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"A REVIEW STUDY ON SWEEP TYPE TINE CULTIVATOR"

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ABSTRACT

The optimal conditions for a weeder tine to work are in loose or lightly crusted soil that is devoid of long-stemmed detritus. For use post-emergence, plants need to have strong roots. A tine's strength varies based on its construction and material. The sweep, or curved form of the tine, is another important factor. It has primary cutting blades that diverge rearward as well as one or more weed cutting edges that protrude outward and forward to prevent weeds from slipping past the sweep. The sweep creates soil mulch by breaking capillary in soil pores. In order to analyze the deformation and stress distribution of sweep type weeder tine, this work is reviewed for using CAD and FEM tools. Stresses caused by the application of force have a considerable impact on the weeder tine. This goal guided the development and presentation of the case study of sweep type tine cultivator.

Key Words: *Sweep Type Tine Cultivator, Push-Pull Type, ANSYS Workbench, Stress Analysis, Force Analysis.*

I. INTRODUCTION

Getting rid of unwanted plants from field crops is the act of weeding. There are many methods for controlling weeds, including mechanical weeding, heat weeding, flames, biological control, chemical control, and altering the agricultural technique. Weeds and other non-harmful plants have never been simple or straightforward to get rid of. Where they are not needed, weeds invariably appear. It takes a lot of labor to weed with a cutlass and a hoe in a commercial farming system. There is rising interest in the usage of mechanical intra-row weeders as a result of concerns over environmental degradation and a rise in consumer demand for food that is produced organically. Today's agricultural industry needs non-chemical weed management to ensure food safety.

The work rate of various weeding devices varies because of variations in crop growth, row and plant spacing, weed intensity, soil conditions, and other factors. Work rates for the hand harrow (Khurpi) can average between 300 and 500 man-h/ha. Between 200 and 300 man-h/ha are needed to manually hoe between rows using a chopping hoe. Under normal conditions, 100–125 man-h/ha are required to draw a push-pull type weeder down a row. For blade hoes and blade harrows, which are drawn by animals, the labor required varies from 6 to 20 man-h/ha. Furthermore, even on a small farm, if labor expenses are high, the cost of improved weeding instruments can be recovered in one season due to labor savings alone. Adopting better weeding tools has benefits such as shorter operation times, cheaper labor, and more effectiveness.

Weeding blades are thin metal blades that are used with various instruments with various names to remove weeds from confined spaces. Some instruments that can be used as weeding blades include gardening knives, pruning knives, Cape Cod Weeders (also known as Yankee weeders or crack weeders), patio knives (also known as Dutch patio knives), Hori-Hori knives from Japan, and Khurpi from India. Each sort of weeding blade has a shape and style that is appropriate for a variety of tasks. For plants like the dandelion, which can regenerate from a section of the tap root, removal of the entire tap root is necessary to stop weed growth, and a tool that can reach all the way to the end and

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remove it is crucial. Another factor to take into account is handle length. While most weeding blade types have short handles by nature, others are available with long handles that allow users to weed without bending or stooping.
The kind of soil, the crops, and the weeds all influence how a sweep-type tine is used. Sweeps should be used as shallowly as possible to prevent clipping the plant roots from harming the crop. Sweeps need to be almost flat. While the tip is on a floor or the ground. The outer tip of the wing should only be lifted 3-6 mm above the floor. The shovels and sweeps should be positioned 5 cm apart from the crop rows and evenly spaced on either side of the row to prevent damage to the standing crop.

II. Literature Review

Numerous studies have been conducted on the design of weeder tines. Several institutionally connected parties made findings that are relevant to these disciplines. The majority of the research entailed creating real models, according to almost all of the material that was studied. Studies on these models were also undertaken. By comparing the findings to parametric data and the findings of the study, the findings are verified. Below is a list of some of the literatures that were examined and judged to be crucial to this study on the examination of weeder tine.

