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Optimization of the Design of the Cultivator Rotary Working Body Blade and Analysis of the Vertical Load Value

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ABSTRACT: The article analyzes active and passive rotating working elements widely used in agriculture and their parameters. In addition, the structure and operation of rotating working elements, as well as agricultural machinery equipped with such elements, are presented. A rotary cultivator is a plowing machine designed to prepare land by breaking and crushing the soil. In motor vehicles, although deformation is associated with tool wear, stress is the main factor leading to tool wear. This article describes the design of a blade analysis using a computer modeling method. The energy required for driving operations and the forces generated at the interface of the device with the soil for 40 hp. and 80 hp. tractors are evaluated.

KEY WORDS: deformation, cutter, rotator, cultivator, structural analysis, von misses stress.

I. INTRODUCTION

In our country, great importance is being attached to the development of agriculture, as in all other sectors. In particular, the Presidential Decree of the Republic of Uzbekistan No. PQ-3117 dated July 7, 2017, "On measures to further develop the scientific and technical base in the field of agricultural machinery," has served as a stimulus for deepening scientific research in this field [1]. Rotational working elements are widely used in various agricultural machines. The diversity of rotational working elements complicates the work of manufacturers and engineer-technicians. Therefore, it is necessary to organize these working elements into a specific system [2]. Rotational working elements are used as the primary working components in soil-cultivating plows, seeders, cultivators, mowers, and other equipment. The main part of a rotational working element is its rotor, that is, the rotating component [3].

II. LITERATURE SURVEY

Rotary cultivator is a special mechanical tool for mechanical soil cultivation, used for row spacing. A rotary cultivator has a series of vertical blades in a drum to break up the soil. Mechanical tillage of the soil is one of the most important factors directly affecting its ability to provide plants with water, air, heat and nutrients. Also, in the process of soil cultivation, weeds and pests are destroyed and fertilizers are mixed. Quality performance of these operations serves to increase soil fertility or at least to replace nutrients absorbed by crops during the growing season [4].
The physical and mechanical characteristics of the soil, the unit's speed, the crop's health, the choice of cultivator working bodies, and their placement plan all affect the quality of inter-row tillage. Cotton crop tillage is unique in that several agrotechnical procedures are carried out during the growing season to optimize plant growth [5].
Intercropping is an essential part of the entire cotton farming system. To prepare cotton in between batches, customized cultivator-seeders with interchangeable passive working components are being employed. It only functions well in mature soil, that is, when the moisture content is between 10 and 10 cm (16 and 18%), which is ideal for optimal soil enrichment during irrigated cotton farming. In organic farming, substrate treatment is frequently employed, although it does not offer the necessary level of soil purification [6].

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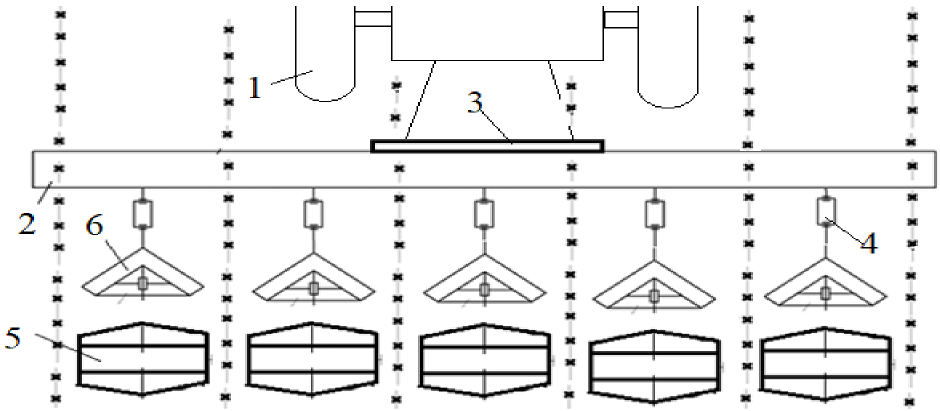
Depending on the mechanism, the most common rotating working elements can be divided into active and passive. The tractor's cardan shaft sets the rotating working elements in motion. The speed of the tractor determines how passively the rotating working elements move. Many years of practical experience show that the currently used bodywork does not ensure proper soil preparation and does not meet the requirements for cotton rows. Numerous studies have shown that the rotary tillage unit is the most advanced soil cultivation tool. Another, simplest mechanism with rotating working elements is the inter-row cultivator (Fig. 2.1).



