FEM analysis for Suitability of Different Materials for a Cultivator Tyne

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Abstract

The present work contributes an analysis of the extensive material that are taken in manufacturing of cultivators .Cultivator is a form of mechanical farm equipment used for breaking up the ground and uprooting weeds for secondary tillage and so are known as secondary tilling implement. The tynes are made up of steel which get rusted and experience failures after multiple use. Present work demonstrates the cause of failure of the cultivator's teeth and to propose the alternate materials for better strength, by making a finite element analysis and checking for the stress developed in the designed part.

Keywords: *Cultivator, tyne, FEM, stress, deformation.*

1. Introduction

The weeds are removed between the row of crops by cultivators which can have straight teeth, curved teeth, spring teeth or disks. Cultivators are relatively lightweight and affordable tools that are good for stirring soil. Between 1915 and 1920, various inventors and farm enforce corporations experimented with a category of machines called motor cultivators, which were truly changed horse drawn shank. But via 1921the overall purpose of tractor tailor-made to cultivating that basically invented the class of row-crop tractors. Tyne Cultivator is a type fitted with tines having blades. Ploughing of land separates the top layer of soil into furrow slices. The furrows are turned sideways and inverted to a varying degree, depending upon the type of plough being used. It is a primary tillage operation, which is performed to shatter soil uniformly with partial or complete soil inversion.

Plough Furrow -It is a trench formed by an implement in the soil during the field operation.

Furrow slice - The mass of soil cut, lifted and thrown to one side is called furrow slice.

Furrow wall - It is an undisturbed soil surface by the side of a furrow.

Crown - The top portion of the turned furrow slice is called crown.

Back furrow - A raised ridge left at the centre of the strip of land when ploughing is started from centre to side is called back furrow.

Dead furrow - An open trench left in between two adjacent strips of land after finishing the ploughing is called dead furrow.

Normally the cast iron and selected steel is being used for the manufacturing of cultivator tine.

2. Problem Identification:

In India the crops are grown two times in a year. These are called rabi and kharif crops. Due to the use of excessive fertilizers the soil becomes hard day by day and year to year. The cultivators are used to turn the soil to make the soil soft and porous so that it can absorb and retain the water and moisture. Various types of cultivators and cultivator tynes are used to turn the soil. This conclude that the two types of cultivators are required in a year for different crops. But usually a single type of cultivator is used by farmers. This results in a earlier failure of the cultivator teeth or tyne. Hence there is a need of proper design of tyne and also of proper selection of material of tyne for better resistance to the soil contact wear.

3. Methodology:

In this research work, two different materials are selected keeping in view the standard material generally used. An analysis of the stresses developed in the tines are calculated using Ansys software. A comparison of the stress developed is made and validated with stress of standard material. The study focused on the deformation of a single tine of the cultivator. Therefore, all components of the assembled solid model of the cultivator were not used in the FEM analysis. The FEM software package, Ansys Work bench, was utilized for the FEM stress analysis process. The FEM analysis was set up in 3D, linear, static and isotropic material model assumptions. When real working conditions were evaluated, the boundary conditions were applied to the model properly. Maximum draft force magnitude for each tine was accounted for according to the experimental study data. The draft force of cultivator was measured as 3500 N that was applied on the surface of the narrow share in the opposite direction of the movement of the tine and weight of implement was 250 kg. Due to the shape of the tine and soil condition used in this study, the vertical force was taken as 19 % of the measured draft. Solving procedure for the FEM analysis was followed starting by pre-processor operations and then post process solving procedures was generated.

