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3D MODELING OF A NEW TYPE OF VIBRATORY ROLLER

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ABSTRACT

This paper presents the design optimization of a new type of roller vibration with amplitudes varying with software NX 7.5. The 3D modeling has been developed optimizing constructive solution, minimizing implementation costs in production.

KEYWORDS: vibratory roller, CAD

1. Introduction

Every prototype made using CAD/CAE/CAM optimizes the production cycle starting from design up to assembly. Fig. 1 shows the 3D model of a new type of variable amplitude vibratory compactor attached to a frontal loader.

The NX software [1] can provide engineers with the possibility of constructive analysis solutions, reducing implementation costs in the production cycle.

In order to achieve 3D modeling of parts assembled there were used initialization commands such as: Sketch, Profile (Line), Arc, Circle, Quick trim, Quick extend, Constraints. Depending on the types of functional surfaces of each piece there were used commands applicable to the 3D model: Chamfer, Rotate, Mirror curve, Offset curve, etc.

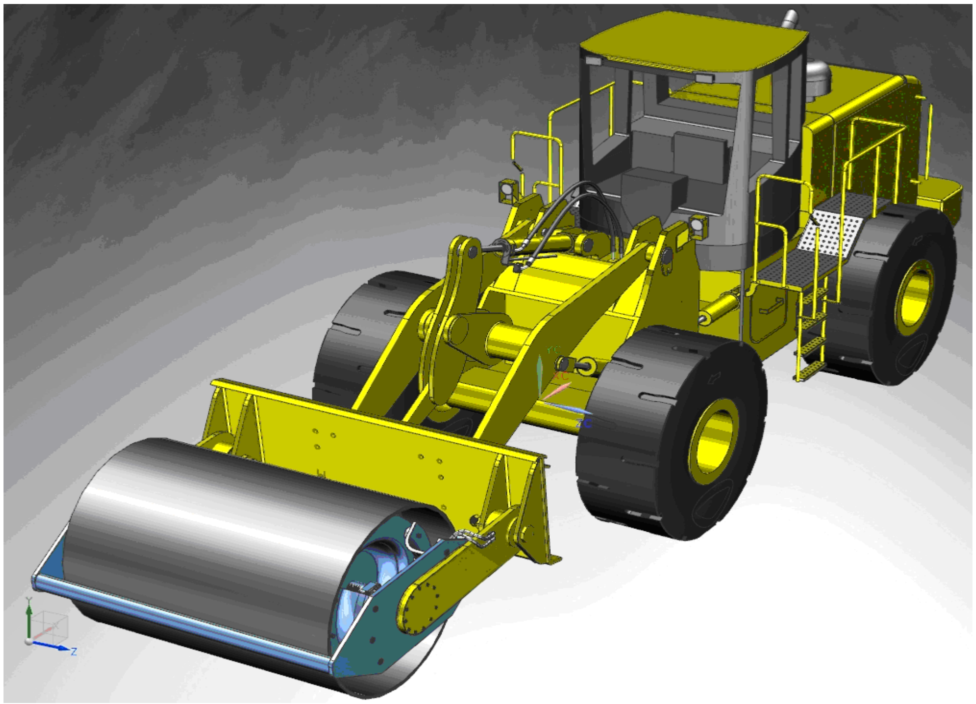

Fig. 1 The 3D model of the vibratory roller attached to a frontal loader

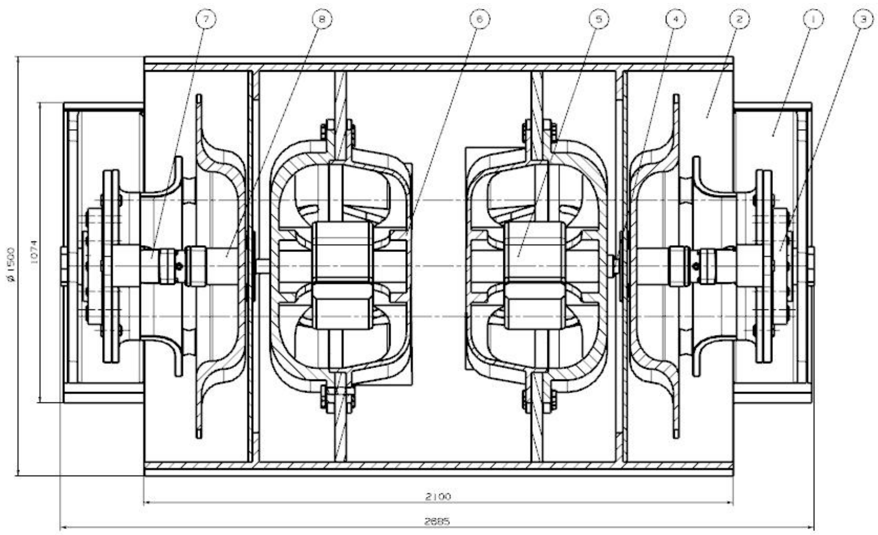

Fig. 2 Sectional view of the vibratory roller

2. Description, components

Figure 2 shows the assembly drawing in 2D of a new type of a compaction equipment with vibrations of variable amplitudes.

