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Photovoltaic Smart Agricultural Tool

Sunil. D. Chougule
Department of Mechanical Engineering
Vishwakarma Institute of Technology,
Pune, India.

Yash Arun Mane
Department of Mechanical Engineering
Vishwakarma Institute of Technology,
Pune, India.

Ajit Balasaheb Satpute
Department of Mechanical Engineering
Vishwakarma Institute of Technology,
Pune,India.

Aniket Ajit Suryawanshi
Department of Mechanical Engineering
Vishwakarma Institute of Technology,
Pune,India.

Mihir Purushottam Shinde
Department of Mechanical Engineering
Vishwakarma Institute of Technology,
Pune,India.

***Abstract*—With the increasing necessity of reducing dependency of agriculture on fossil fuels,the utilization of alternate sources of energy is in great demand. Solar energy being the most abundant source of energy in the country, is the most compatible source of energy for agriculture purposes. Solar Energy can be utilised in different forms by the farmers to get a cost effective and efficient alternative for their farming needs. The proposed project title intends to explore more in the field and develop a Solar Agriculture Multipurpose Machine which we call "All in one Machine". The machine is completely powered by solar energy which performs various farming operations like weeding,spraying pesticides,ploughing etc.**

Keywords*— Agriculture, Solar Energy, labour, farmers, Multi Operations, weeding.

1.. INTRODUCTION

Innovation being the heart of many technological advancement has also found its way to the agriculture sector.Agriculture is a major sector of the Indian economy, accounting for approximately 17% of total GDP and employing more than 60% of the workforce[5]. According to the World Health Organization, officials are concerned about slow agricultural growth because rural employment employs two-thirds of India's population. Agriculture is India's backbone.With increasing fossil fuel prices it is not affordable for the farm owner to hire a tractor for his routine operations.Most of the cases farmer could not recover his entire money that he spent during seed sowing harvesting and field preparation, this is accountable for suicides also unexpected rains play an important role here.A significant quantity of energy is consumed in agriculture to accomplish various field activities such as ploughing, irrigation, spraying of agricultural pesticides, harvesting and post-harvest processing, and so on. Energy security is critical for a country, and attempts are being made to use renewable energy sources, mostly solar energy, as fossil fuel-based energy is depleting at an alarming rate.

After considering all of the issues, whether they be labour[1], skilled labour,Energy efficient and cost, we decided to develop a system that will run on Photovoltaic Solar energy and be capable of performing operations such as ploughing, weeding, seed sowing, cultivation, and so on in a single machine.

A. Problem Statement

From the literature survey and the information we had,we found that most of the machines available in the market are intended to serve a single purpose and most of them were powered by IC engines[5].Considering today's scenario of prices and dependency on fossil fuels, we decided to find an alternative for the same in the form of Solar Energy which is the most compatible one for our application.Using Solar energy machine could perform all the operations with the help of provided attachment .This will address problems such as low yields, extra efforts and higher costs for farming operations.

B.Objective

1. To build a Machine capable of performing a variety of operations.
2. To move from non-renewable energy to clean renewable energy
3. To build a machine which will suitable for small scale farmers
4. Increase efficiency of work and reduce operation cost and time.

2. METHODOLOGY

➢ *Factors Influencing Design*

1. Soil Resistance :- Resistance offered by Soil(kg/cm^^2)
2. Velocity of machine :-Velocity with which the operation is carried out.
3. Row to row spacing :-Spacing between the two successive rows.
4. Cross Sectional Area: The area which the equipment penetrates in the soil.

