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Development of a Model for Simulating the Distribution and Volume of Excentric Rate Grinding of a Conic Grinder

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KEYWORDS
cone, distribution rate, rock types, porphyry, crushing and grinding equipment, distribution, laboratory compression, experiment, calibration of crushing function, compression degree.

ABSTRACT:
The main mechanism of the flow is free fall. Sliding occurs only at low eccentric velocity. The total distance traveled in the vertical direction decreases with increasing eccentric velocity. This is the result of the upload level movement up as CSS increases. These key factors allow for a fundamental and detailed understanding of how a cone crusher works. These factors influence the design and operational parameters. The model allows for establishing a direct relationship between the crusher's structural parameters, the nature of rock crushing, and the crusher's operation.

INTRODUCTION

In developed countries of the world, in-depth theoretical and experimental research is being conducted to improve the reliability and resource saving of crushing and grinding equipment. In the main directions of economic and social development, special attention is paid to improving the quality and reducing the cost of mining and construction products by developing rational values of the main parameters of stone crushing equipment used in the mining industry and road construction, processing data on the hardness, properties of raw materials, their extraction and crushing, creating efficient, improved working parts of ore crushers that ensure resource saving for various industries, as well as accelerating the widespread introduction of modern equipment and technologies into production..

MATERIALS AND METHODS

Nominal compression ratio $(s/b)_{nom}$ are determined from the geometric analysis of the grinding chamber according to the structural drawings. Effective compression ratio $(s/b)_{eff}$, corresponds to the ratio that can be used, taking into account the dynamics of the crusher. Actual compression ratio $(s/b)_u$ less than the effective ratio. Methods for the relationship between nominal, effective, and actual compression ratios have been developed: [6. 15-16-41-p.], [1. 9-49 p.].

$$\left(\frac{s}{b}\right)_u < \left(\frac{s}{b}\right)_{eff} < \left(\frac{s}{b}\right)_{nom} \qquad 1.1$$

Current layer thickness rock flow rate Q/n, density ρ_i, crushing zone height H_i and Q_i can be calculated by the circumference of the zone.

$$b_u = \frac{Q}{n}\cdot\frac{1}{\rho_i}\cdot\frac{1}{h_i o_i} = \frac{\eta_{v,1}\rho_1 V_1}{\rho_i}^{y}\cdot\frac{1}{h_i(2\pi R_i)} \qquad 1.2$$

Next applied force

$$s_u = s_{eff} - b_{eff} + b_u \qquad 1.3$$

Finally, the actual compression ratio is taken as the ratio between the applied force and the layer thickness:

$$\left(\frac{s}{b}\right)_u = \frac{s_u}{b_u} \qquad 1.4$$

The developed model is necessary for calculations that relate the width of the dimension distribution to the mass density of uncompressed stones. The value indicators of the developed model were adjusted using the results of existing grinding tests (Fig. 1). The relationship between the normalized distribution of quantities and the normalized density is as follows $\rho_{\aleph} = \frac{\rho}{\rho_s}$

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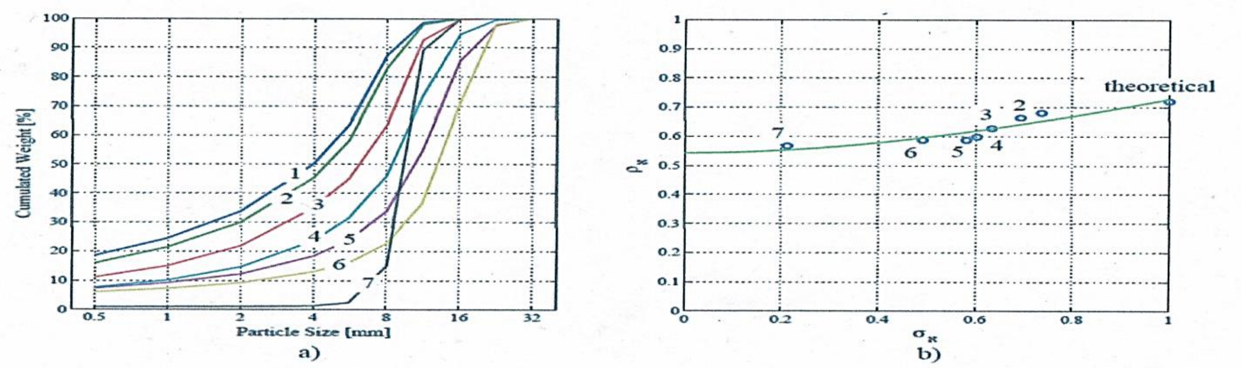

