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ANALYSIS OF ROCK CUTTING PROCESS WITH BUCKET WHEEL EXCAVATORS

The paper describes the use of chip breakout pattern method in the analysis of rock dislocation using BWEs. This method allows analysis of rock dislocation and setting the correct parameters of buckets: teeth number, distance between teeth, angle during work or teeth positioning.

1. GENERAL ASPECTS

Conducted research, obtained results, observations and measurements on site led to the development of a new bucket model, based also on the existing research worldwide.

In the Romanian open pit mines the research has been focused on the classic bucket construction, symmetrical buckets with rounded.

The goal of conducted research was to conceive and design an asymmetrical bucket for older bucket wheel excavators. As a result, a series of components and elements of the classic bucket were reused in order to obtain a new solution, which can be rapidly implemented and also cost effective. The solution is developed in such a way that permits the transformation, during the refurbishment of classical buckets in asymmetrical buckets with polygonal cutting edge.

2. ANALYSIS OF ROCK DISLOCATION PROCESS WITH BUCKED-WHEEL EXCAVATORS USING THE CHIP BREAKOUT PATTERN METHOD

Based on this, from the point of view of rock or lignite dislocation it proved to be an advantage that each tooth or the bucket itself is evenly stressed, regardless of the cutting phase. This means that each tooth is cutting chips with the same transversal section for turns both left to right or right to left.

For such an analysis of the dislocation, a method - applicable to any rock dislocation machine - had to be developed, named the chip breakout pattern method.

This method graphically reconstructs what happens during interaction between the machine (the BWE rotor) and the rock in a plane crossing the rotation centre of the rotor. Conventionally the case when the chip detachment occurs at the intersection of the main horizontal and vertical planes is considered representative.

When the chip breakout pattern method is used we have to consider the constructive parameters and placement of the teeth, the constructive parameters of the buckets, and the functional parameters of the BWE and the chipping characteristics of the material to be cut (mainly the breakout angle of the chips - ψ).

Next we will analyse the waste rock dislocation with a breakout angle of $\psi = 45^o$, and lignite dislocation with a breakout angle $\psi = 65^o$, for three distinct situation: cutting with classic buckets with rounded cutting edge and cutting with buckets with five different segment polygonal cutting edge, asymmetrical by its own geometrical axis and symmetrical by the turn radius. For each case the chip breakout pattern method was used for a chip thickness of h_o = 0,5 m.

Three different situations were analysed for the same cutting capacity of the studied excavator (EsRc 1400), Q_m = 3000 m^3/h. For the mentioned working conditions: R = 5,75 m; H_t = 30 m; H = 7,5 m; $\alpha_o = 107,7^o$ and h_o =0,5 m the obtained chip thicknesses were b = 282 mm; b = 212 mm respectively b = 170 mm, to which the minimal turning speeds of the excavator, of v_{pmin} to v_{pmax} are corresponding.

Next graphic representations are shown for five consecutive bucket positions, using different colours, at the intersection of the main cutting planes, in contact with the rock, for turns both to the left and to the right and also there are graphic representations for the working bucket teeth and chip shapes obtained.

In figures 1 and 2 the corresponding chip breakout patterns for the classic bucket are shown, for h_o = 0,5 m and b = 170 mm.

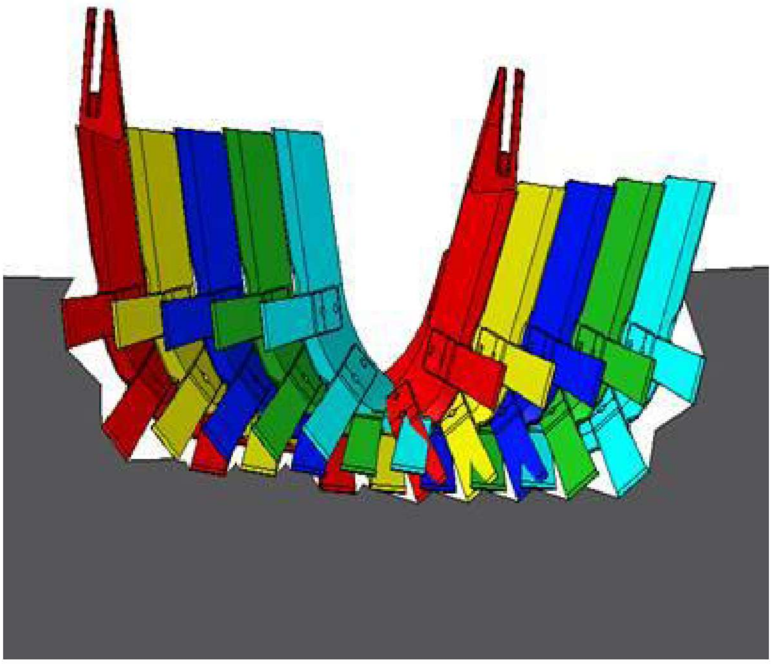

Fig. 1 – Representation of classic buckets in contact with the rock for h_o = 0,5 m

In figure 2 it is observed that at the turn to the left 2 teeth are working and at the turn to the right 5 teeth are working, caused by the asymmetry of the classic bucket related to the turning radius. This leads to an uneven stress and wear out of the teeth and to a disadvantageous and irregular working condition, dependent on the turning direction for the BWE.

