A review of Rotavator Blade Design and Analysis Based on CAD and CAE Packages

Shaikh Hasan Shaikh Nasim[1] Prof. Avinash V. Gaikwad[2] Rushikesh Sanjay Itankar[3] Prajakta Prakash Raut[4]

[1,3,4]Student [2]Assistant Professor

[1,2,3,4]Department of Mechanical Engineering

[1,2,3,4]Jawaharlal Darda Institute of Engineering and Technology, Yavatmal, MH, India

Abstract— Rotavator is utilized to prepare the soil before plantation. It removes the unwanted soil rocks and makes soil smoother. It consists of core and rotavator blades mounted on it. There are several types of rotavator blades are available. Some of them are in L shape; some of them are having C shape etc. Depending on nature of soil, type of blade can be selected. But these blades are fails most of the time during high stress working. It may also fail due to the big rocks coming in the core while working. In this review paper several journal papers are studied well in order to justify the review process. There are lots of journal papers are available on the FEA Analysis of Rotavator blade. Out of them few are downloaded and studied. This review will help to perform our project work on Design and Analysis of Rotavator blade. Also based on this study the final conclusive statement is written.

Keywords: Rotavator Blade, Design and FEA Analysis, Blade Shapes

I. INTRODUCTION

Rotavator is a specialized mechanical tool used for tillage of soil by series of blade. Now a day, utilization of rotavator has been increased in agricultural application because of simple structure and efficiency. [4] However the use of rotary tiller is strongly restricted to shallow type tillage purpose because of high forces coming on blade, life span of blade is less and which result in higher maintenance cost. When rotavator is pulled through a field, the resulting soil texture will be a function of soil condition and geometry of blade. [1] The parameters of rotavator blades are studied for reducing the forces coming on it and these are as follows:

A = area of soil slice (m^2)
m = mass of soil slice (kg)
P = specific soil resistance (N/m^2)
F_s = Static force (N)
F_d = Total dynamic force (N)
F_{ax}= Horizontal component of acceleration force (N)
F_{wx} = horizontal component of pressure force (N)
F_{fx} = horizontal component of friction force (N)
F_{ay} = Vertical component of acceleration force (N)
F_{wy} = Vertical component of pressure force (N)
F_{fy} = Vertical component of friction force (N)
τ = Soil metal friction force (N)
F'_{wy} = Normal force (N)
r = Rotor radius (m)
H = Working depth of blade (m)
H_m = Maximum working depth of blade (m)
R = radius of curvature of blade (m)
L_b = Length of bite (m)
α = Angle of rotation
β = Angle of inclination
θ = Blade angle
S = Span of blade (m)
b = Width of blade (m)
h = Height of blade (m)
dc = Core diameter (mm)
D = Diameter of bolt (mm)
σ_t = Tensile strength of material
a = Radius of flange (m)
b = Distance of hole from machining surface (m)
P = Power (KW)

In these parameter θ (angle of blade), b (width of blade), h (height of blade), S (span of blade) has a direct effect on forces coming on blade and depending on these parameter forces and power requirement and bolt diameter is calculated and compared.

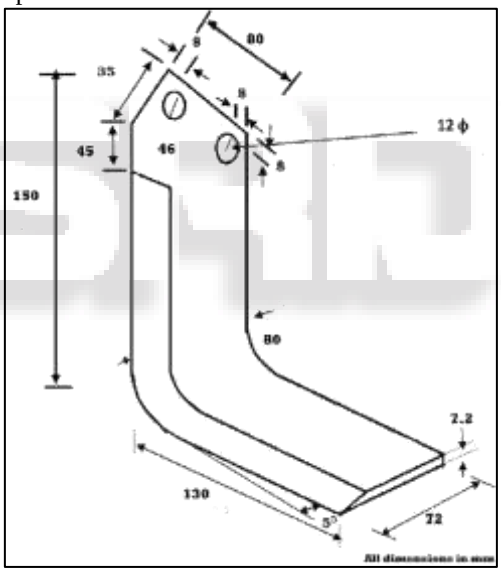

Fig. 1: Dimensions of the Rotavator Blade

II. LITERATURE SURVEY

D.Ramesh Kumar1 and P.Mohanraj2, "Design and Analysis of Rotavator Blades for its Enhanced Performance in Tractors". 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 geometrically constrained with preparation of solid model of blades and simulation has been done with actual field performance rating parameters along with boundary conditions. The proposed work results are identifying sufficient tolerance in changing the material such as EN 8 steel and EN 24 steel. The dimensions of rotavator blade sections and to rise the life cycle of the blades for a reliable strength. The present geometry working model with tillage blade is analysed to new design change constraints of its

geometry for the maximum weed removal efficiency by presenting its analysis results from the field performance. [1]