Figure 1. a) Volume distribution of the product used for calibrating the porphyrite stone density model.

b) normalized density as a normalized function of the dimension distribution.

The modeled vertical position of the block, starting from the loading level, is shown in Fig. 2. The main flow mechanism is free fall. Sliding occurs only at low eccentric velocity. The total distance traveled in the vertical direction decreases with increasing eccentric velocity. It should be noted that if the nominal impact must be applied in full, the selected eccentric velocity should be slightly below 300 rpm. [6. 15-16-41-p.], [1. 9-49 p.].

Theoretical and practical results: The modeling results are shown in Figure 3 together with the measured distribution of raw material and product volume for three different eccentric velocities and two different closed side settings. Same cases, but the size after each contraction eventThe distribution is shown in Figure 4. The corresponding compression coefficients are shown in Fig. 5. [4. [p. 16].

The number of grinding zones between the particles (#1R) decreases with increasing parameter of the closed side. This is the result of the upward movement of the load level as CSS increases. The effect is highly dependent on specific compression, and the overall size shrinkage also decreases. The combined effect of reducing the number of grinding zones and the degree of compression is the total reduction in grinding. [4. p. 16].

The relationship of the model to changes in eccentric velocity is difficult to explain (Fig. 3). The main reduction in overall size is achieved due to the gap between the particles. In all the studied cases, the number of ruptures between the particles is relatively small. [5. 257-264].

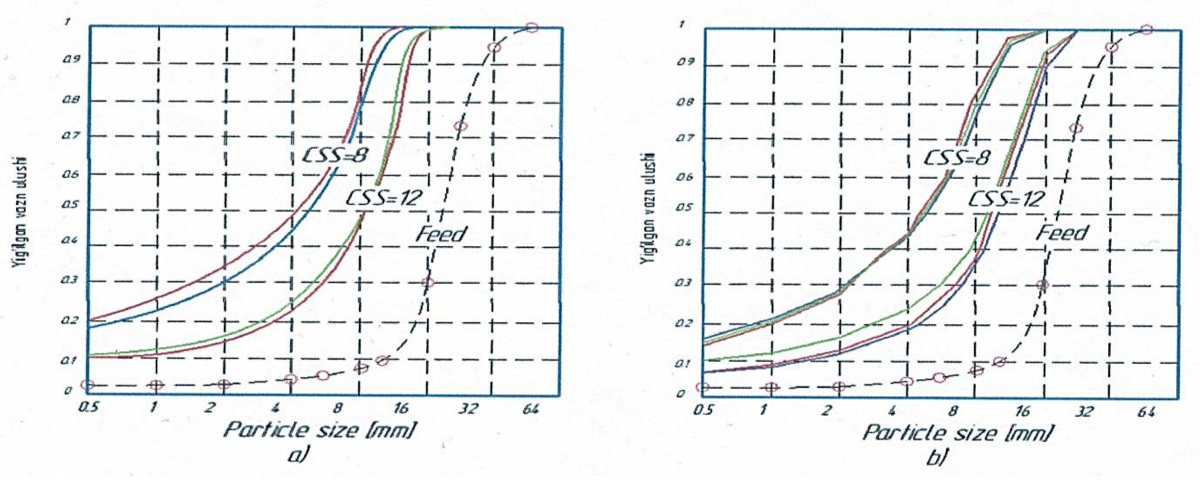

Figure 2. a) Simulation results for three different eccentric speeds and two different CSS. b) Experimental results

