POWER PLOUGH 2.0

A final year project report

Presented to

SCHOOL OF MECHANICAL AND MANUFACTURING ENGINEERING

Department of Mechanical Engineering

NUST

ISLAMABAD, PAKISTAN

In Partial Fulfillment

of the Requirements for the Degree of

Bachelors of Mechanical Engineering

by

Hamza Khalid

Zaigham Naseeb

Zunair Zaheer

June 2017

EXAMINATION COMMITTEE

We hereby recommend that the final year project report prepared under our supervision by: Engr. Muhammad Naweed Hassan. Titled: "Power Plough 2.0" be accepted in partial fulfillment of the requirements for the award of Bachelors of Mechanical Engineering degree.

Supervisor: Engr. Muhammad Naweed Hassan DD MRC, SMME, NUST	______________________ Dated:
Committee Member: Dr. Mian Ashfaq Ali SMME, NUST	______________________ Dated:
Committee Member: Hafiz M. Abd-ur-Rehman SMME, NUST	______________________ Dated:

______________________ ____________

(Head of Department) (Date)

COUNTERSIGNED

Dated: ________________ __________________________

(Dean / Principal)

ABSTRACT

The aim of this project was to further develop the attempt to create a light-weight, two-wheel mini-tractor which could be used for ploughing in upland farms.

This project aims to develop a prototype that is low in cost and effective in functionality for the wider ploughing needs of the small-scale upland farmer in Pakistan. The project began with a comprehensive study of foreign models of existing light-weight tractors and a study into the mini-tractor developed by students of SMME two years ago. It takes on an entirely new approach to the design.

After the study, aggressive design parameters were set in accordance with the power requirements of common farmland. Initial market surveys were conducted to assess the availability of the required components. The design was finalized after following an iterative method. The respective design iterations were created by the dictations of physical availability of space and stress loadings. Following the approval of the final design, components procured from markets in Rawalpindi and Lahore.

The fabrication part of the project was carried out mostly in DMRC, SMME. Various manufacturing techniques were used to fabricate the prototype. The fabrication was followed by successful testing of the prototype.

PREFACE

NUST and the Government of Pakistan has invested money and resources into developing SMME as a world class institution and we see ourselves as the product of that investment. We feel it is our responsibility to apply the engineering knowledge taught to us into formulating solutions to real life problems. This project is a part of those wider efforts to give back to the society.

Work carried out towards the completion of this project is motivated by the desire to manufacture a prototype that leads to a product that could provide a solution to a common problem faced by thousands of farmers in Pakistan.

This project is a brainchild of Col. Naweed Hassan. Our group has been very fortunate to have received his guidance during all phases of this project.

Credit also goes to Mr. Ali Azfar, Mr. Ahmed Hassan Kamal, Mr. Zia Shahid and Mr. Abdul Rafay whose work in the previous effort to create a light-weight mini-tractor served as a yardstick and a guiding point during our research and design approach.

ACKNOWLEDGMENTS

Firstly, we would like to thank Allah Almighty and His never ending blessings bestowed upon us that gave us the platform, energy and the resources required to carry out this project. Nothing would have been possible without His support.

Secondly, we would like to acknowledge the support of SMME that helped us during the way. From the selection of this project down to its successful execution, SMME has always had our back. It has provided us with all the guidance, the technical support and the motivation needed for the completion of this project.

Thirdly, we would mention the single biggest reason for the success of this project; our supervisor, Col. Naweed Hassan. His exemplary attitude towards nudging us on the right paths when required and pushing us through walls when required was the biggest reason our project has managed to stay on track and on time.

Fourthly, for all the help extended to us by SMME faculty, especially by Dr. Mian Ashfaq, and by the technicians working in DMRC, we are eternally grateful.

Finally, we would like to thank our parents whose unwavering support has always been a constant through ups and downs that come with a project like this.

COPYRIGHT

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

PTO- Power Take Off

HP- Horsepower

3D- Third Dimensional

PKR- Pakistani Rupee

PSI- Pounds per square inch

RPM- Revolutions per minute

ASTM- American Society for Testing and Materials

FOS- Factor of Safety

CHAPTER 1

INTRODUCTION

Single-axle two-wheel mini-tractors are commonly used for small scale farming needs worldwide. These mini-tractors have two primary advantages:

1. They are significantly cheaper than full sized tractors.
2. They are much more mobile than full sized tractors.

The profile of such a tractor which is smaller in size, cheaper in cost and more mobile is remarkably similar to the kind of ploughing machine required in the mountainous regions in the north of Pakistan. Since the fields in the north are small in size due to mountainous terrain, a smaller tractor has the potential to fulfill the smaller ploughing needs relative to fields in plains.

Similarly, the average farmer in the northern regions is poor and owns only a small piece of land. Buying a full-sized tractor is neither affordable for him nor is it according to his custom requirements.

However, the biggest problem that renders full sized tractors unsuitable for upland farms is a lack of accessibility. Routes leading to upland farms are often nothing more than a narrow path up a mountain and these paths often have obstacles like streams and ravines in the way. Since any large tractor would need a paved road to traverse the distance, these farms are inaccessible for all major tractors.

Due to all of the above factors, the poor farmers of the north resort to archaic methods of ploughing. Either domesticated animals are used or ploughing is done by hand. Both these methods are inefficient and take up a large amount of time and effort.

This project aims to develop an indigenous mini-tractor that can fulfill the needs of the poor farmer in upland farms.

This project is the second phase of the attempt to design and manufacture a light-weight mini-tractor. The first attempt was carried out two years ago by final year mechanical engineering students from ME-03, SMME.

The first attempt was a partial success. The efforts did yield a working prototype that was well engineered and worked as required. However, there were a few shortcomings:

1. It had a dry weight of 160 kg. This weight is lower than many other mini-tractors but still is not low enough for the mini-tractor to have enough mobility for the mountainous paths.
2. It was powered by a 6.6 hp diesel engine. This is relatively underpowered and would only be provide enough draft force in the most ideal of conditions.
3. The cost was upwards of PKR 100,000/-. This is again a good achievement but it is possible to bring it down even further.

These shortcomings made it necessary for another effort towards the completion of the goal. We were informed of this during our first meeting with our supervisor and after initial studies, we set ourselves some ambitious targets.

1. The weight was to be reduced to under 100 kg.
2. The cost was to be pulled down significantly.

We also wanted to make the mini-tractor more powerful to compete with the more powerful, foreign models in the market.

Since it was the second attempt, some guidance was picked up from the earlier attempt. However, the flaws in their prototype did not allow us to use any of their hardware in our mini-tractor. As a result, a completely fresh approach to design was taken and every single bit of our prototype is either procured from the market or fabricated by us.

Organization of the report

This report details the work done towards the completion of the project.

The first chapter introduces the project. The motivation to do this project is discussed and the previous attempt is analyzed and its shortcomings stated.

The second chapter is the literature review. It is a review of the work already done on similar projects. A few of the models manufactured by foreign companies are discussed and the previous attempt by SMME students is critically analyzed.

In the literature review are also discussed the research papers studied and used to calculate ploughing requirements. Other research papers which were used as reference for design and analysis are also reviewed in this section.

The third chapter introduces the methodology used to design and fabricate the mini-tractor. The process to determine the design parameters is stated followed by calculations to determine the required power.

Next step during design process was to select the components from the market and to design the chassis around it. Design of frame, plough and the various smaller parts that were used to interface the procured components is discussed in this section.

3D modeling to showcase the prototype design and to carry out stress analysis using software is also shown in chapter three.

Chapter four consists of the results of our project. The final prototype is shown in pictures and its features set against the earlier project prototype and the models in the market.

Chapter five discusses concludes the project and suggests recommendations to take it forward for commercialization.

CHAPTER 2

LITERATURE REVIEW

As mentioned before, this idea of a mini-tractor for small scale ploughing needs is neither new nor revolutionary. Mini-tractors similar to our requirements already exist and are manufactured by companies in Germany, USA and China. However, these models are not targeted at the Pakistani market and thus are not available here. Even if a few of them do make their way into our country, they are priced too highly against their manufacturing cost.

But since these models are very similar to what we are trying to achieve, we carried out a study of these models for guidance in our project.

