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Design And Analysis Of Plough For Agricultural Mechanized Robot

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Abstract : Many advances in technology have made the agriculture business a much less labor intensive industry. Farmers are looking for new ways to implement technology to cut costs and reduce labor hours. One of the ways that farmers are beginning to explore new technologies in farming come from the autonomous tractor. This kind of tractor uses RF technology which is something that is very new to the agriculture industry. RF Technology controls the movement of the tractor in multiple direction. The tractor does the work of ploughing, and seed dispensation simultaneously. In this present study a model of plough for the same mechanized robot is designed and analyzed under loading conditions for different materials. Finally the analysis results were compared and found galvanized steel as a best suitable material for plough as it is possessing good mechanical properties.

Index Terms - RF technology, plough, autonomous, deflection, yield strength.

1. INTRODUCTION

Agricultural robots are the fastest growing technology developed to perform various complex tasks that are difficult for humans to achieve. A single solution to implement precision agriculture is the development of a single gantry robot that can perform several precision agriculture related operations. The main objective of this system is to implement soil monitoring and precision irrigation on each crop, perform de- weeding and design a cultivated field using accurate robotic crop planning.

1.1 Literature Survey

Ming Li, Kenji Imou. et.al. has presented the brief review of research in agricultural vehicle guidance technologies. The authors propose the conceptual framework of an agricultural vehicle autonomous guidance system, and then analyse its device characteristics. [1] **Wang Yingkuan. et.al.** have reviewed a global develipment and research progress of precision maize planters. The article summarizes the precision maize planters currently available in the world and classifies them into four types: precision planters for tilled-land, minimum/no tilled-land, hilly & small land, and cold & arid land. Detailed characteristics and comparisons have been provided for some typical precision planters. [2] **M.W.VanLiew. et.al.** studied the impacts of future climate change scenarios on streamflow, water quality, and best management practices (BMPs) for two watersheds in Nebraska, USA. Findings from this study suggest that under the three future climate change scenarios, sediment losses are expected to be about 1.2 to 1.5 times greater than the baseline condition for Shell Creek and 2 to 2.5 times greater for Logan Creek; total N losses are expected to be about 1.2 to 1.4 times greater for Shell Creek and 1.7 to 1.9 times greater for Logan Creek. [3] **Log. et.al.** Studied and made the comparison between various image edge detection techniques used in quality inspection and evaluation of agricultural and food products by computer vision. Also the comparative analysis of various image edge detection techniques is presented. The software is developed using MATLAB 7.6. It has been shown that the Canny's edge detection algorithm performs better than all operators[4].

1.2 Agricultural Component For Analysis

Plough

A **plough** is a tool used in farming for initial cultivation of soil in preparation for sowing seed or planting to loosen or turn the soil. Ploughs are traditionally drawn by working animals such as horses or cattle, but in modern times may be drawn by tractors. A plough may be made of wood, iron, or steel frame with an attached blade or stick used to cut the earth.

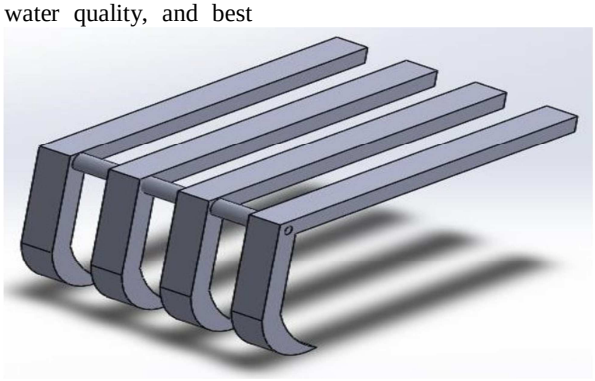

Figure 1.1: Plough model made in solid works

In this present study plough is considered to be a main component of agricultural mechanized robot. The plough is designed for the maximum loading conditions and structural analysis is made for the stress and deflection parameters for the same loading condition.

Solid Works is the software used to analyze and run the simulation for the design considerations. Currently used version is Solid Works 2015×64 edition. This designing platform provides various options for designing of 2D and 3D sketches along with part and assembly drawing features. We can also run simulations like flow simulation, analysis of stresses and strains, inspections of the materials used and many more tools for designing.