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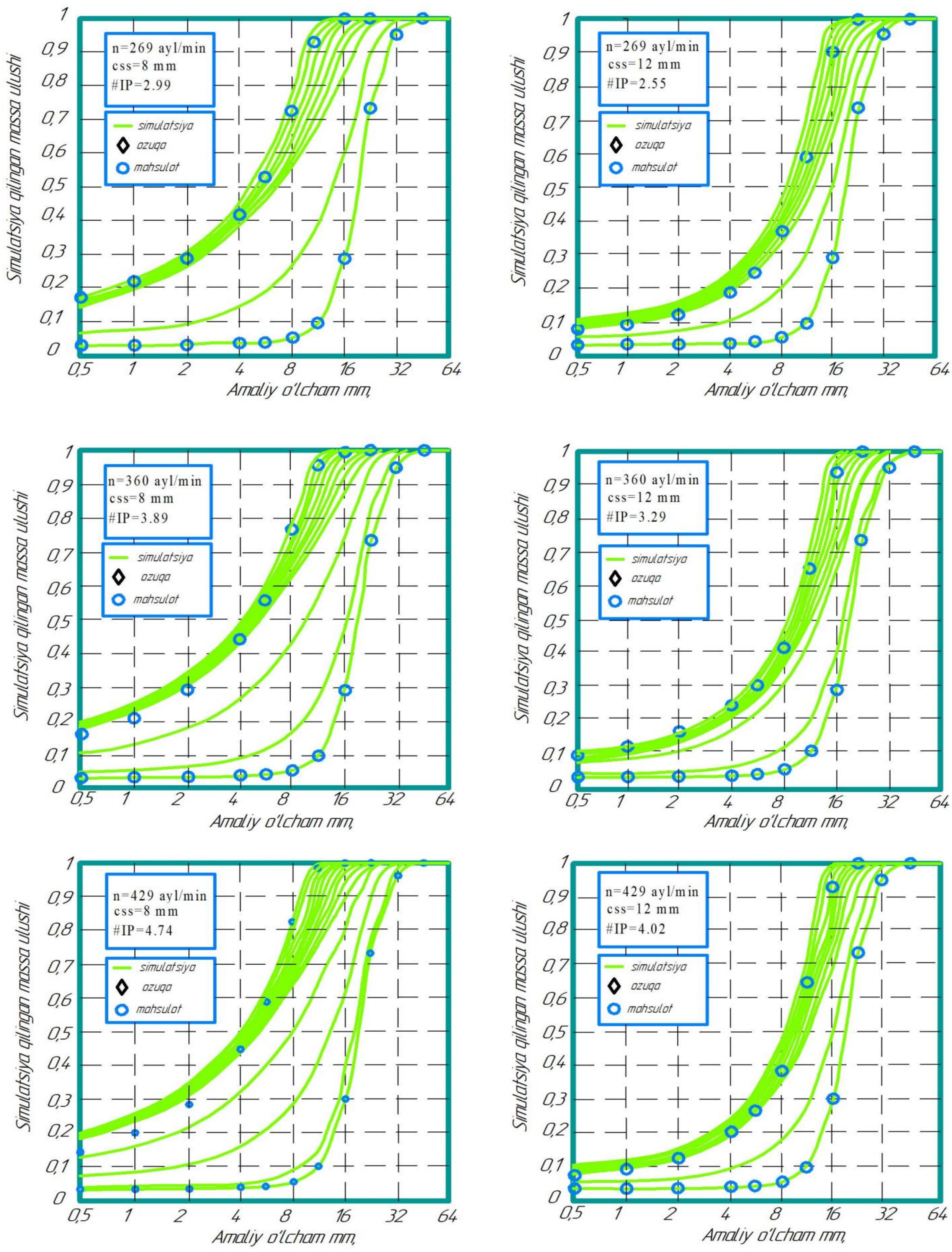

Figure 3. Model of size distribution after each crushing stage for a conical crushing and grinding unit.

