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An overview of Modified Design and Development of Rotavator Blade by using CAD/CAE Approach.

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A B S T R A C T

Rotavator implements are now projected as important tillage machinery for better seedbed preparation and easy agriculture.Compareing different machinery consider Rotary tiller or rotavator is a tillage machine most suitable for seedbed preparation. In a Rotary tiller or Rotavator , Blades are the important and main critical parts which are come in contact with soil to prepare the land. During Operation these blades interact with soil in a different way than normal plows which are subjected to impact and high friction that creates unbalancing and non uniform forces which result in blade life lost and blade wear. This actually decreases the service life of a blade. Therefore, it is necessary to design and develop blade in such a way that self life of blade is enhanced.The present working model with tillage blade is analysed to new design constraints with change of its geometry for the maximum weed removal efficiency by presenting its practical results from the field performance. This paper presents design and development of rotavator blade through the interrogation of computer aided design (CAD) method.

Keywords: Rotary tillage tool, Rotavator, Rotavtor Blade, 3D CAD Model, GCI, SS, Modeling, analysis,

Introduction:

Rotary tillage is a mechanical manipulation of soil for proper seedbed preparation in crop production.The main objective is to develop desirable structure for a seedbed, control weeds or remove unwanted crop plant, manage plant residue and minimize soil erosion. It offers an advantage of rapid and proper seedbed preparation in crop production and reduced draft compared to conventional tillage. It can saved 30-35 % of time and 20-25 % in the cost of operation as compared to tillage by cultivator and harrow.

During operation tillage tool or blades play an important role in preparing proper seedbed and also for power and draft, required for operation as rotavator perform well in suitable soil conditions but consume high amounts of energy. In operation, blades is subjected to continuous fluctuating impact of soil which develops high stress on blade tip or blade critical edges due to which wear of blades take place. From considering this some work has been done to improve the service life of a rotavator blade. The way to improve the service life of blade is the improvement in blade geometry. Hence, there is a need to improve the design through geometrical modifications of blades which will reduce the blade cost. In this paper design improvement and development of blade is describe through CAD & CAM. The selected model of rotavator is measured with accuratedimensions and a solid (3-D) model is prepared in CAD-software such as Solidworks, Ansys, Catia by assembling an individual parts.

Rotavator:

Rotavator or Rotary tillage is tillage machine designed for preparing land for mixing manure or fertilizer into soil, sowing seeds and for crushing clods etc. Widely consider as most important secondary tillage implements it provide great amount of pulverization. Rotavator offers an advantage of rapid seedbed preparation and reduced draft compared to conventional tillage or primary tillage. . It can saved 30-35 % of time and 20-25 % in the cost of operation as compared to tillage by cultivator. The Rotavator is the most efficient means of transmitting engine power directly to the soil with the help of PTO of Tractor and a major reduction in transmission power loss.

Rotavator Assembly consists of following parts:

1 . Independent Top Mast: one end of shaft will be connected to tractor P.T.O. and another end torotavator. Thus it will be used to transmit power from tractor P.T.O. to input rotavator shaft.

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. This helps in throwing the material behind the rotavator, which facilities in preventing the clogging of rotavator.

3 Chain / Gear Cover Part Flange: A chain and gear cover part flange is a supporting element on which chain and gears are mounted.

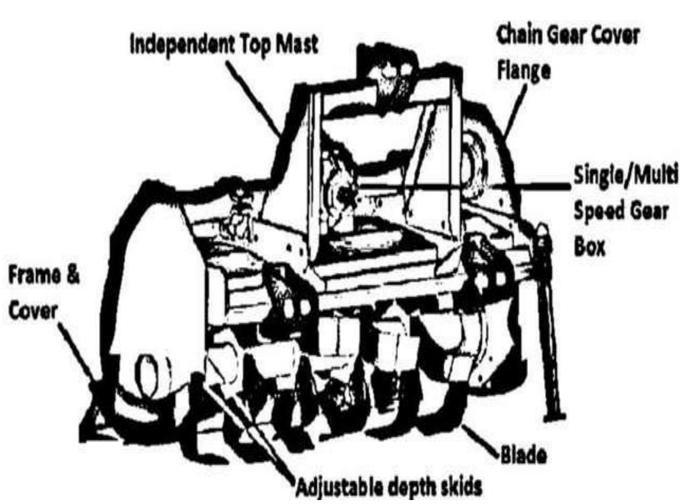
4. Blades: The L shaped, J shaped and C shaped, This types of Blade shape is usually used, to superior to heavy trash. They are better for killing weeds. The material composition of tine is generally carbon (0.52 %), manganese (0.72 %), and silicon (1.56 %).