H. Bernacki et al., The weeder operates by pulling and pushing weeds out of the ground and into the sunlight. The cutting blade enters the ground and cuts the weeds from their roots when force is applied through the handle. The entire component is supported by a wheel fitted with bearings, which lowers friction. The operator can push and pull in the desired direction more easily as a result. They have determined that this pressure is divided between tangential force (S) and normal force (N). The frictional force (T) of the root against the blade, $T = N \tan \varphi$, is produced by normal force during validation. Sweeps resemble a pair of connected shares. When the tangential force (S) exceeds the frictional force (T), the root is broken. [1]

Jonathan Jacob Shiru, to evaluate the performance of Okoro and maize crops grown in rows with a 30-cm space between them and so enable any necessary adjustments that would result in perfection, field tests were done. Although weed spikes left some weeds untouched, the sharp V-shaped cutter that penetrated the soil as a result of the power supplied by the handle allowed the weeder to effectively cut the weeds from the roots. The weeder works by pushing and dragging the weeds off the soil and into the sun. When force is provided through the handle, the cutting blade enters the earth and cuts the weeds from their roots. A wheel fixed with bearings supports the entire component, reducing friction. This makes it easier for the operator to push and pull in the desired direction. The outcome displays a weeding index (e) of 74.53%, a cutting blade efficiency of 88%, and a field capacity of 0.02 ha/hr. It is advised that the weed spikes be spirally welded or angled between 30 and 40 degrees to the direction of movement in order to improve the exposure of the weed to the sun. [2]

Mustafa Ucgul et al., have recommended doing an angle of repose test and penetration experiments with a disc and cone to determine the optimum discrete element modelling (DEM) parameters for simulating soil-tool interactions in a cohesion-free soil. DEM is one numerical method for examining the dynamic behavior of granular material. This study generated estimates for various geometries and speeds relating the draught and vertical forces as well as the furrow profile for a sweep tool. The simulation results were compared to the experimental sweep results for various width and rake angles. The research also showed the construction and simulation of a wide range of tool geometries to concentrate on a key tool geometry parameter, such as rake angle, in order to achieve a desired result, such as the smallest draft force or highest vertical down force. [3]

Rajashekar M et al., have developed and enhanced efficient farming equipment to perform weeding without the usage of energy. They provided low-cost modelling, simulation, analysis, production, and testing services for three-row weeders. The benefits of simulation-based design were discussed, along with the history and key characteristics of the driving mechanism for three-row weeding equipment. CATIA was used to carefully design the weeder's structure and mechanical parts, which included interference checking, kinematics simulation, two- to three-dimensional engineering drawing conversion, and assembly. The Trapezoidal and V weeder blade designs were developed to accommodate diverse soil conditions. [4]

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Uğur YEGÜL et al., in this study, the models that were developed were analyzed using the commercial FEM analysis software ANSYS, whereas the design step was carried out using Solidworks software. In the proposed models, both the operational conditions and the variability in the tillage system parameters were taken into account. The presumptions applied to the 3-D linear FEM analysis of the general material model. Stainless steel was the chosen material for the models. They examined total deformation and associated stress in different types of tines. The safety, displacement, and Von-Mises stress distribution factors are obtained from six different models. They have learned from the information acquired through analysis that the harrows' tines at their three-point linkage have undergone deformation and displacement. The values for total deformation, equivalent stress, and safety factor are all lowest for curved tine models. [5]

Silas O. Nkakini and Abu Husseni, An adjustable long handle, push-type operated wheel weeder was designed, built, and tested as part of this project. Additionally considered were bending moment, shear stress, and deflections. The mild steel weeding blade has dimensions of 51 mm by 210 mm and a 14 mm thickness. The blade is at the bottom end and is sharpened at a 15° angle to the horizontal. It is affixed to a headpiece for easy replacement in the event of wear and tear. The blade's targeted cut breadth is 0.2 m, while its maximum cutting depth is 0.6 m. Field capacity of 0.050 ha/hr. and efficiency of 87.5% were both obtained. The average performance index and weeding index, respectively, were 1108.48 and 86.5%. [6]

Ram Bhavin et al., An experiment was run to evaluate the field performance of a manufactured manual operated weeder at the Department of Farm Machinery and Power of the College of Agricultural Engineering and Technology, Junagadh. During the test, a number of variables were considered, including field capacity, weeding effectiveness, draft demand, and weeder performance index. The blade is made out of cast iron. Blade features a 125° V-shape angle. The blade serves two purposes: it lessens root damage and provides sliding action to prevent root adherence to the blade. The blade is 200 mm long and 60 mm wide. [7]

