Enhancing Agricultural Productivity by Improving Rotavator Design

Ankush D. Bhishnurkar
Assistant Professor
Department of Mechanical Engineering
G. H. Raisoni Institute of Engineering and Management, Jalgaon, India
anky4589@gmail.com

Dr. Ashok G. Matani
Associate Professor
Government College of Engineering, Amravati – 444 604 [M.S.] India
ashokgm333@rediffmail.com, drashokmatani@gmail.com

Abstract: In the permanent agricultural land, soil will be poor in nutrients because of continuous productivity. In recent years, fertilizer consumption increased exponentially throughout the world, causes serious environmental problems. Plants absorb the fertilizers through the soil; they can enter the food chain. Continuous use of chemical fertilizers leads to infertility of land and water pollution. Also farmers are more interested to improve cost to benefit ratio by reducing the land preparation cost and increase the yield. But the increase in diesel fuel prices and fertilizer prices leads to higher level of agricultural land preparation cost which directly leads to increase in the cost of food. Combination of Rotavator for seedbed preparation and organic fertilizers will be highly appreciable to gain higher cost to benefit ratio. Also it will help to maintain fertility in the permanent agricultural land and helps to minimise soil and water pollution. Rotavator can play an important role in double or multiple cropping systems where the time for land preparation is very less or limited. Rotavator is a tillage implement comprising of various types of blades like L-shaped, C-shaped and J-shaped mounted on flanges, L-shaped blades are preferred over C-shaped and J-shaped blades. This implement affixed to a shaft that is driven by tractor Power-Take-Off (PTO). It is used for mixing manure or fertilizers into soil and for seedbed preparation. It offers an advantage of superior soil mixing, better pulverisation, rapid seedbed preparation and reduced draft compared to conventional tillage. Result shows that Rotavator saved 30-35 % of time and 20-25 % in the cost of operation as compared to tillage by cultivator. It gave a higher quality of work (25-30 %) than tillage by cultivator.

This paper describes the design analysis of blade through computational method. 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 and the resultant effect on rotary tiller’s blade is obtained from deformations and various stress distribution plots. The present working model with tillage blade is analysed to new design constraints with the change of its geometry for the maximum weed removal efficiency is suggested for the lab and field testing.

Keywords: CAD-Software, Cost to Benefit Ratio, Fertilizer, Productivity, Rotavator

I. INTRODUCTION

In the permanent agricultural land, soil will be poor in nutrients because of continuous productivity. In recent years, fertilizer consumption increased exponentially throughout the world, causes serious environmental problems. Plants absorb the fertilizers through the soil; they can enter the food chain. Continuous use of chemical fertilizers leads to infertility of land and water pollution.

From literature, it is clear that Rotavator can play an important role in double or multiple cropping systems where the time for land preparation is very less or limited. Rotavator is a tillage implement comprising of various types of blades like L-shaped, C-shaped and J-shaped mounted on flanges, L-shaped blades are preferred over C-shaped and J-shaped blades. This implement affixed to a shaft that is driven by tractor Power-Take-Off (PTO). It is used for mixing manure or fertilizers into soil and for seedbed preparation. It offers an advantage of superior soil mixing, better pulverisation, rapid seedbed preparation and reduced draft compared to conventional tillage. More or less Rotavator can be alternative for the excessive use of chemical fertilizers to improve benefit to cost ratio for farmers.

II. LITERATURE REVIEW

Serpil Savci (2012): In the permanent agricultural land, soil will be poor in nutrients because of continuous productivity, as a result, inefficient. Therefore, producers, fertilize the soil, combat pests, irrigation and process of agricultural activities to make more efficient to soil. Fertilization among these activities remains a priority at all times. Fertilization may affect the accumulation of heavy
metals in soil and plant system. Plants absorb the fertilizers through the soil; they can enter the food chain. Thus, fertilization leads to water, soil and air pollution. Excessive use of chemical fertilizers in agriculture, resulting in a large number of environmental problems because some fertilizers contain heavy metals. In this paper author concludes that the use of fertilizers is necessary in agriculture. But it should be given only after soil analysis in required amounts. The structure and chemical content of the soil should be identified and the most appropriate type of fertilizers should be selected. Excess use of fertilization leads to adverse effects, fertilizers water will mix with the surrounding soil by leaching. For this reason, fertilizer will be lost from the soil, as well as pollution of surrounding water.