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A. Construction and Machine Layout

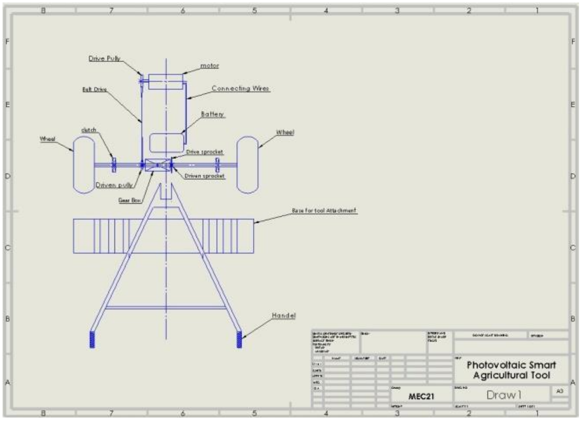

Fig.1 Machine Layout

The construction of a core machine looks like a two wheeled tractor with three main components.:

- ➢ Main Body
- ➢ Transmission Unit
- ➢ Handle

Main Body – On the main body we mounted all the necessary parts which are used, such as the motor, battery ,belt drive etc Transmission Unit:The Transmission Unit consists of a Gearbox,wheels and entire transmission parts. Handle:Handle acts as an armrest for farmers and also helps him in guiding the machine in a straight path.

A. Working

The entire machine is powered by an electric motor which operates on solar power.For speed reduction belt pulley arrangement is used ,the speed of the motor is further reduced by the single speed reducer gearbox.Gearbox further powers the two wheels attached.Agriculture tools are attached at the backside of the machine .Handle is used for hand rest of the farmer.

B. Material Selection

For chassis and Machine structure we used general purpose mild steel with properties given below:

Yield Strength: 250 Mpa
Ultimate tensile Strength: 400 Mpa
Density:4850 kg/m^^3

For farming tools,Grade A Corten is selected.It is commonly known as weathering steel or atmospheric corrosion resistant steel, and is specified in accordance with EN 10025-5. Corten is a low-cost option for structures that are subjected to extreme weather and high shocks.For farming tools we required the same properties ,so this material was selected for plough and star tool.

3. DESIGN PROCEDURE

A. Power Calculations

Considering a depth of 16 cm. The soil resistance of 0.8 kg/cm2 . The speed of the Machine was 1 m/s ,Width of 20cm .
Cross section = 20*15=300 cm2
Force = 300 ×0.8
Total Force=290kg(50 kg additional weight considered for design safety)
Power =290*9.81*1 = 2844 Watts

B. Motor Selection

Motor with the following specification is selected from the power calculated.

Motor Specification	
Brand	Tsuyo
Voltage	48V
Power Source	Electricity
Power	1000W
Speed	2850 RPM
Motor Type	BLDC
Type	Externally Excited
Torque	18 Nm

Table .1 Motor Specifications

C. Transmission Design

1. V belt Pulley Calculations[6] :

While selecting the belt pulley arrangement, maximum speed reduction ratio was considered in order to bring the speed of the motor to a desired value at the input of the gearbox.
Belt Drive Ratio=10
D2/D1=N1/N2
D2=500mm
D1=50mm

a. Axis Distance:
It is evaluated from $D2 + D1 / 2 + c \leq A \leq 2(D2 + D1)$ where:
c = 50 mm
Axis Length Should be in Between 350 and 1100
So, 750mm is Selected

b. Calculation of a length of the belt :
$L = \pi \cdot D1{+}D2/\ 2 + \pi \cdot \gamma\ /180 \cdot (D2 - D1) + 2 \cdot A \cdot cos\gamma =$ 2400mm

c. V – belt dimensions:
For the Given Application SPC section belt is selected

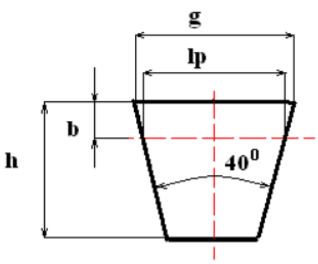

Fig.2

Belt section	g [mm]	lp [mm]	h [mm]	b [mm
SPC	22	19	14	5

Table 2. V-Belt Dimensions

d. Pulley Groove Dimensions

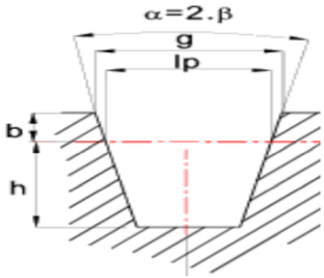

Fig.3

Belt Section	b	h	Ip
SPC	5	19	19

Table 3. Pulley Groove Dimensions

2.Gear Box Design[6]:

