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CHALLENGES IN THE 3D MODELING OF A FIELD CULTIVATOR FOR SOIL PREPARATION

Abstract: *Prior to planting, the soil must be prepared usually by machines called cultivators. Older field cultivators are suitable for modification for row cropping. The crops and the tractor power available will determine specific needs. Factors to consider include row spacing and row spacing flexibility, whether you need a towed or tractor mounted unit, frame size and layout, ease of levelling, ease of moving, removing, and replacing shanks, overall machine condition, and the robustness of the shanks.*
The paper describes the struggle concerning the 3D modelling of such a field cultivator with special features

Key words: *Field cultivator, Computer modelling.*

1. INTRODUCTION

The objective of the proposed theme consists in the contributions relating to the achievement of a combiner for preparing germinative bed, with reduced transport clearance, intended to work as a unit with 60 hp tractors, which will assure an increase of qualitative indices and which has the gauge of transport in accordance with international standards and the national (CA TC-2000), with a new regulation on transportation on public roads.

The combiner is used in the spring, autumn on frozen ploughings to the seedbed preparation (grinding and loosening the soil, land levelling at depths of approx. 10 cm) technology grain crop grains, legumes, vegetables and technical plants.

Specific agrotechnical requirements impose that germinating bed preparation be achieved with an optimal ratio between capillary and non-capillary porosity, with the most favourable water, air and feed regime to avoid loss of soil water through evaporation to obtain a good growth and development of cultivated plants. [1], [2]

2. AGROTECHNICAL REQUIREMENTS

a) For the preparation of the spring germinating bed with combiners on autumn with slag located on the middle of soil with a moisture in the working layer of 20-23%, continuous working depths will be achieved continuously between:

2 ÷ 5 cm with bended-tipped knives;
2 ÷ 5 cm with spoon-tipped knives;
4 ÷ 10 cm with reversible chisels knives;
6 ÷ 14 cm with arrow knives.

b) In the spring works, on a field shown in autumn under the above conditions, the combiner range must achieve a degree of shredding (bulges smaller than 5 cm) of approx. 90%.

c) Under the same conditions as in a) at an initial weed density of 90-100 pcs / cm2 and at a mass of vegetable residues of approx. 170 g / m2, the degree of destruction of the weeds will be at least 90% and the degree of incorporation of the vegetal remains will be at least 85%.

d) The surface of the worked soil shall be uniform without bumps greater than 30 cm.

3. FUNCTIONAL PARAMETERS AND CONSTRUCTIVE DIRECTIONS

a) The proposed combiner for the preparation of the germinative bed with a reduced gauge shall be made in two types, namely:
- Working width max. 4 m with a mass of max. 950 kg for the 60-HP tractor on wheels;
- Working width max. 6.5 m with a mass of max. 2100 kg for the 100 HP double-traction tractor.

b) Fitting in the transport gauge shall be achieved by vertical folding with hydraulic drive.

c) The combiner will have at his disposal active organs composed of:
• Cultivation tools with chisel blades or arrow knives to be used depending on the degree of soiling;
• double rotating helical roller.

d) Copy wheels will allow the working depth to be adjusted within the limits imposed by agrotechnical requirements and will be unified.

e) The combiner will allow for the attachment of ancillary equipment or liquid chemical fertilizer.

4. OPERATIONAL REQUIREMENTS

a) The grower's light will be min. 300 mm and the transport width will not exceed 3 m. [3], [4]

b) The working speed will be max. 3.5 m/s and in max. 4, 1 m/s.

c) The safety factor in operation will be approx. 0.97.

d) When constructing and operating the combine, the legal provisions for the protection of the work and for the safety of the traffic on the public roads shall be observed.

Fig. 1 Articulated combiner proposed to be enhanced.

5. COMBINER PRESENTATION

The combiner is worn type, intended to be used with 60 hp tractor on wheels (see fig.1).