Most of these light weight models are similar in their basic design philosophy. They are designed to be operated by an operator who walks with the tractor during operation. They are all engine powered with the engine sitting on a mount as close to the wheels as possible. The power transmission mechanism from the gear train down to the wheels is kept as simple and compact as possible to minimize weight and to eliminate complexities. The weight is distributed as evenly as possible around the wheels of the tractor to ensure that minimal effort is required to life the handle into the operating position. In cases where other design features do not allow an even weight distribution, a third wheel is often added to ensure that the operator does not have to lift too much weight during operation.

In some cases, plough is made detachable and other accessories like disc harrow, rotary tiller and harvesters can be attached for diverse functionality.

Summary of existing foreign mini-tractors

A few pictures of these foreign models are shared below along with their salient features:

Figure 1- Agria 3600

Table 1- Agria 3600 Product Features

Engine	Robin EH 17 1-cylinder-4-stroke-petrol engine 4.0 kW (6.0 DIN-PS)
Speeds	F: 0-6 km/h; B: 0-4 km/h
	Forward: 1.3; 2.4 and 7.0 km/h, Backward: 2.1 and 3.6 km/h
Gears	Pinion shift gearbox 4-shifts, 2 forward/ 2 backward
	Step less hydrostatic traction drive with one-disk dry clutch
Handle bar	Adjustable in height and lateral without tools, vibration-cushioned
	Turn able by 180°
Steering	Single wheel steering
Standard Equipment	Hand launching
Weight	62.5 kg

Figure 2- Walking Tractor DF-12

Table 2- Walking Tractor DF-12 Features

Engine	S195
Rated power	12 hp
Rated speed	2000 rpm
Type	Single cylinder, horizontal, 4 stroke, hopper water cooled diesel
Walking speed	Forward: 1.4, 2.5, 4.1, 5.3, 9.4, 15.3
	Reverse: 1.0, 3.8
Net weight	130 kg

Overall dimensions (LxWxH)	2680x960x1250 mm
Ground clearance	182 mm

These mini-tractors serve both as a benchmark for our own design while also as a reference against which we can assess the performance parameters of our own mini-tractor.

Mini-tractor made by ME-03 students

The other product that we wanted to assess our mini-tractor against is the one made by students of ME-03. A picture and some product features of their mini-tractor are added below:

Table 3- Mini-tractor (made by ME-03 students) Features

Engine	Diesel engine R175a, 7 hp
Gears	Forward 4, Reverse 1
Start	Hand Crank
Turn	Turn able
Clutch Type	Pressure Plat Type
Weight	160 kg

Figure 3- Mini-tractor (made by ME-03 students)

The existence of such tractors begs the question about the need of developing a similar tractor here. The reasons are:

1. The foreign made tractors are very expensive, upwards of PKR 100,000 /-.
2. These tractors are not easily available in the market. Availability of spare parts is also an issue.
3. Any buyer has to face waiting times of many months if these mini-tractors are bought from retailers from abroad.

In light of these problems, a locally made indigenous mini-tractor that fulfills the local demand at a lower cost and easy availability is the need of the hour.

Locally manufactured machinery would also reduce our import bill, a major portion of which goes towards machinery imports, while increasing agricultural productivity which would reduce the disparity in foreign exchange expenditure and earnings.

Draft Force/engine power calculations

We have worked on the design of our mini-tractor from the very basics. The first step towards design is to work out the requirements according to the application of the machine. The primary application of the mini-tractor is to plough fields. For ploughing, a force is required which is exerted by the plough on the soil. This force is called draft force.

The calculation of required draft force is a complex science. However it has been analyzed and its calculation simplified by previous work. We have made use of this previous work to estimate the required force in the context of soil in a farm and have designed the tractor from there. [4]

The paper referred to above is about calculation of required horsepower from a tractor while considering factors including but not limited to soil type, number of wheels of the tractor, plough type, plough size and depth of ploughing.

Details of the work done to predict draft force in common farmland situations are mentioned in the next section of this report.

Summary

For this project, we have studied and reviewed existing models of similar mini-tractors and the mini-tractor designed and prototyped by our seniors. We have also studied a few papers regarding draft force and soil types and how they are related to the engine size of the tractor that could provide enough power for ploughing.

CHAPTER 3

METHODOLOGY

This mini-tractor has been designed from the bottom up. The first thing studied was the required force for ploughing land effectively. For this, a study was carried out of papers published before. On the basis of the required draft force, power of the engine required to provide enough power to both move the tractor forward and to plough the land with it was formulated using widely used formulae.

Once a suitable engine was selected, a drive train was designed to transmit power down to the wheels. The drive train consisted of a gearbox interfaced with the engine by use of a coupling, a differential to shift the direction of the shaft by 90° and wheel cups to attach the wheels to the shaft.

The next part of the design process was to design the chassis. The primary purpose of the chassis was to support the weight of the engine and to support the attachment to which the plough was attached. Basic design philosophy behind chassis design was to pursue a compact design dictated by physical requirements and constraints. 3D model of the chassis was put through a stress loadings test to verify the solidity of the design.

The next part of the design process was the design of the plough. A very commonly used chisel plough was designed according to the common requirements of ploughing in addition to the attachment. Both were analyzed under stress loadings to verify the design.

Finally, the handle to drive, steer and control the mini-tractor was designed to ensure ease for the operator and good handling.

During this entire process, the end goals of low weight, simple design, low cost, fulfillment of need and easy handling were kept in mind.

Details of the design process briefed above will be shared in the next few pages.

Draft Force:

Draft force is the force required to till soil using a ploughing tool. [6]

All calculations in this section are done according to the specifications of a chisel plough. A chisel plough is a simple, static ploughing tool which is very widely used.

To calculate draft force following data is required:

Width of tool	=	2 inches		
Depth of tillage	=	6 inches		
Ground Speed (max)	=	8 km/h		
Soil Resistance	=	6.4 psi (for moist, fine loam soil)		
No. of tills	=	3		
Total Plough area	=	3*2”*6”	=	36 sq.in
Total Draft Force	=	36 sq in *7.98 psi		
	=	287.28 lbs		

Horsepower Definitions for Tractors

Brake Horsepower is defined as the total power of the engine.

Power Take-Off is defined as the power available for ploughing the land. The Drawbar Horsepower is the power being transferred to the soil through the plough.

Drawbar Horsepower is less than the Power Take-Off because of the slippage between the plough and the soft, farmland soil. The softer the soil, the smaller the percentage of drawbar horsepower will be to the power take-off.

Power take-off is less than brake horsepower because a part of the total available power of the engine is used to drive the tractor forward while only the remaining part of its power is transferred to the soil for ploughing. [5]

Required Horsepower (for Fine Soil):

Drawbar Horsepower = $(Draft$ (lbs) $*Speed$ (mph)) / 373

= ("287.28$*$" 5)/373 = 3.85 hp

Required Power Take-Off = "Drawbar Horsepower" /0.67

= 3.85/0.67

= 5.75 hp

Note: These are empirical formulae conventionally used for ploughing horsepower requirements.

Required Horsepower (Power Take-Off) for Different Soil Types:

No. of Ploughs = 3

Width = 2 inches

Total width = 3*2

= 6 inches

= 0.5 feet

Table 4- Soil Resistance

Soil Type	**Draft (lbs/ft)**	**Drawbar power, hp/ft**
Fine	575	7.7
Medium	500	7.3
Coarse	400	6.4

Table 5- Required Draft Force, Drawbar Horsepower and PTO for Soils at width = 0.5 ft

	Fine	Medium	Coarse
Draft Force	287.28 lbs	250 lbs	200 lbs
Drawbar Horsepower	3.85 hp	3.65 hp	3.20 hp
Power Take-off (PTO)	5.75 hp	5.45 hp	4.78 hp

Engine Specifications:

On the basis of the design requirements and after conducting a market survey using online stores and a visit to the market, we decided to use a 13 hp petrol engine.

Type : Petrol Engine

Power : 13 hp

RPM : 3600 RPM

Torque (Computed) : 17.8 Nm

Weight : 20 kg

Petrol vs Diesel Engine:

A petrol engine is selected due to its lower weight as compared to that of a diesel engine by a factor of 3. A diesel engine of similar horsepower weights upwards of 60 kg while this engine weighs only 20 kgs.