Electric motor power P = 4.1 kW
Motor rotational speed nm = 2000 rpm
Belt drive ratio ub = 10/1
Gear ratio ug = 6/1
Gear input operating conditions: uniform
Gear output operating conditions: High shock
A running time of the reducer: t = 3 hrs/day
From the given input parameters Centre distance of the reducer should be 180mm
Tooth number of the pinion $z1 = 25$
Tooth number of the wheel is
$z2 = z1 \cdot ug = 24 \cdot 6 = 144$
Module(m):
$mn = 2 \cdot a / z1 + z2 = 2*180/ 25+144 = 2.2$
The Nearest module =2.5
For this module the modified centre distance between gear axes is $amod = mn \cdot (z1+z2)\ 2 = 2.5 \cdot (25+144)/ 2 = 210$ [mm]

To Obtain	Pinion Gear	Wheel Gear
Pitch Diameter	$D = m \cdot$ z=2.5*25=62.5mm	D2=m.z2=2.5*144 =360mm
Root Diameter	$DR = 62.5 - 2.5 \cdot 2.5$ z2=56.25mm	$DR = D - 2.5 \cdot$ 2.5=353mm
Outside Diameter	$D0 = D + 2 \cdot m = m(z +$ 2)=67.5	$D0 = D + 2 \cdot m =$ $m(z + 2)$=365mm

Table 4.

3. *Design of Driver and Driven Shaft:*

Calculating Bending Moment and Output Torque for both Driver and Driven Shaft :

The Shaft Diameters were calculated.

Parameters	High speed shaft	Low speed shaft
End shafts diameters	d1 = 40 mm	d1 =50 mm
For an oil seal ring mounting diameter	d2 = 45 mm	d2 = 55 mm
For bearings mounting diameter	d3 = 50 mm	d3 = 60 mm

Table 5. Shaft Dimensions

4.Bearing Calculations[6]:

A. Bearing for high Speed Shaft:
From given input parameters a bearing of 63010-2RS1 (from SKF catalogue we have selected)
B. Bearing Dimensions:

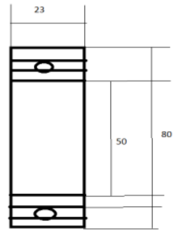

Fig.4

C. Bearing for Low Speed Shaft:
From given input parameters a bearing of 61812 (from SKF catalogue we have selected)

D. Bearing Dimensions:

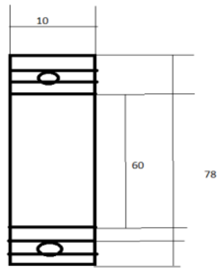

Fig.5

4. MODELING

Designing in SolidWorks:Figures below show the different parts of the Machine. Each and every element is designed and modelled using Solidworks software with appropriate dimensions.

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A. Chassis

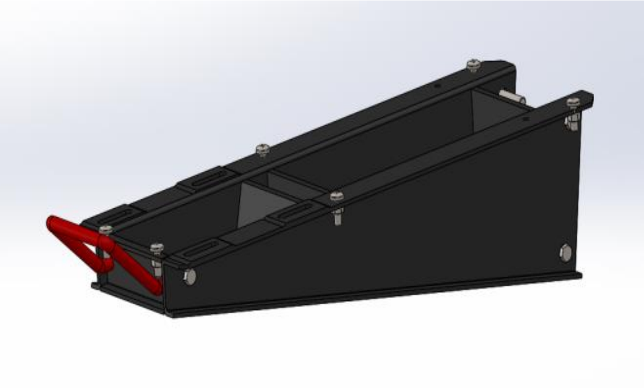

Fig.6

Chassis houses the motor,battery arrangement and belt pulley arrangement.The main function of the chassis is to carry motor and battery without any failure.