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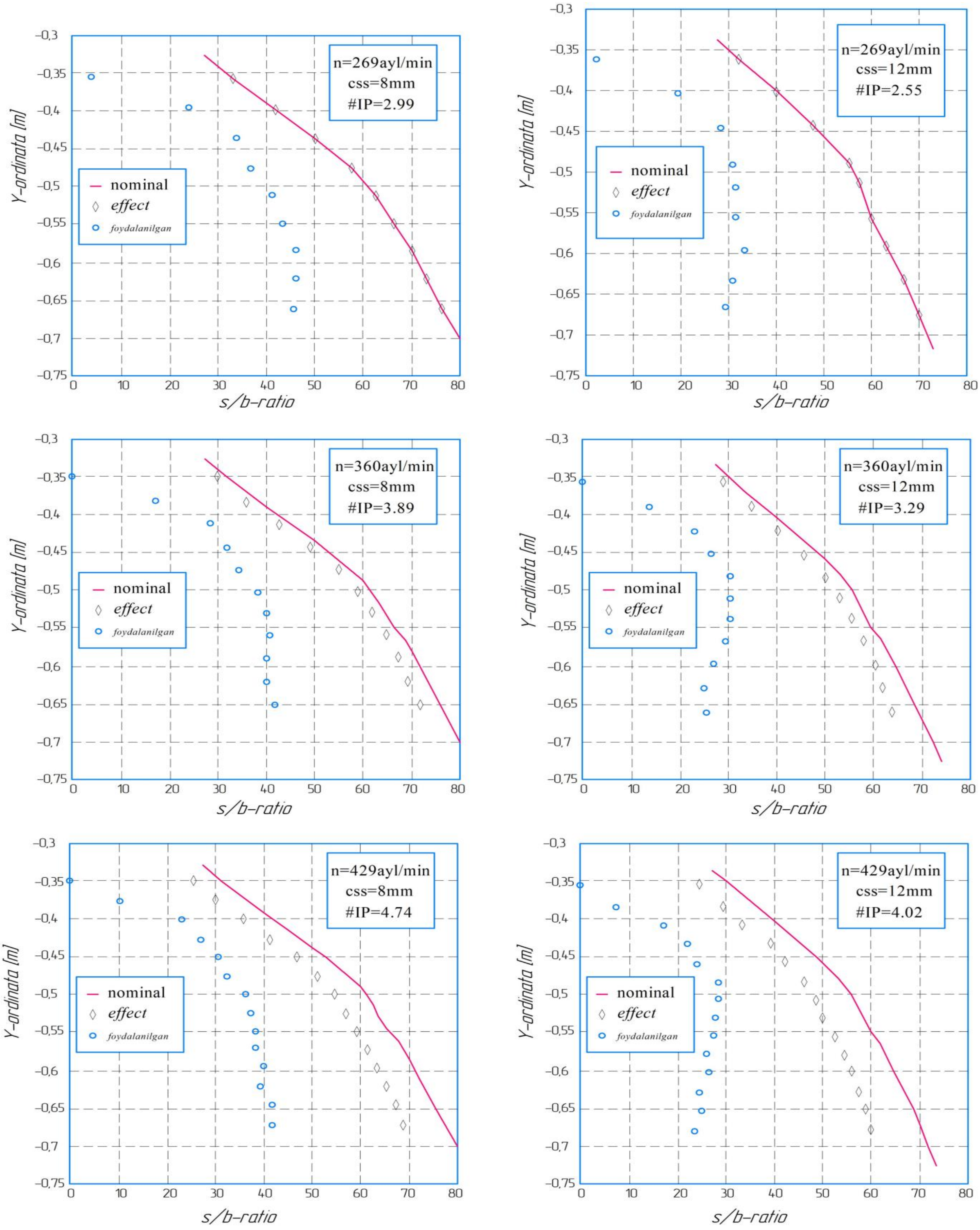

Figure 4. Compression ratio at various settings and speeds, obtained from simulations for a cone crushing crusher

After the inter-piece cutting zones and before the output, there is only one cutting mode. Here, the material is mainly measured by the crusher, and as a result, the size reduction in this area is relatively small. The number of fragmentation events of individual particles ranges from 6 to 10.

