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STATIC STRUCTURAL ANALYSIS OF AN ADVANCED POWER TILLER CHASSIS AND CHISEL PLOUGH

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ABSTRACT

The rapid increase in industrialization and technology has shifted the agriculture sector into themodern era, which also resulted in labor scarcity and rise in investment. In developing countries like India, there are 89% of total land holdings of less than 3 hectares. A normal farmer can't afford the huge amount of labour and machinery, and to overcome this uncertainty, light duty agriculture vehicles are developed. In this paper, an advanced power tiller of 8HP power is designed and modeled. The main objective of this paper is to design the vehicle chassis and integrate various components, analyze the motion. In this paper, optimal design of a plough to be used is designed and modeled. For vehicle analysis and modelling, CATIA V5R20 and ANSYS 18.2 are used.

***KEYWORDS**: Industrialization, Advanced Power Tiller, CATIA V5R20 & ANSYS 18.2*

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Original Article

INTRODUCTION

India is major agricultural dependent and it needs development of modern technologies in this sector. Power tiller is engine operated equipment used mostly for bed preparation. They are very compact to handle and are used for medium duty machines. Power tillers presently manufactured in our country are of capacity 8 to 10 hp and have weight up to 400 Kg. The power tiller for this project is made of 8Hp mainly used for seedbed preparation; inter-row cultivation, pesticides spraying for various crops, water pumping & transportation. This project deals with the design of the chassis, plough and other components mounted on chassis. It also analyses the transmission from the engine to the various parts through belts, pulleys sprockets, and chains.

The power tiller is a single axle, self-propelled and self-powered tractor used for multipurpose tilling and other applications. The power tiller can pull and power various farm implements like a trailer, a plough, cultivator or harrow, various seeders, and harvesters. The operator walks behind it while in operation to maneuver it. The scope of this power tiller is used for seedbed preparation; inter-row cultivation, pesticides spraying for various crops, water pumping & transportation.

Figure 1: Advanced Power Tiller

LITERATURE REVIEW

Swapnil Kadu L [1] et al developed a power tiller with chain and sprocket for power transmission, whereas in other machines gears are used for cost reduction. Subrata Kr. Mandal [2] et al presented scope for power tillers to be used as seedbed preparation and inter culture operation in wide spaced row crops like cotton and sugarcane. Mahmood [3] et al designed a machine which would uproot the weeds and unwanted crops from the field completely and conducted a study on a self-propelled locally made rotary hoe to overcome a problem of frequent transmission failure. In this paper, static structural analysis of advanced power tiller chassis and chisel plough are carried out. Achyut S Raut [5] et al manufactured multifunctional agricultural machine and the performance of the machine was evaluated in order to find maximum field efficiency along with other parameter.

DESIGN CONSIDERATIONS

Transmission

The transmission system of power tiller uses a chain drive to transmit the power from engine to wheels. There are two stages of chain transmission sets for reduction of speed. The first stage has a transmission ratio of 2.57:1 as and the second stage has a transmission ratio of 2.87:1.

Material Selection by ASHBY Charts

ASHBY charts are most commonly used for selection of appropriate materials. The main goal of material selection is to minimize cost and minimize all product requirements. The function is the Beam in bending and shaft of torque transmission. Objectives are minimizing cost, minimize weight. To meet the required functions, two charts based on constraints and objectives are considered.

MODULUS(E) -RELATIVE COST ($C_r\,\rho$) and MODULUS (E) - DENSITY (ρ).

From the charts only two materials meet the requirements cast iron and mild steel. Based on the performance index Mild Steel is chosen as best suited material.

Design Optimization by Using TRIZ Principles

The TRIZ method uses a different approach to solve our problems to get an innovative solution. Contradiction matrix gives us the principles to solve the problem. The key requirements which we defined for our problem are: Reduce manpower and easy repair and maintenance. These requirements lead to contradictions which are solved to get an innovative solution suggested by TRIZ matrix.

