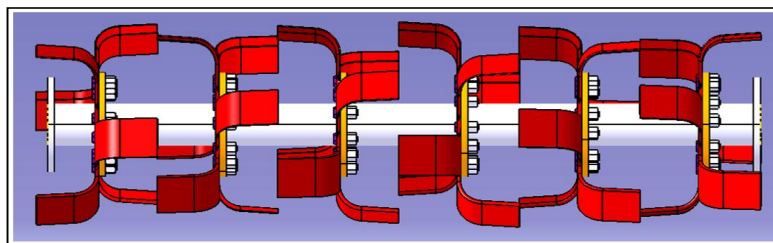


Figure 2: Cad modelling of rotor shaft assembly

IV. DESIGN CALCULATION

The power from the tractor is transmitted to the rotavator through PTO driveshaft. Thus for calculating the force and stress acting on the rotor shaft and flange and blade, the specification of the tractor and rotavator have been studied. For analysis purpose 45 hp tractor and 5 feet raj rotavator is selected.

Table 1: Specification of tractor and rotavator

Sr No.	Parameter	Description
1.	Size of rotavator	5 Feet (1.5 m)
2.	Speed of rotor shaft	195 Rpm to 214 Rpm

3.	Type of rotor axle	Tubular cross-section
4.	Length of rotor shaft	1470mm
5.	Number of blades	36
6.	Tractor required to drive rotavator	45 HP to 50HP
7.	Number of flanges	6

4.1 Power Require for Work Done

For the use of a standard medium size Rotavator a 45 HP tractor is required.

Therefore, the engine power of the Tractor = 45 HP.

Considering 20% Transmission losses, therefore power available at PTO shaft = 36 HP.

Therefore,

Final power required for the implementation = Power at PTO shaft – Power required for propulsion of tractor

Now,

The value of power required for the propulsion of 45 hp tractor is 10 HP-from the reference paper (3)

Therefore, the power required to drive the Rotavator = Power at PTO shaft – power for the propulsion of tractor.

$$= 36 - 10$$

$$= 26 \text{ HP}$$

$$= 19.38 \text{ KW.}$$

4.2 Torque and Force Calculation

$$\text{Now, the Torque generated at the Rotor shaft (T)} = \frac{60P}{2\pi N} = \frac{60 \times 19.38 \times 10^3}{2\pi \times 214} = 864.79 \text{ N-m}$$

where, N is taken as max axial speed at rotor shaft i.e. 214 rpm

Now,

Outer diameter of flange is 220mm and perpendicular length of blade from outer diameter of flange to soil is 120mm.

Therefore, total perpendicular distance from center of rotor shaft to soil is R = 0.170m

Therefore, Force acting on blade due to torque (F) = Torque / R

$$= 864.79 / 0.170$$

$$= 5087 \text{ N}$$

Within the 5 feet raj rotavator there are 6 flanges mounted on rotor pipe and a total of 36 blades mounted on 6 flanges.

Therefore, force acting per flange = 5087 / 6 = 847.83 N

V. RESULT

From the above analysis, it is found that the force acting on the per flange on the rotor shaft is 847.83 Newton, with a torque generated at rotor shaft is 864.79 N-m. so future rotor shaft and flanges will be designed which will have more allowable stress than the above-calculated value.

VI. CONCLUSION

After conducting a in-depth literature review it's observed that large number of authors had studied the rotavator for design optimization of it. They'd also considered the depth of the cut effect, the rotational speed of rotor shaft assembly, forward speed and width of cut cover by blades on the torque requirement, arrangement of blades on flanges of the rotor shaft, etc. But within papers, the authors had given less consideration to torsional response & the varied transient loading condition that occur on the rotor shaft of the rotavator under its working condition at a different interval of time. The study of torsional vibration and forces is of at most importance because it may result in gear wear, gear tooth failure, shrink fit slippage, and might even cause the failure of the rotor shaft in several cases. Within this paper the author has found out torque generated at the rotor shaft i.e., 864.79 N-m, also force acting per flange is 847.83 N. So this paper will be of great help to designers to do well for design optimization.

REFERENCES

- [1]. Stephen K. Armah. (2018). 'Preliminary Design of a Power Transmission Shaft under Fatigue Loading Using ASME Code', American Journal of Engineering and Applied Sciences, specially issued on 06 Feb 2018.
- [2]. Vignesh.M., Dr. Muruganandhan. R., Dasairi. N, Nagarjun. M. (2015). 'Study of Torsional Response on the Rotor shaft of a Rotavator Under Transient Load Conditions', IJRSET volume4, special Issue, 4 April 2015.
- [3]. Mr. S. A. Mishra, Dr. A. R. Sahu, Prof. R. D. Thakre, Prof. U. D. Gulhane. (2015). 'Computer-Aided Design and Analysis of Rotor Shaft of Rotavator', International Engineering Journal for Research & Development, 2015.
- [4]. Srinivasan. K, Viswanath R. P. (2015). 'Design and Optimisation of Blades for Rotavators', IJRSAT, Volume 4, Special Issue 4, April 2015.
- [5]. Subrata Kr. Mandal, Basudeb Bhattacharyya, Somenath Mukherjee, Priyabrata Chattopadhyay. (2013). 'Design & Development of Rotavator blade: Interrogation of CAD Method', International Journal of Scientific Research in Knowledge (IJSRK), 1(10), pp. 439-447, 26 September 2013.
- [6]. D. Ramesh Kumar, P. Mohanraj. (2017). 'Design and Analysis of Rotavator Blades for its Enhanced Performance in Tractors', Asian Journal of Applied Science and Technology (AJAST), Volume 1, Issue 1, Pages 160-185, February 2017.