

# Computer Aided Design Modification And Structural Analysis Of Rotavator Blade

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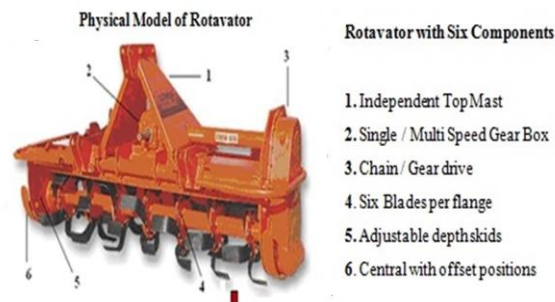
## Abstract

The rotavator tiller is attached with the tractor for soil bed preparation in agricultural land. The main advantage of rotavator is single stage tillage comparing to existing plough machine. The rotavator blade is a critical part of tiller machine that directly engages in soilbed preparation. The life of the blade is restricted to 50 hours. Indian formers worried about the money spent for replacement of blades because the blades are subjected to more wear, when the blades interact with soil. Hence the blades are to be replaced before it fails due to fatigue. To improve the life of blade the design modification are carried out in the blade structure. This paper describes the design modification of rotavator blade and the structural analyses are carried out using finite element method to simulate the stress distribution in the existing and new blades. The improvement of Rotavator blades life is discussed.

**Keywords:** Rotavator blade, design modification, displacement, Stress

## I INTRODUCTION

Rotavator tiller is mainly used in agriculture for loosening of upper layer soil to create seedbed. The rotavator has higher soil mixing capacity compared with other plough machine and it has good weed cutting capability and it leads to the water-air, thermal and nutrient of the soil is improved. The rotavator can be easily adjusted for various working depths for soil bed preparation. The rotavator tiller is suitable for all type of soil preparation no matter about the soil type, soil conditions and Service life of the blade may vary depends upon the property of soil and moisture content in the soil. Normally the heavy loam soil consumes more energy and subjected more wear when compared to other soils.



**Fig.1 Rotavator tiller**

Now a day's Indian farmers are unhappy about money spent for soil bed preparation because of raise in fuel price and rotavator blade replacement cost. So the farmers focused more in reducing the land preparation cost and increase in yield. Blades are the main parts of rotavator tiller (Fig.1), which directly engaged with the soil to prepare the seed bed for cultivation land.

Many types of rotavator blades are available in market. Those are C shape, L shape and J shape which are shown in Fig.2, Fig.3 and Fig.4.



**Fig.2 C shape blade**



**Fig.3 L shape blade**



**Fig.4 J shape blade**

After reviewing research literature of past studies the following general conclusions are drawn

- The tiller has a huge cutting capacity, mixing to top soil preparing the seedbed directly. And also it has seven times more mixing capacity than plough [7].
- L-shaped blades are better when compared with C or J type blades in trashy conditions as they are more effective in killing and they do not pulverize the soil as much[6].
- Normally the average service life time of a rotavator blade is fifty hours [5].

Hence it is important to improve the durability of blade by modifying geometry of existing rotavator blade.

In this work the design modification carried out in L-shape blade. Because the L shaped blade is most widely used in the agriculture land <sup>[9]</sup>.

## II DESIGN MODIFICATION OF ROTAVATOR BLADE.

The existing cutting blade have single cutting edge. Both right hand and left hand blades are used in the tiller machine shown in Fig.5



**Fig.5 Rotavator blade fixed with flange**

### A. *Conceptual design*

To improve the service life of the blade by providing one more cutting edge is introduced in the opposite side of cutting edge. If left side blade is getting wears then it will be changed to right side, similarly right side blade is replaced with left side. This project is mainly works on the principle of interchangeability concept and like automobile tire routing concept.

### B. *Geometry of the Blades*

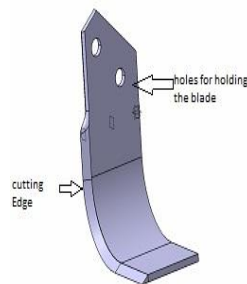
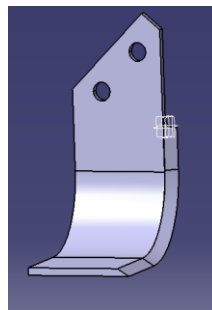
The dimension details are obtained from real component and design modification will be done by changing geometry are given in the Table.1

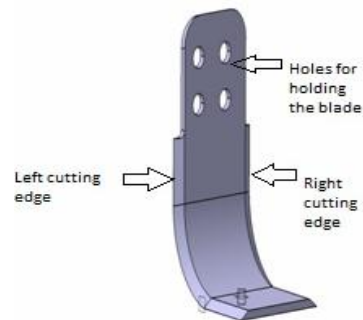
**Table.1**Dimensions of the blade

Si No	Parameters	Notations	Dimensions (mm)	
			Existing blade	New blade
1	Width of blade	W	80	100
2	Effective vertical length	LV	150	220
3	Blade cutting width	BW	10	2 x 10
4	Blade thickness	T	8	8

In addition to this the following design modification also carried out in the existing blade are shown in Fig 6 and Fig 7.