It consists of a frame, three active organ module (s) (flexible reversible knives and / or arrow knives) with flexible supports, three helical roller modules and a hydraulic installation for folding side sections in the vertical plane achieve reduced transport gauge, according to traffic regulations on public roads).

It has the shape of a rectangle reinforced with a longitudinal central crosspiece and is made of square pipe, wide steel and sheet of various thicknesses. It consists of three parts, a central frame and two laterally assembled hinges.

The central frame is made in the shape of "I" and is provided at the front with the combination coupling device on the tractor's hydraulic lifter, at the rear with hydraulic cylinder fastening plates, on the side has two pairs of hinges and in the central area find the bonding plates for fixing active working organs and helical trays.

The side frames are made in U-shaped form and are provided with connecting hinges with the central frame, with fixation plates for active working organs and helical rollers and hydraulic cylinders for fixing the cylinders.

The active organ modules are each composed of a frame, working organs, also called active organs, a front link triangle and a back-link pipe. The module is made of parallel welded stiffeners on which the active knife-type organs reversible chisel and / or arrow knives. A front-side triangle and a back-linking pipe are attached to the frame of the modules and secure against the combustion frame. Modules with active organs are linked, by means of chains, to the rear helical roller modules.

Rear helical roller modules each consist of a crossbar, a rectangular frame, and two helical roller fields with rotation bearings.

Rear helical roller modules are mounted on the combiner frame by means of devices that allow the rear helical roller module to be adjusted longitudinally and transverse, tilt of the ground and, on the other hand, to adjust the depth of work.

The hydraulic system of the combiner is designed to reduce the gauge in transport by vertical folding (with a 110 ° angle) of the side frames to fit the traffic rules on public roads It consists of a hydraulic cylinder with valves hydraulic retention, pipes and hoses.

The main adjustments of the advanced germinating bed preparation units, with a reduced gauge in transport, for 60 hp tractors are the following:

• adjusting the depth of the soil and grinding of the soil in the 4-10 cm beach is done by vertically adjusting the position of the reversible chuck or arrow to the position of the working depth limiting wheels;

• adjusting the depth of grinding and leveling of the soil in the 4-10 cm beach is done by vertically adjusting the position of the rollers to the position of the reversible chisel or arrow or to the position of the working depth limiting wheels;

• vertically adjusting the combinators is done by screwing or unscrewing the central tie so that they have working organs parallel to the ground in the working position;

• Horizontal adjustment of the combinations is done by adjusting the central frame and is designed to achieve the same depth of work across the width.

5.1. Main Design features

Table 1

Main required design features

Characteristics		U.M.	Combiner
Type		-	Worn
Working width		m	3,9
Nr. active organisms for total cultivation		-	36
The distance between two traces of active organs		mm	110
Diameter of rear helical roller		mm	310/250
Light of transport		mm	300
Overall dimensions (open)	length	mm	3350
	width (open)	mm	4080
	height	mm	1150
Constructive mass		kg	960
The gauge in transport		m	2950
The tractor required to drive		CP	60

Table 2

Main functional features required

Characteristics	U.M.	Combiner
The working depth:	cm	4-10
Working speed	km/h	5-8
Transport speed (max.)	km/h	15

Table 3

Constructive features of loosening and shredding organs

Characteristics	U.M.	Combiner
Knife type: arrow knife	buc.	36
chisel knife	buc	36
Roller type: in front	buc	3
rear	buc	3
The width of the work organs		
arrow knife	cm	120
chisel knife	cm	35
The diameter of rollers: in front	cm	310
rear	cm	250

6. CONTRIBUTIONS CONCERNING THE IMPROVEMENT OF CONSTRUCTION AND FUNCTIONAL CHARACTERISTICS OF THE ARTICULATED COMBINER

The combiner lends itself to several improvements from several points of view as follows [6], [7]:

• Reduce gauge and increase transport safety;

