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COMPUTER AIDED DESIGN OF EQUIPMENT TRENCHER

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ABSTRACT

This paper presents a constructive solution of trencher equipment with rotary cup and lateral conveyor belt. 3D model performed using NX 7.5 software and the assembly drawing has been designed to meet the requirements of productivity, stiffness and ease of use.

KEYWORDS: equipment trencher, CAD.

1. Introduction

Special trencher can be used in various fields such as:

- trenchers for drainage in agriculture.
- trenchers for pipes.
- trenchers for electric cables.

Special trenchers are classified as follows:

- Self-propelled trencher
  - with rotary cup (fig. 1)
  - with squeegees (fig. 2)

Fig. 1 Equipment-trencher with rotary cup

Fig. 2 Equipment-trencher with squeegees

- Equipment-trencher attachable construction machinery, tractors.
  - with rotary cup (fig. 3)
  - with squeegees (fig. 4)

Fig.3 Equipment-trencher with rotary cup

Fig.4 Equipment-trencher with squeegees

2. Components, functioning

A new constructive solution of a narrow trencher equipment type milling [1], [2] is shown in fig. 5 (assembly drawing in 2D). It has a higher productivity comparing with existing ones on the market.

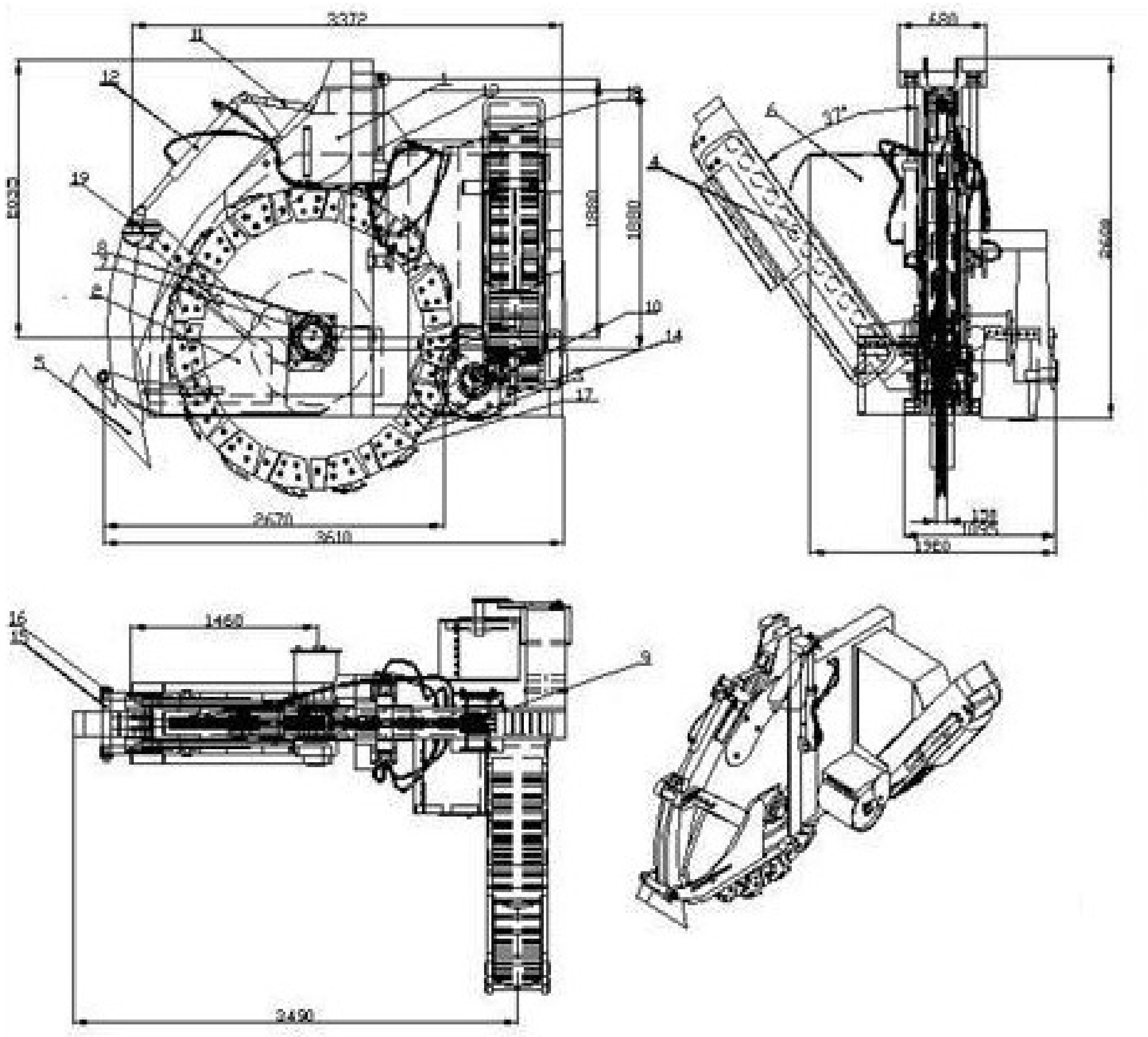

Fig. 5 Assembly 2D drawing of trencher equipment with milling disc:
1.equipment housing; 2.mudguards; 3.milling disc with hydraulic engine; 4. conveyor belt; 5.digging element; 6.transport mudguards; 7.shaft; 8.bearing; 9.worm shaft; 10.bearing; 11.hydraulic cylinder; 12.hydraulic cylinder; 13.hydraulic cylinder; 14.roller conveyor; 15.bolt; 16.nut; 17.screw; 18.hydraulic hose; 19.screw.