2. DESIGN AND ANALYSIS OF PLOUGH

2.1 Plough Design And Modeling

Design parameters and Dimensions

Load	= 300kg
Load on each plough	= 300kg
Distance between ploughs (L_r)	= 1000mm
Distance between Plough and Seeder shaft (Lb)	= 630mm
Total frame dimensions	= 3000x2000x100 mm

Plough Dimensions

length	=1200mm
breadth	=100mm
thickness	=100mm
Radius of curvature for the plough edge	
internal	= 360mm
external	=240mm

The 3D model is developed using solid works tool with the reference of above design criteria. Below figure shows the 3D model of assembly

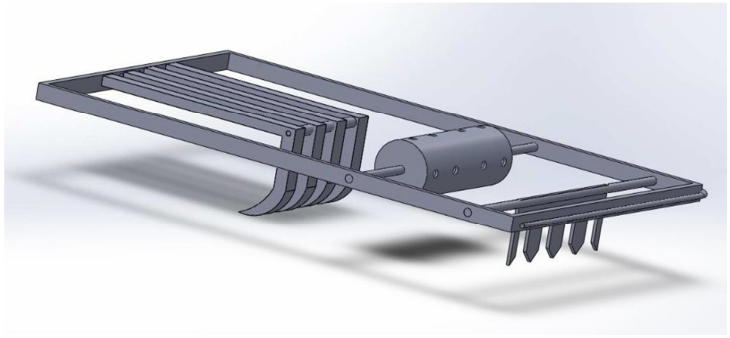

Figure 2.1: Isometric view of plough in the mechanism frame

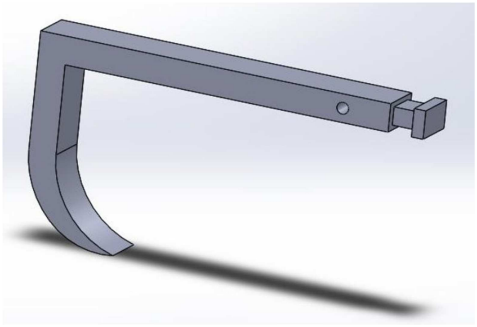

Figure 2.2: Single Plough

2.2 Structural Analysis Of Plough

Static analysis on plough assembly is to check the High Stressed locations and displacement of the plough section attached to a fixed end.

Forces description

The total forces applied on a plough are at its tip of the plough. This load is cause by the soil and there is a bending moment generated in it. There are a total forces of 1000N to 10000N load variations are applied. A total material variety of three are taken into consideration. Materials like Wood-Balsa, Alloy Steel and Galvanized steel are used for the analysis of the plough.

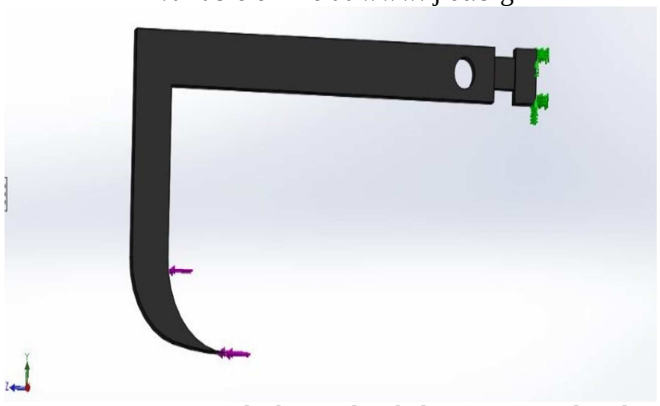

Figure 2.3: Forces applied on a Plough during structural analysis

3. RESULT AND DISCUSSION

Following are the cases considered for the static analysis of the plough.

3.1 Wood Balsa Based Plough

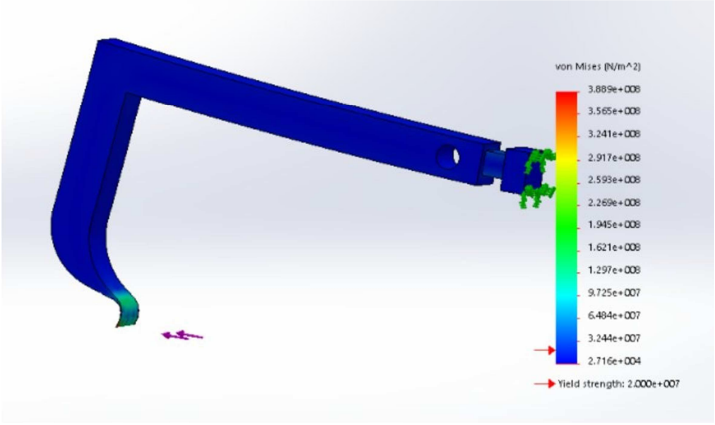

Figure 3.1: Stress for Wood Balsa based Plough

The analysis results showed the total deflection of 14.5mm and the tip got deformed at 3000N load. Yield Strength is found as 20MPa. Here in this analysis of wood-balsa it doesn't have any elastic properties, but deflection does occur in it. The results are tabulated below

Table 3.1: Analysis Data for Wood-Balsa

S.No	Load (N)	Von Mises Stress (MPa)	Strain	Deflection (mm)
1.	1000	18	0.0008	0.15
2.	2000	32	0.0010	0.30
3.	3000	97	0.0013	0.45