Engine Torque Calculation:

Torque	=	$\frac{\text{Horsepower*5252}}{\text{RPM}}$ lb-ft
Horsepower (rated)	=	13 hp
Max RPM (rated)	=	3600 RPM
Torque calculated	=	18.97 lb-ft
	=	25.72 N-m
Torque at 3000 rpm	=	22.76 lb-ft
	=	30.86 N-m

Available Horsepower:

A suitable estimation is that 86% of the brake horsepower can be taken out at the power take-off for ploughing. Thus,

Power Take-Off = 0.86 x BHP = 0.86 x 9 = 7.74 hp

The maximum required power for the ploughing we are designing for is 7.74 hp while this engine will provide 13 hp. This extra 40% power will cater for transmission inefficiencies and any over or under estimation.

Gearbox Calculations:

Our transmission system requires gear reduction because the output of the engine is at a high RPM (3600) whereas it will only move at a much lower speed of 6 km/h.

$v = r\omega$ [2] $v = 6$ km/h = 1.67 m/s (operational speed)

1.7 m/s = 0.1875 m x ωt Tire dia = 15" = 0.375 m

Tire radius = 0.1875 m

ω_{output} = 9 rad/s = 85.94 rpm

Thus, the rotational velocity of the tires will be 85.94 rpm. The diameter of the tires are taken from the tires we selected for use during our initial market survey.

The RPM from the engine is:

ω_{engine} = 3600 rpm

Thus, the required gear ratio reduction is:

Gear Ratio: $\omega_{engine} : \omega_{output}$ = 3600 : 85.94 = 41.9

Gear Ratio = ~42

Thus, our transmission will require a gear reduction ratio of 42:1.

Gearbox Selection:

We selected a gearbox for our mini-tractor based on the above calculations. The base mode of operation sees the mini-tractor move at about 6 km/h. For this speed, reduction of 42:1 is required. The gearbox we selected is imported from China and is primarily used in lifters, caddies and other slow moving vehicles. It provides more than one gear ratio. However, these gear ratios are very similar to our design needs.

The gearbox allows for 2 forward and 1 reverse gears. Additionally, it provides a high and a low speed which allows for a lower or a higher gear ratio respectively.

Shaft Design:

Shafts will transmit the torque from the engine output to the tires. The shaft from the engine output will pass through the two gearboxes, a clutch and a differential. From the differential, two shafts will lead to the axles which will be connected to the tires.

Shafts are designed with considerations given to torsional load and bending load [2]. Since the shaft in our design will not be supporting any heavy components and since it is small in length, the bending load on it will be negligible.

Shafts will be made out of mild steel. According to ASTM, A36 steel (mild steel) has a yield strength of 250 MPa.

However, since we want as little elastic deformation as possible, we will take maximum applied shear stress to be 50 MPa. Thus, the factor of safety with regards to shaft failure would be:

FOS = 250/50 = 5

For torsional loads:

Torque at 3600 RPM = 17.8 N-m

Torque at 85.94 RPM = 745.82 N-m

Thus, the maximum torque in the shaft will be 745.82 N-m.

For shaft design:

$d^3 = (16 \times T)/(\pi \times \tau)$

$d^3 = (16 \times 745.82)/(\pi \times 50 \times 10^6) = 42.35 \text{ mm}$

Chassis:

We have chosen mild steel for our chassis or frame design. The frame sits on the drive shaft housing and supports the engine, transmission and the plough. We have selected mild steel because of its low cost, easy machining/welding/bolting and high strength.

Detailed drawing of the chassis is shown below. The design is based on availability of space and the effort to make it as compact as possible to minimize weight. Design verification through use of software is shown in the results section.

The design of this chassis is dictated by geometry constraints and the drive to keep it as compact as possible for minimum weight. Tests done to verify its performance during application have been performed using software before fabrication. Results of these tests are shared in the next section.

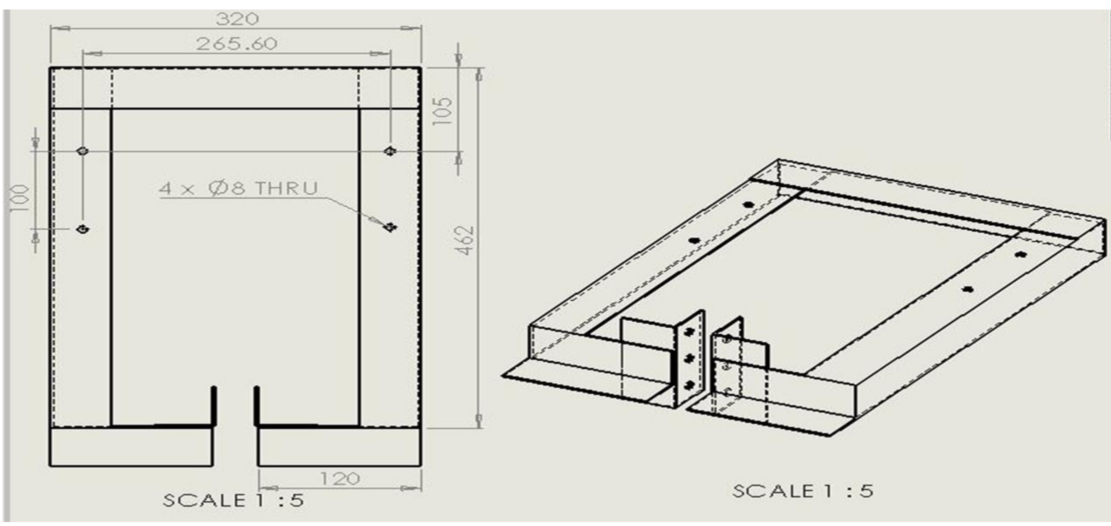

Figure 4- Chassis Drawing

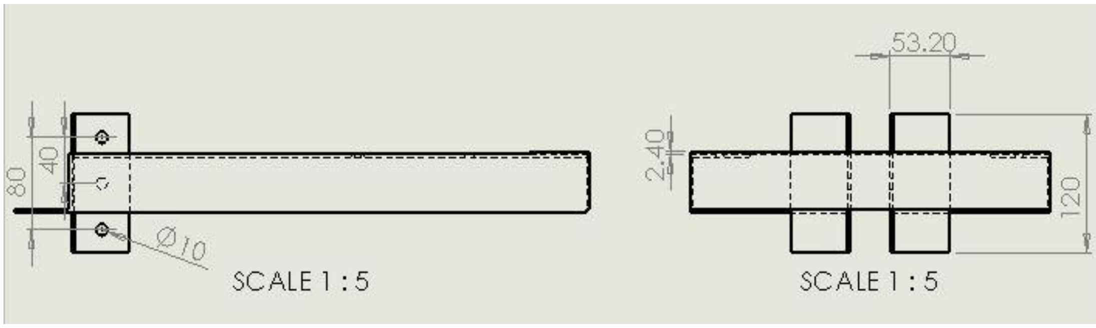

Figure 5- Chassis Drawing (2)

Tires:

We are using V-tread 15" diameter tires for our machine. V-tread provides suitable grip for farmland and the 15" diameter is easily available and suitable to design needs. The tires used are originally produced for use in wheel barrows where high grip is needed.

The weight of each tire will be 3 kg.

Plough:

We have decided to build our machine fitted with a chisel plough. Chisel plough have simple construction and are widely used for ploughing. All calculations performed above are performed according to the power requirements of a chisel plough. The design of the plow is shown. Stress acting on it and deformation produced due to applied stresses are in the next section. A chisel plough of the given design weighs around 8 kg.

The plough is detachable and thus can be detached and replaced by other attachments like cutters and harvesting tools.