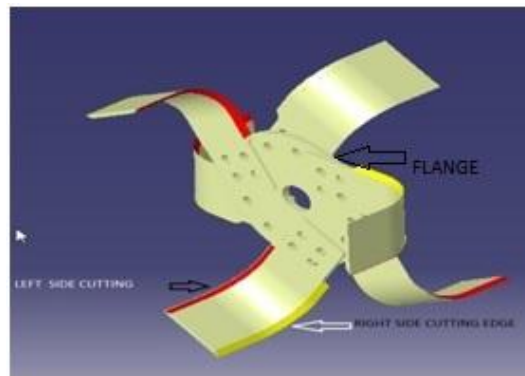
- Adding one more cutting edge on the other side
- Introduced two more holes to fix with flange in the opposite side as shown in fig8

**Fig.6** Left hand blade**Fig.7** Right hand blade



**Fig.8 New blade**

In the modified design the width of the blade is increased and corners are rounded. The new blade contains two cutting edges.



**Fig 9 Assemble view of new rotovator blade**

### ***C. Structural Analysis***

The structural analysis is carried out to check the stress distribution and displacement in the new blades. To compare the existing blade, both existing and new blade are modeled and analyzed using FEM.

### ***D. Modeling of blades***

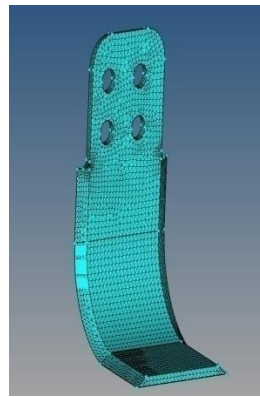
The three dimensional model of new and existing blades are generated using CATIA R20. The solid models are imported to Hyper works to carry out the structural analysis.

### ***E. Meshing of solid model***

The tetra mesh is generated by using hyper mesh 12. The various h-tria is formed in surface are shown in figure 10.



**Fig .10 Meshed Existing blade**



**Fig.11 Meshed New blade**

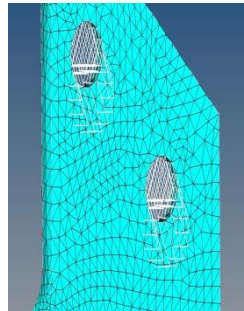
The number of element and node generated from new blade is 3393 and 9788. The number of element and node generated from existing blade is 1538 and 3077 which is shown in figure 10 and 11.

The most commonly used material for the blade is high carbon steel for high grade blades and cast iron are also used by some industries. Hence the high carbon blade is considered for this analysis. The properties are given in Table.2

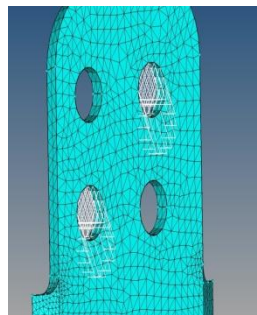
**Table.2 Material property of the blade**

S.No	Material name	Elastic modulus (N/mm <sup>2</sup> )	Poisson Ratio	Density (tone/mm <sup>3</sup> )
1	High carbon steel	$1.97 \times 10^{11}$	0.29	$7.48 \times 10^{-9}$
2	Cast iron	$1.20 \times 10^5$	0.28	$7.20 \times 10^{-9}$

The various boundary conditions of the blades are shown in figure 12 and 13. Then all DOF of nodes corresponding two holes are arrested.



**Fig.12 Existing blade DOF**



**Fig.13 New blade DOF**

**III LOAD CALCULATIONS**

The blades are subjected to impact load when the blades interact with the various soils. And the impact load is depends the properties of soil. The Soil resistance of various type of soil is given in Table 2. In that more amount of resistance is offered by heavy loam soil which produces 0.5 to 0.7 kg/cm<sup>2</sup>.