Saeed Firouzi and Mohammadreza Alizadeh (2012): has performed field experiments to evaluate different weeding method for groundnut. The weeding methods included two power tillers operated weeders Cultivator and Rotavator. Study was carried out at three different forward speeds of 1, 1.5 and 2km/hr. For all the factors Rotavator gave superior results than Cultivator. The maximum soil manipulation was achieved by Rotavator at lowest forward speed of 1km/hr. which leads to higher crop yield. Least time required for weeding was obtained by Rotavator at forward speed of 2km/hr. which is 7.80hr/ha while for Cultivator for same speed it was 8.43hr/ha and for manual wheel Cultivator it was 56.33hr/ha. Minimum operation cost was achieved from Rotavator at forward speed of 2km/hr. also for the speed of 1.5km/hr. was recorded less than for Cultivator. Also the benefit to cost ratio in weeding by Rotavator at a forward speeds of 1, 1.5, 2km/hr. were 2.06, 2.03 and 1.96 respectively while for Cultivator for same speeds it was 1.48, 1.38 and 1.64 respectively. From the experiment author concluded that power tiller operated Rotavator at a forward speed of 1km/hr. was the appropriate method for weeding.

Fereydoun Keshavarzpour (2011): has carried field experiments to study the influence of different tillage methods on weed population indices for sugar beet crop. Author used various tillage implements like moldboard plow, disc harrow, Rotavator, chisel plow, tine cultivator in combination and separately as well as in one pass and in two passes, also and no tillage has been done in one plot. For experiment author made plots each of size 20.0m long and 6.0m wide. There were 12 rows of sugar beet in each plot with 50cm row spacing. Statistical results of experiments indicate that influence of different tillage methods was not significant, but it improves the result compared with no tillage. Also results shows that use of Rotavator was more beneficial than other implements and no tillage.

III. 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.

IV. BLADE DETAILS

L-shaped blades are mostly used in Rotary Tillers manufactured in India 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>
<thead>
<tr>
<th>Sr.</th>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Blade span (mm)</td>
<td>40</td>
</tr>
<tr>
<td>2</td>
<td>Effective Vertical length (mm)</td>
<td>231</td>
</tr>
<tr>
<td>3</td>
<td>Blade cutting width (mm)</td>
<td>135</td>
</tr>
<tr>
<td>4</td>
<td>Blade thickness (mm)</td>
<td>7</td>
</tr>
</tbody>
</table>

V. METHODOLOGY

From the 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.

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

\[
K_S = \frac{Cs \cdot \Sigma c \cdot \Sigma z}{u}
\] (1)
Where-

\[ K_s = \text{maximum tangential force (kg)}, \]

\[ N_c = \text{Prime mover Tractor Power (HP)}, \]

\[ \eta_c = \text{Traction efficiency}, \]

\[ \eta_z = \text{Coefficient of reservation of tractor power}, \]

\[ C_s = \text{is the reliability factor that is equal to 1.5 for non-rocky soils and 2 for rocky soils}, \]

\[ u = \text{Prime mover forward speed (m/s)} \]

\[ K_e = \frac{K_s \cdot C_p}{i \cdot Z_e \cdot N_e} \quad (2) \]

Where-

\[ K_e = \text{soil force acting perpendicularly on the cutting edges of each of the blades} \]

\[ C_p = \text{coefficient of tangential force} \]

\[ i = \text{number of flanges} \]

\[ Z_e = \text{number of blades on each side of the flanges} \]

\[ N_e = \text{number of blades which action jointly on the soil} \]

VI. RESULTS

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

Fig. 1.-3D Model of LH Blade

Fig. 2.-Meshing of LH Blade

Fig. 3.-Deformation of LH Blade

Fig. 4. - Von misses stress of LH Blade

Fig. 5. –Maximum Principal Stress
TABLE III: STRESSES IN BLADE

<table>
<thead>
<tr>
<th>Sr.</th>
<th>Factor</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Maximum Deformations</td>
<td>0.7 mm</td>
</tr>
<tr>
<td>2</td>
<td>Maximum Von-Mises Stress</td>
<td>421.72 MPa</td>
</tr>
<tr>
<td>3</td>
<td>Maximum Principal Stress</td>
<td>379.88 MPa</td>
</tr>
<tr>
<td>4</td>
<td>Maximum Tensile Stress</td>
<td>121.99 MPa</td>
</tr>
</tbody>
</table>

VII. CONCLUSIONS

More or less Rotavator can be an alternative for the excessive use of chemical fertilizers to improve benefit to cost ratio for farmers. Use of Rotavator will improve the crop yield without polluting the soil. 3D CAD model of tillage blade is analysed to new design constraints. This model is analysed for deformations, Von-Mises stress, maximum principal stress, tensile stress and shear stress. The results of structural analysis are evaluated for 45HP tractor. For effective performance of rotavator blade it is suggested for the lab and field testing.

References