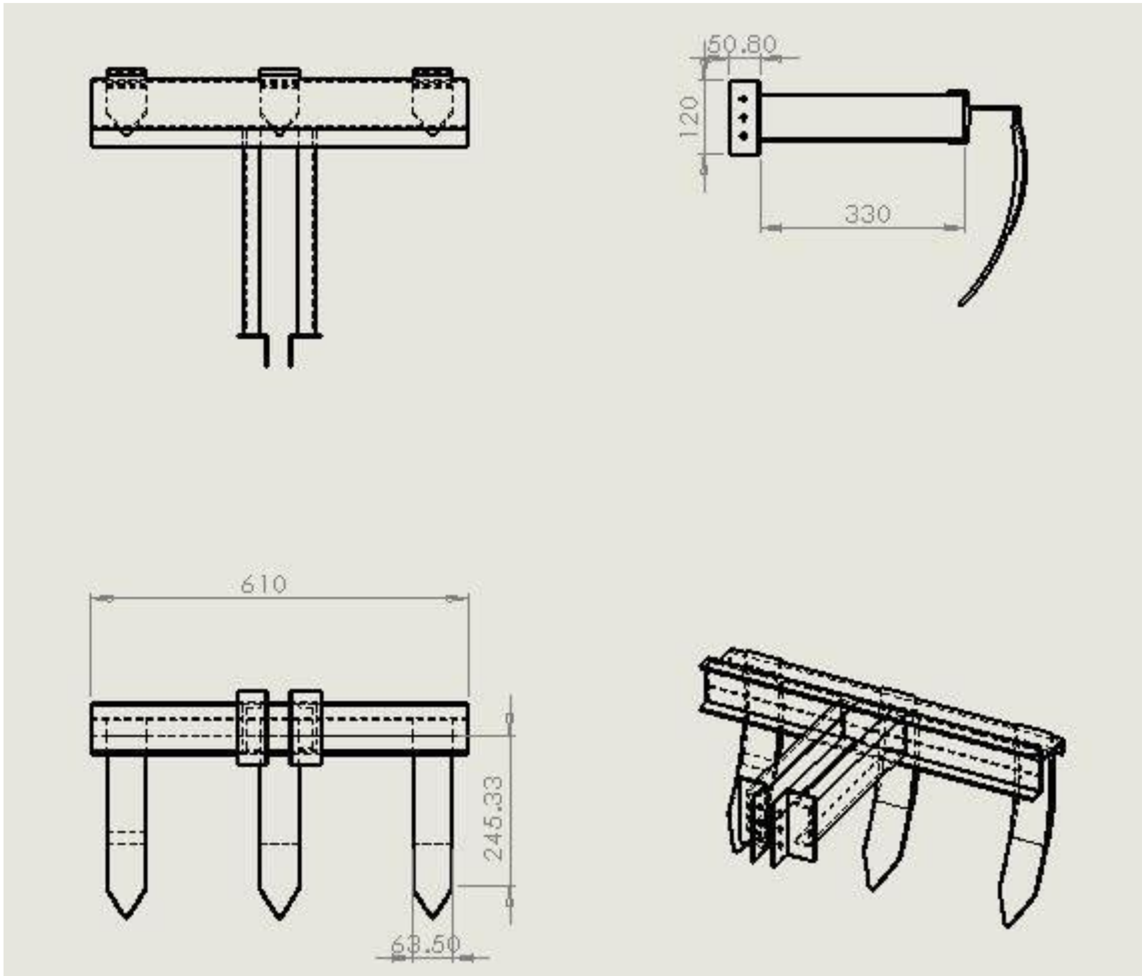

Figure 6- Plough Drawing

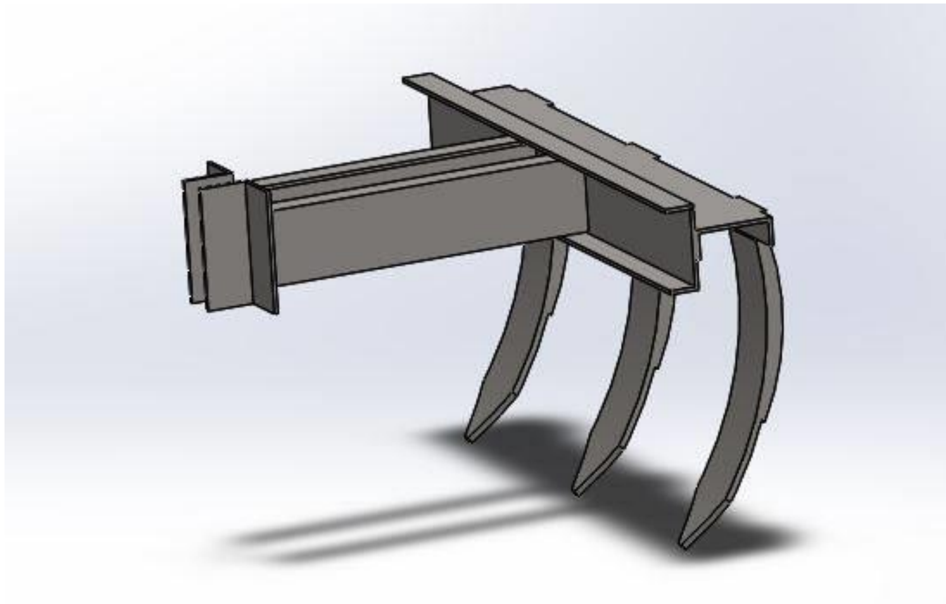

Figure 7- Plough 3D Model

Clutch:

We have used a wet type clutch. The clutch controls the power transmission to the output and to shift gear from forward to reverse and vice versa. The clutch is housed inside the gearbox.

Coupling:

To transmit power from the engine to the gearbox, a coupling was required. It was designed keeping in mind its interfacing with the engine and the gearbox respectively. The material used for fabrication was tool steel which is harder and more durable than mild steel. The reason for this is that the coupling is under heavy torsional loadings at every start up and tool steel resists deformation under loading much better than mild steel.

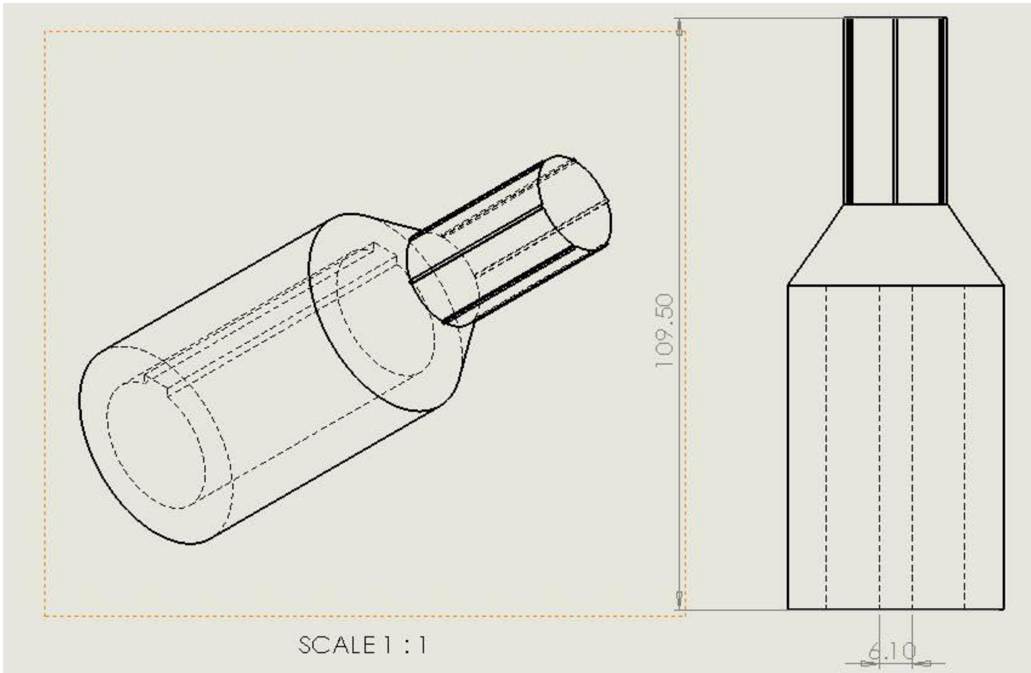

Figure 8- Coupling Drawing

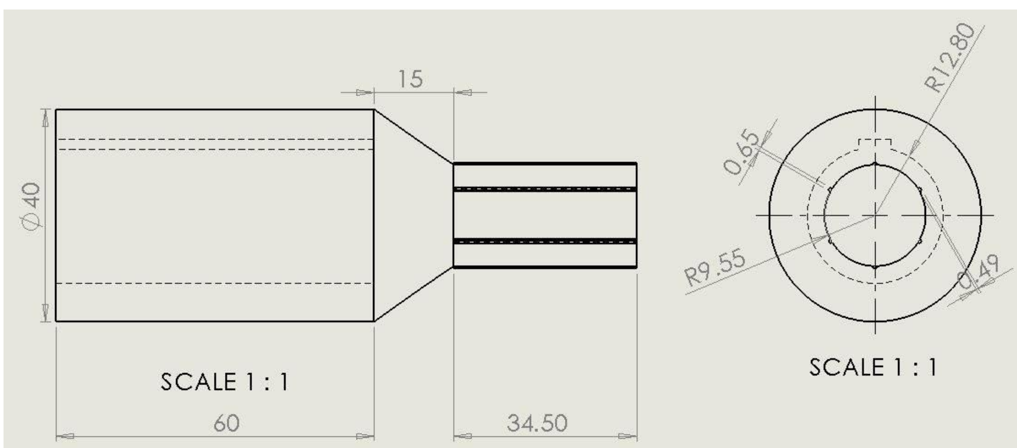

Figure 9- Coupling Drawing (2)

Handle:

For control of the mini-tractor during operation, we designed a handle that can be used to control the tractor while walking behind it. It has the controls and can be used to steer it as well. Drawing of the handle is shown below. Stress analysis to ensure successful operation under stress loadings is also conducted and is shown in the results section. The basic objective driving design was to ensure that the operator has to apply a minimum force to keep the mini-tractor in the operating position. This is done by lengthening the moment arm to a suitable length.

