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FEM ANALYSIS OF NINE TYNE MEDIUM DUTY CULTIVATOR

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ABSTRACT

In last few decades we all witnessed the development in each and every field. In the field of agricultural also we had seen remarkable development, big farmers are now a day's using cultivator, harvester, tractor, advance machine tools and advance farm equipments, but in the country like India where more than 80% of farmers are small and marginal and they are still doing farming by traditional method only they are also in need of improved agricultural tools that may be hand driven or bullock driven. In this paper the FEM analysis of nine tyne medium duty cultivator is presented. Cultivator is important agricultural equipment used for soil preparation. The main objective of this analysis is to increase the life of shovel. The existing cultivator which is manufactured by local small scale manufacturer gets failed at different points after approximately one session of uses. To analyze this tyne mechanism using FEM, firstly a proper CAD model has been developed using Pro/E cad software. Then by using ANSYs software FEM analysis have been done to determine the stresses. [12]

Keyword: Nine Tyne Cultivator, FEM, Design Analysis.

INTRODUCTION

India is an agricultural country and about 80% people in India are farmers and uses agricultural equipment like cultivator, rotavator etc. In each and every sector development is done but as compare to other sector in farm equipment development is not done. A cultivator is a type of farm implement used for secondary tillage. One sense of the name refers to frames with teeth also called shank or shovel that pierce the soil as they are dragged through it linearly.

The tools cultivator which they are required mostly manufactured in small scale industries or by local artisans like carpenter and blacksmiths. The present technique of manufacturing of agricultural tools by all these people is like design by evolution. The design is evaluate long span of time. The leisurely pace of technological change reduced the risk of making major errors. The circumstances rarely demanded analytical capabilities of the designer. Also this technique is unsuitable for mass production, difficult to modify, incapability to tap new technologies. The jobs made are not perfect, inefficient, health hazardous and very poor in quality in comparison to the parts made in big industry.

Cultivator is a mechanical implement for breaking up the ground and uprooting weeds. Cultivators are called "secondary tilling implements." In basic terms, that means that farmers use cultivators after land is initially plowed. The initial process mixes up dirt, gets up roots, and does the heavy lifting of equipment farming. Cultivators do more of the fine tuning of small farms. By using the Pro-E firstly we had developed the CAD model of the cultivator mechanism and then by using ANSYs software the FEM analysis of it is carried out.

TYPES OF CULTIVATOR

There are different types of cultivator following are the classification depending upon the use, Geometrical feature, and power required.

A) Depending Upon Type of Use

- **Small Cultivators:** It is used for gardening, powered by small motors, and controlled by an operator walking behind. Garden cultivators can be used to mix soils with manures and fertilizers in preparation for planting
- **Farm Cultivators:** A tractor-mounted tiller Cultivators are pulled by tractors and can vary greatly in size and shape, from 10 feet (3 m) to 80 feet (24 m) wide. Many are equipped with hydraulic wings that fold up to make road travel easier and safer.
- **Field Cultivator:** Field cultivators are used to complete tillage operations in many types of arable crops fields. The main function of the field cultivator is to prepare a proper seedbed for the crop to be planted

- into, to bury crop residue in the soil (helping to warm the soil before planting), to control weeds, and to mix and incorporate the soil to ensure the growing crop has enough water and nutrients to grow well during the growing season.
  - **Row Crop Cultivator:** The main function of the row crop cultivator is weed control between the rows of an established crop.

B) Depending Upon Type of Geometrical Features

- **Disc Cultivator:** It is cultivator fitted with disc.
- **Tyne Cultivator:** It is a type fitted with tines having blades.
- **Rotary Cultivator:** It is a cultivator with tines or blades mounted on a power driven- horizontal shaft.

