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Design Modelling and Analysis of Rotavator Blades for Better Performance

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Abstract: *The design and optimization of rotary tillage tool on the basis of simulation and finite element method is done by using ANSYS software. The different rotary tillage tool parts are geometrical constrained with preparation of solid model of blades and simulation has been done with actual fieldperformance rating parameters along with boundary condition. The proposed work result are identifying sufficienttolerance in changing the material such a EN 8 steel and EN 24 steel. The dimensions of rotavator blade sections and to risethe life cycle of blades for a reliable strength. The present geometry working model with tillage blade is analyzed to newdesign. The changed constraints of its geometry for the maximum weed removal efficiency by presenting its analysisresults from the field performance.*

Keywords: Structural Analysis

I. INTRODUCTION

The rotary tillage machine has been used in soil-bed preparation and weed control in the field of fruit gardening agriculture. It has a large capacity for cutting, mixing to topsoil preparing the seedbed directly. It has a more mixing capacity seven times than aplough.

Its components works under miscellaneous forces due to power, vibration, pointless, impact effect of soil parts as after reaching to higher side. The manufacturing and design optimization errors can be minimized by its components design analysis and optimization.

The design optimization of tillage tool has obtained by reducing its weight, cost and improving a field performance to high weed removal efficiency. The analysis has been prepared a three dimensional solid modeling and applications of finite element method are getting so widespread in the industry.

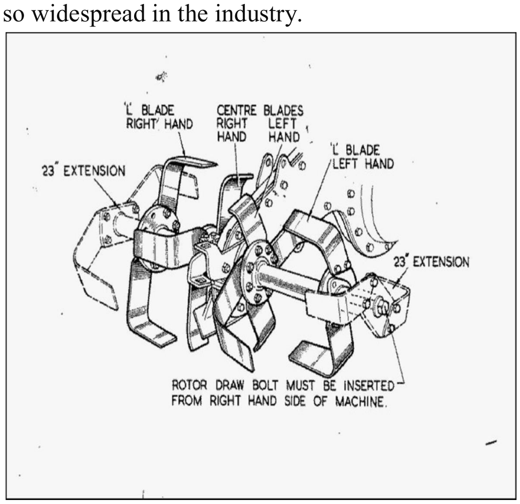

Figure: Assembly of Blades Section in Rotavator Blade

A rotavator is one of the mechanical gardening tools with power blades attached to a spinning surface to plough soil and provides optimum tillage. Different rotavator are designed to suit different gardening needs. A gardening rotavator is a compact machine which may be used on any land size but is more appropriate for gardening. Gardeners usually use a variation of this appliance as sometimes, only small flower beds or miniature vegetable patches tilled. Gardening rotavator cannot really break up huge amounts of soil, but can efficiently churn up the soil and remove unnecessary weeds on the flower beds and can also ensure infusion of the fertilizer into the soil. Such a machine is typically powered by electricity. It is easier to handle because it is not heavy-duty. In addition to this they are usually inexpensive and can be afforded by the avid gardener compared to the varieties that are run on gas or petrol. A rotavator is a most effective tool when used correctly and under the proper conditions

1.1 Research Objective

- To evaluate structural analysis
- To find out deformation analysis
- To evaluate modal analysis

II. LITERATURE REVIEW

[1] **Godwin R.J, O "Dogherty M.J "Integrated soil tillage force prediction models" 2006**. This paper describes the integration of a series of models to predict the forces acting ona range of tillage tools from simple plane tines to mouldboard ploughs. The models adequately reflect the changes in soil strength and implement geometry.

[2] **Khalid Usman, Ejaz Ahmad Khan, Niamatullah Khan "Effect of Tillage and Nitrogen on Wheat Production, Economics, and Soil Fertility in Rice-Wheat Cropping System" 2013**. Conservation tillage and nitrogen may improve soil fertility, yield and income on sustainable basis. The aim of this study was to evaluate the impact of three tillage systems viz. zero (ZT), reduced (RT), and conventional tillage (CT) and five N rates (0, 80, 120, 160, and 200 kg·N·ha−1) on yield and yield components, soil organic matter (SOM), total soil N (TSN), and income of wheat grown after rice

[3] **Gopal U. Shinde and Shyam R. Kajale "Design optimization in rotary tillage tool system components by CAEA" 2012**. The design optimization of rotary tillage tool by the application of Computer Aided Engineering (CAE)-Techniques on the basis of finite element method and simulation method is done by using CAD-Analysis software for the structural analysis. The different tillage tool parts of rotary tillage tools are geometrically constrained by the preparation of solid model, Meshing and Simulation is done with actual field performance rating parameters along with boundary conditions.