Prof. R.V. Kakde1, "Review Paper on Analysis of Rotavator Blade". Rotary rotavator or tiller is one of the tilling machines most suitable for seedbed preparation. In a Rotary tillage machine, Blades are the critical parts which are engaged with soil to prepare the land and to mix the fertilizer. These blades interact with soil in a different way than normal plows which are subjected to impact that create cyclic forces which result in fatigue failure of the blade. This actually decreases the service life of a blade. Therefore, it is necessary to design and develop a suitable blade. Their paper describes the design modification and development of rotavator blade through the (CAD) interrogation method by modifying the design and also by modifying the material properties. Then better design will be compared by comparing the results. [2]

Subrata K.R. Mandal, Basudeb Bhattacharyya, "Use of CAD Tool for Design and Development of Rotavator Blade". Rotary tiller or rotavator is a tillage machine most suitable for seedbed preparation. In a Rotary tiller, Blades are the main critical parts which are engaged with soil to prepare the land. 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 results wearing of the blades as a whole. This actually decreases the service life of a blade. Therefore, it is necessary to design and develop suitable blade so that service life also enhanced. This paper presents design and development of rotavator blade through the use of computer aided design (CAD) tools/method. [3]

Subrata Kr. Mandal1*, Dr. Basudeb Bhattacharyya2, "Rotary Tiller's Blade Design using Finite Element Analysis (FEA)". Blades are the main critical parts of a rotary tiller, which are engaged with soil to prepare the land. These blades interact with soil in a different way than normal plows which are subjected to impact and high friction which ultimately creates unbalancing and non uniform forces on the rotary tiller which results wearing of the blades as a whole. The continuous fluctuating impact of soil crust / clods / stone develops high stress areas on blade tip or blade critical edges. Therefore, it is necessary to optimize the design of blade so that these blades experience less stress. Their paper aims at design optimization of rotary tiller blades using modern tools like FEA. [4]

G. M. Vegad, Dr. R. Yadav, R. G. Jakasania, "Structural Analysis of Hatchet Type Rotavator Blade in CAD Software". In their study finite element analysis of hatchet type blade of rotavator was carried out using Solidworks and ANSYS software. 3D model of blade was made using Solidworks software and static structural analysis of blade was carried out using ANSYS software. The material and dimensions of hatchet type blade was selected as per Indian Standard IS: 6690-1981. Results of simulation showed that maximum deformation was observed as 4.14 mm for hatchet type blade at the given boundary conditions while maximum equivalent (von-mises) stress was 654.25 MPa. Maximum principal stress and maximum shear stress was found as 656.26 MPa and 327.60 MPa respectively in hatchet type blade. The value of factor of safety was 1.05 and found to be very low and obviously this value decreases under unwanted loading conditions of field operation so blade doesn't satisfy the safety conditions. [5]

Prof. Shinde V.B.1, Mr. Malve R.N.2, "Design and Development of Rotavator Blade". This study is aimed at design and development of L-shape rotavator blade of alloy steel and plain carbon steel. The life of blade is crucial factor and it depends non forces coming on blade and force and geometry of blade has direct relationship with each other. For the increase in life span of blade forces coming on it should be reduced. For this reason a mathematical model is developed and analysis of new model and previous model is carried out using SolidWorks software applying Finite element analysis method on the basis of deflection and stresses induced in blade after application of force. This result is compared with each other and it is found that new model has less deflection and less stresses induce in a blade. [6]

Srinivasan. K1, Viswanath R. P2, "Design and Optimisation of Blades for Rotavators". The aim of their study is to design and optimize the Rotavator Blade for better life and performance on field. Hence any improvement in the field performance of the same would in turn, augment the productivity in the agricultural sector. Design and modelling of the Rotavator's Rotor assembly has been completed. The dynamic analysis of rotavator blades during the tilling operation on soil is obtained using the FEA tool Abaqus.[7]

Gopal U.Shinde1, J.M.Potekar2, "Design Analysis of Rotary Tillage Tool Components by CAD-tool: Rotavator". The application of CAD/CAM in design optimization of rotary tillage tool on the basis of finite element method and simulation method is done by using CAD-software for the structural analysis. The different tillage tool parts of rotary tillage tools are geometrically constrained with preparation of solid model and The Simulation is done with actual field performance rating parameters along with boundary conditions. The energy constrained for the tillage tool applications with 35Hp and 45Hp power tractor and estimated forces acting at soil-tool interface. The resultant effect on tillage blade and whole rotavator assembly is obtained from stress distribution and deformations plots. Their work results in identifying sufficient tolerance in changing the dimensions of rotavator frame sections and side gear box for removing the excess weight in a solid section and also to raise the weight of blade for a reliable strength. 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. [8]

Rohan Nanabhau Pawar1, Dr.S.I.Kolhe2, "Design and Analysis of Rotavator Blade for its Enhanced Performance in Tractors". Their proposed work result are identifying sufficient tolerance in changing the material such a EN 8 steel and EN 24 steel. The dimensions of rotavator blade sections and to rise the life cycle of blades for a reliable strength. The present geometry working model with tillage blade is analyzed to new design. The changed constraints of its geometry for the maximum weed removal efficiency by presenting its analysis results from the field performance. [9]