The equipment is attached to the tractor and it is coupling to its hydraulic system. Milling disc is driven by a rotary hydraulic engine and can be adjusted by means of hydraulic cylinders [3]. Ground conveyor belt is composed of a worm shaft and conveyor belt driven by rotary hydraulic engines.

Milling disc is composed of 16 interchangeable segments with mechanical fastening (pins and screws). It allows changing the piston rings worn with minimal effort under conditions of the site. Segment implanted teeth are heat treated steel having increased durability.

The auger plate that allows loading the conveyor with earth has on its flanks a high frequency of quenching treatment to hardness of 42-46 HRC.

The equipment can be raised above the ground and in this position the tractor can run in optimal conditions moving to another position.

The technical characteristics of the equipment are:

- productivity = 60 m/h at a depth of
- 0,75m, ground category 3;
- length = 3610mm;
- height = 2600mm;
- width (without conveyor belt) = 1095mm
- width (with conveyor belt) = 3490mm
- Total weight = 1100kg
- Maximum depth = 750mm
- Cutter diameter / width = 1500mm/150mm

3D modeling was performed using specialized software such as: AutoCAD – 2010 [4] and SOLID EDGE v.4 [5], until desired results were determined based on calculations.

This allows the computer aided designing of any equipment size by changing the operating parameters.

Fig. 6 and 7 show the 3D model of the equipment type milling narrow trencher with the same composition as in fig. 5.

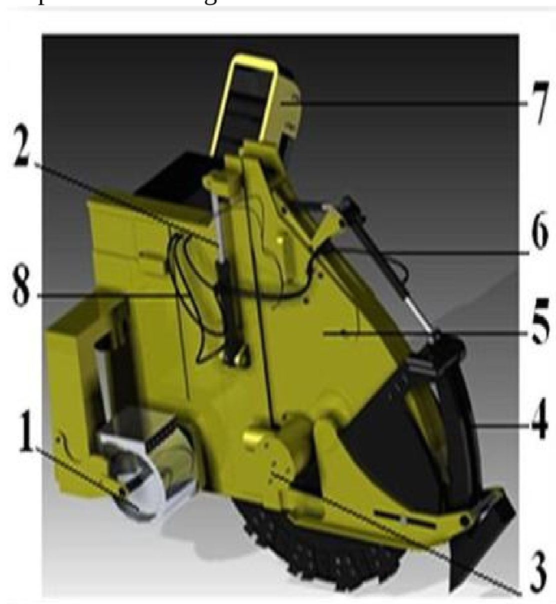

Fig. 6 3D-modelling of equipment (left view) 1&3.rotary hydraulic engine; 2&6.hydraulic cylinders; 4.spur of direction; 5.protective metal housing; 7.conveyor belt; 8.hoses and fittings

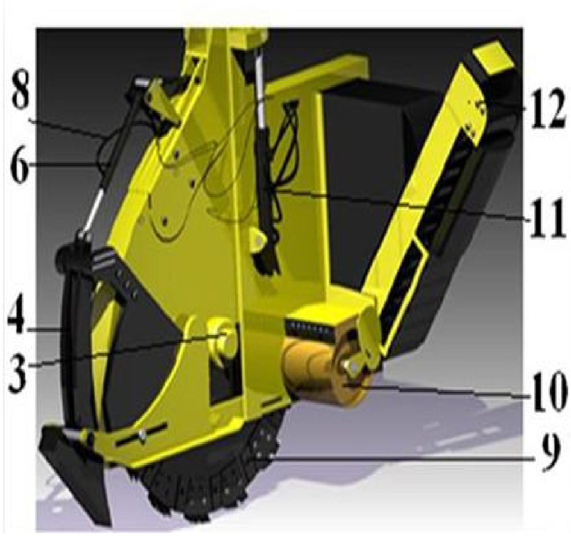

Fig.7 3D-modeling of equipment (right view) 3.rotary hydraulic engine; 4.spur of direction; 6.hydraulic cylinders; 8.hoses and fittings; 9.milling disc excavation; 10.helical worm shaft driven by a rotary hydraulic engine; 11.hydraulic cylinder; 12.conveyor drum.

Figure 8 shows the 2D drawing of the cutter disc narrow trencher equipment.

Constructive solution to the mills segment is removable allowing their fast replacement if necessary. By centering the axle grooves the torque disc cutter is transmitted.