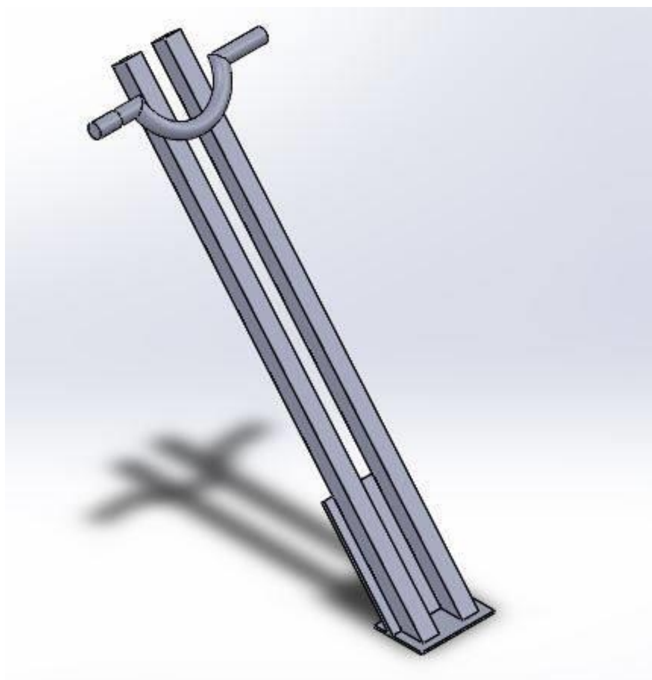

Figure 10- Handle 3D Model

Summary:

This chapter starts with a description of the design process. It is followed by details of work done during each phase of the design process. Output parameters used to dictate the design are justified and the equations used to work out other parameters are shown. Calculations and results of the mathematical working are also shown. The thinking behind selection of various components bought from the market is explained and the design of parts fabricated in-house is shared. Detailed part drawings and 3D models are shown where required.

CHAPTER 4

RESULTS

Software Analysis

In the analysis of the chassis, the main forces acting on it were due to the mass of the engine (20kg) as well as the mass of the chassis itself (10kg). The chassis had to be strong enough to bear these loads with the minimum amount of deflection and stresses. While simulating the chassis, the above-mentioned forces were applied on it and the resulting deflection, stresses and strains were visualized. The material selected for the chassis was mild steel. The chassis was clamped at the holes i.e. where it was to be bolted to the differential housing. The results showed a maximum deflection of about 0.157 mm and maximum stress of about 5.6 MPa which were well within the safety limits of the material.

While analyzing the plough, a force of 287.28 lbs was applied on the tills. This force is the maximum draft force calculated for soil. The material selected for the plough was mild steel and the material of the tills was tool steel. The force due to the mass of the plough and the tills (15kg) was also applied. The plough was clamped at the hole; where it was to be bolted to the differential housing. The resulting deflection, stresses and strains were visualized. The maximum deflection in the simulation was about 8mm which was at the edge of the tills. The maximum stress we encountered in our result was 129 MPa. This result was also within the factor of safety of our design.

The handle was designed to effectively steer the machine; while also being strong enough to counter all the weight distributions with minimum deflection and stresses. In our analysis, the handle was clamped at the base plate and a force equal to the weight of the whole tractor was applied at the grip to get the best result. The material of the handle was mild steel. The resulting deflection, stresses and strains were then visualized. The maximum deflection seen in our result was about 0.0114 mm and the maximum stress encountered was 0.34 MPa. The results were within our safety requirements.