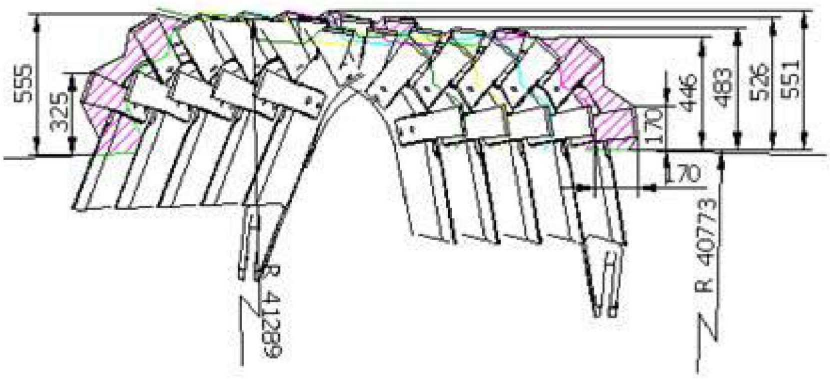

Fig. 2 – Chip breakout pattern for the classic bucket and h_o = 0,5 m

Figures 3 and 4 represent the chip breakout patterns for the polygonal asymmetrical bucket for h_o=0,5 m.

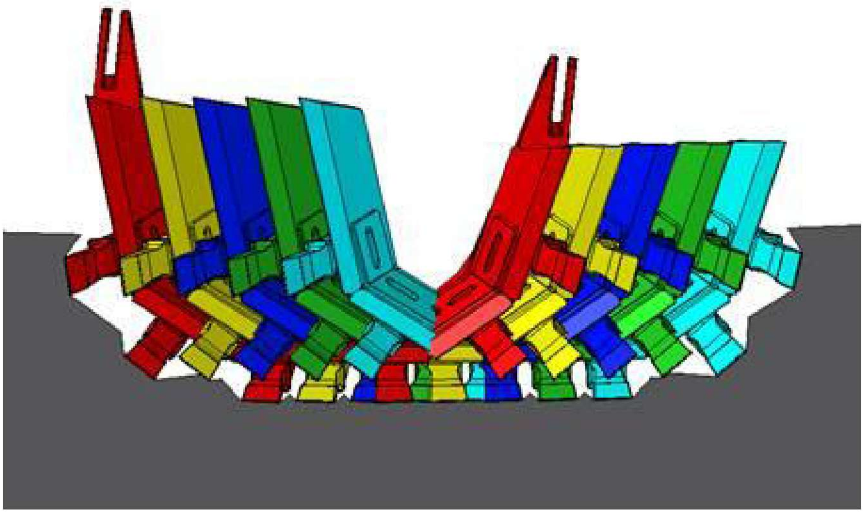

Fig. 3 – Representation of the proposed polygonal asymmetrical bucket
in contact with the rock for h_o = 0,5 m

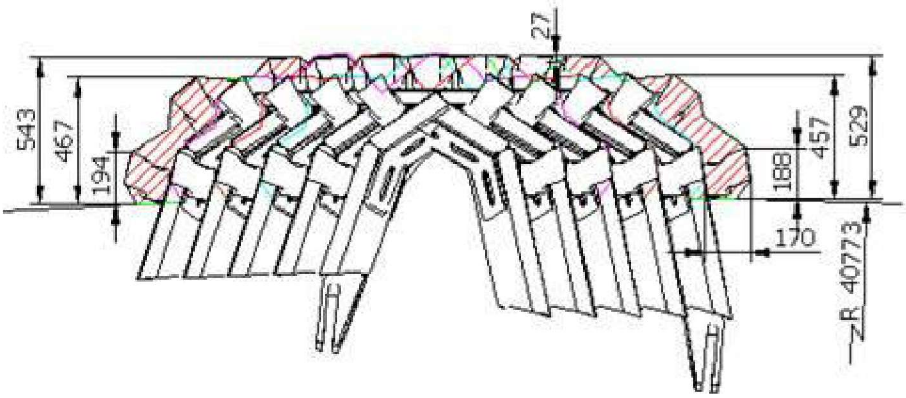

Fig. 4 – Chip breakout pattern for the proposed polygonal asymmetrical bucket
in contact with the rock for h_o = 0,5 m

We can conclude that the polygonal asymmetrical bucked has a more advantageous behaviour over the previous two types.

3. CONCLUSION

Based on the presented facts we can conclude that for the proposed asymmetrical bucked: at each turn all the teeth situated on the same side of the bucket are working; the transversal section of the chip is the same for one tooth for both turning directions; there is no significant difference of teeth stress and wear off between the two sides of the cutting edge of the bucket; differences between chips are smaller, and the working conditions of the BWE are the same regardless of the turning direction, being advantageous because of less teeth, bucket and rotor wear off, even stresses in the rotation and turning mechanical and electrical systems and energy consumption for cutting is reduced; teeth and cutting edge consumption is lowered; BWE stability is improved; improvement of excavation parameters leads to lower operational expenses of the excavators and the increase of its lifetime.

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