THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XIV MECHANICHAL ENGINEERING, ISSN 1224-5615
2014

GYRATORY CRUSHER BUCKET-TYPE ATTACHED TO THE EXCAVATOR ARM

PhD. Assoc. Prof. Eftimie Dorin
"Dunarea de Jos" University of Galati,Romania

ABSTRACT

The paper aims to present a new technological solution of a crusher bucket-type attached to excavator arm. The optimized solution of the gyratory crusher bucket type is the computer aided design (CAD) which enables virtual prototyping for evidence of standardized sizes.

KEYWORDS: gyratory crusher bucket-type, CAD.

1. Overview

Studying the process of crushing and related equipments is particularly important because the crushing operation is energy-intensive and aims to decrease the energy needed to reduce the size of raw materials. Currently there are more constructive solutions of crusher bucket type such as:

- Jaw crusher bucket type (fig. 1) [1]
- Hammer crusher bucket type (fig. 2) [2]
- Crushing mills bucket type (fig. 3) [3]

Fig. 1 Jaw crusher bucket type

Fig. 2 Hammer crusher bucket type

Fig. 3 Crushing mills bucket type

For demolition and crushing small amounts of material, it is required a device attached to the existing equipment.

The crusher bucket-type attached to the excavator arm is a productive solution, reliable and with future potential for construction sites.

2. Determination of the main structural and functional elements

The cone crusher is also known as the granulator. Grinding takes place by the action of crushing and friction forces on the pieces of material when these pieces reach between active conical surfaces of the fixed and mobile cones. The degree of crushing for these cars is up to the value i = 5.

The gyratory crusher is used to crush coarse, medium and fine materials.

Material between the inner (mobile) cone and the outer (fixed) is continually shattered by circular movement (eccentric) of the inner (mobile) cone (fig.4). Due to the continuous movement of the slot between the two cones, the material is compressed and crushed, from the maximum size '*l*' corresponding to the supply area up to the 'e' size.

Due to the friction between the inner mobile cone and the material that fills the space between the two cones, the mobile cone rotates in the opposite direction of the eccentric rotation.

Axis *O′—O″* of mobile cone is inclined to the axis *O′—O* of the crusher 2...5°, and during operation it describes a cone headed *O′*.

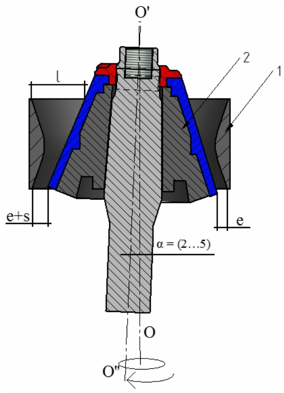

Fig. 4 Gyratory crusher scheme
1-fixed cone, 2-mobile cone, *O′—O″* - mobile cone axis; *O′—O* crusher axis

The crushing mechanism is shown in (fig. 5)

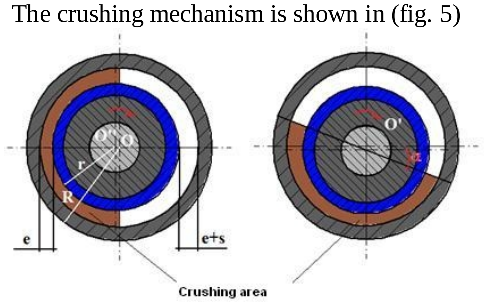

Fig. 5 Crushing phenomenon scheme in gyratory crusher

2.1. Sizing calculation and verification

2.1.1. Grip angle will be equal to (fig. 6):

$$\alpha = \alpha_1 + \alpha_2 \le 2\varphi \qquad (1)$$

where φ is the friction angle of material with surface of crushing parts.

