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Design, Development and Operation of 3.5HP Power Tiller

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Abstract: **A power tiller is a mechanized agricultural implement popularly used to save time, human efforts and fuel in preparation of soil bed. In this paper presents the design and fabrication of maintenance free and efficient 3.5HP lightweight power tiller. However, under complex abrasive environment, tiller blades are subjected to extreme surface wear, particularly in dry sand which considerably affects its service life. Our aim of this paper is to improve service life of the tiller blade. Working of transmission system is based on chain sprocket mechanism to reduce cost. Different component of machine are modeled by using modeling software CATIA V5R21. The developed model is useful for agricultural industry especially developing countries.**

Keywords: **Soil bed, Power tiller, Blades, Chain Sprocket Mechanism, CATIA V5R21.**

1. INTRODUCTION

India being farming major, the need for modern technologies in agriculture routines is undisputed. Power tiller are engine operated low power machine used for bed preparation. They are compact, handy and medium duty machine. Currently, power tiller of capacity 8 hp-10 hp and weighting up to 350 kg are widely manufactured across the country. The power tiller presented in this project is a 3.5 hp power tiller specializing in weeding operation, suitable for black soil of sugarcane cultivation. This project deals with design and development of Chain and Sprockets, Shafts, Belt Drives, Bearing, Transmission Case and Chassis etc. to change the engine speed to tilting speed of the Power Tiller.

This machine is specifically for sugarcane cultivation requirement and can be used for black moist silted soil. The trials performed showed considerable saving due to use of power tiller over men.

At present, most of the power tiller manufactured in the country are in the range of 8-10 hp and weight about 350 kg. The power tillers are not potentially used in hilly areas due to the lack of its maneuverability on slopes. This is primarily due to its heavy weight, which needs to be optimized further Therefore it is felt necessary to develop a lightweight power tiller fitted with 2-4 hp engines. Considering all these factors, and as a small effort towards mechanizing agriculture and helping the 60% Indian population who depend on agriculture for their livelihood and to encourage their share in developing our economy.

This power tiller that we present here in this report is meant for operation of weeding in sugarcane farms with minimum inter row distance of 1.2 meters. This machine is easy to operate, cheap, portable and simple in construction and maintenance with easily available spare.

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Figure 1: Overview of power tiller

2. SELECTION FOR POWER TILLER

Selecting and designing of power tiller is an important activity in the design of power tiller. It requires highly expert person for design task. Power tiller consists of various components such as transmission case, engine, blades, handle, etc.

2.1 Selection and modification of transmission system:

Transmission system is one the important part of power tiller. It acts as a main driving mechanism which consists of chain sprocket mechanism. Following figure 2 shows block diagram of transmission system.

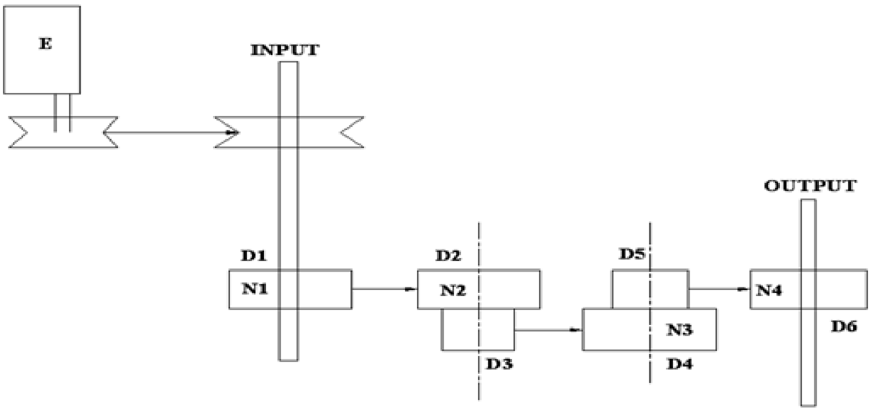

Figure 2: Three stage chain sprocket mechanism

Instead of gear drive, we decided to use a chain drive for speed reduction to reduce cost and make the machine compact. It is three stage speed reduction mechanism in which speed is reduced from 3000rpm to 150-200rpm.To obtain required output we used one input shaft ,two intermediate shafts and one output shaft, belt. The selection of diameters for sprocket is done by trial and error method.