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. If the cover will be kept wide open, the clods are thrown away from the rotor. The closed position of cover facilities the clods to get further pulverized by the action of rotating blades and fine tilth will be obtained.

7. Adjustable depth skids : It is fixed on adjustable frame to fix up a distance a gap between soil Vs Blade contact I.e depth skid

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



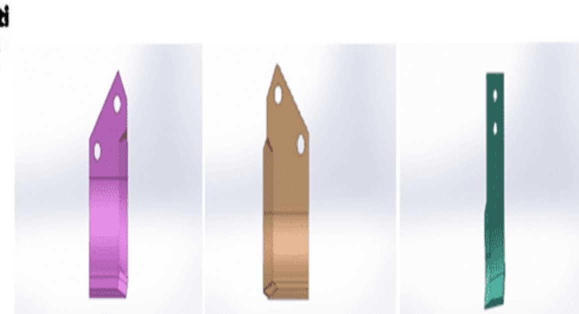
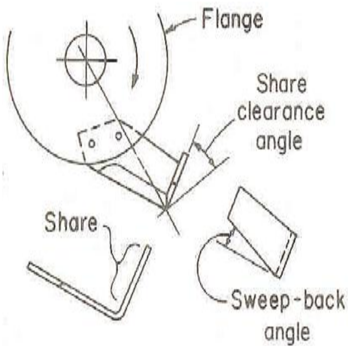


Figure 1: Rotavator **C Type Blade** **L Type Blade** **J Type Blade**

The soil properties relevant to the design of rotavator were identified as soil type, moisture, bulk density and cone index. The manners of measurement and characterization of these properties are discussed in the following sections. The type of soil was black soil were experiment was conducted. Moisture content of soil plays an important role for the growth of the crop hence following Soil resistance and Moisture content of soil are considered as given in table 1.



Sr. No.	Type of soil	Soil resistance (kg/cm^2)	Optimum moisture Content (%)
1.	Sandy soil	0.2	3.5
2.	Sandy loam	0.3	5.8
3.	Silt loam	0.35-0.5	
4.	Clay	0.4-0.56	7.18
5.	Heavy loam	0.5-0.7	13.30

Figure 2: Angle of Cutting in soil **Table 1: Soil Properties**

Objectives of the Work

The work presented here, is the investigation of structural parameters like stress, deformation and strain energy of Rotavator Blade by varying their materials and geometry. Therefore it draws following objectives.

To design the Rotavator Blade with Modifications in Design and geometry by CAD approach. The Important change in Stracture is to change the Existing simple cutting Edge into the Saw type teeth cutting edge.

To design the Rotavator Blade with changing materials and geometry by analytical approach.

To model the Rotavator Blade in Pro-Engineer/ Creo by using technical fundamentals.

To obtain the stress, deformation and strain energy of Rotavator Blade using Finite Element Method.
To compare and optimize the FEA and analytical results.

3.3.1 Design of Rotavator Blade.

The Design of rotary tiller blades depends on the type and number of blades and also the working condition of rotary tiller. In this design, the L type blades were considered for the rotary tiller according to the working condition presented. In rotary tillers, one fourth of the blades action will be jointly on the soil .The total power of the machine is distributed between the blades. The std. value taken from IS 800:2007.

The L shape blades has rectangular cross section which is same from end to end so that considering the uniform distributed load on the edge of blade.