B. Transmission Unit:

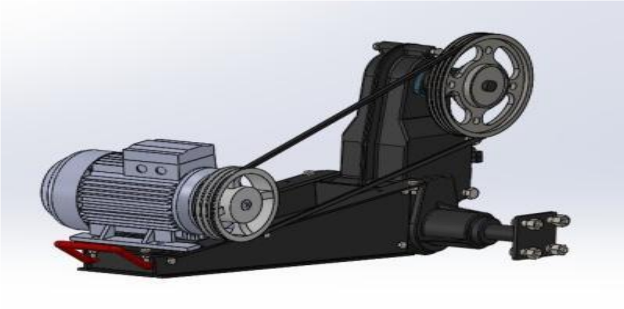

Fig.7

Transmission unit consists of a motor ,belt pulley arrangement, gearbox and axle.The motor is connected to belt pulley arrangement which is further attached to the Gearbox.

C. Handle:

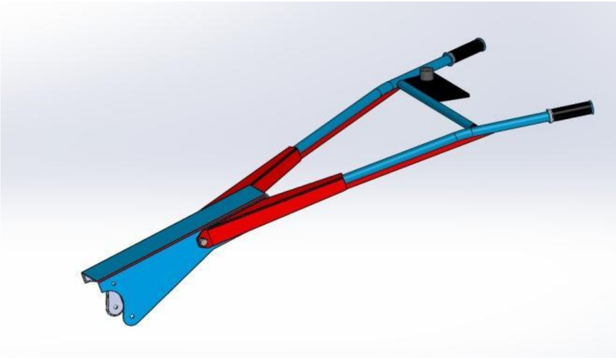

Fig.8

Handle is used for arm rest and modelled as shown in the fig.

D. Machine Assembly:

a. Assembly with rubber tyres:

Fig.9

b. Assembly with Steel Wheels:

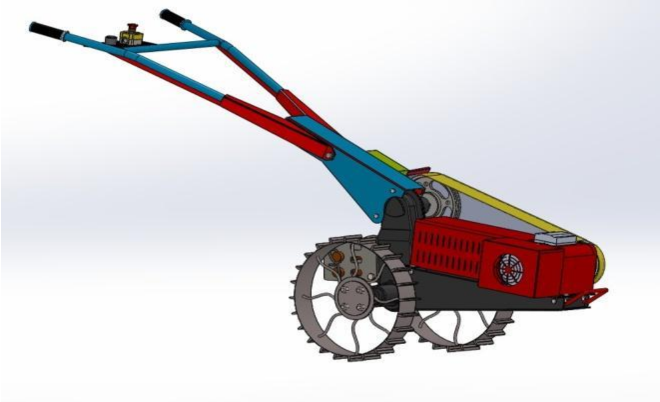

Fig.10

The main Machine consists of the chassis,Transmission unit and the Gearbox assembly.

E. Plough Tool:

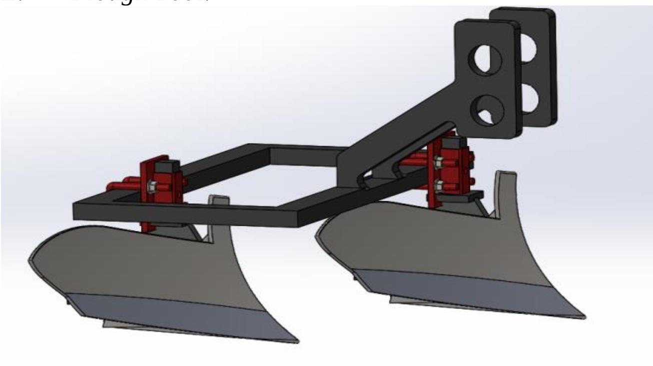

Fig.11

Plough tool is used for ploughing operation, the solid model is as shown in the figure

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F. *Star Tool:*

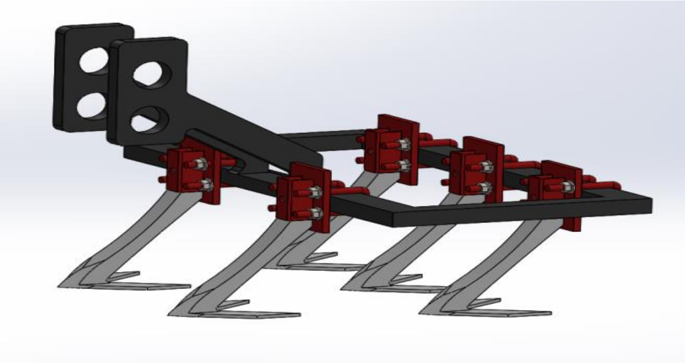


Fig.12

The Star tool is generally used for soil preparation and weeding purpose.Solid model is as shown in the above fig.