• Material savings by resizing subassemblies and benchmarks while retaining proposed work parameters;
• Increase dynamic and cinematic performance.
The folding soil combiner has the following optimized design features, as follows (see fig.2, fig.3 and fig.4):

1. Main frame
   - Central framework;
   - Left side frame;
   - Right side frame.
2. Hydraulic cylinder
3. Frame for the attachment of the work bodies
4. Organs of work
   - Springs for stiffening
   - Clamps for holding active organs
5. Roller tensioner
6. Roll up with notches
7. Roll smooth
8. Adjustable wheels
9. Support for rollers

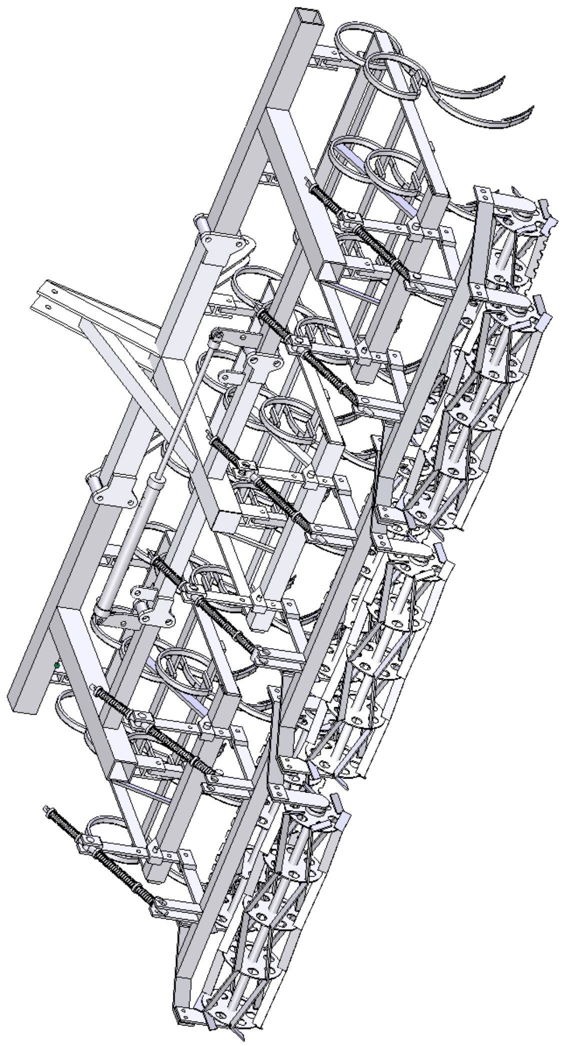

Fig. 2 3D view of the combiner.

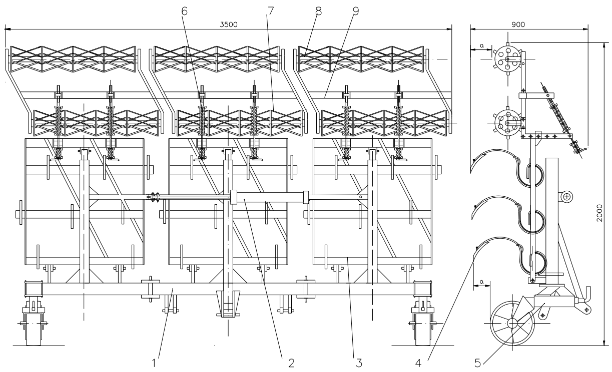

Fig. 3 Scheme of hinged soil combiner.

