DESIGN OPTIMIZATION OF ROTAVATOR BLADE TOWARDS IMPROVED AGRICULTURAL PRODUCTIVITY

Dr. Ashok G. Matani*

Ankush D. Bhishnurkar**

ABSTRACT:

A Rotavator or rotary tiller is a specialized mechanical tool used to plough the land by a series of blades which are used to swirl up the earth. Tillage is an operation performed on the field to obtain a desirable soil structure for perfect seedbed preparation for sowing seeds. Rotavator or Rotary tiller is a tillage machine Manufactured for preparing land by breaking the soil with the help of rotating blades. In case of tillage tools, deformation is related to tool wear but stress plays a major role which results in wear of the tool. This paper describes the design analysis of blade through computational method. The energy constrained for the tillage tool operations with 37Hp and 45Hp power tractor and estimated forces acting at soil-tool interface.

Keywords: Deformation, Rotary Tiller's Blade, Rotavator, structural analysis, von misses stress.

* Associate Professor, Government College of Engineering, Amravati – 444 604 [M.S.] India

** M.Tech. [Production Engineering], Government College of Engineering, Amravati – 444 604 [M.S.] India

Introduction

A rotary tiller is a specialized mechanical tool used to plough the land by a series of blades which are used to swirl up the earth. Increase in fossil fuel prices leads to higher level of Agricultural land preparation cost which directly leads to increase in the cost of food. Farmers are more interested to improve cost to benefit ratio by reduce the land preparation cost and increase the yield. Now a day it is possible by using Rotary tiller or Rotavator for seedbed preparation. In a Rotavator Blades are the main parts which are engaged with soil to prepare the seedbed for sowing. Rotavator is a widely used machine for tillage operation in Indian farming because of its superior ability to mix, flatten and pulverize soil.

Objectives

1. To prepare a geometric solid model of Rotary Tiller's Blade by using CAD-software.
2. To generate a CAD analysis report of rotary tillage tool components.

Blade Details

The geometry of tiller blades is considered to be the most important factor in their design since both the shape of the blade tip and the length of the tiller blade facilitate cutting. Hence there is a need to improve the design through geometrical modifications so that will reduce the blade cost as well as land preparation cost. L-shaped blades are mostly used in Rotary Tillers manufactured in Indian because of its effectiveness over "C" type and "J" type blades. These blades are normally mounted with three right handed and three left handed blades per flange.

TABLE 1:Blade Parameters

Sr.	Parameters	Values
1	Blade span (mm)	40
2	Effective Vertical length (mm)	231
3	Blade cutting width (mm)	135
4	Blade thickness (mm)	9

Methodology

Table 2: Input Parameters for the Analysis

Sr.	Parameters	Values
1	Rotary tiller work depth (mm)	220
2	Rotary tiller work width (mm)	1500
3	Rotor rpm	210
4	Blade peripheral velocity (m/s)	5
5	Total number of blade	36
6	Number of blades on each side of the flanges	6
7	Prime mover forward speed (m/s)	1.2
8	Number of blades which action jointly on the soil	6
9	Prime mover Power (HP)	37-45
10	Traction efficiency ($_{c}$)	0.9

From literature it is clear that an “L” type blade is most suitable for Indian farming conditions compared to “C” and “J” type Blade, a blade was designed in 3D CAD software on the basis of geometrical parameters of actual “L” type blade, followed by analysis in ANSYS. The steps performed in ANSYS for analysis are import design, meshing, input parameters and solution. The structural analysis was done based on field trial data available from the manufacturer and farmers.

$$Ks = Cs\frac{75Nc.c.z}{u} \qquad (1)$$

Where-

Ks = maximum tangential force (kg),

Nc = Prime mover Tractor Power (HP),

c = Traction efficiency,

z= Coefficient of reservation of tractor power,

Cs = is the reliability factor that is equal to 1.5 for non-rocky soils and 2 for rocky soils,

u = Prime mover forward speed (m/s)

$$Ke = \frac{Ks.Cp}{i.Ze.Ne} \qquad (2)$$

Where-

Ke = soil force acting perpendicularly on the cutting edges of each of the blades

Cp = coefficient of tangential force,

i= number of flanges,

Ze = number of blades on each side of the flanges,

Ne = number of blades which action jointly on the soil.