Vivek Kumar Bishwal and Joji Thomas, after evaluating the value of the stresses there, they made fillets and holes where the stresses were concentrated most heavily. Software from CREO Parametric and ANSYS were used to create the tines' model and determine the stresses. There may be loads acting on the cultivator parts that are far more than what the manufacturer had originally planned. In place of standard moldboard ploughs, cultivator shovel (sweeps) tools are utilized to penetrate deeply into the soil. It is now crucial to have a deeper understanding of the forces that exist under such demanding operating conditions in order to make any necessary changes to the design. [8]

M. U. Singh, In this study, four different types of manually operated weeders—straight-blade hand hoes, push pull weeders with five tines, push pull weeders with sweep blades, and peg type dry-land weeders—were evaluated for their field effectiveness. The journey took place on a farmer's cabbage field in the Papum Pare district of Lakhi, Arunachal Pradesh. The average effective field capacity of wheel hoes with five tines, wheel hoes with sweep blades, peg type dry-land weeders, and straight blade hand hoes was observed to be 0.0185, 0.022, 0.016, and 0.017 ha/h, respectively, at forward speeds of 0.285, 0.338, 0.290, and 0.270 m/s. According to the findings, sweep-type dry-land weeders had the best weeding effectiveness, at 79.72 percent, followed by straight-blade weeders, at 78.1 percent, tine weeders, at 75.7 percent, and peg weeders, at 72.5 percent. [9]

Alankrit Dewangan and Nakul Singh Rajput, in this essay, we examine nine-toothed cultivators that failed in various soil types. The tine acts as the real member of the cultivator which is in direct touch with the soil. Cultivators are utilized as key agricultural equipment for soil preparation. We can lessen the strain caused by altering the cultivator's tine design. The research that has been done on cultivators utilizing various approaches is presented in this study. The most prevalent V-shaped middle worker tool was a one-piece sweep that was used on chisel ploughs and field cultivators. It is feasible to accurately analyze the many types of stress that will develop on the product under various loading conditions by employing FEM technology. Additionally, by utilizing this technology, it is feasible to solve every issue with intuitive manufacturing and make enhanced tools that are high-quality, long-lasting, and affordable. [10]

Mehari Z. Tekeste et al., In this work, the DEM parameters of the Hertz-Mindlin with Parallel Bond model were calibrated to match the results of the evaluation of draught force and the soil failure zone using a tool bar moving at

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0.22 m/s and a 38 mm cutting depth. Discrete element modelling could be used to mimic tool-to-soil contact (DEM). The expected draught force and soil forward failure zone show relative variances from measured values of 7% and 24%, respectively. The interaction of three 3D reconstructed sweeps (fresh sweep, carbide treated-worn, and untreated-worn) with the soil was simulated using the optimized DEM soil model to evaluate the geometric wear, dimensional loss, performance on soil forces, and soil flow. The untreated worn sweep had less vertical force (less suction) than the carbide-treated-worn sweep and the new sweep, and the soil in its wing-induced soil failure zone (front and lateral) was of poor quality. [11]

Dhiraj V. Astonkar et al., Power weeders have been created and intended to give crops the best opportunity to take root after planting and grow quickly till harvest. A weeder is used to remove weeds from the entire cultivating area. This machine is propelled forward by a human, and its back end features a blade that is used to cut weed roots. The weeder is moved to the following row after the procedure is complete. The blade starts cutting the weeds as soon as the wheel starts turning. The process is made to be so simple that anyone may do it without any issues. Power requirements and machine size will be decreased by altering the shape of the blades, which are where soil and machinery come into touch. Blades are often secured to a flange on a rotating shaft using nuts and bolts. There are three main types of blades: L-shaped, C-shaped, and J-shaped. L-shaped blades are efficient and inexpensive because they lower expenditures associated with weeding and plant damage by 10.88% and 91%, respectively. [12]

Sergei Pirogov et al. have displayed the findings of their estimates of the stresses and strains that the proposed cultivator stand will undergo under external force loading. For the research, a finite element method was used with the ANSYS application. To simulate the motion of a cultivating shovel in the soil, they made the following assumption: the treated soil was thought of as a continuous medium. The objectives of developing a grid model of the flexible tubular element, determining the speed at which buckling of the flexible tubular element is removed, and identifying the horizontal component of the force exerted on the cultivator by the soil that causes buckling were finished. To ensure the trouble-free operation of the cultivator, it is necessary to execute tasks like creating a grid model of a tube element, calculating the forces of soil resistance acting on the cultivator tool, and determining the maximum speed. [13]