**Table .2 Soil Properties [7]**

Sl:No	Type of soil	Soil resistance(kg/cm <sup>2</sup> )
1	Sandy soil	0.2
2	Sandy loam	0.3
3	Slit loam	0.35-0.5
4	Clay	0.4-0.56
5	Heavy loam	0.5-0.7

The force acting on the blade are calculated by using the following equation and parameters listed in Table 2 and table 3

The soil force [9]

$$K_e = K_s \frac{C_p}{i z_e} n \tag{1}$$

The tangential force acting along the blade

$$K_s = 75cs Nc \eta_c \frac{n^2}{\omega_{mi}} n \quad (2)$$

The tangential force  $K_s = 2542$  kg and

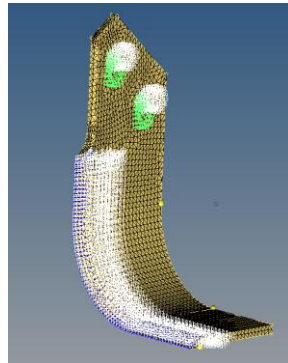
The soil force  $K_e = 3700$  N

**Table.3 Input parameters [5]**

SI NO	Parameters	Values
1	Rotor rpm	200- 220
2	Maximum number of blades (n)	66
3	Maximum number of blades on each side of the flanges [Ze]	11
4	Traction efficiency [ $\eta_c$ ]	0.8-0.9
5	Coefficient of reservation of tractor power [ $\eta_z$ ]	0.7-0.8
6	The coefficient of tangential force [Cp]	0.6-3
7	The reliability factor [C]	1.5-2
10	Prime mover forward speed	0.7-1.7 m/s

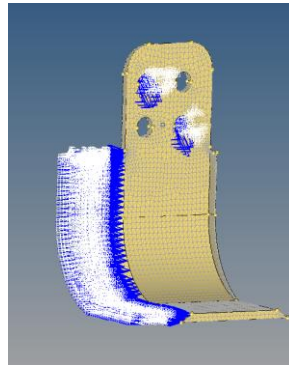
The load acting on the blade is found out

Then the load is given to the cutting edges of the blade as shown in fig 13 and fig 14.



**Fig .13 Existing blade**





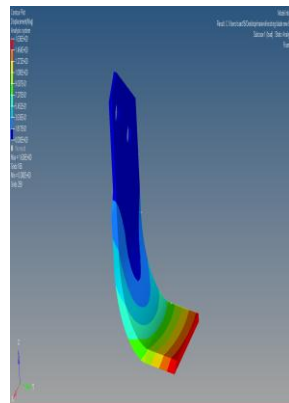
**Fig.14 New blade**

#### **IV. DISCUSSION OF RESULTS**

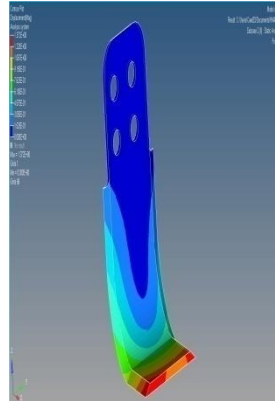
The displacement plot and Stress distribution of existing and new blades are obtained from the structural analysis and results are discussed as follows.

##### **A. Displacement of blade**

The maximum displacement of existing blade is 1.7mm and for the new rotavator blade displacement is 1.372mm



**Fig.14 Displacement of Existing Blade**



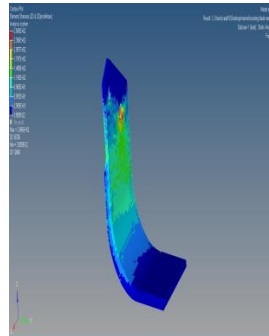
**Fig 15 Displacement of New blade**

The various stress induced in the blades are studied.

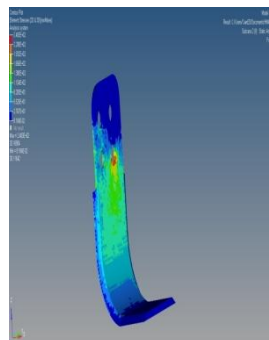
**B. Von mises stress**

The vonmises stress is the average stress which is considers for verifying the design is safe.

The von mises stress of existing blade is  $2.692 \times 10^2 \text{ N/mm}^2$  and new blade stress value is  $2.483 \times 10^2 \text{ N/mm}^2$ .



