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RESEARCH ARTICLE OPEN ACCESS

Static Structural Analysis of Electric Tiller Machine

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Abstract:

Agriculture has always been an important aspect of the human ecology. It is a n important part of human life as it feeds us and thereby it runs the ecosystem. It is an extremely important section for living beings. Bust modern farming techniques are heavy-coughed and very intensive. In Indian Agriculture, generally, tractors or cultivator machines are commonly used for ploughing. Farm tilling is one of the most labor-intensive agricultural procedures. A low-cost portable battery-powered electric mini tiller machine is manufactured as a one-stop contemporary solution to improve traditional farming practices by reducing labour at a very cheap cost through the use of a motorized tilling mechanism. An electric tiller is capable of digging the soil using speed speed-rotating motor that has spikes. The motor is rotating with the help of a rechargeable battery which is mounted on the machine frame. A handle with controller switches helps the farmer to start and stop the motor as required. The rear supporting wheel helps the machine to counterbalance the weight. The cutter wheel rotates at high speed and penetrates the soil. A rechargeable battery and motor system make this machine cheaper as compared to IC engine-driven machines.

Keywords — **Electric tiller, Farmer, Tiller machine, Battery & Engine**

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I. INTRODUCTION

India being farming major, the need for modern technologies in agriculture routines is undisputed. Traditionally, manual labour or bulky machinery was employed to till the soil, preparing it for planting. Conventional tool like a Pick, Shovel, Hoe, or Trowel needs to be used one after another for land digging, soil lifting, and moving operations respectively. Wheelbarrow also required transporting small amounts of soil However, with advancements in technology, the introduction of electrical portable mini tillers has transformed the agriculture landscape. These compact and efficient machines offer numerous advantages, making them a game-changer in the world of farming. Electrical portable mini tillers are small-sized, lightweight machines powered by electricity. They are designed to assist farmers in soil cultivation, seedbed preparation, and weed removal. Unlike their gas-powered counterparts, electrical tillers operate quietly, emit no harmful fumes, and require minimal maintenance. Their compact size and manoeuvrability make them ideal for small spaces, raised beds, and urban farming. One of the standout features of electrical portable mini tillers is their convenience and portability. Traditional tillers are often heavy and challenging to transport, limiting their usability. In contrast, electrical tillers are compact and lightweight, making them easy to carry and manoeuvre. Their portability allows farmers to effortlessly move them around the farm, reaching tight corners and confined spaces with ease. Furthermore, their small size facilitates effortless storage, requiring minimal space in sheds or garages. Electrical portable mini tillers are designed with user-friendliness in mind. They typically feature intuitive controls, allowing farmers of all experience levels to operate them without difficulty. Starting an electrical tiller is as

simple as plugging it in and pressing a button. The absence of a pull cord or complex starting procedures eliminates the frustration and physical strain associated with traditional tillers. Farmers can now focus more on their farming tasks rather than struggling with machinery. In an era where environmental consciousness is paramount, electrical portable mini tillers provide a sustainable alternative to their gas-powered counterparts. They produce zero emissions during operation, contributing to cleaner air quality in the farm environment. Additionally, electrical tillers operate quietly, minimizing noise pollution and creating a peaceful farming experience. Their eco-friendly nature aligns with the growing trend of organic farming and sustainable practices, making them an attractive choice for environmentally conscious farmers. Compared to gas-powered tillers, electrical portable mini tillers require minimal maintenance. They eliminate the need for oil changes, fuel mixing, and spark plug replacements. Routine maintenance typically involves cleaning and inspecting the machine, ensuring it remains in optimal working condition. Moreover, electrical tillers have a longer lifespan due to their simpler construction and fewer moving parts, translating into cost savings for farmers in the long run.