C) Depending Upon Type of Power Available For The Implements

- **Trailed type cultivator:** It consists of a main frame which carries a number of cross members to which tines are fitted. A pair of wheel is provided in the cultivator. The lift is operated by both wheels simultaneously so that draft remains even and uniform.
- **Mounted cultivator:** Tractors fitted with hydraulic lift operate the mounted type cultivators.
- Cultivator with spring loaded tyne: A tine hinged to the frame and loaded with a spring so that it swings back when an obstacle is encountered, is called spring loaded tine.
- **Cultivator with rigid tyne:** Rigid tines of the cultivator are those tines which do not deflect during the work in the field.
- **Duck foot cultivator:** It is type of rigid cultivator which is used mostly for shallow ploughing, destruction of weed and retention of moisture.
- **Animal drawn cultivator:** Depending upon local conditions, soil and climate, different types of cultivators have been designed and are being used extensively throughout country. Three tined cultivators with seeding attachment are popular in some part of the country.

SHOVEL

The most important part in cultivator is a shovel one sense of the name refers to frames with teeth also called shank or shovels that pierce the soil as they are dragged through it linearly.

- **Plane Shovel:** Blade is made up from carbon steel. Triangular arrow shaped blades are used which actually cuts the soil. Three blades are used.
- **Saw Tooth Shovel:** These are made up of carbon steel. It has performed for cutting stem of weed which comes during cultivation.
- **Reversible Shovel:** These are made up of carbon steel. These are also use to cut the soil surface.
- **Blade Harrow Shovel:** These are made up of carbon steel. These are used to level the soil surface, so that the land becoming levelled and loss due to rain fall is reduces. And by levelling the soil with cultivator levelling operation is saved.
- **Step Tooth Shovel:** These are made up of carbon steel. These type of shovels are use to remove the deep rooted weeds.

NOMENCLATURE OF VARIOUS COMPONENTS OF CULTIVATOR:

- **Tyne:** The three types of tynes are used for the testing of the flexible cultivator. The tynes are S, C and L types.
- **Shovel:** The plane tooth shovel saw tooth shovel, step tooth shovel, reversible shovel, and harrow type shovel are used for the testing purpose.
- **Frame:** The rectangular frame is use for the cultivator.
- **Hitching Arrangement:** The three point linkage is used for the hitching arrangement.

ADVANTAGES OF CULTIVATOR

- Cultivator cultivates the soil properly as compare to ox driven cultivator.
- It requires less time for preparing a seed bed of the soil.
- Cultivator is use before ploughing and after ploughing.
- Cultivator cost is low as compare to rotavator and other agricultural implement

PROBLEM IDENTIFICATION

About 80% people in India are farmer and use an agricultural implement like rotavator, plow, cultivator, plough, tillage etc. But those farmers use agricultural implement face some problem like breakage of shovel tip, because of material of shovel, soil, root, stone etc.

MATERIALS AND SOIL DATA MATERIAL

The materials are taken from the manufacturing database of cultivator production system according to following data in the table.

Table1: Material Used For Cultivator

Sr. No.	Material Name	Material Properties	
		Elastic modulus (N/mm^2)	Poisson Ratio
1	Mild Steel	$2.10Xe^5$	0.303
2	EN45(Spring Steel)	$2.04Xe^5$	0.3
3	EN8	$2.10Xe^5$	0.3
4	Boron Steel	$1.98Xe^{11}$	0.3

SOIL PROPERTIES

Table2: Soil Properties[9]

Type of soil	Soil resistance (Kg/cm^2)	Optimum moisture content (%)
Sandy soil	0.2	3.5
Sandy loam	0.3	5.8
Slit loam	0.35-0.5	
Clay	0.4-0.56	7.18
Heavy loam	0.5-0.7	13.3

