New Buckets Mounted on Rotor Excavators, as a Result of Dislocation Tested Process

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Abstract— 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.

Keywords—bucket, chip breakout pattern, tooth, wheel excavator (BWE).

I. GENERAL ASPECTS

Conducted document 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 or trapezoidal cutting edges.

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.

II. 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.

For the drawing up of a comprehensive cutting flow chart, there shall be taken into consideration the constructive parameters and the laying out of teeth, the constructive parameters of the buckets, the operating parameters of the excavator and the specific features to cutting of the material to be cut (mainly ψ angle for splinter tearing).

There follows an analysis of the sterile rock that is being dislodged at ψ angle of 45° and of lignite that is being dislodged at a tearing angle of 65° for four different situations: a classic cutting process by the help of normal buckets with a round cutting edge; cutting by the help of buckets with trapezoidal cutting edge (SIP) mounted on EsRc 1400 excavator that hasn’t been modernized; cutting by the help of buckets with polygonal cutting edge mounted on EsRc 1400 excavator that has been modernized; at last, there has been studied the cutting process achieved by the help of the proposed polygonal cutting edge (with five different segments), asymmetrical against its geometrical axis and symmetrical against the rotating axis of the excavator that hasn’t been modernized. Additionally, there is presented the cutting process achieved by the help of the symmetrical bucket with a round cutting edge mounted on SRS excavator. An extended cutting flow chart has been drawn up for three different values of thickness of splinters dislodged by the bucket, i.e. $h_o = 0.4; 0.5$ and $0.6$ m. Consequently, there have been developed and analysed 12 different situations for EsRc 1400 excavator, starting from the idea to preserve a constant cutting output rationally selected, that is, $Q_o = 3000$ m³/h in the massif for the case of the excavator under study (EsRc 1400). If we have the following working conditions: $R = 5.75$ m; $H_1 = 28$ m; $H = 7$ m; $\alpha_o = 102^\circ$ and $h_o = 0.4; 0.5$ and $0.6$ m for the case of the excavator that has not been modernized, it resulted a width of the dislodged splinter of $b = 185$ mm; $b = 148$ mm and $b = 123$ mm to whom we have minimum rotating velocities situated within the $\nu_{min}$ and $\nu_{max}$ that can be reached by the excavator, more exactly 0.1 ... 0.5 m/s.

For the case of the excavator that has been modernized, the following parameters shall be taken into consideration: a cutting speed of 2.6 m/s, 20 cutting – loading buckets, 1.3 buckets/sec.
it resulted a width of the dislodged splinter of \( b = 198 \text{ mm}, 158 \text{ mm şi 132 mm} \), in relation to the cutting depth of 0.4; 0.5 and 0.6.

There follows five graphical presentations of 5 consecutive positions of buckets, marked by different colours at the meeting point of the main cutting planes that come into contact with the rock massif, on one side during the left rotation and on the other side during the right rotation, and the working manner of the teeth located on the bucket and the shape of splinters that have been dislodged by taking into consideration the above said geometrical, constructive and operating parameters, also for the rotation of the rotor both ways.

Therefore, Figures 1, 2, 3 and 4 show the corresponding flow charts, orderly for \( h_0 = 0.4 \text{ m} \) and \( b = 185 \text{ mm}; h_0 = 0.5 \text{ and } b = 148 \text{ mm}, \text{ respectively}.\)

As one can see from Figures 2 and 4 that 2 teeth work during left rotation and 5 teeth during right rotation due to the asymmetry of the bucket against the rotating axis in case of the classic bucket; consequently, there shall be an uneven wear and strain of teeth and when the excavator operates irregularly and inefficient, it shall depend on the rotation way of the rotor.

Figures 5, 6, 7, and 8 show the extended flow charts for the trapezoidal bucket (SIP) equipped with 7 teeth for the same depths of penetration and the same width of splinters as in the above mentioned case. One can see from Figures 6 and 8 that teeth also operates differently (the shape of the dislodged splinter, strain and wear) for the two ways of rotation, especially the tooth in the middle of the central segment of the cutting edge of the bucket. These give birth to obvious inconveniences considering the operation of teeth, bucket and rotor and also for the driving system of the rotor, together with the rotating system of the rotor.

Figures 9, 10, 11 and 12 show the contact between the modernized EsRc 1400 excavator bucket and the massif together with the comprehensive cutting flow chart for the three values of the thickness for the splinters cut by a bucket at the meeting point of the main working plans.
After studying these flow charts, one can notice the same shortcomings as the ones occurred on the symmetrical buckets mounted on EsRe excavator that hasn’t been modernized.

Figures 13, 14 and 15 show the polygonal asymmetrical buckets that have been proposed for EsRe excavator, for three cutting depths: 0.3; 0.4 and 0.5 m.
Fig. 13. Presentation of the modernized EsRe 1400 excavator bucket in contact with the massif for $h_o = 0.3$ m

Fig. 14. Presentation of the modernized EsRe 1400 excavator bucket in contact with the massif for $h_o = 0.4$ m

Fig. 15. Presentation of the modernized EsRe 1400 excavator bucket in contact with the massif for $h_o = 0.5$ m

III. CONCLUSION

Based on the presented facts we can conclude that for the proposed asymmetrical bucket: 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.

REFERENCES