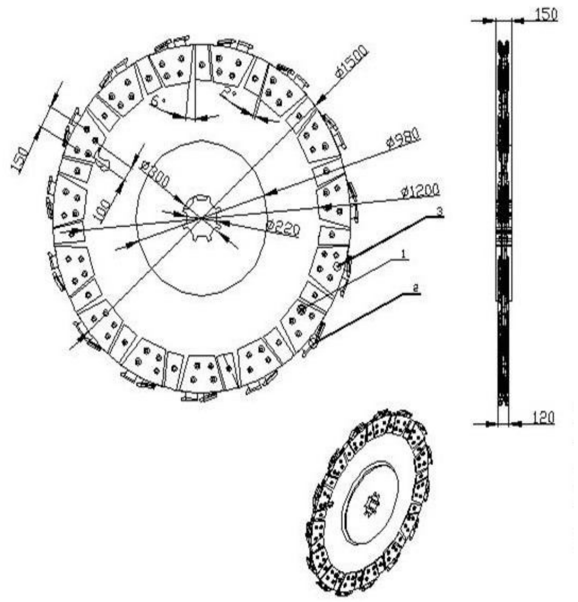

Fig. 8 Drawing 2D of disc cutter: 1.screws; 2.teeth; 3.protection.

3. Constructive parameters calculation

3.1. Productivity digging technique

Productivity digging technique is given by:

$$P_e = \frac{60 \cdot \alpha \cdot L \cdot b \cdot h \cdot k_p \cdot k_t}{T_c} ;[\mathrm{m^3/h}] \qquad (1)$$

where:

L – excavation length, [m];
b – excavation width, b = (0.1÷0.5) D, [m];
D – diameter disc cutter;
h – digging depth, h = (0.3÷0.9) D,[m];
α – coefficient that depends on the shape of the furrow excavated section, (α=0.70÷0.90);
k_p – coefficient of loss, (k_p = 0.70÷0.90);
k_t – utilization coefficient of working time, (0,70÷0,90);
T_c – cycle time, (min).

3.2. The thrust force

The thrust force which is given to the basic power of the engine is calculated using the formula:

$$F_{imp} = \frac{360 \cdot P_{m\max}}{v\left(1-\delta_p\right)} \cdot \eta_{tr} - G \cdot f ; \qquad (2)$$

where:

$P_{m\max}$ – maximum power of the machine, [kw] ;
V – speed of the cutter during operation, [km/h];
δ_p - slippage;
η_{tr} – transmission efficiency;
f – coefficient of resistance movement.

3.3. Drive power disc cutter digging

$$N = \frac{Q_t \cdot x}{102}, [kW], \quad (3)$$

where:

x is the coefficient of soil resistance, whose value is determined experimentally, recommending $12 < x < 23$;

Q_t – rotary hydraulic engine power.

3.4 Calculation of rotary hydraulic engine

3.4.1. Resistant momentum to the drive system shaft

● it is required by roading site, during working, taking into account the rolling resistance coefficient, f=0.00365, is considered the beam dynamics of tires tractor r_D = 0.43 m :

$$M_R = f \cdot r_D \cdot G \cdot g \text{ ; [Nm]} \quad (4)$$

● it is imposed by the necessity to provide the thrust:

$$M_R^* = r_D \cdot F_{max} \text{ ; [Nm]} \quad (5)$$

● it is required by driving on public road equipped with rolling resistance coefficient f = 0.02:

3.4.2. Adhesion moment limit imposed by adherence to the road, (beaten soil).

$$M_A = \varphi \cdot r_D \cdot G \cdot g \text{ ; [Nm]} \quad (6)$$

3.5. Wheel speed

Maximum speed for movement under work site:

$$n_E = \frac{F \cdot v}{\pi \cdot r_D} \text{ ; [rot/min]} \quad (7)$$

which shows that the regime tractor site should provide a continuously variable speed in area 0÷17rot/min.

3.6. Pre-dimensioning the rotary hydraulic engine

3.6.1. Calculation of the required engine capacity

It is adopted the initialization pressure calculation $p_0 = 250$ bar, which determines the required engine capacity, according to the relation:

$$V_{om} = \frac{\pi \cdot M_R^*}{5 \cdot \eta_{mh} \cdot p_0} \text{ ; [l/rot]} \quad (8)$$

where:

M_R^* - resistant momentum to axis traction [daNm];

p_0 - pressure initialization [bar];

η_{mh} - mechanical efficiency hydraulic pump

η_{mh} = 0,90

In equation (9) is shown verify characteristics of the hydraulic engine to ensure the system dynamic fast moving thing in terms of the dynamic:

$$V_{om} = \frac{\pi \cdot M_R^{**}}{5 \cdot \eta_{mh} \cdot p_0} \text{ ; [l/rot];} \quad (9)$$

Engine capacity report max / min is 0.90/0.1 = 9, which exceeds the normal ratio ensured by the existing hydraulic component on the market. In these circumstances, it is considered that there is sufficient data to ensure optimal working parameters.

4. Conclusions

This paper presents a constructive solution of equipment trenchers narrow disc cutter, respectively side loader and conveyor belt, optimized in terms of technological parameters. This constructive solution compared to other variants of technological equipment existing on the market work provides mechanized trenching operations narrow grooves to increase productivity and efficiency.

Custom design methodology for this type of equipment meets the requirements of rigidity, reliability and productivity.

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