1 - Tractor; 2 - Cultivator frame; 3 - Automatic coupling; 4 - Parallelogram linkage mechanism; 5 - Rotary tillage unit; 6 - Flat-cutting blade.
Fig. 2.1 Structural and Technological Layout of the Proposed Inter-Row Cultivation Unit

The geometry of rotary drum vertical knives is the most important part of their design as the length of the vertical knife and the shape of the knife tip facilitate cutting. Therefore, it is necessary to alter the design by implementing changes in geometry in order to reduce the cost of the knife and the cost of land preparation.
application.

III. MATERIALS AND METHODS

Objectives
1. Using CAD software, a concrete geometric model of the revolving tiller blade will be created.
2. Provide a CAD analysis of the parts of a rotary cultivator [7].
Blade details

Table 3.1
Blade parameters

№	Parameters	Values
1	Effective Vertical length (mm)	127
2	Blade cutting width (mm)	500
3	Blade thickness (mm)	8

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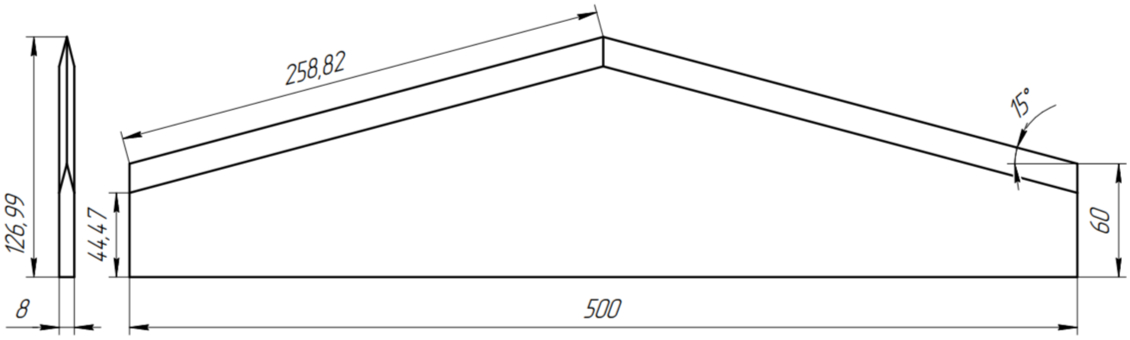

Fig 3.1 Blade for rotary drum

Table 3.2

№	Parameters	Values
1	Rotary tiller work depth (mm)	100
2	Rotary tiller work width (mm)	500
3	Rotor rpm	90
4	Blade peripheral velocity (m/s)	5
5	Total number of blade	36
6	Prime mover forward speed (m/s)	1.2
7	Number of blades which action jointly on the soil	3
8	Prime mover Power (HP)	40-80
9	Traction efficiency (c)	0.9

The model was developed in 3D CAD software and the analysis was evaluated in ANSYS software [8].

$$K_e = \frac{K_s \cdot C_p}{i \cdot Z_e \cdot N_e}, \qquad (1)$$

Where -

K_e - soil force acting perpendicularly on the cutting edges of each of the blades

C_p - coefficient of tangential force,

i - number of flanges,

Z_e - number of blades on each side of the flanges,

N_e - number of blades which action jointly on the soil.

IV. RESULTS

The results of the analysis are shown in the following figures for the blade in graphical format. Stress is the main factor driving tool wear, even if deformation and tool wear are related in the case of tillage tools. In this experiment,

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different tool forms resulted in different stress distributions. The Von Mises stress and total deformation data for the rotary cultivator blades are shown in the accompanying figure.