G. *InsertPin:*

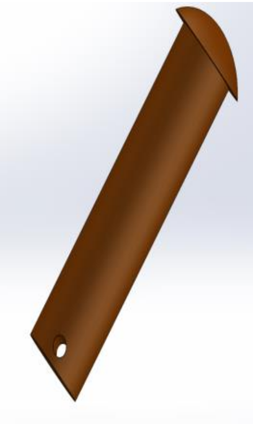


Fig.13 Fig.14

Insert pin is used to attach the farming equipment to the main machine. Lock Pin is used to lock in the insert pin and fix it. The solid model is as shown in the above fig.

H. *Final Assembly:*

I.Assembly with plough tool:

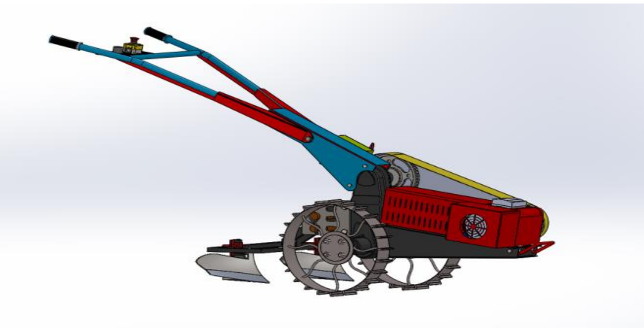


Fig.15

Assembly consists of a Main Machine and plough tool attached to it as shown in the above figure.

II.Assembly with star tool:

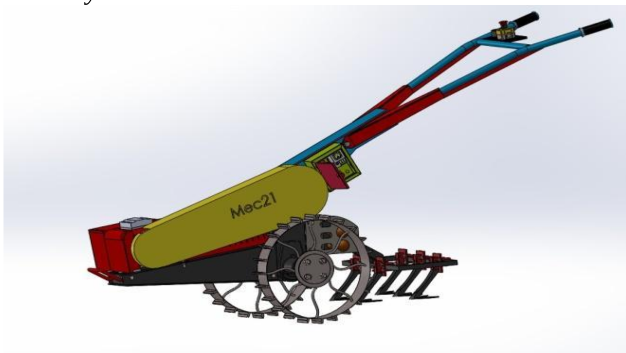
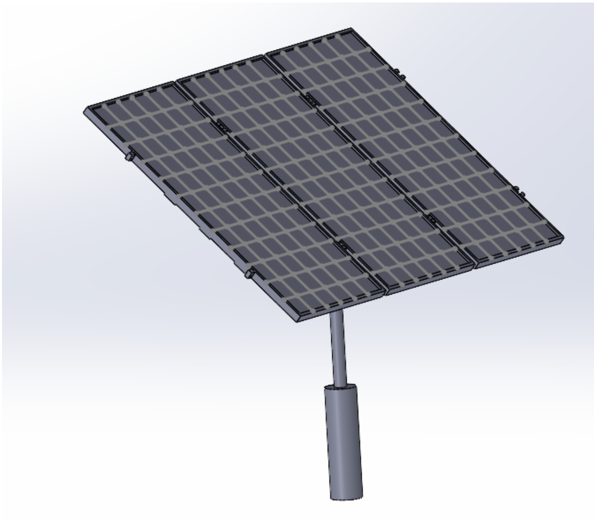


Fig.16

Assembly consists of a Main Machine and star tool attached to it as shown in the above figure.

I.Solar Panel Assembly



5. ELECTRICAL SYSTEM

A sun mobileular panel, sun electric powered panel, photo-voltaic (PV) module or simply sun panel is an meeting of photo-voltaic cells hooked up in a framework for installation. Solar panels use daylight as a supply of electricity to generate direct modern energy. A series of PV modules is known as a PV panel, and a device of PV panels is known as an array[2]. Arrays of a photovoltaic device deliver sun energy to electric equipment.