ROTAVATOR BLADE MODIFICATION

The work started from introduction to rotavator blade including basic knowledge of rotavator, its function, construction and working. Various types of rotavator blade are studied and soil parameters, L-Type Rotavator Blade is selected for modification of saw type teeth is for analysis purpose. Later on market survey is collected to identify the problems associated with rotavator blade. The main problems are farm bed making in case of biger size soil breaking and removal of unwanted roots, and materials and the performance of Rotavaor and Rotavator Blades life. For this problem several literatures were studied and two materials are selected as Gray Cast Iron and Structural Steel. Then three geometry of rotavator blade selected as CP, for analysis purpose. Then, design load calculated for rotavator blade. The system is designed by considering the load calculations. The analytical calculations were performed for the designed system.

After that, the system is modelled in PRO-E/Creo solid modeling software and analyzed in ANSYS 15.0 software for stress and deformation analysis. Here, transient analysis is used to obtain better results. The results from FEA are compared with the analytical one.

MODELING AND ANALYSIS

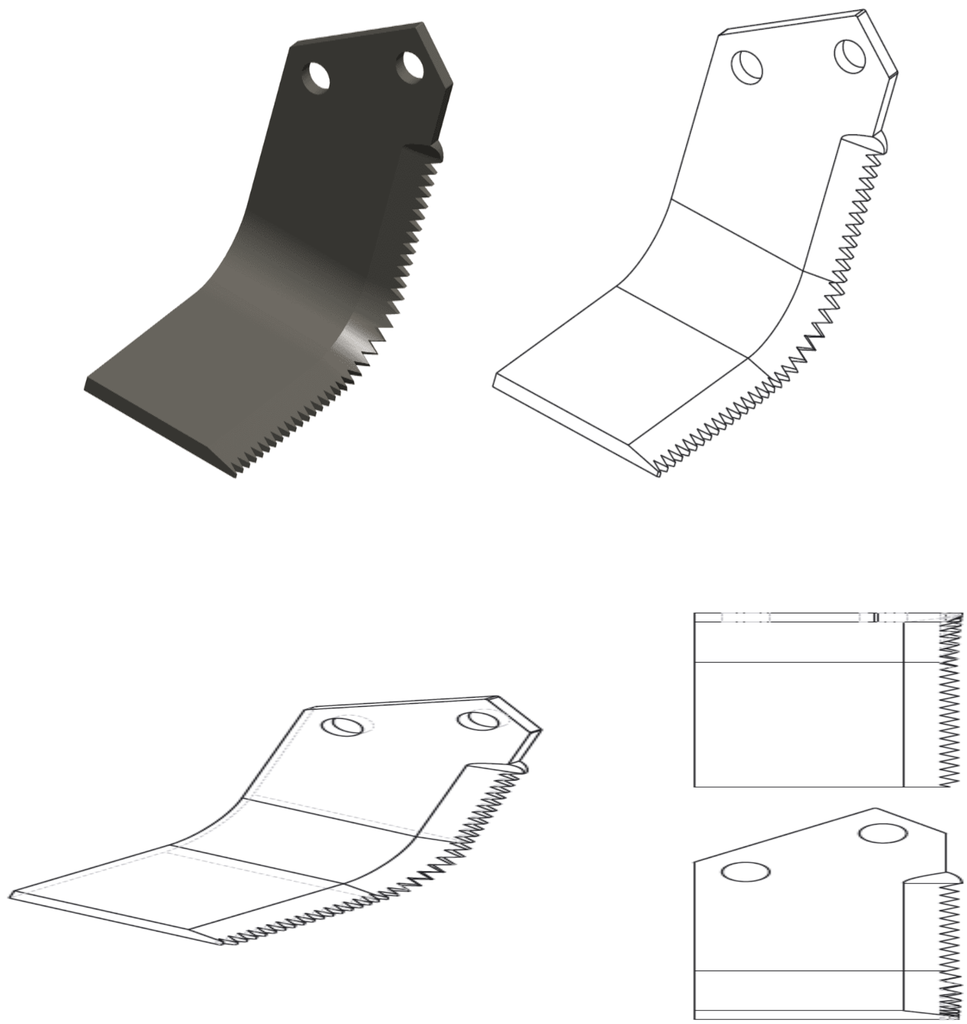


Figure 2: Modified L- Rotavator Blade with saw teeth.