After solving the contradictions the solutions TRIZ matrix obtained are as: Local Quality and Segmentation

- **Local Quality:** We made our power tiller to do more than one function as most of the conventional power tiller is designed only to fulfill one requirement. This makes the advanced power tiller to fulfill more than one useful requirement.
- **Segmentation:** In designing the power tiller every care is taken that each part should be easily dismantled without causing disturbance to other parts for repair and maintenance works.

MODELLING AND ANALYSIS

CAD Modeling in CATIA V5R20

The chassis and plough models are shown in the Figure 2 and Figure 3.

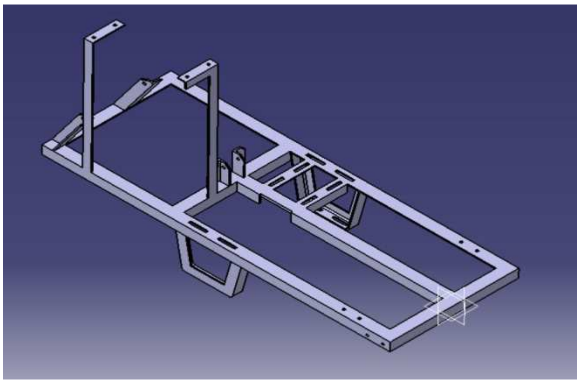

Figure 2: Chassis 3D Design for Power Tiller

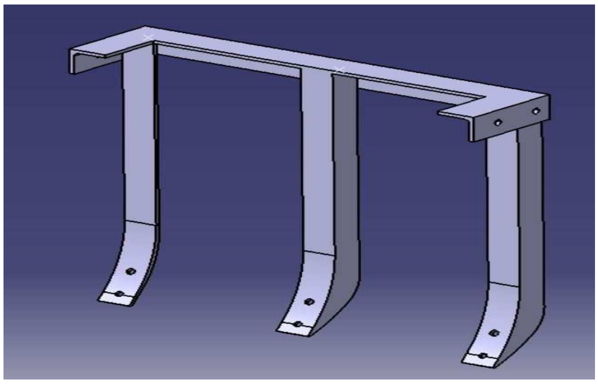

Figure 3: Plough 3D Design for Power Tiller

Table 1: **Meshing in ANSYS 18.2**

Properties	Chassis	Chisel Plough
Element shape	Tetrahedral	Tetrahedral
Element size	20mm	10 mm
Nodes	31205	20360

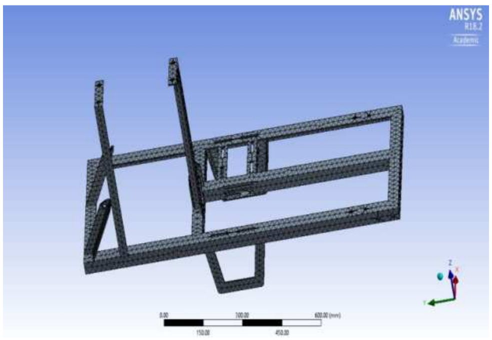

Figure 4: Meshing of Chassis

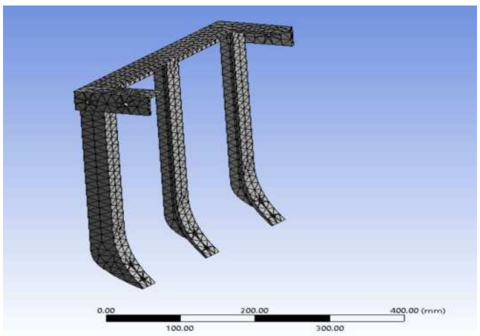

Figure 5: Meshing of Plough

Meshing of Chassis and Plough is shown in the Figure4 and Figure5.

Loads and Inputs

The first boundary condition for the chassis is shown in the figure 6. To the base of the Chassis, the wheels assembles are fixed. A load of 65N acts on the top of fuel tank mounting, a load of 450N acts at the engine mounting, and a load of 1000N acts on the entire frame. A standard gravitational force is being added to its own weight.