Monocrystalline (or mono) sun panels are crafted from skinny silicon wafers, which might be reduce right into a recognizable cylindrical shape, taken from artificially grown crystals. Efficiency prices for this form of panel are commonly among 15 and 24%. They may have blessings along with an extended lifespan than different varieties of panel and being greater area green as they yield the best quantity of power, which means you may require fewer of them for the equal output.

Polycrystalline (or poly) sun panels also are crafted from silicon wafers from artificially grown crystals, however instead of being taken from a unmarried supply they're made the usage of many interlocking crystals. Visually they're distinguishable from mono panels as they're reduce in square

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shapes. This form of sun panel is less expensive however commonly gives barely decrease efficiency: round thirteen to 18%.

Components of the Solar Power System.

a. Solar Panel
b. Solar Regulator
c. Inverter
d. Battery

A. Circuit and Working

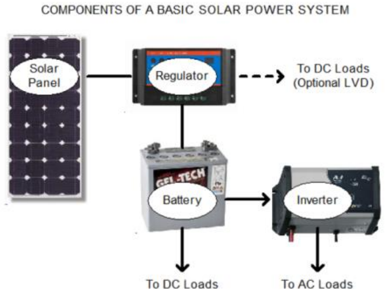

Fig.17

The sun panel converts daylight into DC energy to rate the battery. This DC energy is fed to the battery thru a sun regulator which guarantees the battery is charged nicely and now no longer damaged. DC home equipment may be powered immediately from the battery, however AC home equipment requires an inverter to transform the DC energy into 240 Volt AC power. Some DC home equipment may be linked to the regulator to take gain of the Low Voltage Disconnect and defend your battery.

B. *Calculation.*

1. Calculate Loads:

In order for you to size the system correctly, you need to note the power rating of each appliance that will be drawing power from the system.

For this example, we will calculate the power requirements for Our Smart Machine:

Bulb = 5*15

Electric Motor= 1*1000

Calculate Loads

Total Load = (Quantity)*(Watt)*(No. Of hours per day)

= 5* 15*2 + 1* 1000*3

= 3150 Wh/day

2. *Solar Input* :

In India, Avg Sun peak hour is 5.2 hour per day[1]

Required solar panel input = (3150Wh / 5.2 h) * 1.4 = 848.88

Note: The 1.4 used in this formula is a factor we have found that can be used to simplify the calculations for basic systems.

3. Select Solar Panels:

Select solar panels to provide a minimum of 390W. Always best to go bigger if possible:

Number of solar panels = 3

3 * 390W solar panels chosen which, when connected in parallel, will provide 1170W.

Type of Product	Solar Panel
Dimension	1956×992×36 mm
Max input current per MPPI(A)	9.63 A
Maximum output power	390 Watt
Start-up Voltage (V)	48 V
Mppt Voltage Range	38.4 V
Short Circuit Current	3.01

Table No.6 Solar Panel Specification

4. Select Solar Regulators:

The rated quick circuit modern of the 390W sun panels is 3.01 Amps each, giving a complete of nine Amps.

Select a sun regulator this is extra than able to coping with the whole quick circuit modern: nine x 1.25 = 10.22 Amps.

Steca 20Amp regulator chosen.

Note that, as defined withinside the notes above, you ought to permit 25% greater potential withinside the regulator score as sun panels can exceed their rated output in in particular cool sunny conditions. A 20A regulator will permit for a further panel withinside the future.

5. Select Inverter:

Select an inverter that is more than capable of supplying the maximum anticipated combined AC load required. Our appliances are DC operated so we have not selected any inverter.

Note: A pure sine wave inverter is the preferred choice, but if the budget is tight, a modified sine wave unit could be used.

6. Select Battery:

Select a battery, or a matched aggregate of batteries, this is able to present the full energy utilization with out being discharged greater than 70%.

In maximum instances it's far encouraged that the batteries are sized such that they've round three to four days back-up potential. This lets in for days with low daylight and decreases the each day intensity of discharge ensuing in longer battery life.

With 1 days garage potential and voltage of forty eight V, the battery sizing could be as follows:

Ah Required = (3150Wh * 1/ 48V) / 0.7 * 1.1 = 70.5Ah.