Ravikumar Hirpara et al., have developed a mini-tractor-operated weeding equipment that is time and cost-effective for multi-crop weeding operations in commercial and intensive agricultural systems in India. This section covers the design of sweep-type weeding tools for five different row-to-row crop spacing, including castor (900mm), sorghum (300mm), chickpea (450mm), and maize (600mm) (1200mm). During the design process, a few of the most important factors taken into account included operational safety, user convenience, and production costs. Mild steel flats with a carbon content ranging from 0.15 to 0.25% were used to make the most typical cultivator tines. The frame mounted on a miniature tractor was chosen to have a sweep-style blade attached to it. The sweep blade outperformed the straight and curved blades in terms of performance, having the lowest draft force per unit working width and the best performance index. The frame contained three different types of sweep blades that were arranged in accordance with the crop spacing standards. [14]

Deep Kishorkumar Bhatt, The constraints of conventional weeding tool attachments can be overcome by the design of the motor-powered, small, lightweight, and manoeuvrable weeding tool presented in this work. The proposed weeding tool can also be used to precisely remove weeds near to the crops when doing a range of weeding jobs, such as intra-row, inter-row, and between-row weeding. In order to perform additional design optimizations, the computer-aided design (CAD) of the suggested weeding tool is additionally subjected to stress analysis utilizing the finite element analysis (FEA) method in this research. The tool's design is later altered in light of the analysis's findings. [15]

Akash M. Awachat and Dr. M. J. Sheikh, their study employs the technique of analyzing the stresses placed on the shovel during operation. This shovel was meticulously modelled using CATIA CAD software before being subjected to FEM analysis. Then, using ANSY software and FEM analysis, the stresses were determined. In this study, the maximum cutting depth and the strains exerted on the tines while operating on the field are verified using a 5-Tine Duck Foot Cultivator. The duck foot cultivator is made up of inflexible tines, sweeps, and a box-shaped steel rectangular frame. The sweeps' triangular design, which resembled a duck's foot, earned them the nickname "duck foot cultivators." The sweeps are detachable when they grow worn or dull since they are made of En45 material and connected to the tines with fasteners. [16]

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III. Sweep Type Tine Cultivator

Sweep is a cross-cultural term for a method of removing weeds with shallow roots from in between rows of crops. Sweeps, or V-shaped blades with beveled edges, make up this device. The blades are fastened to the tines with countersunk bolts and nuts, and the tines are subsequently fastened to a frame. Sweep blades skim the soil at a shallow depth of 2 to 3 cm, cutting the weeds. The cutting motion of the blades breaks the soil capillary tubes and produces soil mulch for moisture absorption. Every day, it covers 1.75 to 2.5 ha. The following are the main features of the unit:

- Suitable for all types of soils and row crops
- Provides mulch for the soil and preserves soil moisture
- Effective for intercultural operations
- The cultivator stirs the soil and breaks up clods.

The tines on the cultivator's frame fully comb the soil of the field. The duties of a cultivator are positioned somewhere between those of a plough and a harrow. The main responsibility of a cultivator is to get rid of weeds. The crucial duties stated below are carried out by the farmer:

- Pull the weeds from the field.
- Open up the soil to encourage the growth of healthy crops.
- Mulching the surface might help you keep moisture in check.
- To plant seeds when it has accessible sowing attachments.
- To prevent soil evaporation on the surface and encourage rapid rainwater infiltration.

Figure 1: Different Type of Sweep Shape Used in Tine Cultivators

IV. Conclusion

In this project, a sweep type tine is made using the modelling programmed SOLIDWORKS. ANSYS Workbench software is used to study total deformation, equivalent stresses, and strains arising from shape change in specific situations. The method for predicting stress distribution and deformation is one of the most crucial elements of tine design and analysis. When force is applied through the handle, the weeder operates by pushing and drawing the cutting blade into the soil to pull out the weeds from their roots. We must make an educated guess regarding the weeder's velocity, draughts, travel speed, and necessary power in order to establish the force acting on the tine. Observation suggests that this strategy is advantageous to small-scale and local farmers who must exercise extra caution and operate on fields for weeding and intercultural operations in row-grown vegetables and other crops.

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