Results

The analysis results of right hand blade in graphical mode have shown in figures below. As in case of tillage tools, deformation is related to tool wear but stress plays a majorrole which results in wear of the tool [6]. In this analysis, because of variations in tool shape the stress variation is obtained. The resultant deformation and Van-Misses stress is shown in figure below for LH and RH Rotavator blade.

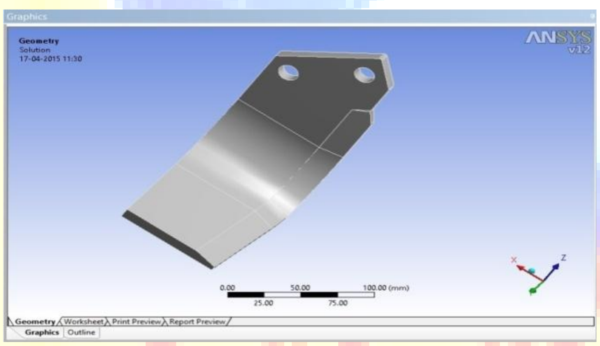

Figure 5.-3D Model of RH Blade

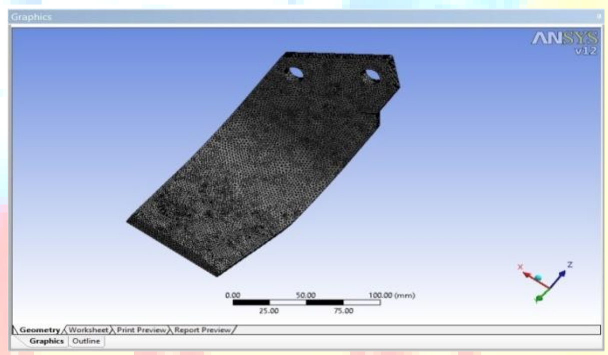

Figure 6.-Meshingof RH Blade

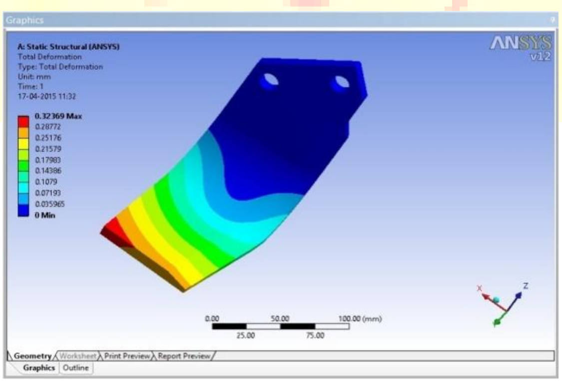

Figure 7.-Deformationof RH Blade

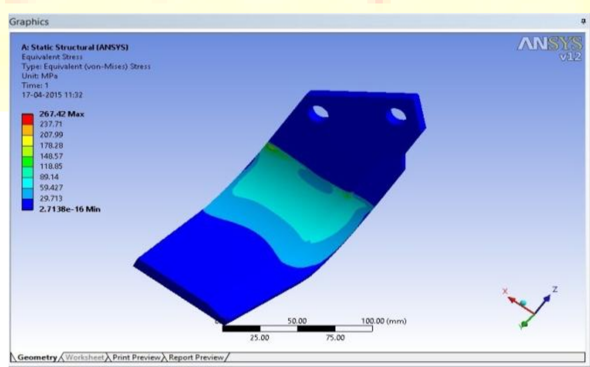

Figure 8. - Von misses stressof RH Blade

1. Maximum deformation is 0.32mm for RH Blade.
2. Maximum Van-Misses stress is 267.42MPa for 45HP and minimum Van-Misses stress is 220.13MPa for 37HP for RH Blade.