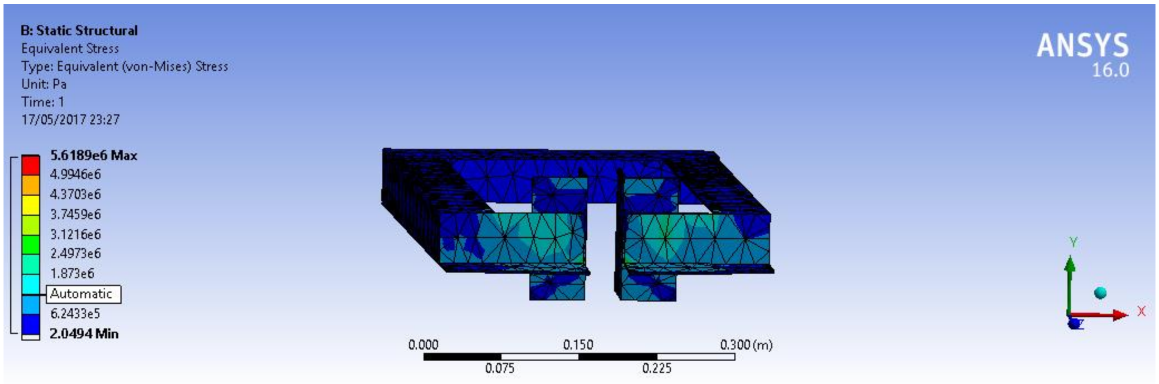

Figure 11- von Mises Stress on Chassis

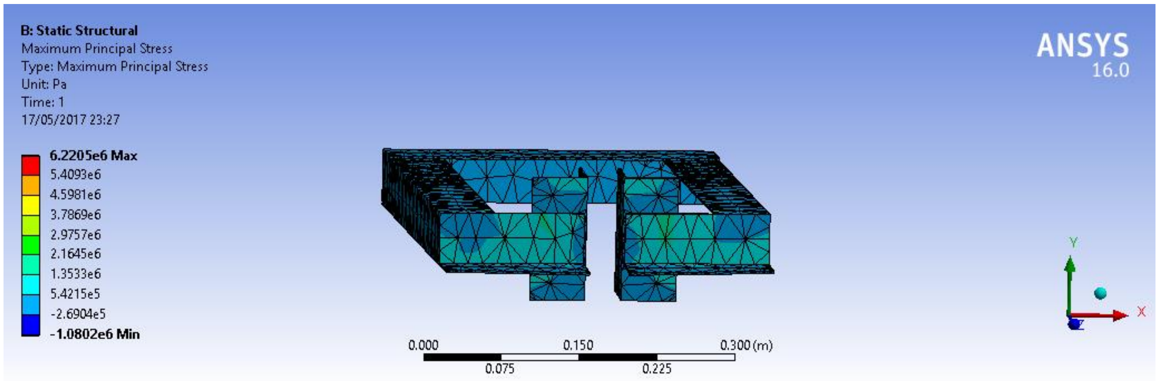

Figure 12- Principal Stress on Chassis

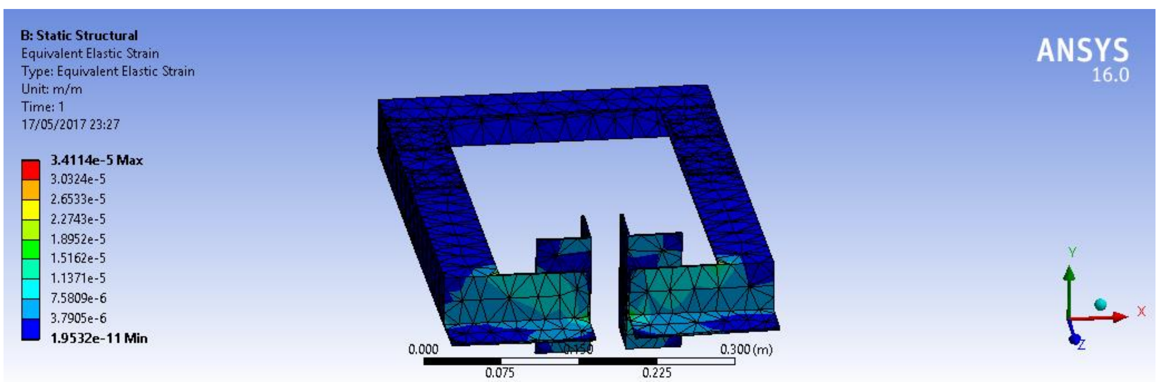

Figure 13- Elastic Strain on Chassis

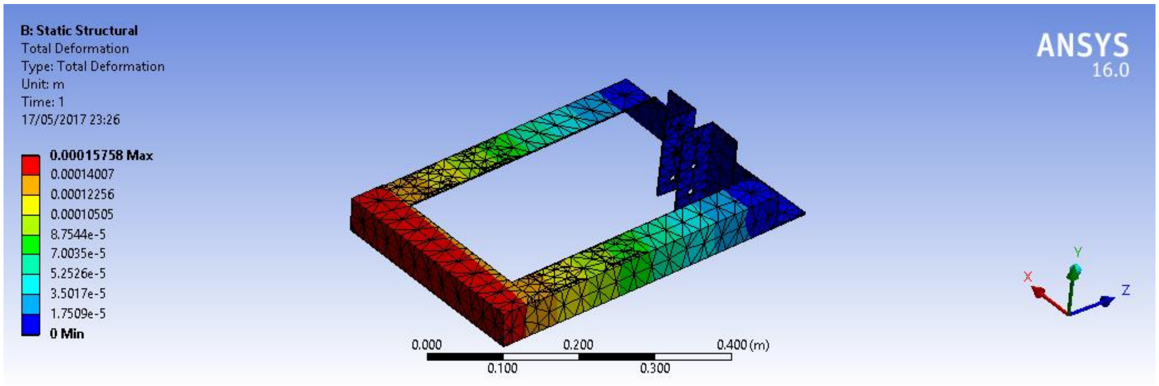

Figure 14- Deformation on Chassis

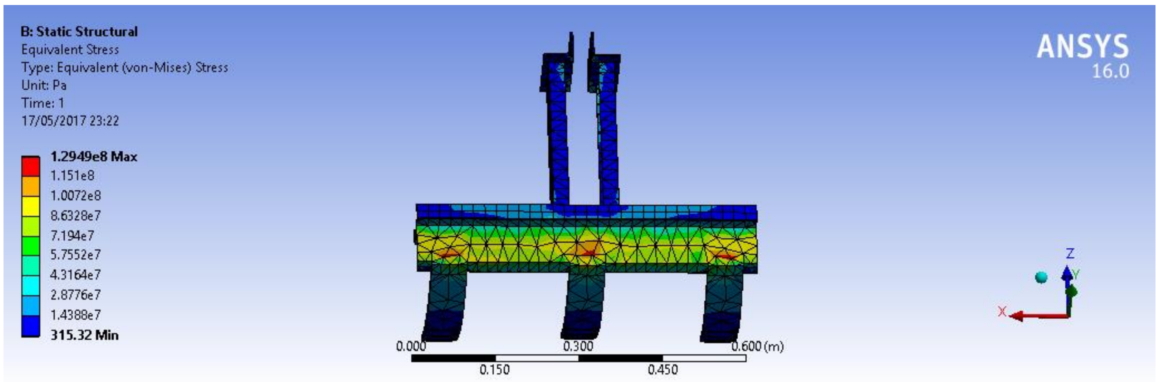

Figure 15- von Mises Stress on Plough

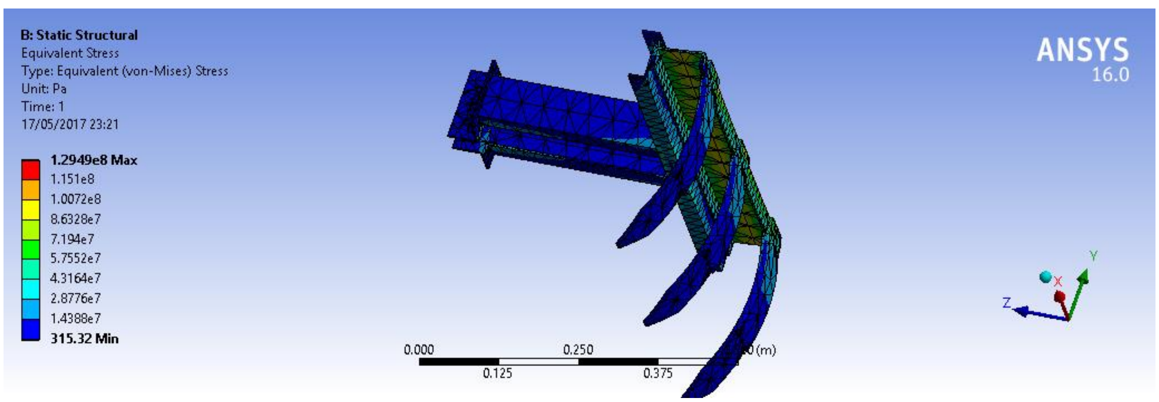

Figure 16- von Mises Stress on Plough (2)