II. LITERATURE REVIEW

A J Rane et.al [1], Portable Electric Power Tiller Machine is a portable battery-charged electric power tiller machine. Farming practices used in traditional agriculture. To provide maximum soil grip, the machine uses a wheel with welded angles. The wheel design was created to offer a strong grip on the soil that would allow the cultivator prongs to drag during the tilling process. An electric motor drives the pulling wheel through a sprocket chain arrangement. By adopting a motorized tilling system, it minimizes human effort at a very low cost. Using a unique portable design, the electric power tiller reduces the time and cost of tilling, enhancing agricultural output and efficiency.

Srinidhi Campliet.al [2], Multipurpose Battery Operated Electric Mini Cultivator for Tilling Operation this entails the design and development of chain and sprockets, shafts, belt drives, bearings, transmission cases, and chassis, among other components, in order to convert engine speed to Power Tiller tilting speed. This power tiller is designed for weeding in sugarcane plantations with a minimum inter row spacing of 1.2 meters. performance on the farm was good, and its capacity was 93 percent higher than hand harvesting, saving 35 percent in operation costs and two times the labor. Small and irregularly shaped plots of less than 150 m^2 were determined to be unsuitable for the machine

Shailendra Zaveriet.al [3], The portable electric power tiller and cutter machine is operated on battery power. The tiller machine is running on an electric motor which uses a chain and sprocket mechanism arrangement to drive the bike wheel rim. A lithium-ion battery is used to power the hub motor with a tiller blade through the soil. The machine makes use of a bike wheel rim with welded angles to provide efficient gripping on agricultural soil. This tiller machine provides a smart new fuel-free system for farming and farming. This Machine Works 2 to 3 hours.

III. 2D AND 3D MODELLING

Solid Edge V20 is computer-aided design (CAD) software developed by Siemens Digital Industries Software. It is a version of the Solid Edge software suite, which is designed to assist engineers and designers in creating 3D models and 2D drawings for various industries. Solid Edge V20 provides advanced capabilities for creating and manipulating 3D models.

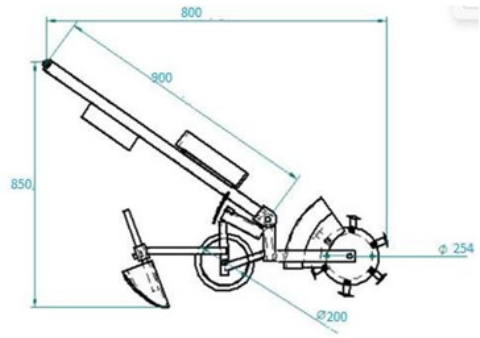

Fig 1: 2D Model

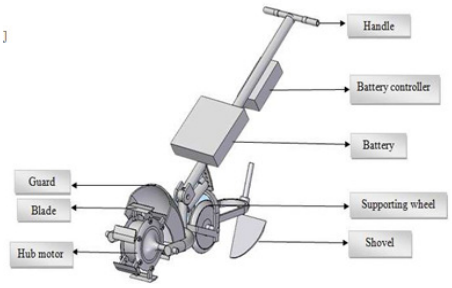

Fig 2: 3D Model

Table 1: Specifications

Si No.	Specifications	Units (mm)
1.	Hub Motor Diameter	254
2.	Supporting Wheel Diameter	200
3.	Length Of Handle	600
4.	Thickness Of Blade	3
5.	Blade Length	120
6.	Shovel Thickness	1
7.	Battery Box	260×240
8.	Controller Box Height	260
9.	Hub Motor Width	70

IV. DESIGN OF MINI TILLER

P= (2ΠNT)/60

Where P is power in Watt and N is motor speed in rpm 1000=(2π×650×T)/60

T=14.69Nm

MOTOR

- Loading capacity up to 200kg
- Total or Gross Power = 1400W
- Motor efficiency = 71.6%
- Net Power = 1000W
- Voltage = 48V
- Current= 30A

BATTERY

Battery output: 48 Volts x 34A = 1,632 Watts.