Conclusion

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 deformations and von-misses stress distribution plots. The present working model with tillage blade is analyzed to new design constraints with change of its geometry for the maximum weed removal efficiency is suggested for the lab and field testing.

References

[1] Amardeep Singh Kang, Jasmaninder Singh Grewal, Deepak Jain and Shivani Kang,2012, Wear Behaviour of Thermal Spray Coatings on Rotavator Blades, 21(2), pp. 355-359.
[2] Dr. A.G. Matani, 2011, Automobile exhaust emissions in Indian Environment Programmes and strategies needed for controlling, Journal of Environmental Research and Development, 5(3), pp. 584 – 590.
[3] Dr. A. G. Matani,1999, Common Effluent Treatment Plants: Prospects and Potentialities in Indian Manufacturing", Journal of Industrial Pollution Control, 15(3), pp. 113-116.
[4] Dr. Ashok G. Matani S. K. Doifode, 2015, Effective Industrial Waste Utilization Technologies towards Cleaner Environment, International Journal of Chemical and Physical Sciences, 4(1), pp. 536-540.
[5] Dr. A.G. Matani, 1999, Managing new product innovations, Industrial Engineering Journal, 4(1), pp. 21-23.
[6] Dr. A.G. Matani, Curricula Challenges of Technical and Management Education Institutions, International Journal of Management (IJM), 2013, 4(1),pp.56-60.
[7] Dr. A.G. Matani, Strategies for better waste management in industrial estates **,** Journal of Industrial Pollution Control, 2006, 22(1), pp.67-72.
[8] Dr. A.G. Matani, Automobile exhaust emissions in Indian Environment Programmes and strategies needed for controlling, Journal of Environmental Research and Development, 2011, 5(3), pp. 584 – 590.
[9] Dr. A.G. Matani, Information Technology Improving Retail Marketing in Agriculture, Proceedings of International Conference on Marketing and Society, Indian Institute of Management ,(IIM) Kozikhode , 2007, pp.185-186
[10] Gopal U. Shinde and Shyam R. Kajale,June 2012, Design Optimization in Rotary Tillage Tool System Components by Computer Aided Engineering Analysis, International Journal of Environmental Science and Development, 3(3), pp. 279-282.

[11] G.U.Shinde, J.M.Potekar, R.V.Shinde, Dr.S.R.Kajale,2011, Design Analysis of Rotary Tillage Tool Components by CAD-tool: Rotavator, International Conference on Environmental and Agriculture Engineering IPCBEE, Singapore, 15.

[12] Jain-Song Ju, 2007, Study on the Characteristics of Tiller Blade Shapes by Spray- Welding Hardening, Journal of Marine Science and Technology, 15(3), pp. 219-231.

[13] M. Sadiq, M. Jamil, S. M. Mehdi, G. Hassan, Akhtar, 2002, Effect of Different Tillage Implements on Wheat Production in Rice-Wheat Cropping System in Saline Sodic Soil, Pakistan Journal of Agronomy, 1(2-3), pp. 98-100.

[14] S.K. Mandal, Dr. B. Bhattacharya, Dr. S. Mukherjee,2013, Optimization of Design Parameters for Rotary tillers Blade, Proceedings of the 1st International and 16th National Conference on Machines and Mechanisms, IIT Roorkee, India, Dec 18-20.

[15] Subrata K.R. Mandal, Basudeb Bhattacharyya, Somenath Mukherjee and P. Chattopadhyay,2014, Use of CAD Tool for Design and Development of Rotavator Blade, Middle-East Journal of Scientific Research, 20(2), pp. 171-177.

[16] 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.

[17] V. N. Ahuja Dr. A. G. Somvanshi, Dr. A. G. Matani, 2010, CSR of Industries Towards Improving Quality of Education, Journal of Teacher Education in Developing Nations, 1(1), pp.96-100.

****