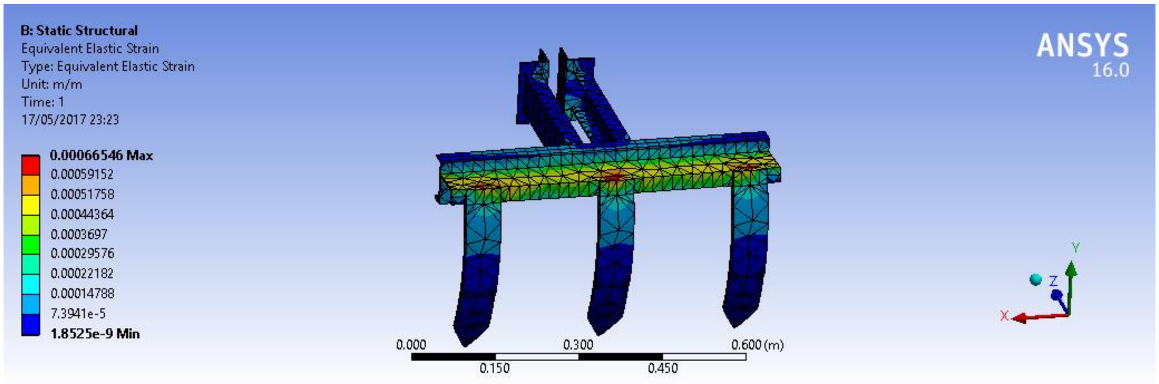

Figure 17- Elastic Strain on Plough

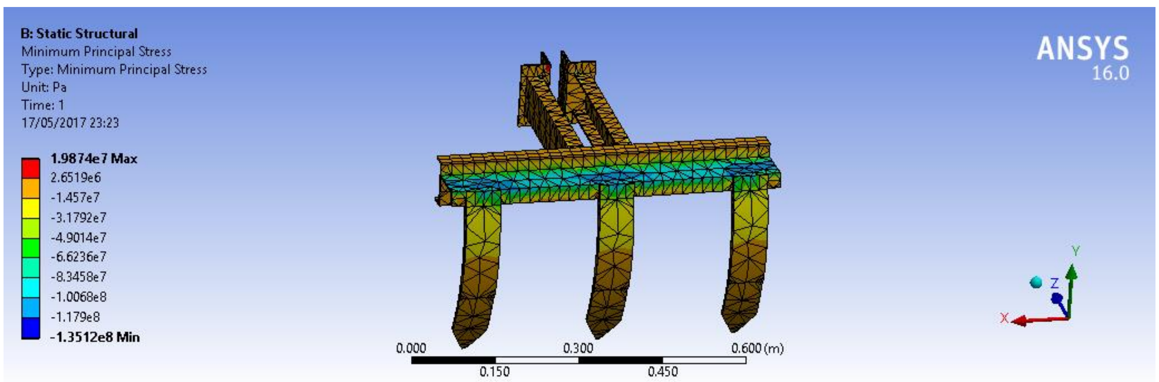

Figure 18- Principal Stress on Plough

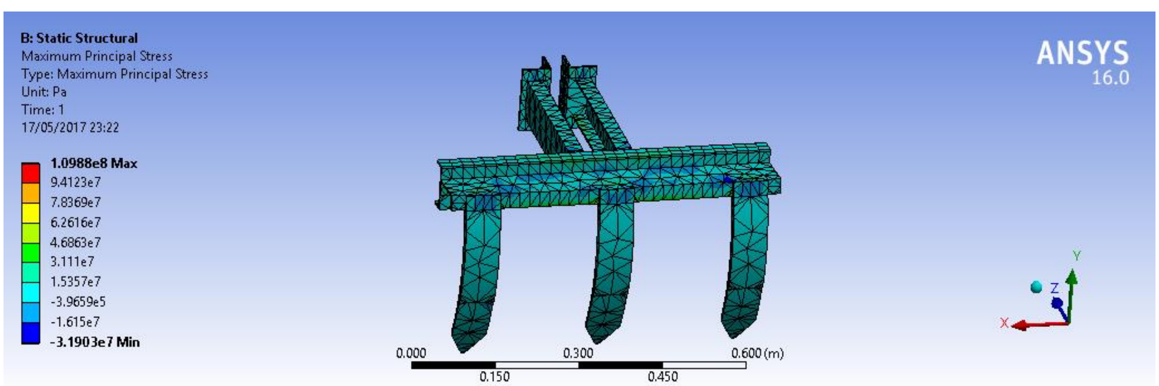

Figure 19- Principal Stress on Plough

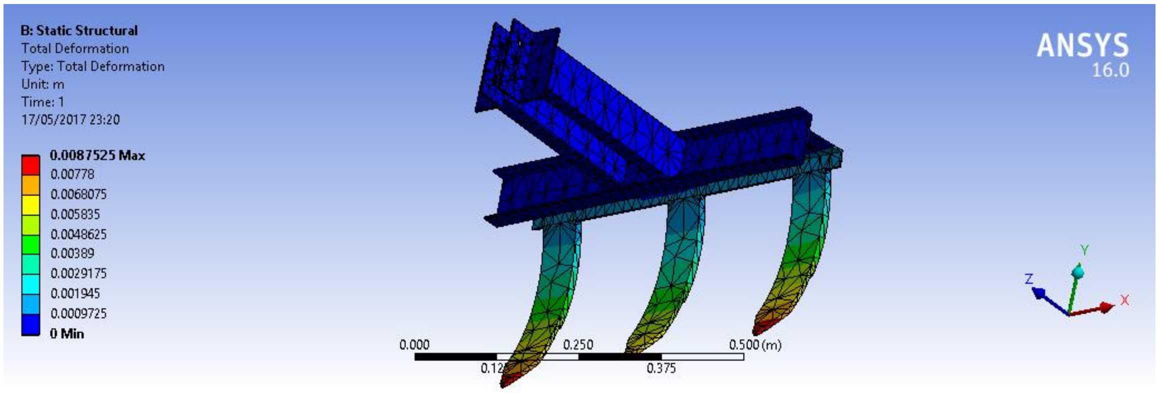

Figure 20- Deformation on Plough

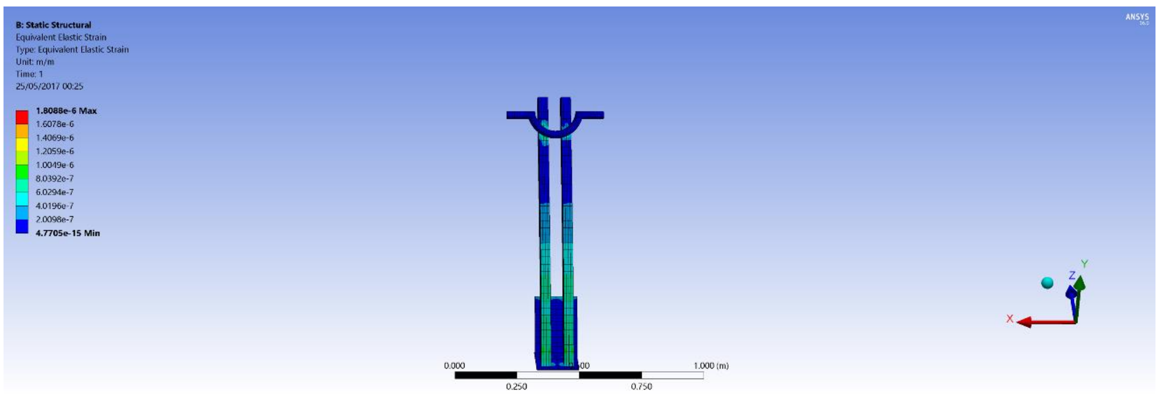

Figure 21- Elastic Strain on Handle

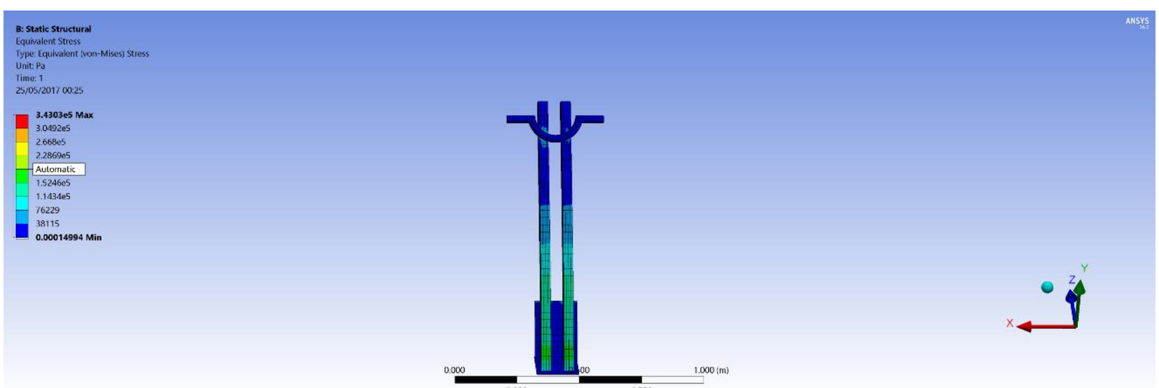

Figure 22- von Mises Stress on Handle

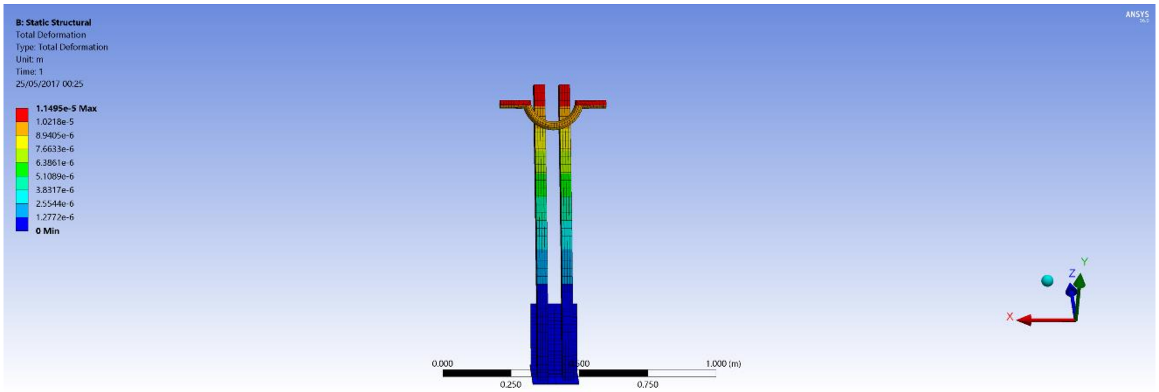

Figure 23- Deformation on Handle

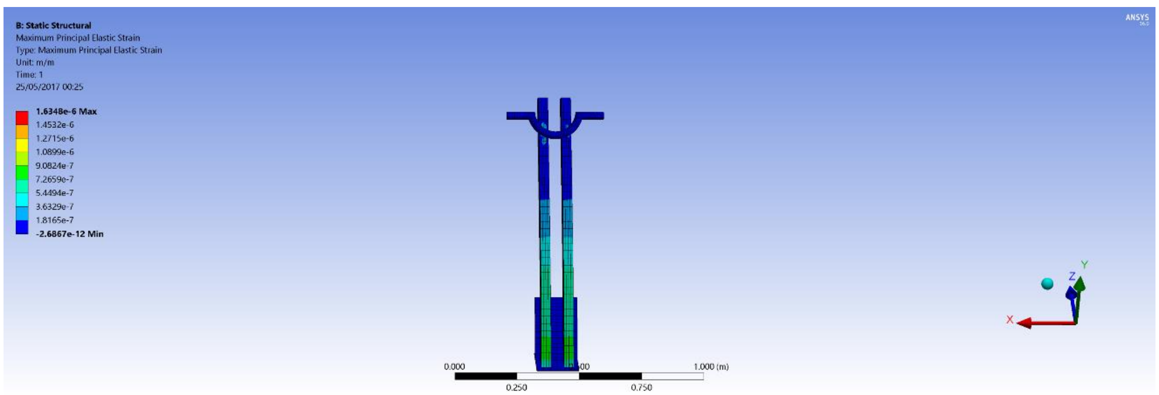

Figure 24- Strain on Handle

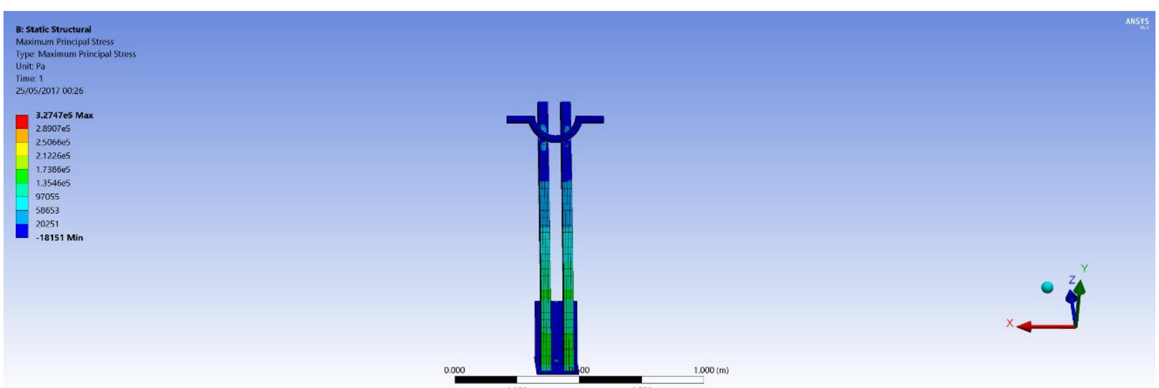

Figure 25- Principal Stress on Handle

Table 6- Product Features

Engine	Petrol Engine 13 hp
Engine Company	Fastgold (Chinese)
Gears	Forward 2, Reverse 1
Gearbox Modes	Two (High and Low RPM)
Start	Hand Crank
Turn	Turn able
Clutch Type	Pressure Plate Type
Weight	80 kg
Attachment	Chisel plough (removable)
Prototype Cost	PKR 65,000
Tires	15” V- tread

The objective of this project was to build a prototype that could improve upon the previous prototype and compete with the models available in the market already. Below is a table that shows a comparison of the most important features in a tractor.

Table 7- Comparison against existing models

Parameters	Agria 3600 (available in market)	Power Plough (By ME-03 students)	Power Plough 2.0 (Our project)
Weight	62.5 kg	160 kg	80 kg
Power	8 hp	6.6 hp	13 hp
Max Torque	19.10 Nm	15.81 Nm	21.42 Nm
Price/Cost	PKR 150,000	PKR 100,000	PKR 60,000

As the above table shows, our prototype competes with or beats all the major performance parameters when it comes to tractor performance. It is also versatile with the option of attaching different attachments in place of plough. These attachments could be harvesters, disc harrows etc. which can then be used for harvesting and other farming activities.

Final Product:

Figure 26- Final Product

Figure 27- Final Product (2)

Figure 28- Final Product (3)

Summary

In this section, results of all the work done are shared. The results of analysis done using software on various parts of our design are mentioned followed by the detailed features of the mini-tractor fabricated. Finally, comparisons are carried out against a foreign manufactured mini-tractor and one designed and prototyped by students of ME-03.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

Need for Mass Adoption

Pakistan is an agricultural country with most of its population relying on agriculture and associated industries for their livelihoods. 43% of Pakistan's labor force is employed in agriculture. Ever since the creation of Pakistan in 1947, agricultural output of Pakistan has increased manifold. However, Pakistan's agricultural output per square meter of cultivated land still lags behind those of developed and even developing countries. One of the primary factors for poor output per square meter is the lack of mechanization of agricultural procedures like ploughing, harvesting etc.

Furthermore, the people of the mountainous areas in the north of Pakistan also rely primarily on agriculture for their livelihoods. Since the mountainous fields require mechanized methods of ploughing, their yield depends on the ploughing methods available.

Since farms in the north are often located in locations without road access, it is difficult, and often impossible, for full sized tractors to reach the farms. As a result, the farmers have to rely on archaic ploughing methods to plough their land.