Pro-E MODEL

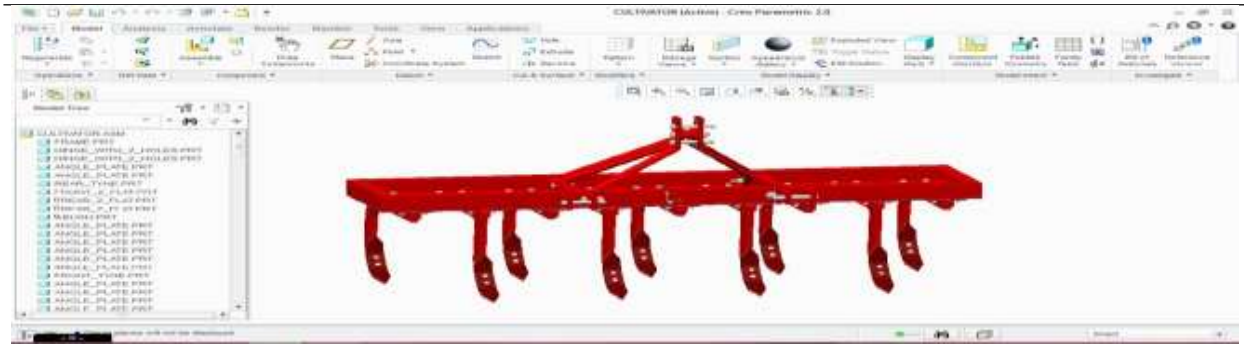

Fig1: Pro-E model of nine tyne medium duty cultivator

ANALYSIS

The design and analysis has been carried out with the help of 3D modeling software and FEA technique using standard FEM tool. PRO-E (4.0) is used for the modeling assembly of cultivator tyne and Inventor has been used for the analysis of model. In the boundary condition, cultivator tyne is fixed at top means to the structure of the cultivator.

There are a number of steps in the solution procedure using finite element methods. All finite element packages require going through these steps in one form or another.

1) Specifying Geometry : First the geometry of the structure to be analyzed is defined. This can be done either by entering the geometric information in the finite element package through the keyboard or mouse, or by importing the model from a solid modeller like Pro/ENGINEER, NX-4. For the cultivator modeling and cultivator tyne modeling is done by using Pro/ENGINEER software. First all the parts modeling done & then assembled. Assembled file of cultivator tyne is saved in IGES format.

2) Specify Element Type and Material Properties: The material properties are defined. In an elastic analysis of an isotropic solid these consist of the Young's modulus and the Poisson's ratio of the material.

3) Mesh the Object: Then, the structure is broken (or meshed) into small elements. This involves defining the types of elements into which the structure will be broken, as well as specifying how the structure will be subdivided into elements (how it will be meshed). This subdivision into elements can either be input by the user or, with some finite element programs (or add-ons) can be chosen automatically by the computer based on the geometry of the structure (this is called auto meshing).

4) Apply Boundary Conditions and External Loads: This is followed by specifying the boundary conditions (e.g. location of supports) and the external loads are specified. For cultivator tyne it is fixed at the top where it is attach to the structure of the cultivator.

5) Processing or solution: The analysis is made on the previously input parameters. The modified algebraic equations are solved to find the nodal values of the primary variable.

The five steps mentioned above have to be carried out before any meaningful information can be obtained regardless of the size and complexity of the problem to be solved. However, the specific commands and procedures that must be used for each of the steps will vary from one finite element package to another.