4. Dimensions of selected tine:

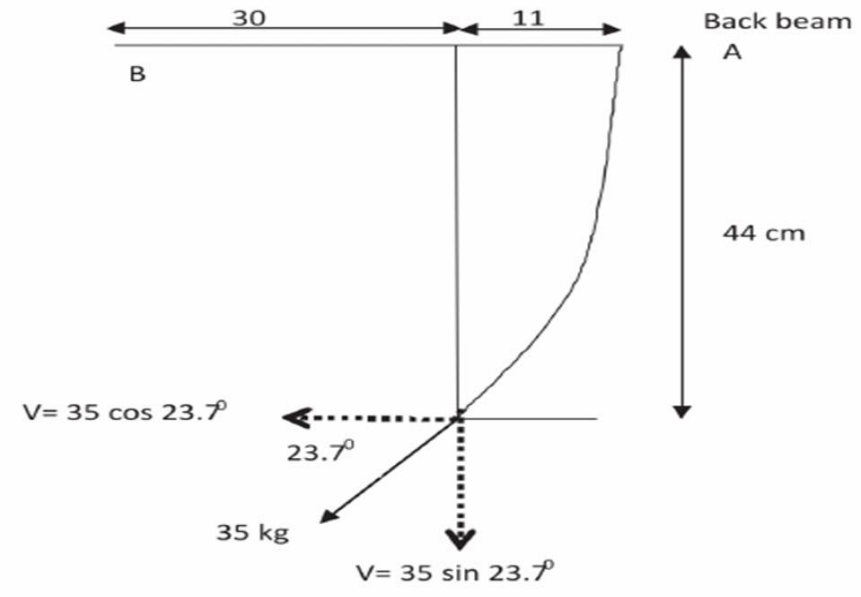

Figure 1. Line Diagram of Tyne

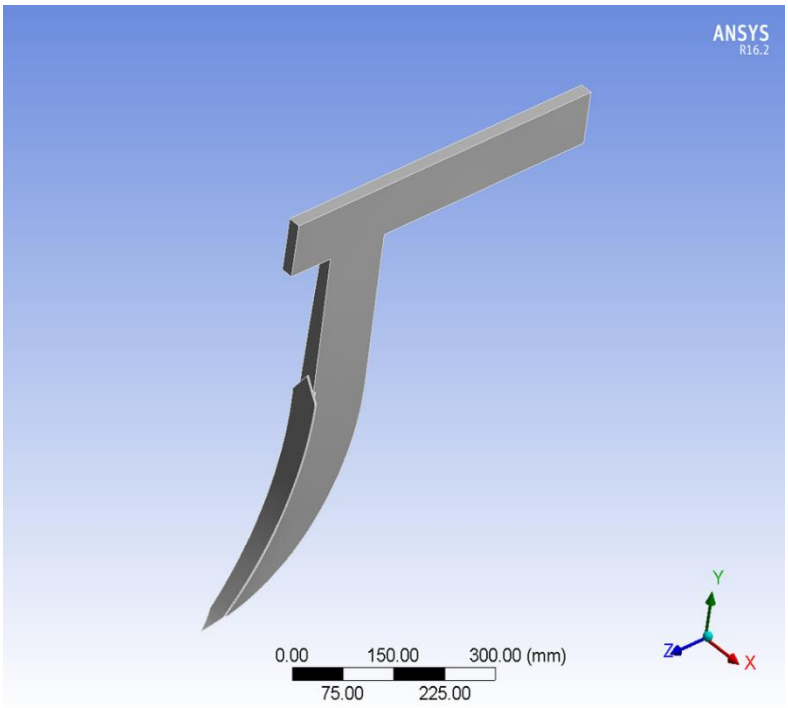

Figure 2. 3 - D Model of Tyne

Boundary conditions applied:

Assuming the top portion of the tine to be fixed, the vertical force applied is 74 N and the draft is assumed to be 390 N. The forces assumed here are same as taken in for Standard Steel St-57.

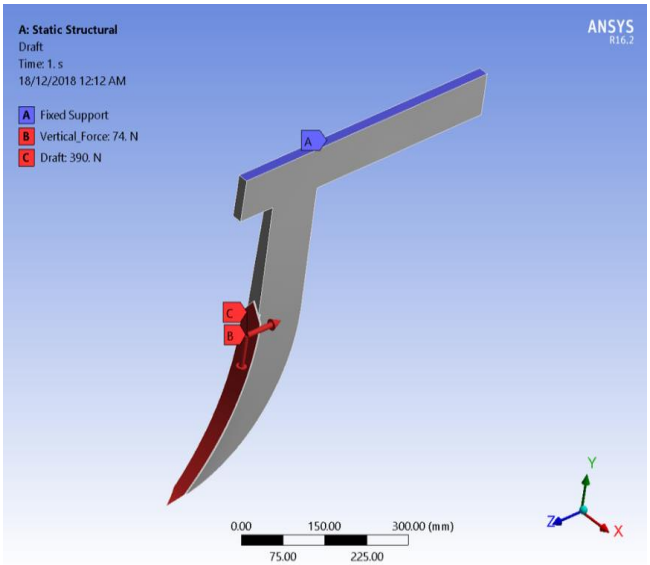

Figure 3. 3 - D Model with Boundary Conditions.

5. Analysis and results:

Standard Steel St-57 (Standard material generally used).

Structural Steel (S257JR) - (first selected material for analysis-M-1) has reliable mechanical property, good formability and excellent welding performance. S275JR is a structural grade steel.

Spring Steel (EN45) - (Second selected material for analysis-M2) is a steel with a high carbon content, hints of manganese that impact the metal's properties, and that it is commonly utilized for springs.

Table 1. Properties of Tyne materials*.

Properties	Unit	Standard Steel St-57	S275JR	EN45
Young's Modulus	Gpa	205	210	204
Tensile Ultimate Strength	Mpa	520	410	551
Yield Strength	Mpa	355	275	241
Poisson Ratio	-	0.29	0.28	0.3
Density	Kg/m^3	7870	7800	8080

**https://www.britannica.com/technology/steel*

Formula used:

Draft of one tine = Total draft / No. of tines
= 3500 / 9
= 390 N
Vertical force acting on cultivator = 74 N (19 % of draft)

Table 2. Load Applied

Loads on tine	Draft on One Tyne, N	Vertical force, N
	390	74

Table 3. Results

Results obtained by	Material Type	Von-Mises Stress in Mpa	Max Principal Stress in Mpa	Min Principal Stress in Mpa	Deformation In mm	% change in deformation

Nelson Makange	Standard Steel St-52	5.1688	5.1726	0.20944	0.07695	0
Present	S275JR	7.9647	8.0877	0.40980	0.11468	49.03
	EN45	8.6778	8.8121	0.44650	0.12495	62.37

6. Conclusion:

The stress developed over the tyne body is less than the yield point of the selected tyne materials hence the deformation does not cause failure on the tine. Investigations of the tyne also confirmed that there was no significant deformation on the tine. The deformations obtained are 49.03% and 62.37% more than the earlier analyzed material.

7. Acknowledgement:

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