2.2 Selection and design of transmission case and chassis:

Transmission case is made out of M.S sheet, 2 mm thickness by press bending process. The designing is done by judgment and virtual trial and error method. The dimensions and shapes of chassis are made by considering assembly of transmission case, shaft and engine positions and the handle bar positions. Design is done by judgment and virtual trial and error method.

2.3 Selection and modification of blades:

According to various soil conditions, a stress on blades varies and they affect tillage performance and blade life. For all rotors, experimental results showed that the mean soil clod diameter decreased and soil inversion increased with increasing rotational speed of the rotor. Therefore rotary blade with 45^0 lengthwise slice angle and 4cm tilling width of blade was selected.

Following figures shows blades with varying slice angle:

Fig 3: Blade with 15^0 slice angle

Fig 4: Blade with 30^0 slice angle

Fig 5: Blade with 45^0 slice angle

2.4 Selection of material for different components:

Abrasive wear is major cause for the premature failure of many agricultural ground tools especially engaged in some dry land agricultural areas. Heavy agricultural equipment operators and farmers always faced with the frequent labour. Equipment downtime and reinstating costs of warn out earth engaging component. The tillage capacity of the warn out tools decreases whereas the fuel penalty increases. To getting required strength and tillage capacity we select EN42J material for blades. In whole frame design of power tiller, to reduce weight and cost we select mild steel.

In transmission system, there is high bending stress induced during tillage operation. Hence to avoid bending failure we select EN9 material for all shafts in transmission mechanism.

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3. MODELLING OF POWER TILLER

3.1 Design consideration for power tiller:

Design of transmission system is trial and error approach. It require to take various decision during designing power tiller such as transmission case, chassis, shaft, drive mechanism, control architecture, autonomy, operation features, cost, robust.

3.2 CAD Modeling of different parts of power tiller:

Thus the different part models of power tiller are as follows:

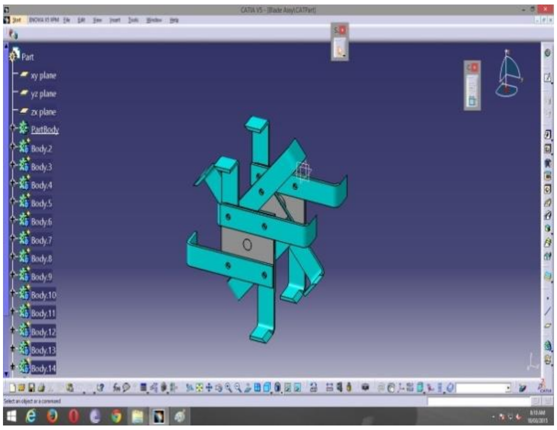

Fig 3: 3D view of Blade

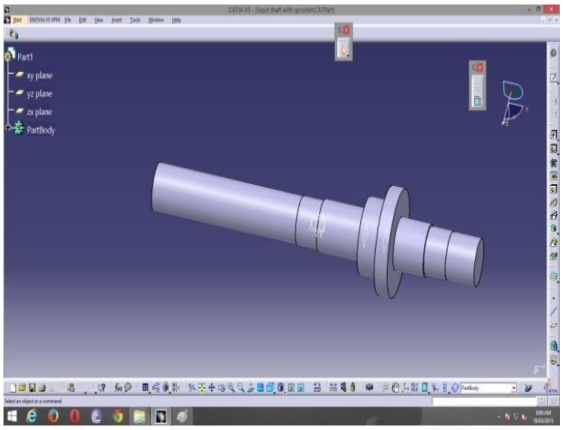

Fig 4: 3D view of input shaft

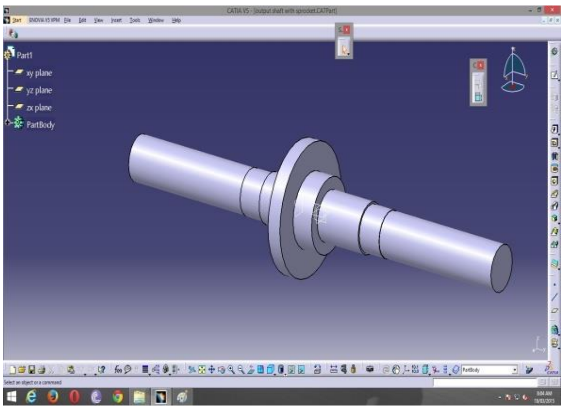

Fig 5: 3D view of output shaft

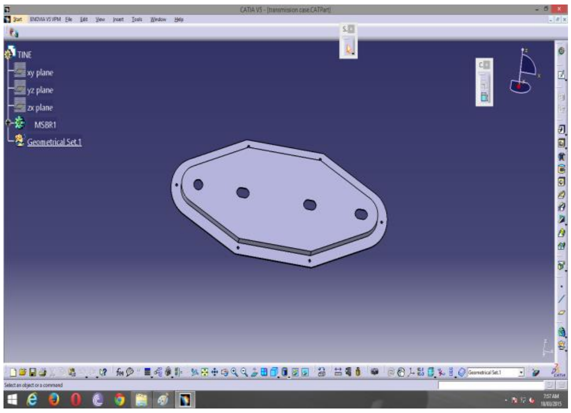

Fig 6: 3D view of transmission case

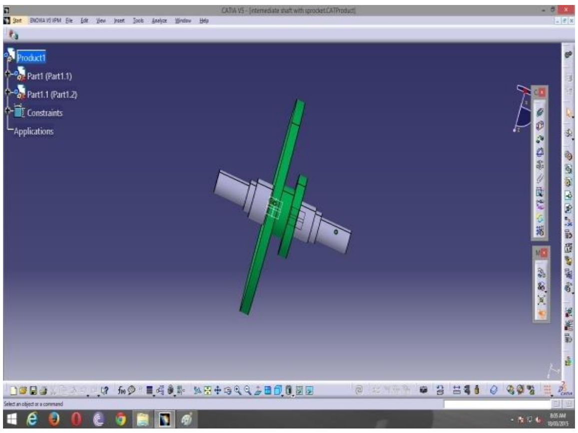

Fig 7: 3D view of intermediate shaft

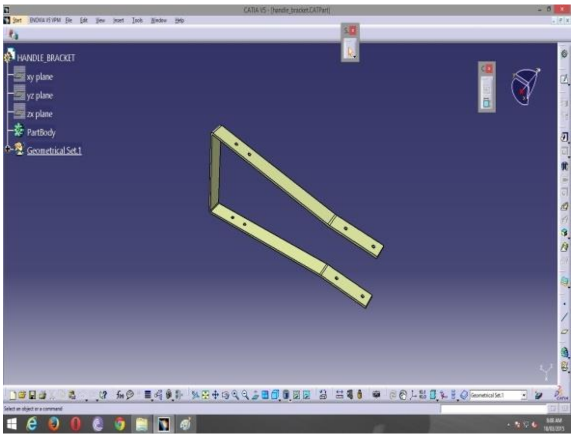

Fig 8: 3D view of handle bracket

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4. FE ANALYSIS OF POWER TILLER

The designs of parts are analyzed by using Ansys to calculate the stresses of the system based on the material, fixtures, and loads. A material fails when the stress reaches a certain level on the material strength because each material has different stress levels. Ansys uses linear static analysis, based on the Finite Element Method, to calculate stresses. Linear static analysis makes several assumptions to calculate stresses in the part.

Stress is used to measure the strength of a material in how the material can stand without undergoes on physical change when pressure or force is applied. The formula used to calculate the stress is σ=F/A , which is F is force and A is cross sectional area. In addition, stress is dividing into two types that are tensile strength or known as fracture stress and yield strength or known as yield stress. Stress will cause strain which is the stretched of the object. The formula for strain is $\varepsilon=\Delta L/L_0$, which is L_0 is the original length and ΔL is the different of length stretched. The relation between stress and strain will obtain Young's modulus in order to measure the stiffness of a material. The formula is given by E= σ/ε with units as N/m² or Pa.