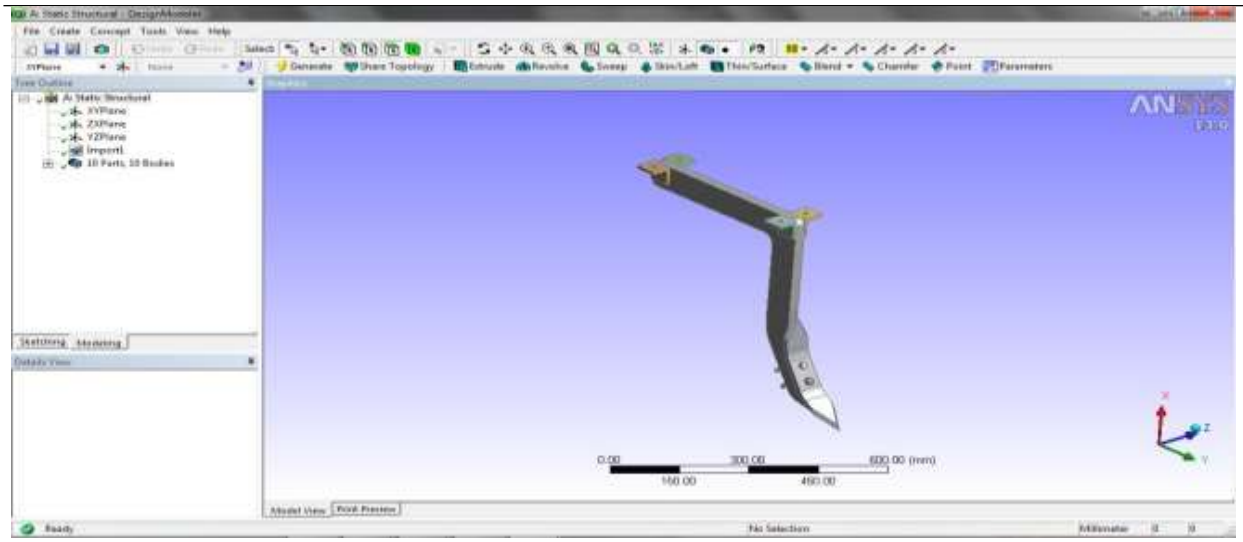

Fig2: CAD Model

CALCULATION

Cultivate 0.6 hector area in one hour

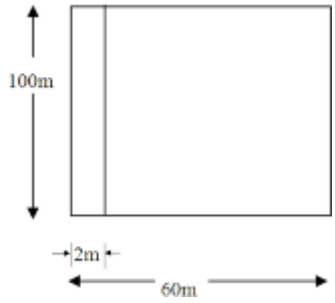

Fig 3: Area to be Cultivated

Cultivation of 0.6 hector land with nine tyne medium duty cultivator of 2m width one hour is required Time required to calculate the 0.6hec land=1hr

Width of nine tyne medium duty cultivator=2m For Velocity=Distance/Time

For distance travel in 0.6hec

No. of turns required for nine tyne medium duty cultivator of 2m width is =60/2=30 turns Total distance travelled to cultivate is=30x100=3000m

Velocity=Distance/Time

=3000/3600

=0.83m/s

We know the horse power of tractor For 35hp

Force=Power/Velocity Power=Force x Velocity Power=35hp

=35x746=26110W

Force=Power / Velocity
=26110/0.83
=31457.8N (for nine tyne) For one tyne
Force=31457.8/9
=3495.3N (Pulling Force) Soil Resistive Force
Soil Resistive Pressure=0.56kg/cm^2 Pressure=
Force/Area Area=762.187mm^2
Force=0.56x762.187
=426.82x9.81
=4187.15/10x10
=41.87N
Total Force=Pulling Force + Soil Resistive Force
=3495.3+41.87
=3537.17N
For impact loading
Kinetic Energy=Force x Displacement For material (En 45)
Apply a load of 100 N dl =4.9x10^{-7} m
Stiffness (K) =100/4.9x10^{-7}
=204 x 10^{6}N/m
F= (1/2mv^2 x K) ^{½}
For Velocity 0.5m/s
F1= (22.7x0.5^2 x204x10^6 /2) ^{½} =24059N dl = 24059/204x10^6 =1.179x10^{-4}m

For Velocity 0.83m/s
F2= (22.7x0.83^2 x204x10^6 /2) ^{½} =39938N dl = 39938/204x10^6 =1.957x10^{-4}m

For Velocity 1.0m/s
F3= (22.7x1^2 x204x10^6 /2) ^{½} =48118.6N dl = 48118.6/204x10^6 =2.358x10^{-4}m

For Velocity 1.5m/s
F4= (22.7x1.5^2 x204x10^6 /2) ^{½} =72178N dl = 72178/204x10^6 =3.538x10^{-4}m

Table 3: Force and Displacement for Material En45

Sr. No.	Velocity (m/s)	Force (N)	Displacement(m)
1	0.5	24059	1.179x10^{-4}
2	0.83	39938	1.957x10^{-4}
3	1	48118.6	2.358x10^{-4}
4	1.5	72178	3.538x10^{-4}