3.2 Alloy Steel Based Plough

Below figure shows the static analysis results for alloy steel based plough

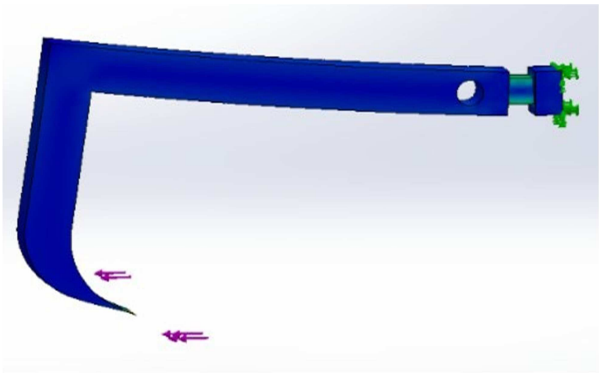

Figure 3.2 Stresses in plough made with Alloy steel

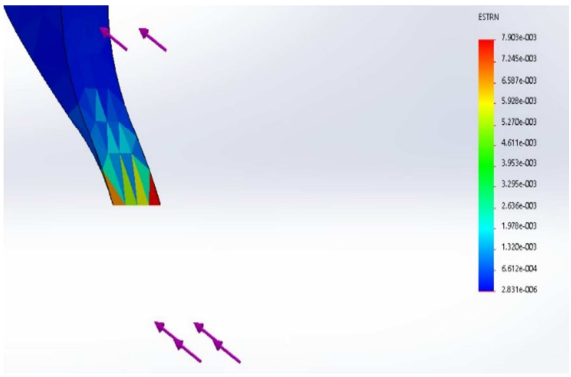

Figure 3.3 Strain in plough made with Alloy steel

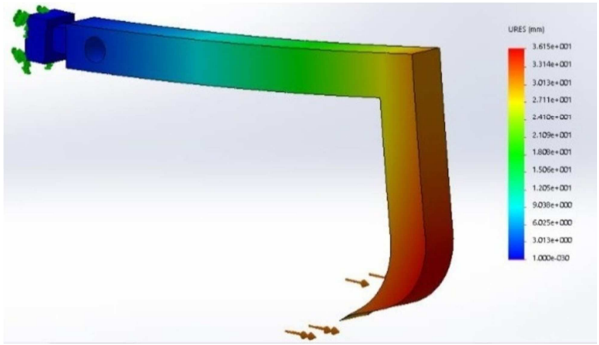

Figure 3.4 Deflection in plough made with Alloy steel

For the given loading condition on plough made with Alloy steel the Yield Strength is found as 155.8MPa. For the material the deforming load is 8000N and the maximum deflection noticed is 13mm. the results are tabulated below.

Table 3.2 : Analysis results for Alloy steel based Plough

S.No.	Loads(N)	Von Misess Stress (MPa)	Strain	Deflection (mm)
1.	1000	21	0.0012	0.6
2.	2000	43	0.0016	1.3
3.	3000	55	0.0019	1.8

3.3 Galvanized Steel Based Plough:Below figure shows the stress, strain and deflection analysis results for Galvanized steel based plough under given loading conditions

