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INFLUENCE OF BALL CHARGE GRANULOMETRY ON BOND INDEX DETERMINATION

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ABSTRACT. Comminution energy costs represent an important part in estimating the mineral processing costs. Quick and accurate methods for estimating the respective costs for each step of the comminution process are developed during the time and the Bond work index test is the most used procedure.

ВЛИЯНИЕ ГОЛЕМИНАТА НА ТОКОВИЯ ТОВАР ВЪРХУ ОПРЕДЕЛЯНЕ ИНДЕКСА НА БОНД

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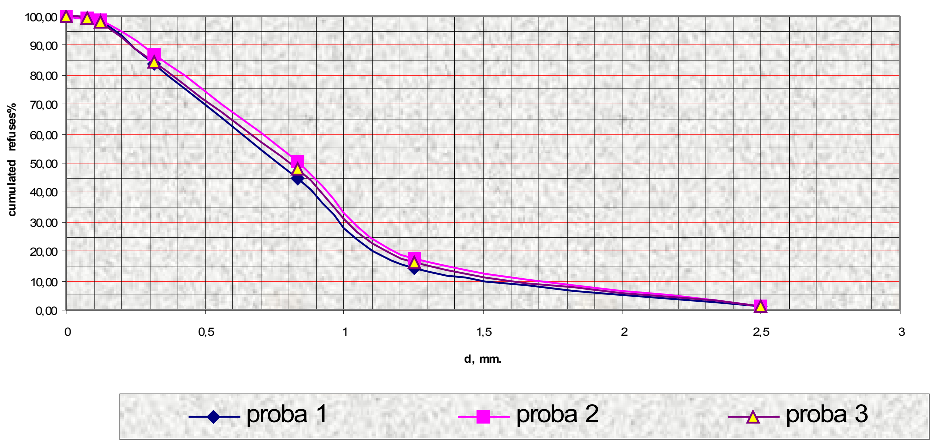
Index detrmination

The Bond work index determination is based on a simplified closed milling circuit, using Mergan mill of Outokumpu with the standard characteristics for this procedure. In standard condition, the ball charge was 21,129 kg and the charge volumetric weight was of 4500 kg/m^3 with a loading of 21%. The mill revolution was of 70 rpm, i.e. 90% of critical revolution. The grinding cycles are continued until a 250% circulating load is achieved. In each sequence, the milling does not exceed 1/3,5, namely 28,57% fine class. At each sequence, the undersize fraction is substituted with fresh material from mill feed. The contribution of undersize is calculated each time and finally is calculated the new created class weight. The operation is recurrent until the grindability index is constant in three successive experiments.

The sample was of heterogenous material with quartz and shale granules. Although we repeat the sample homogenization in order to prepare the test material, a size variation was observed in the three sub-sample extracted but this variation was in acceptable limits, figure1.

Fig. 1. Material for mill feed



The samples were tested complying with a pre-established program, following all the stages of the test. The program refers to establish the influence of size ball charge, like average size, on Bond index value. In this experiments, the feed sized, the ball charge and the mill revolution were unchanged.

The ball size in mill was thus selected to include boundary and far-off standard size.

In program elaboration refer to:

- constant keeping of ball charge;
- calculation of ball diameter of standard charge;
- variation of average diameter in limit of ±2%;

– variation of average diameter in limit of ±5%;
– variation of average diameter in wider limits.

Ball charge realization refers to balls with standard diameter and varying only the ball number. The regimes were selected so that prevalent are either ball with large, or medium, or small diameter. In the case of balls with medium diameter, the standard value was preferable. In order to establish the ball charge influence on Bond index determination, an experiment planning was achieved:

– The charge in first experiment is characterized of an average diameter with 6% lower than standard value and of viewpoint of ball number, 45% is the exceeded value.

– The charge in second experiment is characterized of an average diameter with 0,2% lower than standard value and of ball number with 1% higher than standard value.

– The third experiment is characterized of an average diameter with 10% higher than the standard value and of point of view of ball number, 20% lower than standard value.

– In the fourth experiment, charge was at standard value.

– The charge in five experiment is characterized by an average diameter 1% lower than standard value and the ball number exceed with 4,5% standard value.

