“STUDY OF EFFECT OF LEAD ANGLE OF SHANKS ON PERFORMANCE OF DUCKFOOT SWEEP CULTIVATOR”

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ABSTRACT

Tractor drawn duck foot cultivator is the most eminent equipment being manufactured by small scale manufacturers and adopted by farmers of Madhya Pradesh. Almost all tractor owner farmers owns it. While using cultivator, farmers come across problems of bending of shanks, encountered mainly due to improper design, use of non appropriate material and manufacturing process. Finite element analysis was done to study the behavior of shanks with respect to their shape. The objective were to analyze the stress distribution over different shapes of shanks, to analyze the displacement behavior and to determine which type of shank is most efficient for performance under specified conditions of operations. Dimensions of all the shanks were recorded and soft models of all the shanks were prepared to original shape and dimension using Auto cad and IDEAS software. The draft (horizontal force) acting on the shank during field operation is the main factor causing bending in shanks. To study the effect of lead angle on bending, shank with lead angle of 0, 8, 16 and 24 degrees were also prepared. All the solid models were assigned the material properties what mild steel possesses. Modulus of elasticity, yield strength and poissions ratio were taken as $2 \times 10^{11}$ Pascal, $2.5 \times 10^{8}$ Pascal and 0.266 respectively. The required force (draft) for finite element analysis was worked out to be 4000 Newton by conducting field operations.

It was observed that the bending behavior of shanks is influenced by lead angle. The shank with 0 degree lead angle give least displacement of $3.8 \times 10^{-4}$mm. It was observed to be increasing with increasing lead angle. The displacement values for 8, 16 and 24 degrees were found to be $4.26 \times 10^{-4}$, $5.15 \times 10^{-4}$ and $7.23 \times 10^{-4}$mm respectively. These displacement values were 40-43% lower in comparison to double bend shanks which are largely being used by the farmers.

INTRODUCTION

Agricultural Mechanization necessitates application of quality farm machine for more profitable crop production. The manufacturers of agricultural machines especially in small scale sector generally face problem due to non availability of quality materials and inadequate manufacturing process because of which the quality of machine is up to that standard. Also design is carried out on trial and error basis without bringing the concept of optimization resulting in over design, excessive manufacturing cost time. The working group constituted by the Ministry of industry, Government of India in its report stressed for more research on development on the design and quality production of agricultural implements. The fabrication methodology used by small scale and unorganized sector, which is conventional and leads to poor performance of machine for the following reasons:
1. Inadequate knowing in implement design and assembly

2. Lack of adequate knowledge of material selection and its specification and manufacturing process.

3. Over design and higher cost due to lack of optimized design concept.

During the last three decades, the growth of agricultural mechanization has been rapid. Demand of bigger size agricultural machinery for farm operations is increasing. The growth rate in population of selected agricultural machinery have been as 10-13% for tillage equipment like plough and harrows, 18% for seed drills and 14% for cultivator. There are more than 20,000 manufacturers of agricultural machinery of which are about 500 are in medium and large scale sector manufacturing tractors, combines, power tillers, pump set, drip irrigation system, engines etc. Rest are small scale industries which are catering to the need of farmers of manufacturing equipments like cultivators, seed drills, threshers etc. In Bhopal alone there are 23 manufacturers if Duck foot cultivator, producing around 1500 units and the annual turnover is estimated to be around 1.2 crores (@Rs.8000/-per unit).

The survey of agricultural machinery manufacturers have revealed that almost all manufacturers are using MS plate of size ranging from 60X32 to 65X32mm for making shanks. The shanks are made by gas cutting from thick MS plate for the required shape and size. The weight of these shanks are from 9.5 to 12.5 kg. Despite being heavier, bending and twisting of shanks very frequently in duck foot sweep cultivator which leads to poor tilting of soil. The reasons for poor performance of duck foot sweep cultivator may be attributed to inadequate design and improper selection of materials and manufacturing process.

<table>
<thead>
<tr>
<th>Types of shanks</th>
<th>bending of shanks</th>
</tr>
</thead>
</table>

**Methodology Pertained**

Stress distribution of shanks of various lead angles was observed using finite element analysis to determine most effectively performing shape.

Dimension of all the shanks were recorded and soft models of all these shanks were prepared to exact shape and dimension, using AUTOCAD and IDEAS. To study the effect of lead angle on
bending shanks with lead angle of 0,8,16 and 24 degrees were also prepared. The entire solid model was assigned the material properties what mild steel possesses. Modulus of elasticity, Yield strength and Poisson’s ratio were taken as $2 \times 10^{11} \text{N/m}^2$, $2.5 \times 10^8 \text{N/m}^2$ and 0.266 respectively. Finite element analysis was generated for further analysis. The force was assumed to be 4000N.