Subrata Kr Mandal, "Optimization of Design Parameters for Rotary tiller's Blade". These blades interact with soil in a different way than normal plows which are subjected to impact and high friction which ultimately creates

unbalancing and non uniform forces on the rotary tiller which results wearing of the blades as a whole. The continuous fluctuating impact of soil crust / clods / stone develops high stress areas on blade tip or blade critical edges. Therefore, it is necessary to optimize the design of blade so that these blades experience less stress thereby reduces the wear. Thus an "L" type blade for tractor drawn Rotary tiller or Rotavator was designed and developed. Computer Aided Design package for designing of the blade and ANSYS programming was used for the simulation and optimization of the blade. Based on the simulation results optimized design of blade through was suggested. [10]

D.Ramesh Kumar1 and P.Mohanraj2, "Design and Analysis of Rotavator Blades for its Enhanced Performance in Tractors". 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 geometrically constrained with preparation of solid model of blades and simulation has been done with actual field performance rating parameters along with boundary conditions. Their work results are identifying sufficient tolerance in changing the material such as EN 8 steel and EN 24 steel. The dimensions of rotavator blade sections and to rise the life cycle of the blades for a reliable strength. [11]

Jeevarathinam.A, Velmurugan.C, "Design Modification and Analysis of Rotavator Blade". In a Rotary tillage machine, Blades are the critical parts which are engaged with soil to prepare the land and to mix the fertilizer. These blades interact with soil in a different way than normal plows which are subjected to impact that creates cyclic forces which result in fatigue failure of the blade. This actually decreases the service life of a blade. Therefore, it is necessary to design and develop a suitable blade. Their paper describes the design modification and development of rotavator blade through the (CAD) interrogation method by modifying the design and also by modifying the material properties. Then better design will be compared by comparing the results. [12]

Dr. Ashok G. Matani1, Ankush D. Bhishnurkar2, "Use of Cad Tool for Design, Analysis and Development of Rotary Tillage Tool". The Rotary Tiller's Blade is geometrically constrained with preparation of solid model in CAD-Software and the Analysis is done with actual field performance rating parameters by using CAD-Analysis software for the structural analysis. The energy constrained for the tillage tool operations with 37Hp and 45Hp power tractor and estimated forces acting at soil-tool interface. The resultant effect on Rotary Tiller's Blade is obtained from Von-Mises stress, maximum principal stress, tensile stress and shear stress distribution plots. Their working model with tillage blade is analysed to new design constraints with change of its geometry for the maximum weed removal efficiency is suggested for the lab and field testing. [13]

Mr. Prasad D. Tupkari1, Dr. P. K. Sharma, "Computer Aided Design and Analysis of Rotavator Blade". The rotavator or rotary tiller is a tillage tool primarily comprising blades mounted on flanges, which are attached to a shaft that is driven by the tractor power-take-off (PTO) shaft through gears or chain drive. Nowadays, utilization of rotary tillers has been increased in agricultural applications because of simple structure and high efficiency for this type of tillage implements. By taking advantage of rotary tillers, the primary and secondary tillage applications could be conjugated in one stage. [14]

Mr. Ravindra B. Kankal and Prof. K. R. Sontakke, "Design and Analysis of L Shape Rotavator Blade". Their proposed work results are identifying sufficient tolerance in changing the material such as EN 8 steel and EN 24 steel. The dimensions of rotavator blade sections and to rise the life cycle of the blades for a reliable strength. The present geometry working model with tillage blade is analysed to new design change constraints of its geometry for the maximum weed removal efficiency by presenting its analysis results from the field performance. [15]

Prof. N.A.Ghanokar1 & Prof. S. P. Pawar2, "Computer Aided Design and Analysis of Rotary Tillage Tool Component For Failure". Their paper presents stress analysis of rotavator blade for different thickness and different materials. They have selected L-shaped blade for the study because L shape is usually superior to others in heavy trash. They are better for killing weeds. Rotavators work in the very difficult conditions, so they bear heavy dynamic loads. Therefore, proper design of these equipment is necessary to increase their working life time and reduce the farming costs. For the study we have selected A 15 HP Mahindra Yuvraj 215 tractor and Shaktiman SRT 2.5 mini rotavator. We calculated Forces acting on each blade for different thickness as well as different materials. After modeling of blade, we applied boundary and loading conditions on the models. Finally, models were analysed with analysis software. Results of this research can help the designers of rotavator blade to make similar works in their designs and increase the working life of blade. [16]

III. Conclusion

By studying all above journal papers, it is found that the CAD Modelling and FEA Method is one of the best suitable method for design and testing of rotavator blade. Research shows the importance of these two tools for design of rotavator blade. Static Structural and dynamic conditions are taken into consideration to analyse the rotavator blade.

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