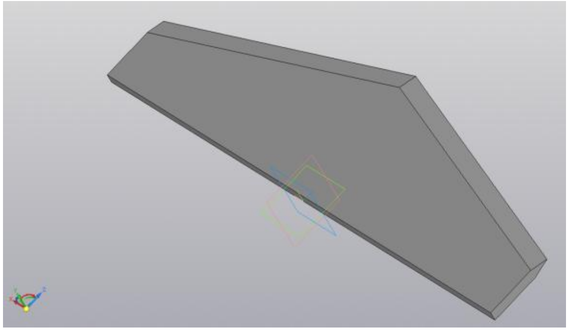

Fig. 4.1 3D Model of Blade

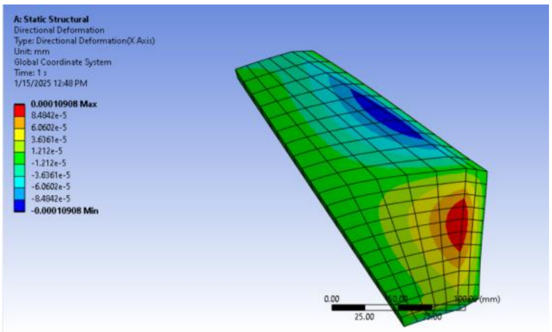

Fig. 4.2 Directional deformation of Blade

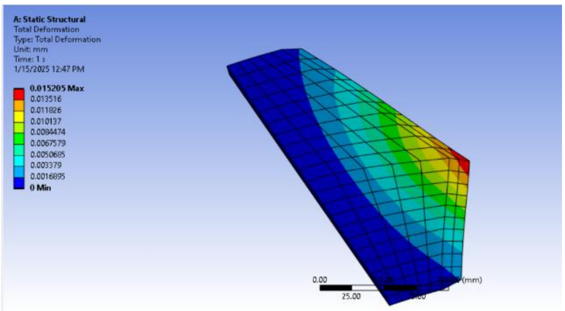

Fig. 4.3 Total Deformation of Blade

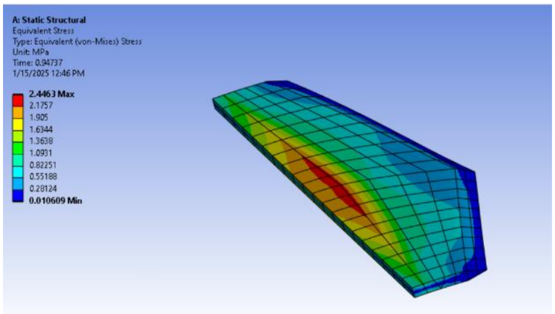

Fig. 4.4 Von-Misses stress of Blade

Equivalent (Von-Misses) stress of Blade

1. Maximum Stress: As shown in red, the highest equivalent stress value is 2.4463 MPa. This is the region that is most heavily loaded.
2. Minimum Stress: The area with the least load has a minimum stress value of 0.010609 MPa, which is shown in blue.
3. Stress Distribution: Although stress is present throughout the item, the core region (the red and yellow patches) has the largest concentrations. This suggests that this area of the structure bears the majority of the weight.

Total Deformation of Blade

1. Maximum Deformation: As shown in red, the highest overall deformation value is 0.015205 mm. This is the region that is most affected by the load.
2. Minimum Deformation: These locations undergo either no deformation or very little distortion, as shown by the minimum deformation value of 0 mm (shown in blue).
3. Distribution of Deformation: The top-right section of the structure (the red and yellow sections) shows the highest deformation and is probably the area most affected by the applied load.

Directional deformation of Blade

1. Maximum Directional Deformation: The red zone shows a maximum deformation value of 0.00010908 mm. The greatest elongation or contraction along the X-axis is represented by this.
2. Minimum Directional Deformation: The maximum contraction in this direction is shown by the minimum deformation value of -0.00010908 mm (blue area).
3. Distribution of Deformation: The yellow and green areas along the X-axis show the most deformation, indicating extremely low deformation values. The extremes of extension and contraction are shown by the red and blue zones, respectively.

V. CONCLUSION

In this special article, we designed the newly developed cultivator rotary drum blade in a 3D CAD software based on the dimensions determined through field experiments and analyzed it in ANSYS to optimize its dimensions. For the

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analysis, a 300 N vertical load force was applied, and the following conclusions were reached:
• Stress Values: For both steel and aluminum, the maximum stress value is far lower than typical industry norms, regardless of the material utilized. This shows that the imposed loads can be safely supported by the structure.
• Suggestion: The building satisfies safety regulations. However, it is crucial to confirm the material qualities and particular design criteria in order to guarantee correctness.
• distortion Values: The findings show that the maximum distortion is negligible and has no effect on the stability of the structure or the performance of the material.
• Suggestion: These deformation values satisfy the structural specifications. It is advised to compare the outcomes with any deformation limitations that may be in place, such as those found in precision mechanical systems or aircraft.
• Directional distortion Values: There is little to no distortion of the structure along the X-axis. The construction is stable under the imposed load since both the maximum and lowest deformation values are incredibly modest.
• Suggestion: These findings are consistent with the structural specifications. It would be useful to compare the findings to any specified deformation limits if they are given.

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