The second boundary condition is for plough shown in the figure 7. The sides of the plough top are fixed. A pull force of 500N acts in the direction of motion and a drag force in addition with frictional force acts in the down side of plough where chisel is attached. A standard gravitational force acts for its own weight.

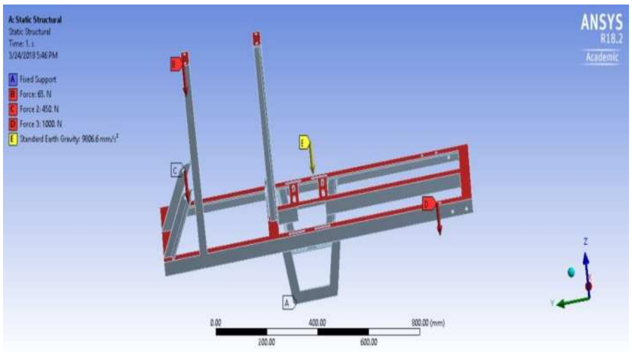

Figure 6: Boundary Conditions for Chassis

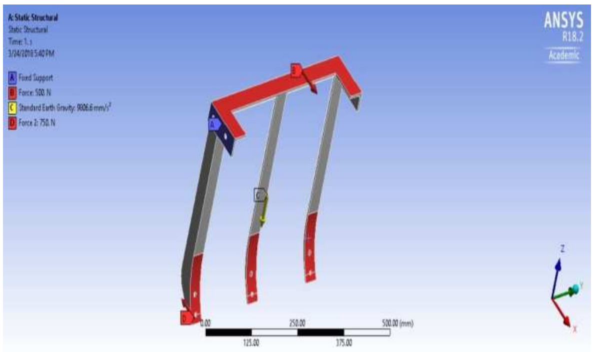

Figure 7: Boundary Conditions for Plough

Permissible Limits

The material selected is mild steel and the following are the properties of the mild steel.

Grade designation: E 350, Tensile strength= 490 N/mm^2, Yield Strength= 350 N/mm^2, Percentage of elongation = 22% of Gauge Length, Factor of Safety = 3.

For Equivalent Stress or Von Mises Stress the limiting value is the yield strength. The von Mises stress should be less than the Yield Strength for a safe design. For Maximum Principle Stress the limiting value is the ratio of Yield strength to the Factor of Safety (FoS). Maximum Principle Stress < 116.667N/mm^2. For Maximum Shear Stress the limiting Value is the ratio of Maximum Shear Stress to Factor of Safety. Maximum Shear Stress <58.33 N/mm^2.

RESULTS AND DISCUSSIONS

The main aim of static structural analysis is to find out the deformation and stresses developed in the structure under different loading conditions. These results depend upon the parameters like forces (gravitational and inertia forces), and some constraints applied to the body. The Equivalent Stress, Maximum Principle Stress, Maximum Shear Stress and Total Deformation are presented in the figures 8 to 15.