We have designed and prototyped a light-weight, engine-powered plough to fulfill the small scale ploughing needs of the farmers, especially in the northern areas of Pakistan.

The primary design features of our power plough in accordance with the need are:

- Enough power to plough farmland.
- A compact, light-weight design to be driven with ease to upland farms.
- Cost effectiveness with affordability of the power plough for small scale farmers kept in mind.
- Simple and easy-to-use design to be easily adapted by farmers.
- Basic and simple mechanical parts to be used; for low costs and easy repairs.

- Simple design for maximum durability.

Keeping in mind these design features, our mini-tractor is perfectly suited for mass adoption by Pakistani farmers. Since the major reason for poor agricultural yield in Pakistan is a lack of mechanization, this would result in substantial improvement in the agricultural output of the country.

Secondly, further development towards mass production would lead to production of high value machines inside Pakistan, something which our economy has struggled to do. This would reduce import bills and save invaluable foreign exchange reserves.

Technical Summary:

The components used in our mini-tractor are either self-fabricated or are easily available off-the-shelf in Pakistan. Any effort towards the manufacturing of such mini-tractors on a larger scale can be easily carried out.

The engine and gearbox used are the most critical parts. They are originally manufactured in China but can be imported at a surprisingly low cost if bought in large numbers. Other parts are simple to fabricate and require only basic technology easily available in Pakistan. Thus manufacturing of a large number of these tractors does not pose a big technological challenge but only is a matter of availability of funds.

WORKS CITED

[1] Ahmadi I. (2016). *Development and assessment of a draft force calculator for disk plow using the laws of classical mechanics.* Isfahan, Iran.

[2] Khurmi R. and Gupta J. (2005). *Machine Design*. New Delhi, India.

[3] Kumar S. (2008). *Textbook of Tractor at a Glance: Unique Book of Farm Power*. Lucknow, India.

[4] Aboukarima A. (2007). *Draft models of chisel plow based on simulation using artificial neural networks.* Available at https://www.mjae.eg.net/pdf/2007/jan/3.pdf

[5] Michelin N. (2015). *Estimating Tractor Power Needs.* Available at https://www.nswfarmers.org.au/__data/assets/pdf_file/0010/35848/Efficient-Farm-Vehicles-Estimating-tractor-power-needs.pdf

[6] Walters R. (2016). *Soil, Draft and Traction.* Available at http://open-furrow.soil.ncsu.edu/Documents/DHC/Soil,%20Draft,%20and%20Traction.pdf

Power Plough 2.0 Thesis

ORIGINALITY REPORT

6%	5%	2%	5%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Ajman University of Science and Technology Student Paper	1%
2	Submitted to Higher Education Commission Pakistan Student Paper	1%
3	www.swedishryk.edu.pk Internet Source	1%
4	www.ceme.nust.edu.pk Internet Source	1%
5	scholarworks.unr.edu Internet Source	<1%
6	Submitted to Bishop Burton College Student Paper	<1%
7	www.tqmmm.com.cn Internet Source	<1%
8	Ahmadi, Iman. "Development and assessment of a draft force calculator for disk plow using the laws of classical mechanics", Soil and	<1%

Tillage Research, 2016.
Publicat ion

9	Submitted to Hadlow College, Kent Student Paper	<1%
10	file.scirp.org Internet Source	<1%
11	repository.up.ac.za Internet Source	<1%
12	eprints.utm.my Internet Source	<1%
13	repository.cimmyt.org Internet Source	<1%
14	www.nmri.go.jp Internet Source	<1%

EXCLUDE QUOTES OFF
EXCLUDE BIBLIOGRAPHY OFF
EXCLUDE MATCHES OFF