Note: The 1.1 is used on this system as batteries are commonly handiest approximately 90%ficient.

Model Name Number	48V 100Ah
Battery Capacity	100Ah
Voltage	48V
Brand	GES
Weight	27 kgs

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Batter Type	Lithium-ion
Usage/Application	Electric Vehicle
Capacity	100 Ah
Size	Prismatic
Minimum Order Quantity	1

Table.7 Battery Specifications

6. ANALYSIS

Static Structural Analysis turned into achieved for the vital elements which make contributions to the essential power and may be taken into consideration as structural elements of the system. This makes use of Finite Element Analysis with the aid of using growing right meshing. We have evaluated the whole deformation and pressure attention withinside the given elements.

1. Chassis

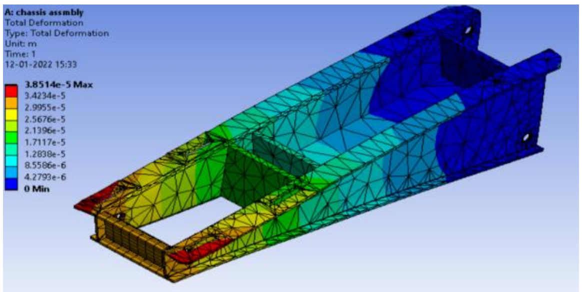

Fig.18

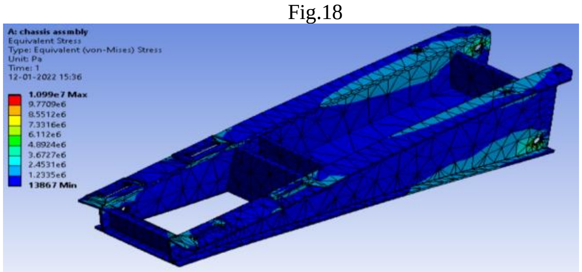

Fig.19

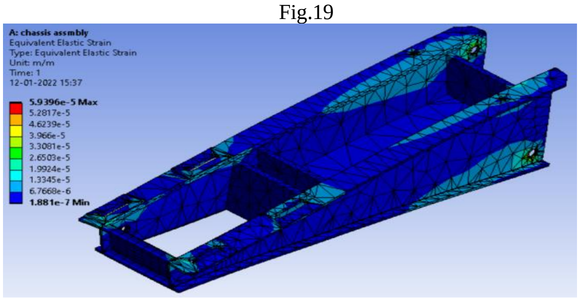

Fig.20

1. The maximum deformation of the Chassis is at the front part, which is 3.851e-5m, This deformation is due to the front load acting on the chassis. The deformation is negligible and doesn't affect the structure.
2. The maximum Equivalent Stress is 1.0977e7 Pa which is at the rear joint part of the chassis.The values are within the permissible limit.
3. The maximum equivalent Elastic strain is 5.9396 m/m. The values are in the permissible limit.