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In terms of crushing efficiency, the upper part of the crushing chamber above the loading level is more efficient than the lower part.

If the simulation of reducing repeated dimensions is performed, different values of one or more operating parameters of the crusher are obtained. Figure 4 shows the size distribution for various closed-sided settings. The working diagram of the corresponding crusher is shown in Fig. 5. For comparison, the results of modeling and experiments are shown in Fig. 6. A good quality agreement, especially in terms of the joint allocation of maximum relative powers, with the trends of different factions.

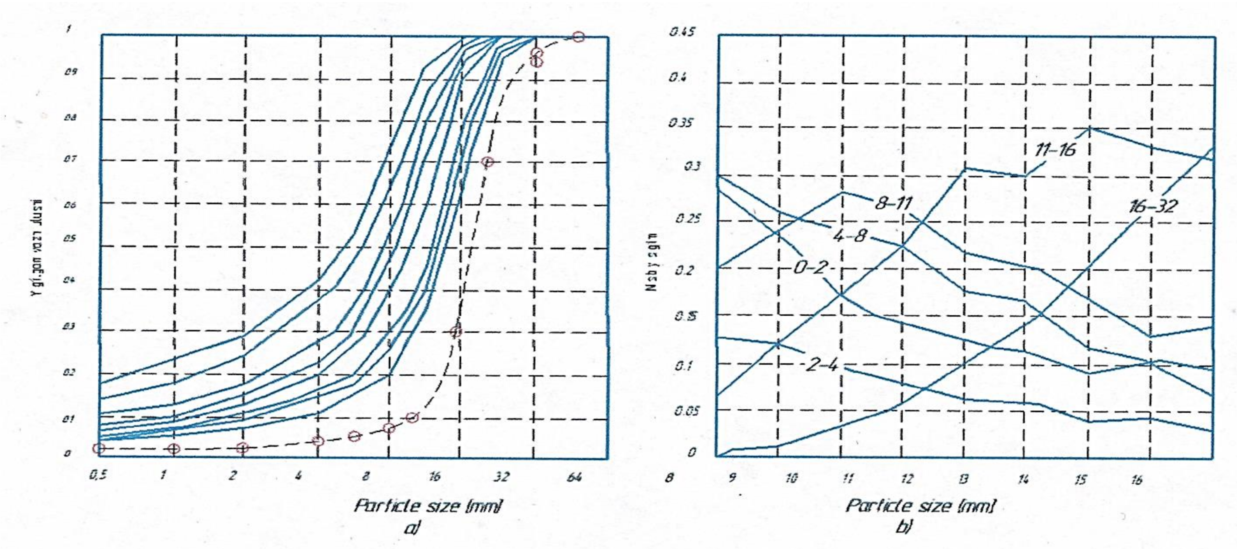

Fig. 5. a) Simulation of the product volume distribution at an eccentric speed of 269 rpm. CSS varies from 8 to 16 mm with 1 mm steps.

b) operation map of the simulated crusher for an eccentric speed of 269 rpm.