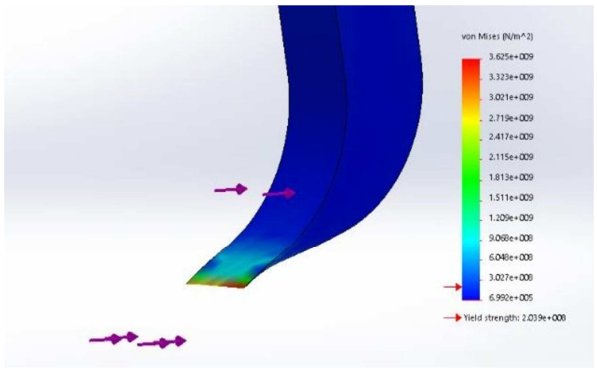

Figure 3.5 Stresses in plough made with Galvanized steel

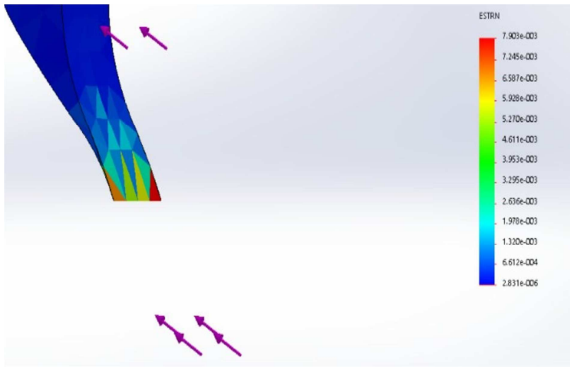

Figure 3.6 Strain in plough made with Galvanized steel

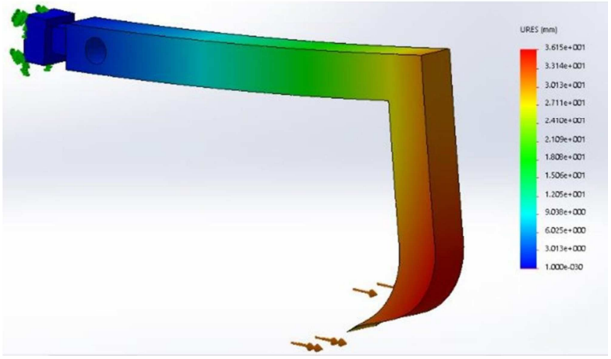

Figure 3.7 Deflection in plough made with Galvanized steel

For the given loading condition on plough made with Alloy steel the Yield Strength is found as 203.9MPa. For the material the deforming load is 1500N and the maximum deflection noticed is 13mm. the results are tabulated below.

Table 3.3 : Analysis results for Galvanized steel based Plough

S.No	Loads(N)	Von Mises Stress (MPa)	Strain	Deflection (mm)
1.	1000	3.2	0.0001	0.01
2.	2000	10.7	0.0009	0.097
3.	3000	17.9	0.0013	0.156

3.4 Result Comparison

The below plotted graph and the table gives the comparison of analysis results between different material based plough.

Table 4.4 Analysis result comparison

S.No	Material	Max. Load(N)	Von Mises Stress (MPa)	Strain	Deflection (mm)
1.	Wood- Balsa	3000	97	0.0013	0.45
2.	Alloy Steel	8000	169	0.004	3.8
3.	Galvanized Steel	15000	215	0.007	4.5

From the above table it can be observed that the load value for three material is varying for the certain value of yield stress and deflection. For Wood-Balsa it's deformation and deflection taking place at 3000N, for Alloy Steel deformation and deflection taking place at 8000N load and for Galvanized Steel it's deformation and deflection taking place at 15000N load.

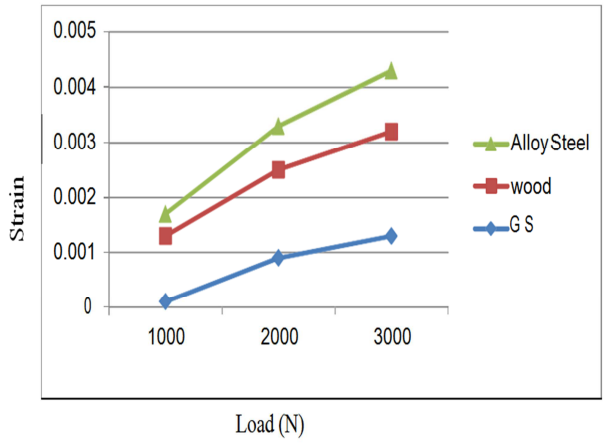

Figure 3.8 Graph

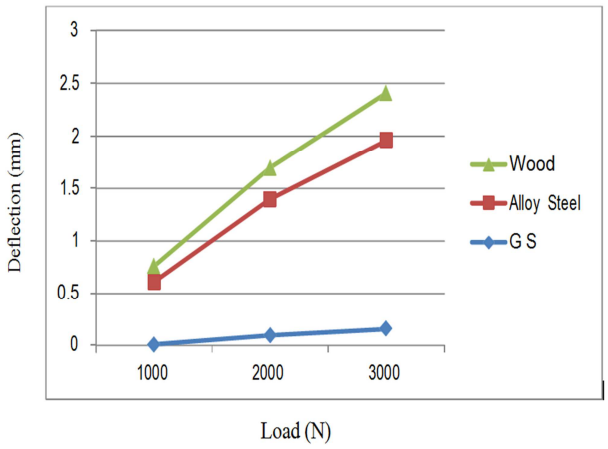

Figure 3.9 Graph of Load (N) vs Deflection (mm)

of Load (N) vs Strain

Above graphs shows the comparing between the results obtained from static analysis for plough with different material. As per the observation from the graph Galvanized Steel based plough bearing a good Yield Strength and low deformation at 15000N load, which is most preferable.

4. CONCLUSION

Present development of agriculture mechanized robot is a semi-automatic mechanism which is semi controlled by an operator, where as the ploughing, seeding, straightening and watering to soil are done automatically. Development of such robot reduces the man power involvement in the process and complexity compared to conventional agriculture. In this present study plough is considered to be a main component of agricultural mechanized robot. The plough is designed for the maximum loading conditions and structural analysis is made for the stress and deflection parameters by varying the material. As per the analysis results Galvanized Steel based plough bearing a good Yield Strength and considerable deformation of 13mm at 15000N load, which is most preferable material for plough manufacturing.

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