[4] **Mahesh M. Sonekar, Dr. Santosh B. Jaju "Fracture analysis of exhaust Manifold stud of Mahindra Tractor through finite Element method (FEM) – a past Review" 2011**. Failures were observed even after designing the components with maximum stress value well below yield / ultimate stress. Tests were then carried out for time varying loads. Results proved that the component fails at values below yield stress when subjected to time varying load. It was also observed that below a specific stress value components were not failing at all.

[5] **Rahul Davis "Optimization of surface roughness in wet turning operation of EN24 steel"** 2012. The present experimental study is concerned with the optimization of cutting parameters (depth of cut, feed rate, spindle speed) in wet turning EN24 steel (0.4% C) with hardness 40+2 HRC. In the present work, turning operations were carried out on EN24 steel by carbide P-30 cutting tool in wet condition and the combination of the optimal levels of the parameters was obtained.

[6] **Rahul Davis, Jitendra Singh Madhukar "A parameteric analysis and optimization of tool life in dry turning of EN24 steel using taguchi method"** 2012. To obtain an optimal setting of these turning process parameters –spindle speed, feed rate and depth of cut, which may result in optimization of tool life of Carbide P-30 cutting tool in turning En24 steel (0.4 % C).

[7] **Rohan pawar, Dr. S.I. Kolhe "Design and analysis of rotavater blade for its enhanced performance in tractors 2020"** International Research Journal of Engineering And Technology Vol-07, pp. 2395-0072

III. METHODOLOGY

The proposed work results in identifying sufficient tolerance in changing the material (EN 8 steel & EN 24 steel). It is expressed in methodology as **[pp. 2395-0072]**

3.1 Communication Phase

Communication phase includes:

- Discussion of topic with guide
- Actual farm visit and understanding various farming method
- Literature survey
- Problem identification
- Analysis of problem
- Concept development
- Discussing various certainties and uncertainties

We have discussed the topic with Guide and get an approval to to perform this research first of all we have visited the actual farm and understanding various farming methods like cultivation seeding pesticide spraying etc. after that we have selected to perform research work on cultivation process in which we have studied the rotavator which have multiple blades so we have decided to to analyse the the blades and study various researches done on that topic to improve blade efficiency then we have searched various research done on rotavator blade to improve its performance all that it is searches we have mentioned in literature survey after studying literature survey we have identified the problem that we have to increase working hours of rotavator blade why changing their dimensions and material so we have selected three material that is mild steel EN 8 and EN 24 and a fixed dimension with variable radius of curvature that is 34mm and 38 mm radius

3.2 Planning Phase

Planning phase includes

- Process planning
- Raw material planning
- Force analysis
- Process scheduling

After discussion of various study the analysis we have decided to perform our research work on two condition that is black soil and black soil with clay so we have calculated the force exerted while cultivating the black soil and black soil with clay we have also calculated the exact force exerted in both condition as well as direction of force applied.

3.3 Modeling Phase

Modeling phase includes

- Design of various components
- Catia/Cad modeling of components
- Prototype model making

After that we have prepared CAD model on fusion 360 as per dimension and then applied the exerted force on the themselves so we have did 18 analysis on various combination of blade dimension and material and condition all the analysis result we have studied and prepared graph and data chart for analysis

3.4 Construction and Testing

Construction phase includes

- Selection of proper manufacturing methods
- Working as per process scheduling and plan
- Testing of equipment on field
- Error analysis
- Repair if any

After theoretical analysis we have prepared the physical model of blade as per dimension and we are ready to to test it on field during testing we have recorded various data physically and compared it with theoretical data which we have get from finite element analysis.