– In sixth experiment, the ball charge had an average diameter 2,5% lower than standard value and their number is 23% higher the standard number.

– In seventh experiment, the average diameter was at standard value and their number is 20% higher than standard value.

– In eighth experiment, the average diameter was 2% higher than standard value and ball number is 4,5% lower than standard value.

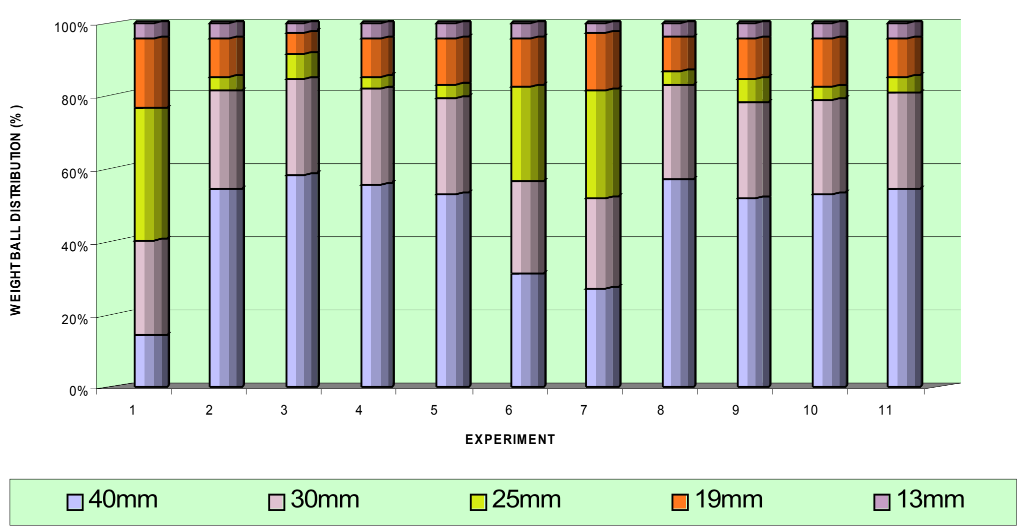
– The ninth experiment was characterized by an average diameter of 0,6% lower than standard value and the ball number was 4% higher than standard value.

– The charge in tenth experiment had an average diameter of 1,5% lower than standard value and their number was of 6% higher than standard value.

– The charge in eleventh experiment was characterized by an average diameter of 0,2% lower than standard value and the ball number was of 1% higher than standard number.

The graphics presentation of the ball weight distribution for each experiment is in figure 2, for their numerical distribution in figure 3 and for percentage distribution in figure 4.

fig 2 THE BALL WEIGTH DISTRIBUTION FOR EACH EXPERIMENT



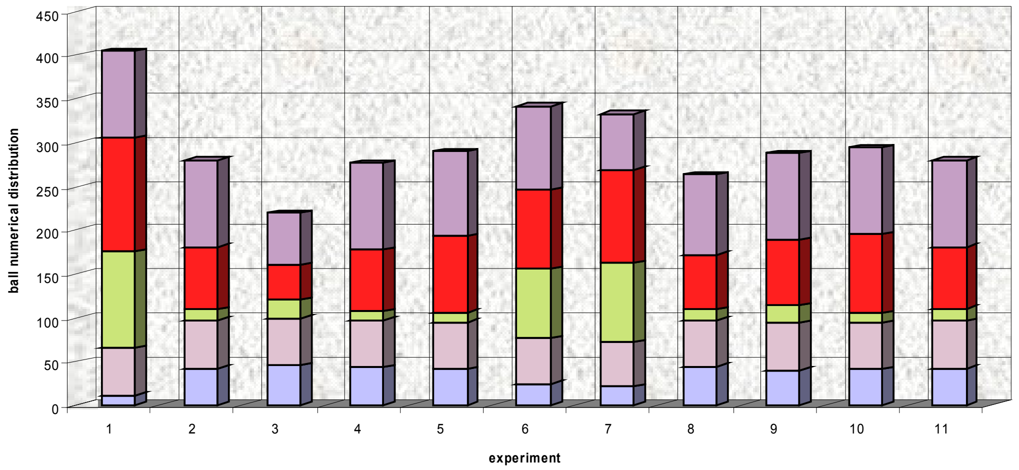
From point of view of weight composition, presented in figure 2, is seen a reduced quantity of small balls comparative with coarse balls, the average classes being representative in experiments 1, 6 and 7. In all other experiments, balls with diameter value of 40mm represent higher than 50% in charge weight.