In above Figure 2 shows the Modified Design of Rotavator Blade by using CAD/CAE approach.This modification done developed in L type Rotavator Blade.The main modification is to modify existing cutting edge to Saw type cutting edge.

1.1. Finite Element Analysis

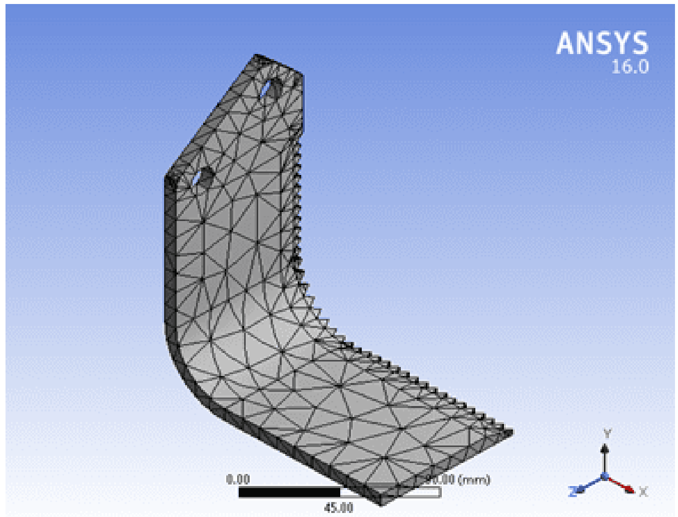


Figure 3: Meshed Model of Rotavator Blade (2781 Nodes & 1202 Elements)