3.5 Deployment

1. Comparing the project with the designed output
2. Preparation of testing results
3. Preparation of project report
4. Final submission of project

After that we have prepared a grade chart for theoretical analysis as well as practical analysis for both condition in that great cat we have find the better combination for the rotavator blade and prepared final report on it.

IV. BLADE CONFIGURATION

The rotavator is a tillage tool primarily comprising of L-shape blades mounted on flanges that are fixed to a shaft and it is driven by the tractor power-take- off (PTO) shaft. In comparison to passive tools, the rotavator has a superior soil mixing and pulverization capability. During rotavator tillage operations various factors affect its energy requirements. These factors can include soil conditions, operational conditions and rotavator configuration. [pp. 2395-0072]

There are two types of blade configuration used in rotavator. The following blade configuration shows high grade of cultivation,

4.1 Three Blade Configuration

This is the standard blades configuration and has a three pair of blades per flange except the end flanges which are fitted with one hand only.

4.2 Two Blade Configuration

The rotor may be converted into two blade configuration. Two blades per flange used in the rotavator except the end flanges. In this blade configuration, less tendency to the rotor to clog in sticky soil conditions. A cloddy finish can be obtained and rotor can be driven at faster rpm.

4.3 Types of Blade

Rotavator are usually supplied with power' or L blades for general work. When working in heavy and puggy clay soils, the „speed' or „C' blades should be used.

- **'L' blade:** The long shank blade as the name implies, has longer shank than the standard power blade. This allows the greater clearance between the blade and rotor. With this, a greater depth of cultivation is obtainable if tractor power and conditions are allowed.
- **'J' blade:** This blade has more efficient self-cleaning action, uses less power and produces a coarser finish than the other blades.

Before we proceed to the process of manufacturing, it's necessary to have some knowledge about the project design essential to design the project before starting the manufacturing. Maximum cost of producing a part of product is established originally by the designer. When a new product or their elements are to be designed, a designer may proceed as follows:

- Make a detailed statement of the problems completely; it should be as clear as possible & also of the purpose
- For which the machine is to be designed.
- Make selection of the possible mechanism which will give the desire motion.
- Determine the forces acting on it and energy transmitted by each element of the machine
- Select the material best suited for each element of the machine.
- Determine the allowable or design stress considering all the factors that affect the strength of the machine part
- Identify the importance and necessary and application of the machine
- Problems with existing requirement of the machine productivity and demand.

Dimensions

The design for existing blade is given below Usually, rotavator blades dimensions are taken from "industry manufacturer's catalogue". In that different types of blades are used in their process.

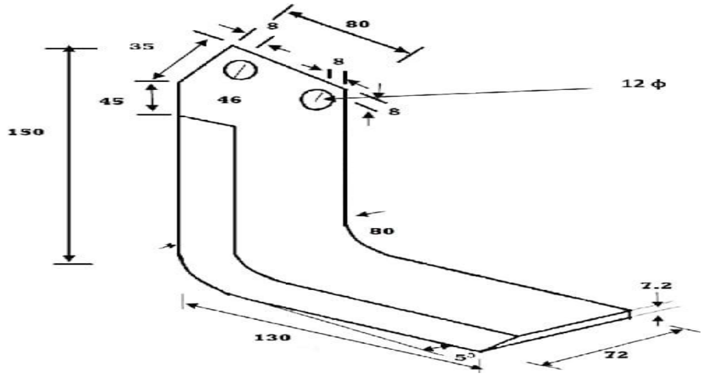

Fig: Dimensions of Blade

V. DESIGN PROCEDURE, MATERIALS

Generally blade materials are classified into two types as given below,

- Gray Cast Iron (CGI)
- Mild Steel (MS)

It is very difficult to seek out the simplest design for rotavator blades. The research is still carried to find out behavior of blades during agricultural applications. There is always a requirement of some assumptions to model any complex geometry. These assumptions are made, keeping in mind the difficulties involved in the theoretical calculation and the importance of the parameters that are taken and those which are ignored. In modeling, the things which are of less importance and have little impact on the analysis are usually ignored. The assumptions are always made according to the details and accuracy required in modeling

VI. ANALYSIS REPORT

We have done two types of analysis in it.