If it is thought the milling classical theory, the higher weight of small balls, the higher is the product fineness and conversely, the higher weight of large balls, the coarse product is obtained. In Bond index determination, the standard charge is preferred, the fourth experiment being the most equidistant from optimum in case of each material taking account of the higher size in mill feed and of granule strength at impact. For each material prepared and tested in accordance with procedure can be find out a weight distribution of charge that improves the process, but this value lies close by the value realized with the standard charge, the difference being insignificantly. That is, regardless of charge size composition, at constant charge weight and pre-established size interval, the index value must be not significantly different of what we proposed to demonstrate.

In figure 3, is noticeable that the total ball number varies in inverse ratio to ball number with 40mm diameter, the ball classes with diameter of 30mm and 13mm being constantly.

The ball number change was influenced by the intermediate ball class weight, increasing in number of ball with diameter value of 19mm determines strictly increasing in ball number in charge, when must be always introduced the same ball quantity in charge.

Fig. 3. The ball numerical variation from the load



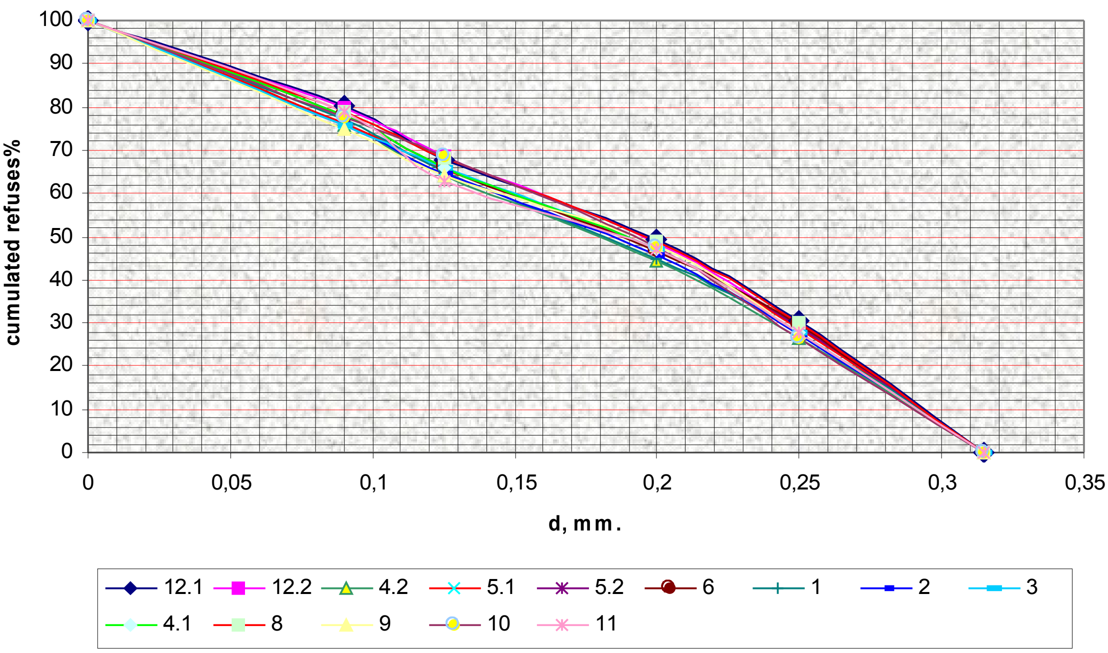
Because there is a high grad of material segregation during processing, some measures were taken in order to avoid the errors:

– material homogenizing before each sequence;
– determination of content of – 0,315mm class in feed material that remakes mill charge of 1208g at each sequence.