It admits : $\alpha = 21^0$

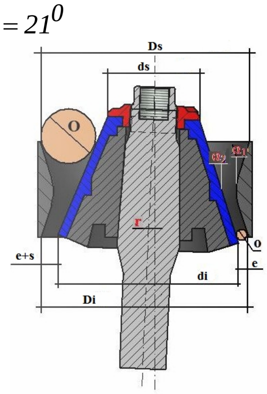

Fig. 6 Scheme for the study of cone crusher mechanics

2.1.2. Productivity is calculated using the equation:

$$\Pi_V = \frac{340\Psi_a \cdot n \cdot D_i \cdot r \cdot d}{tg\alpha_1 + tg\alpha_2}\left[\frac{m^3}{h}\right] \qquad (2)$$

where: Ψ_a – is the coefficient of loosening of the crushed material;
n – eccentric rotations, [rot/min];
D_i – outer diameter of the outlet, [m];
r – size of cone eccentricity oscillation in the outlet section, [m];
d – average size of crushed pieces, [m].

If the product outlet is pressed into the parallelism area once during a rotation, the volume of product that comes out at the same time will be (fig. 7):

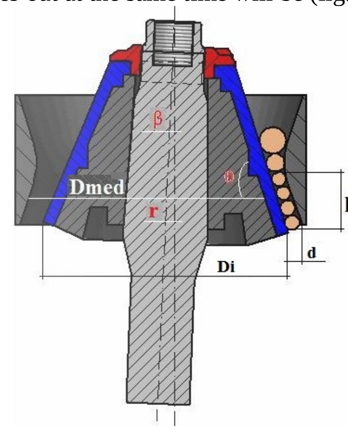

Fig. 7 Cone crusher productivity determination scheme, for crushing medium materials

$$V = A \cdot \pi \cdot D_{med} \left[m^3\right] \qquad (3)$$

where: A – is the area of the parallel section;

$$A = d \cdot l \left[m^2\right] \qquad (4)$$

d – width of parallel area, [m];
l – length of parallel area, [m].

We accept:

$$D_{med} = D_i \qquad (5)$$

(lower diameter of inner crusher)

2.1.3. The theoretical speed of this type of crusher is determined by the relation:

$$n \cong 30\sqrt{\frac{1}{r \cdot tg\theta}}\left[\frac{rot}{min}\right] \qquad (6)$$

We adopt $n = 80\left[\frac{rot}{min}\right]$

where: θ – is the inclination angle of the mobile cone generatrix beside the base of the fixed cone
r – the eccentricity of the lower edge of the fixed cone, [m].

3. Kinematic scheme of gyratory crusher bucket-type attached to the excavator arm

The typical gyratory crusher is composed of a mobile cone and a fixed cone (fig. 8).