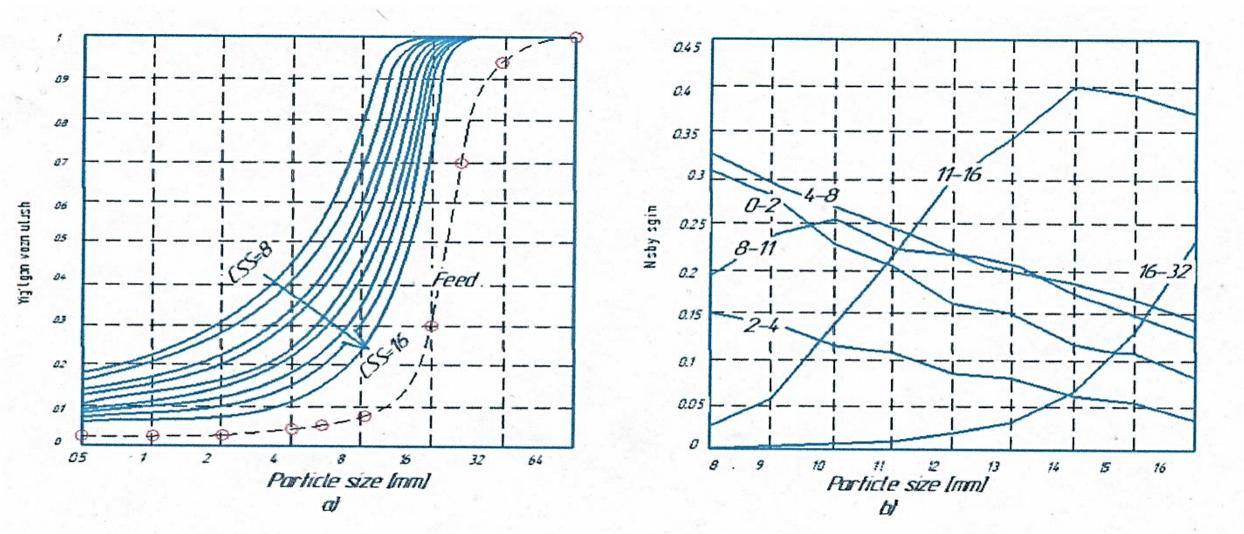

Fig. 6. a) Distribution of product dimensions based on the results of full-scale tests at an eccentric speed of 269 rpm. CSS varies from 8 to 16 mm with 1 mm steps.

b) Field tests of the crusher at an eccentric speed of 269 rpm.

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Three main factors were identified in the crushing process occurring in the cone crushing unit: crushing modes, the number of crushing zones, and the degree of compression. These key factors allow for a fundamental and detailed understanding of how the cone crusher works. These factors influence the design and operational parameters. [4. p. 16].

Disruption between the particles determines the shape of the particles, and the most energy-saving is the grinding of individual particles. If there is a calibration zone after several particle grinding zones, it is strictly recommended that this zone be parallel or slightly different.

The number of crushing zones is regulated by the crusher height and eccentric speed. The crusher with a relatively high distribution zone in the chamber can be shortened at the bottom by adding several crushing zones without significantly reducing its overall dimensions.

For a crusher located in the zone close to the outlet of the chamber, the first crushing zones between the pieces have very little effect on crushing. Ratios in these zones (*s/b*) so small that their value does not contribute to any volume reduction.

The compression ratio is mainly controlled by chamber profiles, crusher dynamics, and volumetric fill factor. Together, these factors lead to the compression ratio used *(s/b)u* which, in turn, determines the selection of the applied compression ratio and crushing values.

The developed model is a comprehensive analytical tool for predicting the operation of the cone crushing unit, providing detailed information on how and where crushing is carried out in the cone crusher. The values between the simulation results and the experimental data are very close. The model allows establishing a direct relationship between the design parameters of the crusher, the nature of rock crushing, and the operation of the crusher.

At ordinary eccentric velocities, the main mechanism of the flow is free fall. The standard eccentric speeds selected by the crusher manufacturers do not fully utilize the nominal impact at the break-even point. The choice of a specific eccentric velocity is likely determined empirically and reflects the complex situation between the crusher's operation and the overall size reduction.

The simulation shows that there is a noticeable upward flow of material due to the lifting effect. The upward movement of the material reduces overall performance and should not be ignored. The same effect is required to transfer the horizontal (radial) material from the inlet to the outlet of the grinding chamber. [2; P. 11, 3; 10-p.].

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