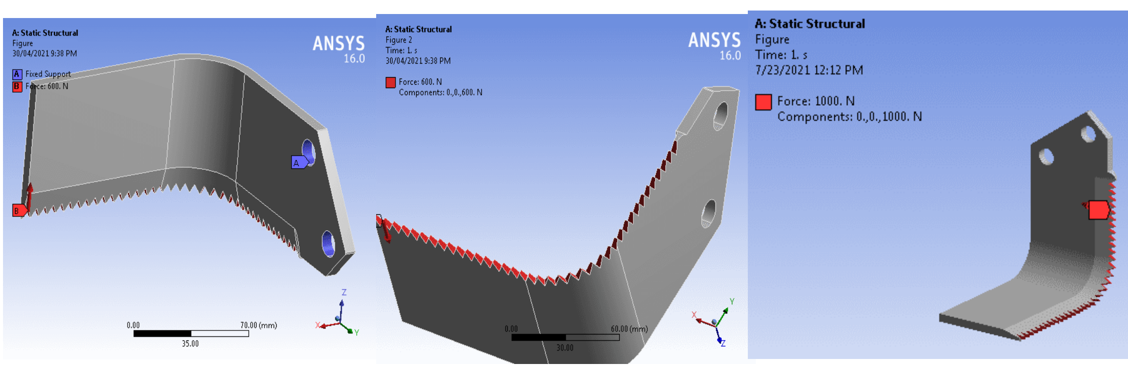


Figure4: Load 600 N to 1000 N & Fix Support

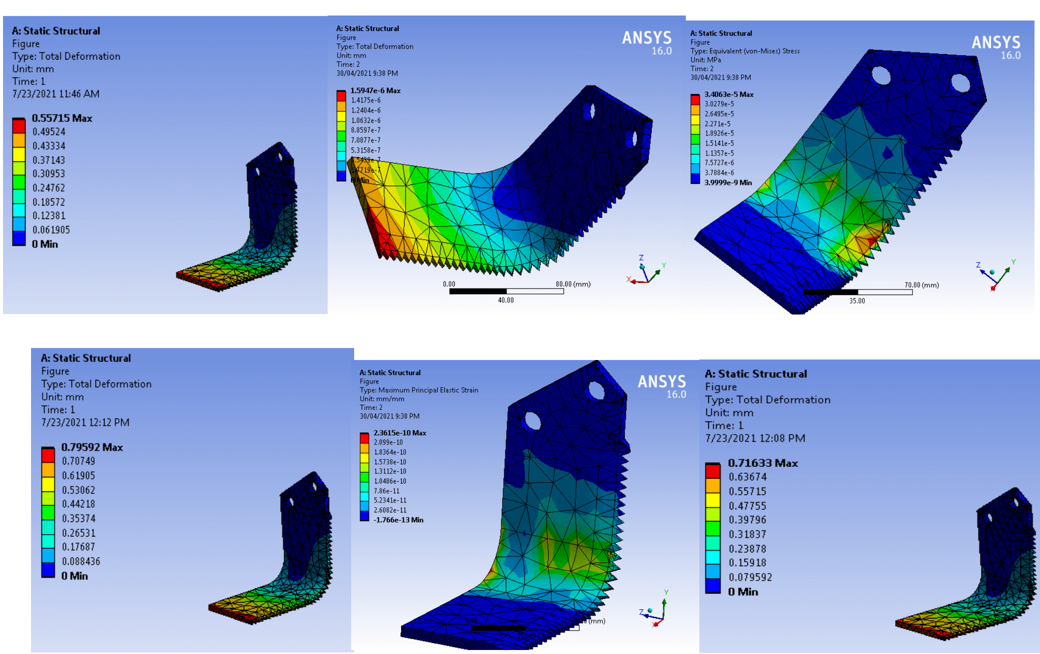


Figure4: Results With various load with Different Material.

RESULTS

When Compare two Material with Maximum Permissible Stress of Gray Cast Iron & StructuralSteel Analysis Results with different Load on Rotavator Blade due different conditions of soil, the results are as follows.

Permissible Stress of Gray Cast Iron is 105 MPa.

Permissible Stress of Structural Steel is 140 MPa.

1. When consider min. load is 600 N on Gray Cast Iron then found max. Stress on body is **42.832 MPa**& When applied maximum load 1000 N on body then maximum stress produced is **74.283 Mpa.** Both results are within the limit of Permissible stress of 105 MPa hence Design is Safe.
2. When we consider min. load is 600 N on Structural Steel then found max. stress on body is **42.505MPa**& When applied maximum load 1000 N on body then maximum stress produced is **73.234 Mpa.** Both results are within the limit of Permissible stress of 140 MPa hence Design is Safe.
3. In the same way we check result on Ansys with Different Material GCI , SS & Load 700N, 800N, 900N to check in various loading conditions, results as shown in Table 2 and all is under Permissible Limit.
4. Total Deformation when maximum load applied 1000N for Gray Cast Iron is **1.4324mm &**for Structural Steel is **0.79592mm.**

Table 4.1 Results of Finite Element Analysis Gray Cast Iron.Table 4.1 Results of Finite Element Analysis Gray C

Maximum Stress with Various Load

Load	Equivalent Stress/ Von Mises Stress (Mpa)	Shear Stress (Mpa)	Normal Stress (Mpa)
600 N	42.832	9.5134	12.685
700 N	51.998	10.975	18.831
800 N	59.426	12.543	21.521
900 N	66.855	14.111	24.211
1000 N	74.283	15.678	26.901

Load	Equivalent Stress/ Von Mises Stress (Mpa)	Shear Stress (Mpa)	Normal Stress (Mpa)
600 N	42.505	9.3822	12.922
700 N	51.264	11.013	21.032
800 N	58.587	12.586	24.036
900 N	65.911	14.159	27.041
1000 N	73.234	15.732	30.045

Maximum Total Deformation during Various Load

Load	Total Deformation (mm)
600 N	0.85231
700 N	1.0027
800 N	1.1459
900 N	1.2892
1000 N	1.4324

Load	Total Deformation (mm)
600 N	0.47078
700 N	0.55715
800 N	0.63674
900 N	0.71633
1000 N	0.79592