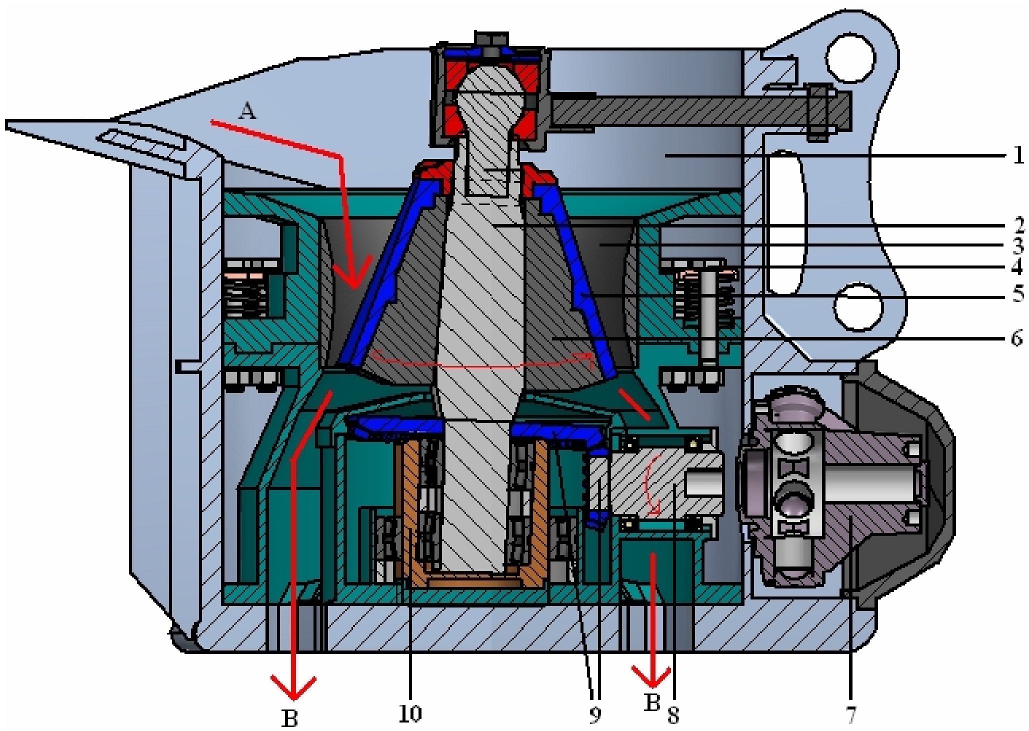

Fig. 8 Description of kinematic scheme : 1-bucket body, 2-vertical axis, 3-fixed armor, 4-elastic elements, 5-armoured mobile cone, 6-mobile cone, 7- rotary hydraulic engine, 8-drive shaft conical group, 9- conical group, 10- assembled box, A-supply, B-evacuation.

The gyratory movement of the mobile cone is achieved by engaging the rotation of the drive shaft of the conical group (item 8), driven by rotary hydraulic engine (item 7) coupled to the hydraulic system of the excavator, resulting vertical axis rotation (item 2).

The evacuation of the non-crushed elements which penetrated inside the crusher is allowed with the aid of elastic elements of the equipment (item 4).

4. Composition, description, functioning of gyratory crusher bucket-type attached to the excavator arm

In fig. 9 is presented the 2D section [4] of the gyratory crusher bucket-type (bucket, item 14) for medium and middle sized crushing with the shaft rested on top. The shaft (item 5), on which is mounted the mobile cone (item 6), protected by armor (item 7), is suspended in the upper bearing (item 13) anchored with beams (item 16). The lower part of the shaft is placed free in the eccentric bore inclined of the bush (item 4), which is inside the bearing (item 1) and determines eccentric rotary motion of the shaft (item 5) (gyratory movement of regular precession) in relation to the inner surface of the fixed cone (item 8), protected by armor (item 9).

Armor surfaces are smooth, shaped or mixed. Smooth surfaces have higher wear resistance and are recommended for grinding materials with high hardness. Armored surfaces cause lower energy consumption of the machine but also a product more evenly crushed.

The shaft (item 5), through the spherical joint (item 11), rests on the bush (item 12). During the rotation of the shaft (item 5), the spherical joint (item 11) has a rollover movement on the surface of the spherical articulated bushes (item 12), and the lateral surface slides in their spherical surface.

Following the crane lifting of the shaft (item 5) and of the mobile cone (item 6), the exhaust outlet can be adjusted mechanically, narrow limits. For this purpose, at the end of the shaft there is a threaded hole for inserting a lifting ring. The cover (item 15) protects the bearing (item 13) and the spherical joint (item 11) against dust.

The spherical joint (item 11) allows the shaft to perform conical circular movement.

The components of the upper bearing are made of special steel, processed in such a way as to ensure a high quality of the surface, so after the heat treatment the surfaces should have high hardness (47÷52 and respectively 53÷58 HRC).

With elastic elements (with coil springs) (item 10), nominal load overcoming allows increasing discharge gap to evacuate very hard objects which have entered the crusher.