**Stress distribution and displacement in shank with lead angle 0, 8, 16, 24:**

<table>
<thead>
<tr>
<th>Degree</th>
<th>Element Length</th>
<th>No of elements</th>
<th>No of nodes</th>
<th>Min Stress (MN/MM$^2$)</th>
<th>Max Stress (MN/MM$^2$)</th>
<th>Displacement (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10.5</td>
<td>795</td>
<td>2381</td>
<td>5.89E-001</td>
<td>5.79E+002</td>
<td>3.8E-004</td>
</tr>
<tr>
<td>8</td>
<td>10.5</td>
<td>759</td>
<td>2319</td>
<td>6.003E-001</td>
<td>1.98E+002</td>
<td>4.26E-004</td>
</tr>
<tr>
<td>16</td>
<td>10.5</td>
<td>749</td>
<td>2279</td>
<td>5.23E-001</td>
<td>2.57E+002</td>
<td>5.15E-004</td>
</tr>
<tr>
<td>24</td>
<td>10.5</td>
<td>702</td>
<td>2176</td>
<td>6.17E-001</td>
<td>3.74E+002</td>
<td>7.23E-004</td>
</tr>
</tbody>
</table>

This figure shows the stress distribution in single bend straight shank with lead angle 8 degree. Similarly analysis were done on shanks with lead angle 0,16 and 24 degree. The best result was obtained on shank with lead angle 8 degree having least stress.
Draft measurement studies

Draft measurement was conducted on surfaces having varying moisture (15-25%) and bulk density, to study the magnitude of horizontal force acting on the shanks. This is being done by a method called **TOWING METHOD**. The soil failure with multi shank implement is dependent upon the relative position of shanks which affects the draft. With reducing number of shanks, the overlap decreases and draft per unit increases. The implement was therefore operated with minimum two shanks, so as to measure the average max horizontal force.

Draft on shanks during field operation:-

<table>
<thead>
<tr>
<th>No of shanks</th>
<th>Field surface No</th>
<th>Average Draft</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>F1</td>
<td>950</td>
</tr>
<tr>
<td></td>
<td>F2</td>
<td>948</td>
</tr>
<tr>
<td></td>
<td>F3</td>
<td>849</td>
</tr>
<tr>
<td></td>
<td>F4</td>
<td>1028</td>
</tr>
<tr>
<td>3</td>
<td>F1</td>
<td>652</td>
</tr>
<tr>
<td></td>
<td>F2</td>
<td>675</td>
</tr>
<tr>
<td></td>
<td>F3</td>
<td>664</td>
</tr>
<tr>
<td></td>
<td>F4</td>
<td>786</td>
</tr>
<tr>
<td>4</td>
<td>F1</td>
<td>506</td>
</tr>
<tr>
<td></td>
<td>F2</td>
<td>614</td>
</tr>
<tr>
<td></td>
<td>F3</td>
<td>460</td>
</tr>
<tr>
<td></td>
<td>F4</td>
<td>547</td>
</tr>
</tbody>
</table>

Results and Discussion

After focusing light on various parameters of shanks and doing its analysis the following vital points comes in existence which we are declaring as the output of our protrude(project).

- The maximum principal stresses for shanks with lead angles:
  
<table>
<thead>
<tr>
<th>angle (degree)</th>
<th>Maximum principal stresses (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5.79E+002</td>
</tr>
<tr>
<td>8</td>
<td>1.98E+002</td>
</tr>
<tr>
<td>16</td>
<td>2.57E+002</td>
</tr>
<tr>
<td>24</td>
<td>3.74E+002</td>
</tr>
</tbody>
</table>

- The displacement for shank with lead angles:
0 degree is $3.8\times10^{-04}$mm
8 degree is $4.26\times10^{-04}$mm
16 degree is $5.15\times10^{-04}$mm
24 degree is $7.23\times10^{-04}$mm

✓ The shank with zero degree lead angle gave least displacement of $3.8\times10^{-04}$mm. It was observed to be increasing with increase in lead angle.

✓ The displacement values were 40-43% lower in comparison to double bend shanks tremendously used by the farmers.

✓ The stress concentration is least in shank of lead angle 8degree.

✓ After analysis using mechanical software’s it is being found that least bending will give optimum result.

Thus, straight shanks can be used most efficiently in field operation with no frequent bending as it has the least value of stress concentration and displacement.

✓ As number of shanks decreases the draft also decreases resulting in increment in unit draft which is the fabulous requirement for operation.

**Conclusion**

After having a deep and crystal clear study of shanks and various other faces it have been concluded that shanks with different lead angles influences its bending resistance.

The displacement values were 40-43% lower in comparison to double bend shank widely used by the farmers for all the values of lead angle

The attachment position of shanks to the main frame equipments significantly affects the bending of shanks. Considering the bending resistance and weight, the single bend shank with a lead angle of 8degree proved to be efficient over shanks of other shapes. Thus, if this approach is adopted in field of agricultural then,

Agriculture field will definitely reach to the    "

"PINNACLE OF TRIUMPH"

**Dissertation**

"LEAST BENDING WILL GIVE OPTIMUM RESULT"

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