Maximum Principal Elastic Strain (mm/mm)

Load	Maximum Principal Elastic Strain (mm/mm)
600 N	0.00036199
700 N	4.55E-04
800 N	0.00052042
900 N	0.00058547
1000 N	0.00065053

Load	Maximum Principal Elastic Strain (mm/mm)
600 N	0.00019821
700 N	2.48E-04
800 N	0.00028303
900 N	0.00031841
1000 N	0.00035379

Modified L-Type Saw Teeth Blade Testing

The Modified saw tooth type rotavator blade testing are as per reference from 'The Rotary tillage blade modified and physically tested in the field operation which was satisfactorily resulted with high weed removal efficiency and excellent soil bed performance'.(In Gopal U. Shinde and Shyam R. Kajale 'Design Optimization in Rotary Tillage Tool System Components by Computer Aided Engineering Analysis' *International Journal of Environmental Science and Development, Vol. 3, No. 3, June 2012)*

The reverse engineering concept for redesigning and conceptual modifications in the Blade was found to be significant in cereal inter crop secondary tillage operation Fig CAD Model of Modified Blade mentioned.

CONCLUSION

The work presented here is the Modified design and development of Rotavator Blade by using CAD/CAE Approach. The major Modification in this Blade is to make with Saw teeth in L-Type Rotavator blade instead of existing type rotavator blade simple Cutting edge to making a good bed cultivation by using Rotavator. There are two materials (Gray Cast Iron & Structural Steel) are taken for study and the geometry CP are taken to understand the static behavior of Rotavator Blade when loaded by 600 N , 700 N, 800 N, 900 N, 1000 N load. Therefore, it draws the following conclusions:

- It is concluded that one of the main part of Rotavator is the Blade and its direct contact with the soil land when it's rotating, blade is the main part for bed making. Hence, design of Blade is more important.
- It is concluded that, the L-Type Modified blade with saw teeth is safe in FEA Results.
- It is concluded that, the FEA method gives practical results to make a Blade.
- On the base of Total Deformation, it is concluded that the Gray Cast Iron is higher deformation than Structural Steel.
- It is concluded that in Gray Cast Iron maximum Stress Produced higher than Structural Steel.
- It is concluded that, variation in geometry effects on the deformation and stiffness of Rotavatar Blade.
- The Gray Cast Iron Material is Cost Effective as compared Structural Steel.
- Structural Steel is efficient material than Gray Cast Iron.
- The Gray Cast Iron & Structural Steel Both material in various load conditions that is 600N, 700N, 800N, 900N, 1000N Maximum Stress is within Permissible limit.

FUTURE-SCOPE

Agriculture sector is one of the fastest growing sector. Farming is one of the important business for Indians.The farming sector is only one which is fulfill the basic need of food for every peoples. In Agriculture sector farmers adopts new technologies to improve the productivity of farm, There are various advanced products for farming are introduced in a market to ease of Farming. One of from that is Rotavator, Rotavator is the Machine which is running with the help of Tractor PTO. The main Function of Rotavator blade is to seedbed making, land preparation, remove unwanted roots, trash etc. for this work the important part is Rotavator Blade.

In the Rotavator & Rotavator blade there are large scope, to modify Blade shape, new shape can be improve overall efficiency of land preparation.

The shape introduced in this research Modified Design and Development of Rotavator Blade by using CAD/CAE Approach this can be used in Rotavator by replacing existing one. It can be more efficient for land preparationdue to teeth type cutting edge.

This type blade with saw teeth cutting edge will be used with existing type blade, one blade is existing type and another one is Modified saw teeth, that combination is more efficient because of one existing type blade is perform like regular cutting soil slice and modified blade can be cutting higher slices of soil and unwanted roots more efficiently cut due to saw type cutting edge than existing type blade.

There are large scope in various modifications in Rotavator blade. In Geometry change, New Combination shape for more cutting efficiency, to increase life of blade research of new material for increase overall life and efficiency.

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