2. Plough Tool

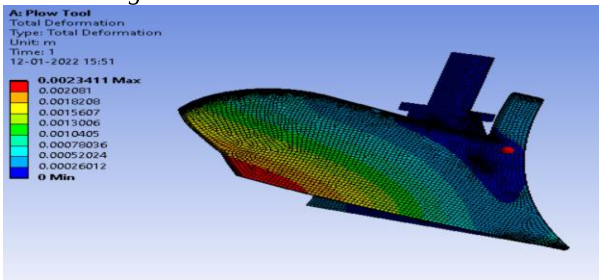

Fig.21

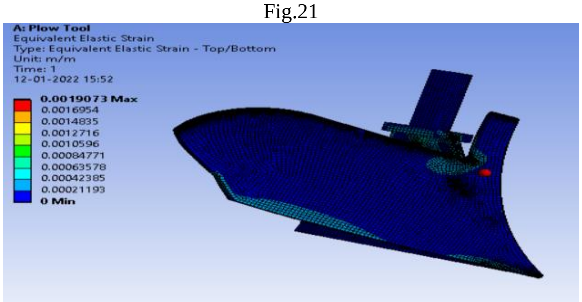

Fig.22

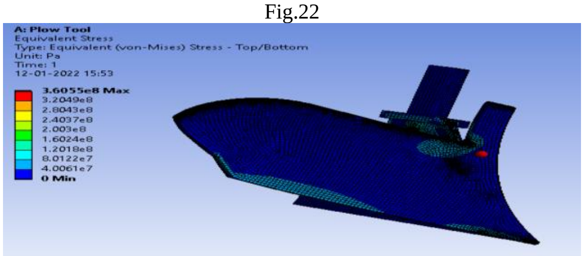

Fig. 23

1) The maximum deformation of the plough tool is at the side curve plate, which is 0.0023411mm, This deformation is due to the resistance force act due to soil. The deformation is negligible and doesn't affect the structure.
2) The maximum equivalent elastic strain is 0.0019073 mm/mm. The values are in the permissible limit.
3) The maximum Equivalent Stress is 3.6055e8 Pa which is at the bottom and joint part of the tool.The values are within the permissible limit.

3. Star Tool

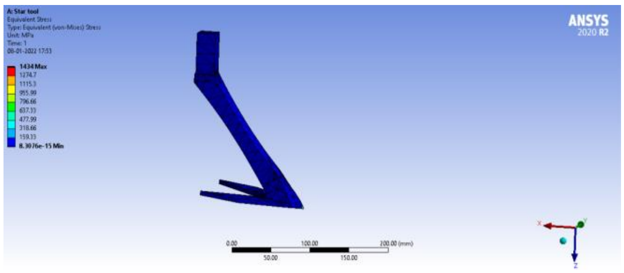

Fig.24

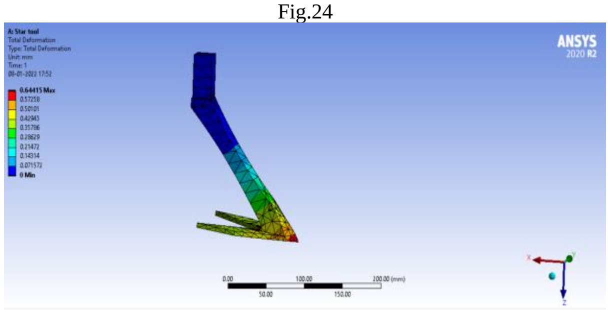

Fig.25

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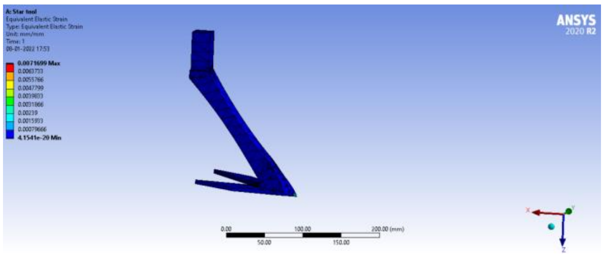

Fig.26

1. The maximum deformation of the Star Tool is 0.64415 mm, which is at Bottom Point. This deformation is due to the resistance force due to soil. The deformation can be reduced when the force will be divided in the same multiple tools.
2. The maximum equivalent plastic strain is in the bottom tip point, which is 0.0071699 mm/mm. The values are in the permissible limit.
3. The maximum Equivalent Stress is 1434 Mpa which is also at the bottom part of the Tool.The values are within the permissible limit.

ACKNOWLEDGMENT

It gives us immense pleasure and satisfaction in presenting this project report on “Photovoltaic Smart Agricultural Tool”. This report work has opened up new vistas of knowledge for us. We can now justifiably claim that this experience will stand us in good stead in the years to come. There are a large number of people without them this large and unique learning experience would be a nonstarter.

We wish to express our deep sense of gratitude to our internal guide Prof. Sunil. D. Chougule, Mechanical Engineering, for his valuable guidance and useful suggestions which helped in completing the project and this report work in time. Without his cooperation, it would have been extremely difficult for us to complete this report.

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We are grateful to other staff members of the Department for giving us important suggestions. We also heartily thank our Director Dr. Rajesh Jalnekar for giving us an opportunity to make work a success.

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