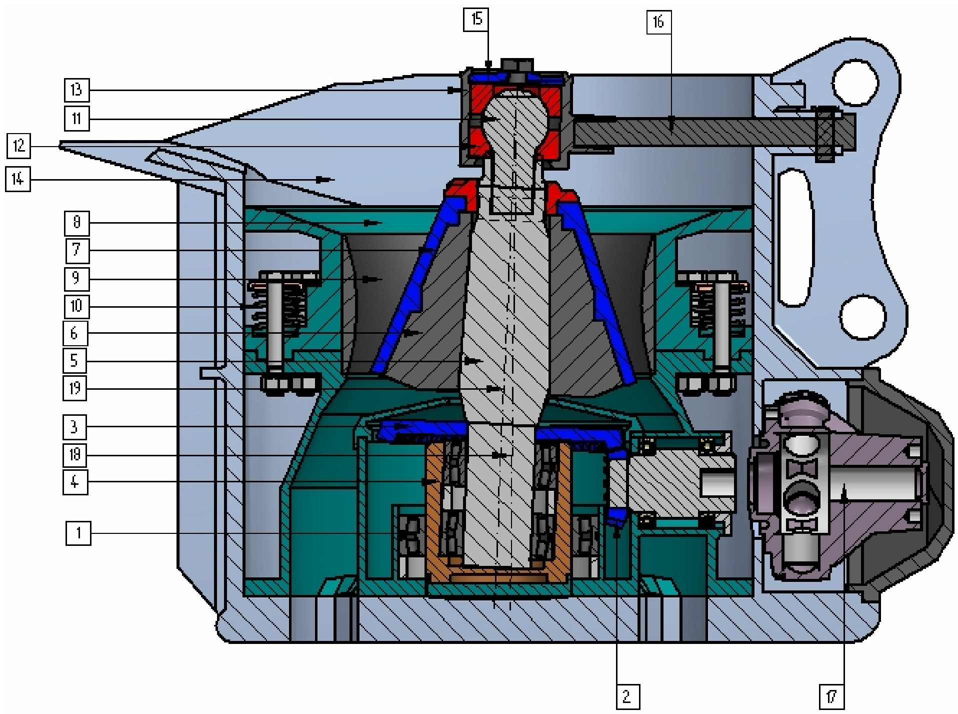

Fig. 9 Gyratory crusher bucket type: 1- bearing, 2- conical pinion, 3-conical gear, 4-bushing, 5-shaft, 6-mobile cone, 7-armor, 8-fixed cone, 9-armor, 10-elastical elements, 11-spherical joint, 12- bushing, 13-bearing, 14-bucket, 15-cover, 16-anchored beam, 17-engine, 18-shaft axis, 19-vertical axis

The beams (item 16) provide support for the upper bearing frame subassembly. These are the most stressed parts because they take the weight of the mobile cone, horizontal and vertical reactions of the bearing, as well the corresponding bending moments. During functioning, beams orientation is longitudinal along the direction of the material flow supplied to achieve a uniform filling of the working area.

The axis (item 18) of the shaft (item 5) makes with the vertical axis (item 19) the angle γ. The bush (item 4) together with conical gear (item 3) fixed on the shaft (item 5) are driven in rotation by the conical pinion (item 2) of the rotary hydraulic engine (item 17).

The lower bearing (item 1) in which there is the bush (item 4) is protected against dust by a system of seals.

The crusher has a centralized lubrication system for lubricating gears, eccentric bushing and gear shaft bearings (item 2) and (item 3). Electric warming of lubricant is provided for periods of low temperature.

5. Conclusions

In this paper we attempted to develop a new solution of crushing equipment attached to the excavator arm adapted to technological requirements, taking into account the existing construction equipment market solutions.

It was presented the design methodology used for this type of cup type gyratory crusher, which satisfies the requirements of rigidity, reliability and productivity.

We performed 2D drawings of the gyratory crusher, which can be a step forward for designing this type of equipment.

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