- Stress
- Deformation

We have devided in three types of sharpness angel 14 degree, 16 degree, 18 degree in gray cast iron and mild steel.

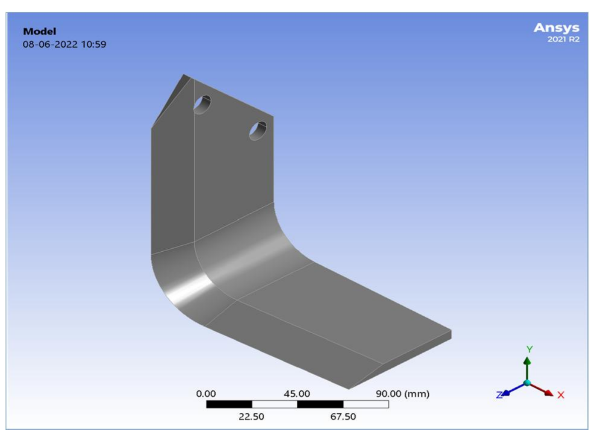

Fig: Blade model

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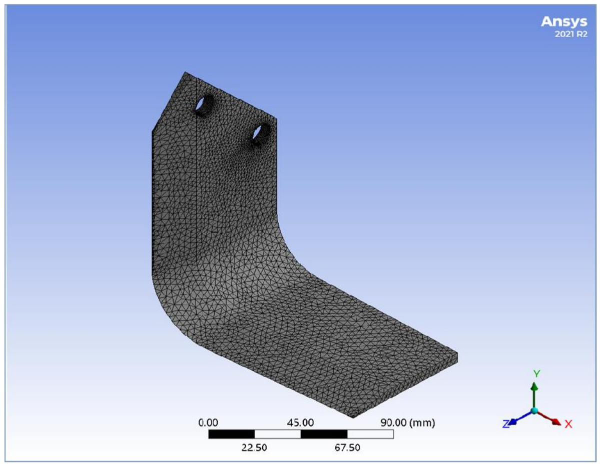

Fig: Blade Static Structural View

VII. MODELLING AND ANALYSIS

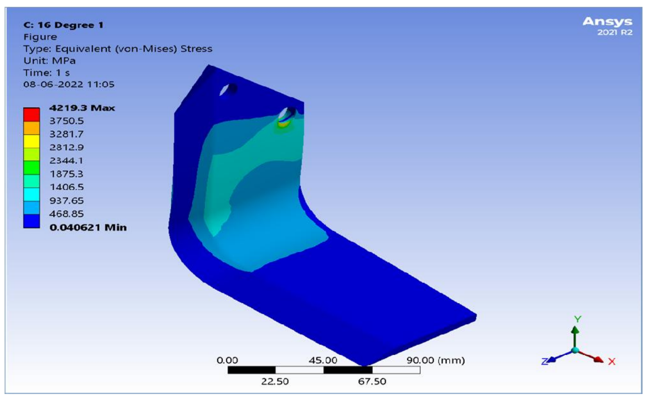

Fig: Analysis of total deformation and stress

Time [s]	Minimum [mm]	Maximum [mm]	Average [mm]
1.	0.	23.174	3.9173

Table 1. Total Deformation

Time [s]	Minimum [MPa]	Maximum [MPa]	Average [MPa]
1.	4.0621e-002	4219.3	368.00

Table 2. Equivalent Stress

VIII. RESULT

- The finite element analysis was done for investigation of stresses experienced by the blade has shown in the above figure.
- A comparison was made between the developed blade are made.
- The result showed that deformation and stresses are maximum
- For the developed blades from the above analysis of rotavator.

IX. CONCLUSION

As we have discussed and analyzed the result we have prepared a chart for better conclusion analysis the following conclusion.

- In the analysis done in we have compared cutting radius in 3 types 14 degree, 16 degree,18 degree blade of all two mentioned materials in conditions i.e black soil for Stress and deformation Is shows that gray cast iron and mild steel.
- The good model is mild steel 16 degree.

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