V. STATIC ANALYSIS

Electric mini-tiller analysis involves using software tools to simulate and analyze the performance of the tiller under various conditions. HYPER MESH software tools are used for stress displacement analysis. These tools simulate the physical behaviour of the tiller by solving mathematical equations that describe the relationships between forces, material properties, and displacements. Identifying areas of the tiller that experience high stress during operation. This is crucial for ensuring that the components can withstand the applied loads without failure. Understanding how different parts of the tiller move or deform under the applied forces. Excessive displacement could lead to operational issues or indicate potential design flaws. The analysis results can guide design improvements or optimizations to enhance the tiller's performance, durability, and safety.

A. Stress Analysis Of Battery Box Supporting Arm Analysis

A load of 80 N (kg) has been applied to the battery box and supporting arm of the electric mini tiller by considering three constraints separated by 160 mm & 715mm distance, Angle 59° , Length of the arm is 270mm, Total length is 800mm, Area of cross section is 1451.61mm2 ,Thickness 3mm, Material is GI square pipe(Mild steel strips of low carbon steel coils), Material properties are high level of abrasion resistance and can withstand harsh condition such as wind and rain, Modules of elasticity is 210 GPa, poisons ratio 0.3, Point A = rational freedom in x axis. The result of stress and displacement analysis shown below. As it can be seen from the analysis that the machine handle and battery box can able to withstand the load of battery easily without any buckling or deformation.

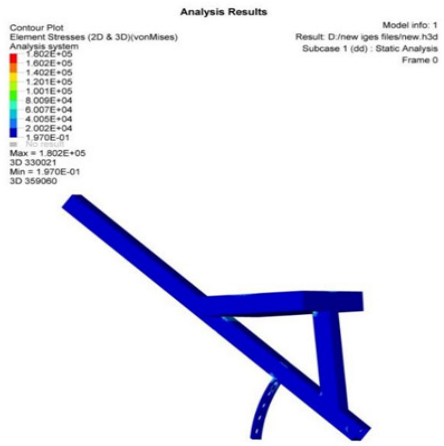

Fig. 3: Stress Analysis of Battery Box Supporting Arm Analysis

VI. STRESS ANALYSIS OF BASE FRAME

A load of 68N and 172N has been applied to the Base frame of the electric mini tiller by considering three constraints separated by 450mm and 300mm distance, Total length is 750mm, the Area of the cross-section is 1451.61mm2, Thickness 3mm, Material is GI square pipe(Mild steel strips of low carbon steel coils), Material properties are high level of abrasion resistance and can withstand harsh condition such as wind and rain, Modules of elasticity is 210 GPa, poisons ratio 0.3, Point A = rational freedom in x-axis

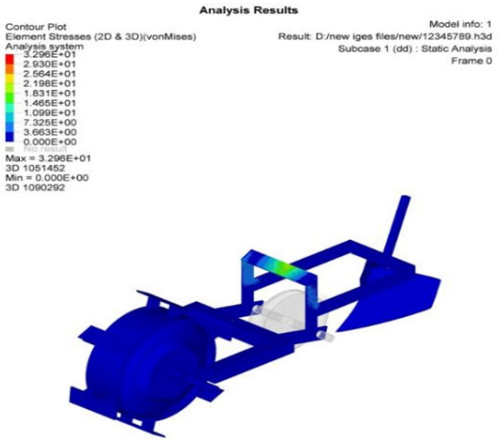

Fig.4: Stress Analysis of Base Frame

It was found that the weakest part of the frame exists at the centre but it can able to withstand heavy load and can have longer life.

VIII RESULT AND DISCUSSIONS

The maximum and minimum of stress analysis on the battery supporting arm are 1.802E+05 and 1.970E+01. The maximum stress is observed at the welded joint and minimum stress is observed in the remaining part of the section. As a result, it will lead to the deformation of the battery supporting arm.

The maximum and minimum stress analysis of the base frame are 3.295E+01 and 0E+00, the overall weight of the battery frame acts on the support wheel structure.

IX CONCLUSIONS

By using the Finite element method software, the base frame and Battery Box were analyzed. It was observed that the maximum and minimum stress values lie within the fracture limit and hence, it can be fabricated.

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