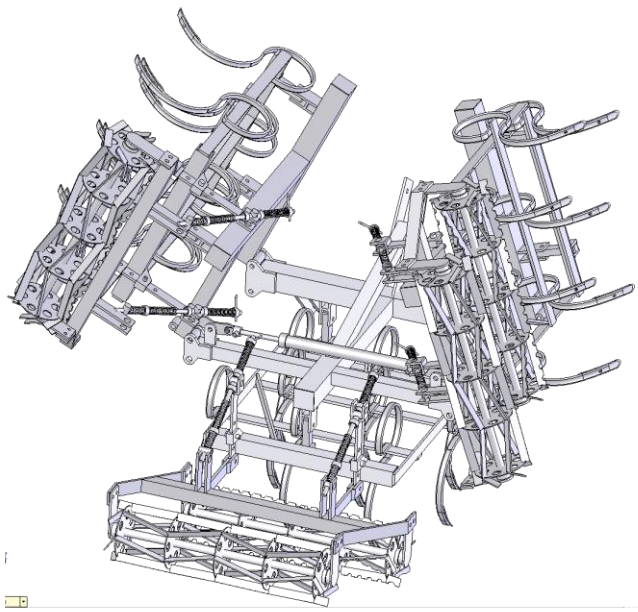

Fig. 4 3D view of the articulated combiner for road transport.

7. THE MAIN FRAME

The frame acts as a support and stiffener for the combiner and can be assimilated to a skeleton on which other active parts are mounted. It is composed of three parts articulated between them:
• the central framework;
• right frame;
• the left frame.

The role of the frame is to ensure the geometric stability of the combiner and the constancy of the proposed work parameters. Rigidity is ensured by using square profiles of □ 90, the entire construction being welded. [5], [6]

The modeling of the frame consisted in the exact determination of the demands it underwent, followed by the geometric remodeling. As a result, a reduction in material consumption, a better distribution of effort and greater stability of the combiner all took place.

As a result, a reduction in material consumption, a better distribution of efforts and greater stability of the combiner all took place. Below is the optimization of the central framework (see fig.5).

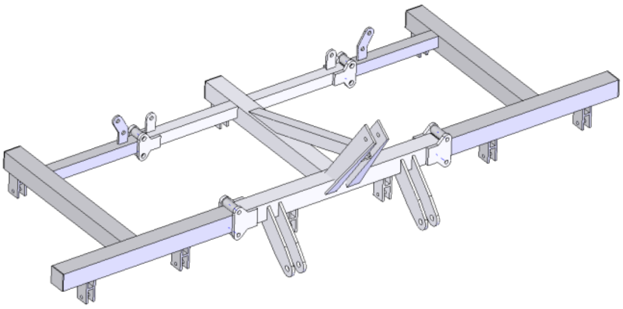

Fig. 5 3D view of the main frame of the combiner.

7.1. Maine frame modeling [10]

The modeling of the central frame was made using SolidWorks 2019 version. The advantages of this modeling are as follows:

• Automatic detection of material interferences or modeling errors;

• Accurate determination of the center of gravity and all other geometric-mechanical characteristics;

• Easy generation of technical documentation and material requirements;

Once the geometric model is realized, the optimization activity takes place in several stages as follows:

 Accurate positioning of the center of gravity for correct positioning of the subassemblies (knife support and roller support) as well as a correct balancing of the combination assembly;

 Simulate frame loading as close as possible to reality;

 Run a computer numeric analysis to determine the stresses as well as the movements that occur in the frame in the real work process;

 Adopt an optimal construction solution that will track maximum work and technological performance in reasonable cost and material consumption.

8. CONCLUSIONS

The constructive optimization of the combiner has gone through the following stages:

o Studying the specialized literature in the field of combinators

o Reporting the execution documentation of existing combiners

o Solid modelling of all parts

o Creating subassemblies

o Creating the overall functional assembly

o Simulation of combiner operation

o Reanalysing the sub-assemblies through functional improvements

o reanalysing and remodelling component components to reduce mass and increase technological feasibility.

o A new approach to the functional dynamics of the remodelled simulator by computer simulation

Analyses performed on the combiner's components have revealed many optimization possibilities such as reducing the mass of components, improving their performance, reducing fuel consumption per unit of hectare processed.

The results of the study were implemented and verified in practice at AGROMEC STAR Society in Bistrita.

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