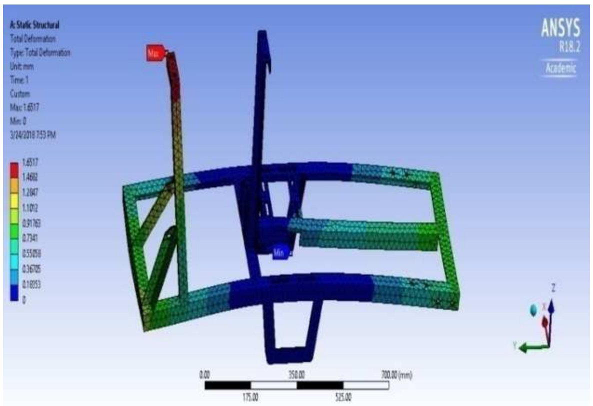

Figure 8: Total Deformation of Chassis

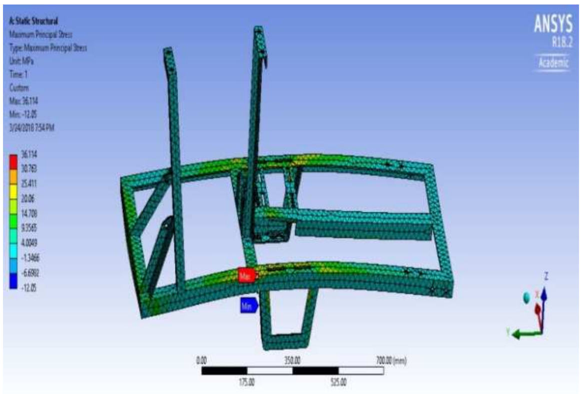

Figure 9: Maximum Principle Stress of Chassis

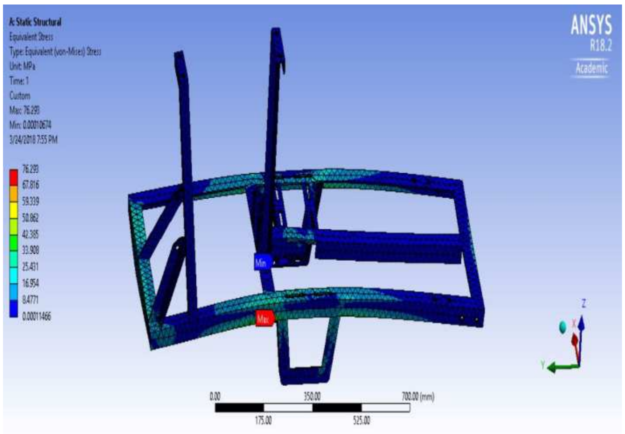

Figure 10: Equivalent Stress of Chassis

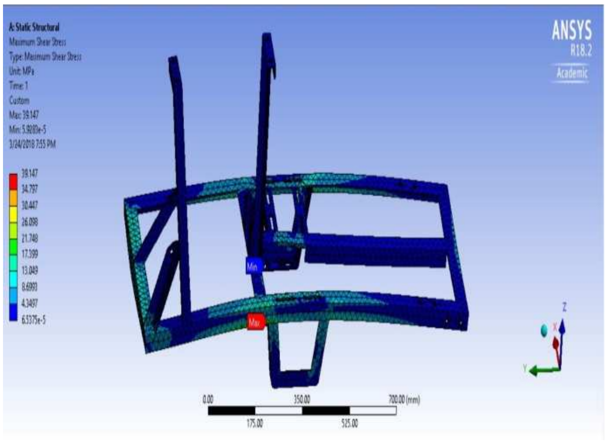

Figure 11: Maximum Shear Stress of Chassis

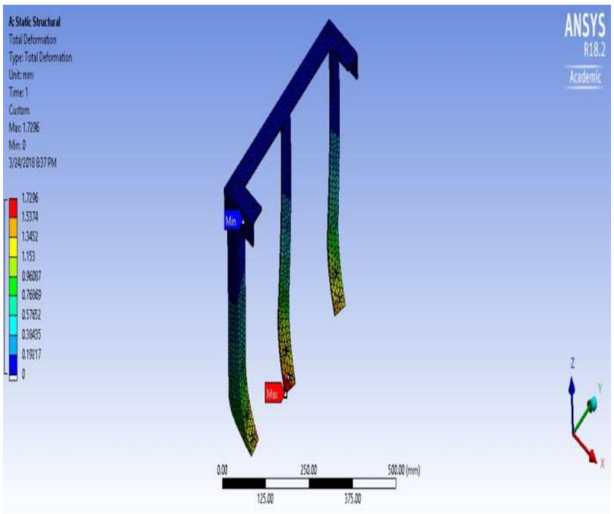

Figure 12: Total Deformation of Plough

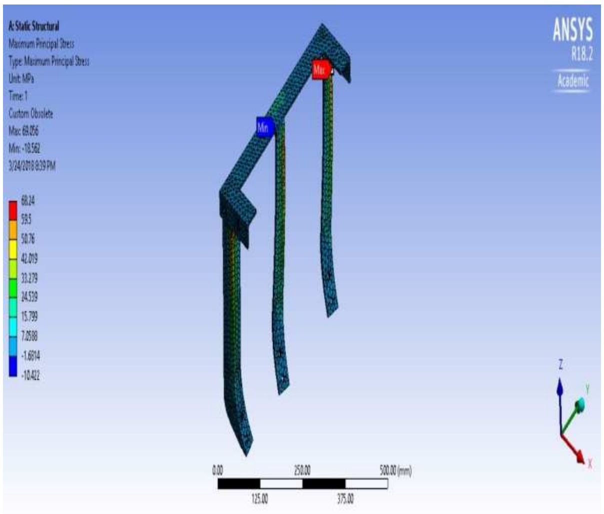

Figure 13: Maximum Principle Stress of Plough

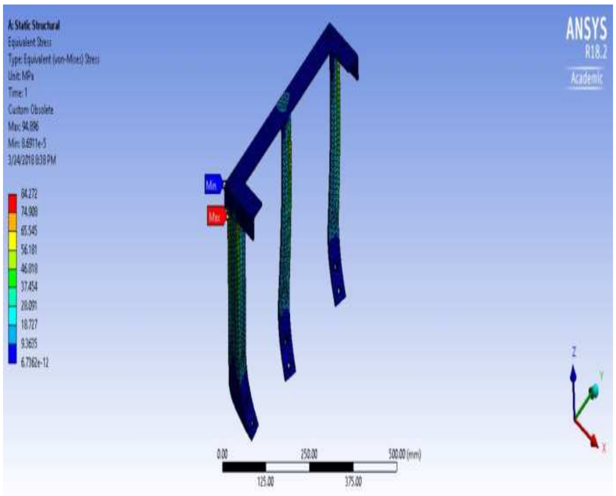

Figure 14: Equivalent Stress of Plough

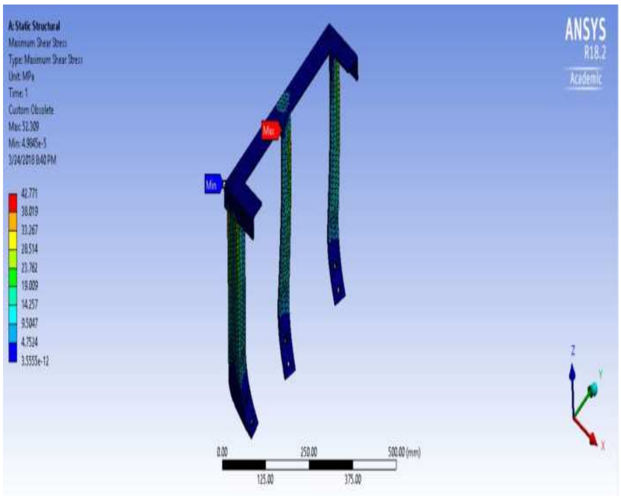

Figure 15: Maximum Shear Stress of Plough

Table 2: Results of Static Structural Analysis

Properties		Chassis	Chisel Plough
Total Deformation (mm)	Min	0	0
	Max	1.6517	1.7296
Maximum Principle Stress (N/mm^2)	Min	-12.05	-18.562
	Max	36.114	69.056
Equivalent Stress(Von Mises) (N/mm^2)	Min	$1.067\times10-^{4}$	8.69×10^{-5}
	Max	76.293	94.896
Maximum Shear Stress (N/mm^2)	Min	5.9283×10^{-5}	4.984×10^{-5}
	Max	39.147	52.309

CONCLUSIONS

In this paper, the best material is selected for design consideration using Ashby charts, and selected material is Mild Steel. The design is optimized using TRIZ approach. In this paper, static structural analysis of advanced power tiller chassis and chisel plough are carried out. The results are analyzed for Total Deformation, Maximum Principle Stress, Maximum Shear Stress, and Equivalent Stress in the static structural analysis. The total deformation of both chassis and chisel are less, sometimes it can be neglected. The stresses developed in the chassis and plough are analyzed and compared with the permissible stresses considering factor of safety of 3. It has been observed that all the stress is within the permissible limits. So the material selected for chassis and chisel plough is good and design of chassis and plough is safe in all the parameters of the design.

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