**Fig.16 Vonmises stress of new blade**



**Fig.17 Vonmises stress of Existing blade**

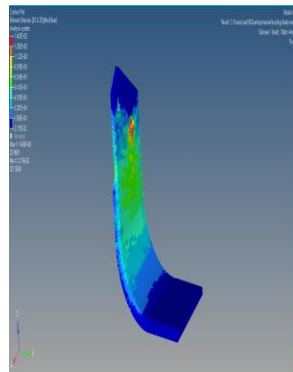
The Von mises stress value generated is low when compared with existing blade value so that the blade design is safe.

Here the maximum stress occurred in the blade is at holes for fasteners.

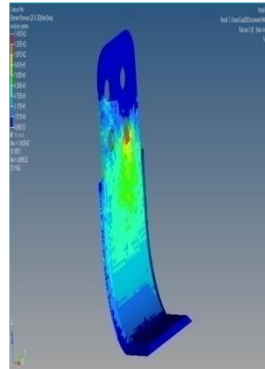
### C. Maximum shear stress

The shear stress is stress state where the stress parallel to the surface of the blade.

Here the maximum shear stress of existing blade is  $1.50 \times 10^2 \text{ N/mm}^2$  and New blade stress value is  $1.43 \times 10^2 \text{ N/mm}^2$



**Fig.10 Shear stress of Existing blade**



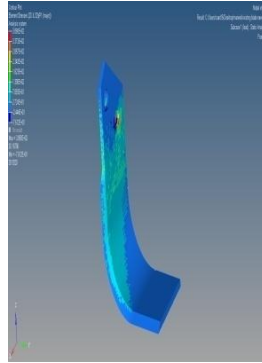
**Fig.11 Shear stress of New blade**

The maximum principle stress value generated is low when compared with existing blade value so that the blade design is safe.

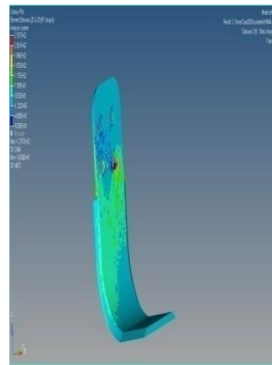
Here the maximum stress occurred in the blade is at holes for fasteners.

### D. Maximum principle stress.

The principle shear stress of existing blade is  $3.89 \times 10^2 \text{ N/mm}^2$  and new Blade stress value is  $2.35 \times 10^2 \text{ N/mm}^2$



**Fig.12 Principle Stress Of Existing blade**

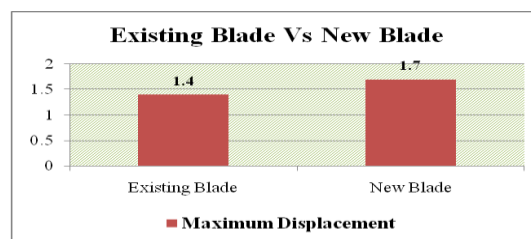


**Fig.13 Principle stress of New blade**

The maximum principle stress value generated is low when compared with existing blade value so that the blade design is safe.

**E. Comparison of blades using Bar chart**

Here the maximum stress occurred in the blade is at holes for fasteners. From the figure14 indicates that the displacement of new blade is 1.7mm and Existing blade 1.4mm.

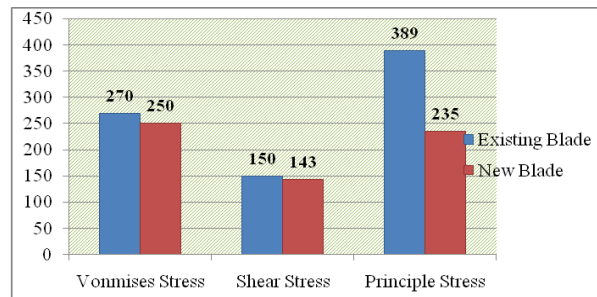


**Fig 14 Comparison of Existing and new Blade**

**F. Displacement in bar chart.**

From the figure15 indicates that the Principle stress is maximum Existing and new

Blade stress is  $389\text{N/mm}^2$  and  $235\text{N/mm}^2$ .



**Fig 15 Comparison of Existing and new Blade stress in bar chart.**

## V. CONCLUSION

In this Study, Design of rotavator blade is investigated and design modifications are done by introducing one more cutting edge in other side of the blade.

After obtaining the geometry of the new blade, structural Analysis for old and new blade is done by using hyper mesh software.

From the analysis displacement and stress are compared for new and old blades. The displacement of new blade reduced to 0.3mm when compared to the old one. The shear, principal and von misses stress are studied from structural analysis. From the above analysis the stress value of new blade is low compared with existing blade.

The main outcome of this study is 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 interchangeability concept.

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