Coupling support (item 1) is compatible with the frontal loader mounting system. Vertical operation of the equipment is given by the technological possibilities of the frontal loader.

The lateral arms for coupling (item 3) allow the drum support rollers (Item 2). The grooved shaft is a bushing with bearings (Item 4). The variable angular speed of eccentric mass (item 5) allows obtaining oscillations with variable amplitudes.

The hydraulic motors with variable flow (item 7) powered of hydraulic pump from the frontal loader allow obtaining a variable angular speed.

The reducing (pos 8) decreases the speed, multiplies the power produced by the hydraulic pump, this one turning the grooving shaft which transmits rotation to the eccentric mass.

The hydraulic operation on both sides of the vibratory roller allows for a uniform compaction depending on the material to be compacted.

Fig. 3 shows the 3D geometric modeling of a new type of vibratory roller. The positions are the same as those set in fig. 2.

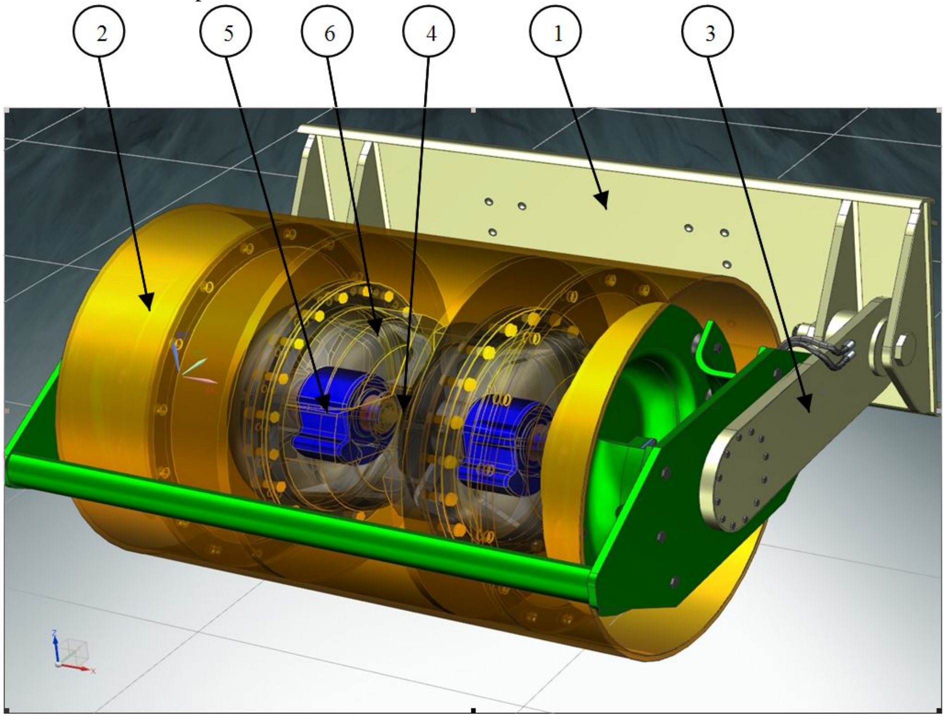

Fig. 3 3D geometric modeling of the vibratory roller

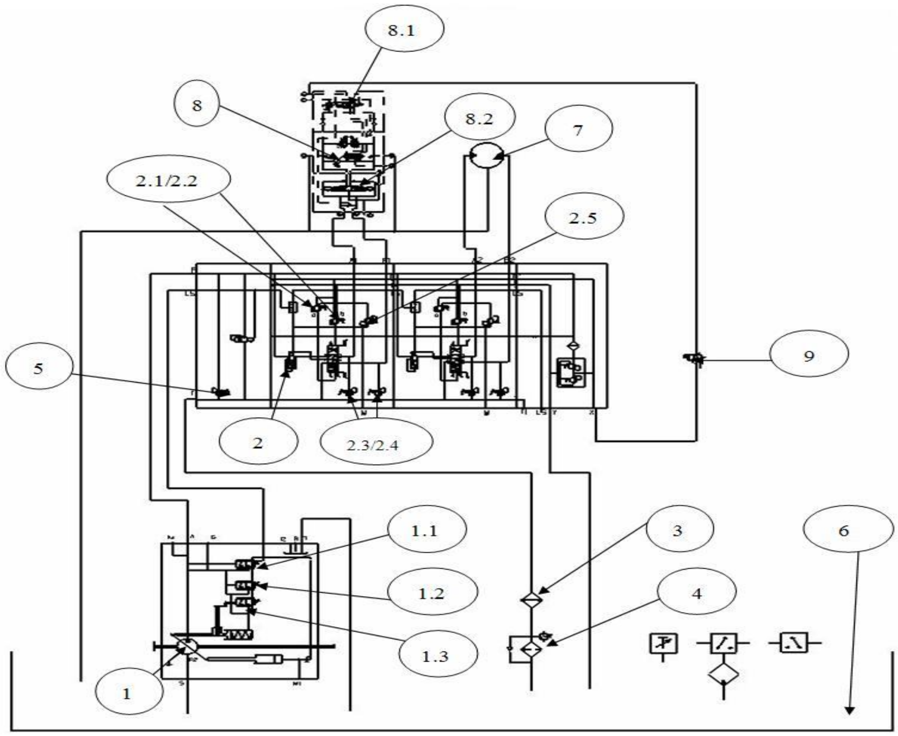

Fig. 4 The hydraulic scheme of the vibratory roller

The hydraulic system shown in fig. 4 is built in system LS (load sensing) and is composed as follows:

- the pump in LS (item 1) is composed of pump controller (item 1.1) which maintains a constant pressure drop on the throttle elements of the hydraulic circuit accomplished by hydraulic manifolds (item 2);
- item 1.2 represents the pump constant pressure regulator, it puts the pump on zero displacement when it reaches the set pressure of the regulator;
- item 1.3 represents the pump power controller which mechanically sets some value depending on the hydraulic power drive motor;
- the debtors (item 2) are designed to determine the flow to consumers. This is done by moving the plunger of the distributor which makes such a variable throttle, resulting in a debit to the value of distributor throttle. The plunger movement is done with pressure reducing valves items 2.1 and 2.2, electronically powered from electronic joysticks.

Thus depending on the angle of the lever joystick is determined an electrical current sent to the reducing valve which sets the pressure value and makes the plunger move right or left thus establishing a flow value that goes to consumers due to valve shock and anti-cavitations distributor item 2.3 and item 2.4. Item 2.5 is the valve (LS) of the distributor and it is set below the value of the shock valves to reduce energy consumption meaning that achieving this value will allow stopping the flow distribution to the actual consumer.

- item 3 is the cooler and is sized as it can remove the heat from the system;
- item 4 is the oil filter that comes on the route distributor-cooler, then is retired in the tank;
- item 5 is the general valve of the distributors battery;
- item 6, the tank, is sized to ensure proper flow pump and it also helps to remove the heat from the system;
- the engine, item 7, provides the vibrator with speed;
- the engine, item 8, controlled from outside by the distributor item 9, ensures the movement of the system with two operating modes.

The engine, item 8, is equipped with counter balance valves, item 8.2, which control the movement including on the inclination.

3. Sizing calculation and verification

The main design parameters of the vibratory roller are:

The roller diameter executes a substantial influence on the quality of compaction. Reducing the diameter of the roll of material increases the phenomena in the direction of forward movement, resulting in surface waves.

The compactor roller diameter is determined by a linear load of specific formula:

$$D = (20...25)\sqrt{q} \quad [\text{cm}] \qquad (1)$$

Where:

- "D" is the diameter of the roll, [cm];
- "q" is the specific linear load [daN/cm].

Width of roll compactor determines the width of the compaction strip, while ensuring stability conditions, handling and loading local layer.

To determine the width of the roll the following relationship is recommended:

$$B = (1,3...1,7)D \quad [\text{cm}] \qquad (2)$$

The power of the rotary hydraulic engine, N, required for overcoming the resistance forces which occur during operation, are determined by the formulas:

$$N = \frac{(nR+R_r)v}{270\eta_{tr}} \quad [\text{CP}] \qquad (3)$$

Where:

n is the number of rollers;

R – total resistance of a roller to movement [kgf];

R_T – total resistance of rolling [kgf];

v – the attached compactor speed [km / h];

η_{tr} – efficiency of the vibratory compactor transmission.

$(\eta_{tr} \cong 0,75...0,95)$

The thickness of the compacted layer may be determined using the formula:

- the cohesive land:

$$h = 0,28\frac{w}{w_0}\sqrt{pr} \quad [\text{cm}] \qquad (4)$$

- in the lands blunt:

$$h = 0,35\frac{w}{w_0}\sqrt{pr} \quad [\text{cm}] \qquad (5)$$

Where :

w – the compacted layer humidity [%];

w_0 – optimum moisture content for compacting of the same layer [%];

p – linear pressure of the compaction [kgf / cm];

r – the compacted roll radius [cm];

The number of successive passages, *n*, needed for the compaction can be calculated with the formulas:

- for smooth roller compactors:

$$n = (\frac{\varepsilon}{K_i\varepsilon_1})^3 \qquad (6)$$

Where

ε – is the relative plastic deformation, at the end of the compaction;

K_i – coefficient of the intensity accumulation of the plastic deformation;

ε_1 – relative plastic deformation after the first pass;

4. Conclusions

The new constructive solution of the equipment vibratory roller allows getting an oscillation with variable amplitudes. Depending on the nature of the material compaction it can be optimized the compaction ratio.

The other constructive solutions of compaction equipments do not allow getting for variable amplitudes.

Based on the hydraulic scheme which is newly developed, could be performed 3D modeling of this type of equipment using NX 7.5 software.

The 3D model allowed to verify the assembly and using virtual prototype to avoid different design problems.

This simulation allows shortening the production cycle and minimizing costs.

The design of compaction equipments with variable amplitude vibrations open the possibility to use them in various areas unused so far.

5. References

[1] PLM ADAPTOR, (2013). Simulation and analysis using virtual prototype, module I. „Dunarea de Jos” University of Galati, Faculty of Engineering in Braila.