For material Boron Steel Apply a load of
100 N dl =5.05x10^{-7} m K=100/5.05x10^{-7}
=198x10^{6}N/m
For Velocity 0.5m/s
F1= (22.7x0.5^2 x198x10^6 /2) ^{½} =23703N
dl = 23703/198x10^6 =1.197x10^{-4}m

For Velocity 0.83m/s
F2= (22.7x0.83^2 x198x10^6 /2) ^{½} =39347N
dl = 39347/198x10^6 =1.987x10^{-4}m

For Velocity 1.0m/s
F3= (22.7x1^2 x198x10^6 /2) ^{½} =47406N dl = 47406/198x10^6 =2.394x10^{-4}m

For Velocity 1.5m/s
F4= (22.7x1.5^2 x198x10^6 /2) ^{½} =71109N dl = 71109/198x10^6 =3.591x10^{-4}m

Table 4: Force and Displacement For Material Boron Steel

Sr. No.	Velocity (m/s)	Force (N)	Displacement(m)
1	0.5	23703	$1.197x10^{-4}$
2	0.83	39347	$1.987x10^{-4}$
3	1	47406	$2.394x10^{-4}$
4	1.5	71109	$3.591x10^{-4}$

RESULT AND DISCUSSION

In this project as decided in the objectives CAD model were modeled as per specified dimension by using Pro/E software.

After that FEM analys was carried out with the help of Ansys software and Deformation and Maximum Shear Stress were calculated and following solution has been obtained.

FOR MATERIAL EN 45

Table 5: Total Deformation and Maximum Shear Stress For material En 45

Sr. No.	Velocity (m/s)	Force (N)	Total Deformation(mm)	Maximum Shear Stress (MPa)
1	0.5	24059	0.11784	1108.6
2	0.83	39938	0.19945	1840.2
3	1	48118.6	0.24599	2217.1
4	1.5	72178	0.35382	3325.7

It has been observed from above solution that Maximum Shear Stress is more than the allowable stress for material EN45 at very low velocity 0.5m/s Force is 24059N, Total Deformation is $1.179x10^{-4}$ and Maximum Shear Stress is 1108.6 MPa.

Hence I change the material Boron Steel for shovel whose allowable stress is more than the material EN45.

FOR MATERIAL BORON STEEL

Table 6: Displacement and Maximum Shear Stress For material Boron Steel

Sr. No.	Velocity (m/s)	Force (N)	Total Deformation (mm)	Maximum Shear Stress(MPa)
1	0.5	23703	0.11899	429.84
2	0.83	39347	0.19874	713.54
3	1	47406	0.24994	859.69
4	1.5	71109	0.35936	1289.5

After changing the material Boron Steel for velocity 1m/s Force is 47406N, Total Deformation is $2.394x10^{-4}$ and Maximum Shear Stress is 859.69 MPa. So Boron Steel is suitable material for shovel upto velocity 1m/s if speed is increased breakage may occur.

CONCLUSION

The analysis of Nine Tyne Medium Duty Cultivator is carried out to find out the failure in the shovel due to different loading condition at different speed. By conducting FEM analysis of existing model it has been observed that the shovel gets break due to impact force on the shovel of material En45 at very low speed. Accordingly I change the material of shovel Boron Steel it is suitable material for Shovel.

Modern engineering tools like CAD, CAM, FEM, QFD and RP etc are the powerful tools for the manufacturing of improved agricultural tools. By using CAD/CAM technology visualization, Color selection, checking interference between mating parts of an assembly, Modifying and improvement in the models of the

components become easy. Also this technology helpful in preparing detailed component drawings and assembly drawings. By using FEM technology it is possible to analyze correctly different type of stress which is going too developed on the product with the different loading condition. Also by applying this technology it is possible to overcome all the problem of intuitive manufacturing and produced the improved tools with good quality, improved life and cheaper in cost.

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