Following figures shows the total deformation and stress acting on different parts of Power tiller.

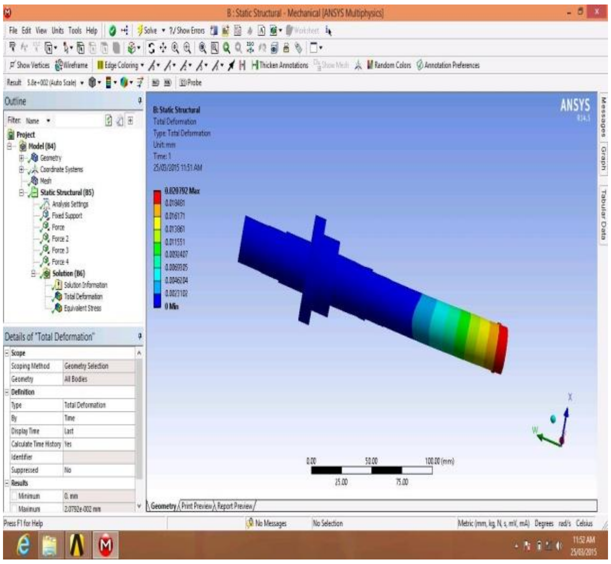

Fig 9: Total Deformation of input shaft

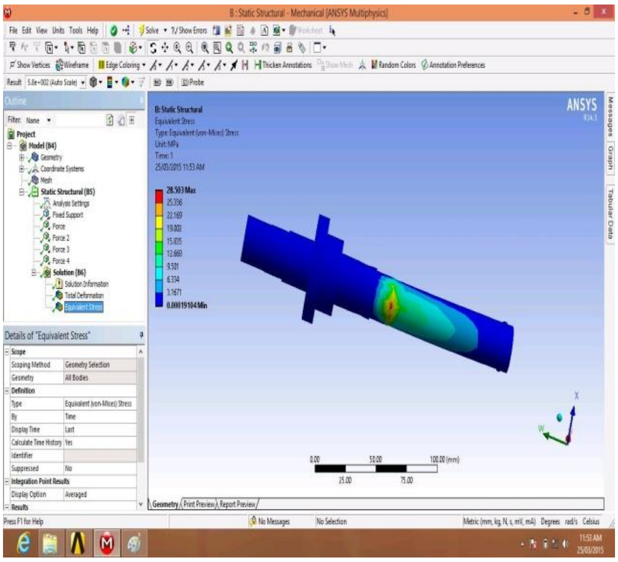

Fig 10: Stresses on input shaft

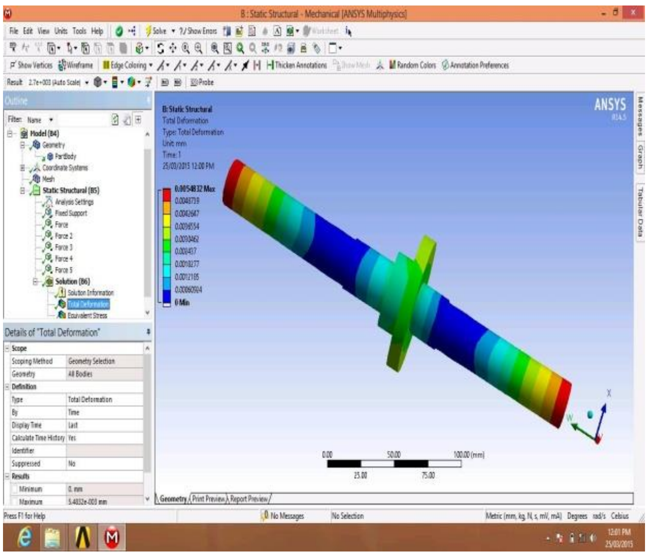

Fig 11: Total Deformation of output shaft

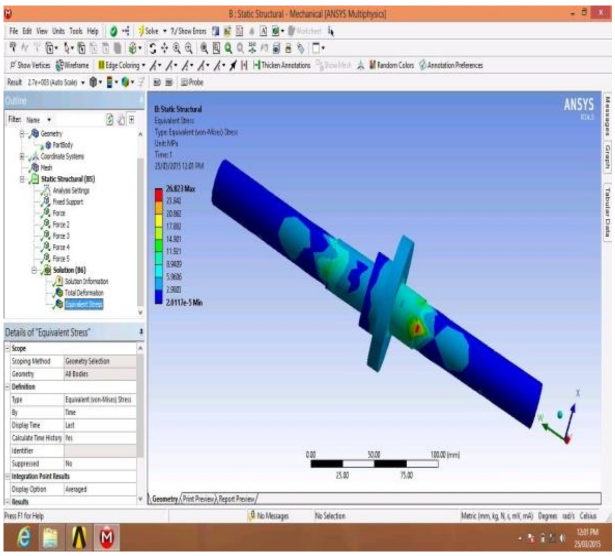

Fig 12: Stresses on output shaft

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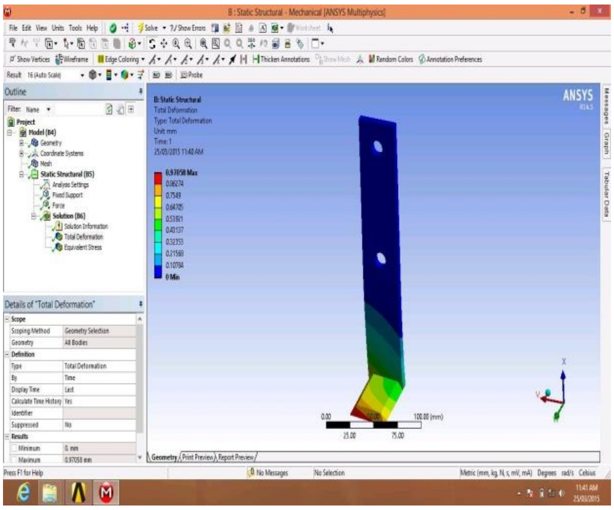

Fig 13: Total Deformation of blade

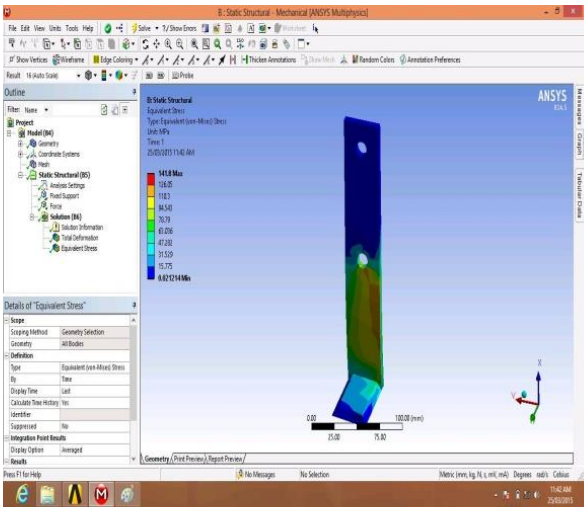

Fig 14: Stresses on blade

5. VALIDATION

The test where conducted in dry-land field of clay loam with soil moisture content 16.04% (d.b)

And dry bulk density of 1.51g/cm^3 at different rotational speeds of 300,350,400 rpm at one and two tilling passes. Blade can sustain that load and test is successfully carried out.

6. CONCLUSION

In this machine chain and sprocket are used for power transmission whereas in other machines gears are used for cost reduction. As machine is simple in construction, accurate manufacturing and standard components are used, so machine required less maintenance. As machine is developed by sheet metal formation hence weight of the machine is low. There are no casting parts. It is designed on the basis of optimum material consideration. The working capacity of this machine is 2.5 Acre per day. It requires 10 liters of petrol per day for the operation. Single operator can operate this machine easily.

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