As we underline, at each sequence, the undersized in replaced with material from mill feed. After each operation the undersize contribution in mill and finally the new created class weight are calculated. This is related to specific rotation of each sequence in order to establish the grindability, G, that means the new created class weight during one revolution at stabilized circuit.

In concordance with the method principle, - 0,315mm class from product of the last three experiments in which the grindability coefficient is constant, was combined and homogenized. One representative sample of 200g from this material was subjected to sizing analysis. The results were used to achieve the granulometric curves presented in figure 5.

Fig. 4. The material granulometry -0,315 in the grinded product



Crossing point with straight of 20% ordinate (passing 80%) determines Xp, material size –0,315mm resulted from experiment at each attempt. In Bond logarithmic scale was enough the material to pass through one sieve from the set.

In crossing point of the same straight with feed curves was determined X_F values, taking the average value in calculus. These values were used for the calculation of P and F, using the equations:

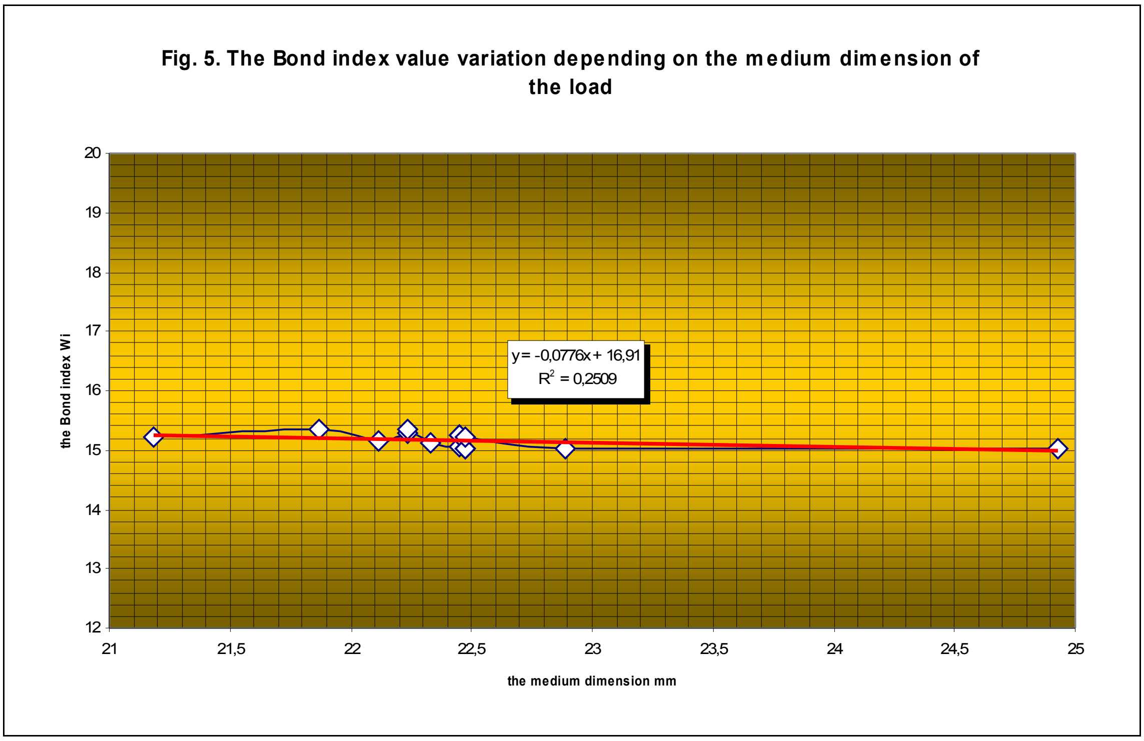
$$F = \frac{10}{\sqrt{X_F}}$$

$$P = \frac{10}{\sqrt{X_P}}$$

Values used in Bond determination relation:

$$W_i = \frac{44.5 \cdot 1,1}{P_i^{0,23} \cdot G^{0,82} \cdot (P^{-0,5} - F^{-0,5})} [kwh / t]$$

Analyzing such determined values, it come out that Bond index values vary in limited values depending on charge average size, lower value in standard average diameter domain and a little higher with diameter decreasing, figure 5. This influence is insignificantly.



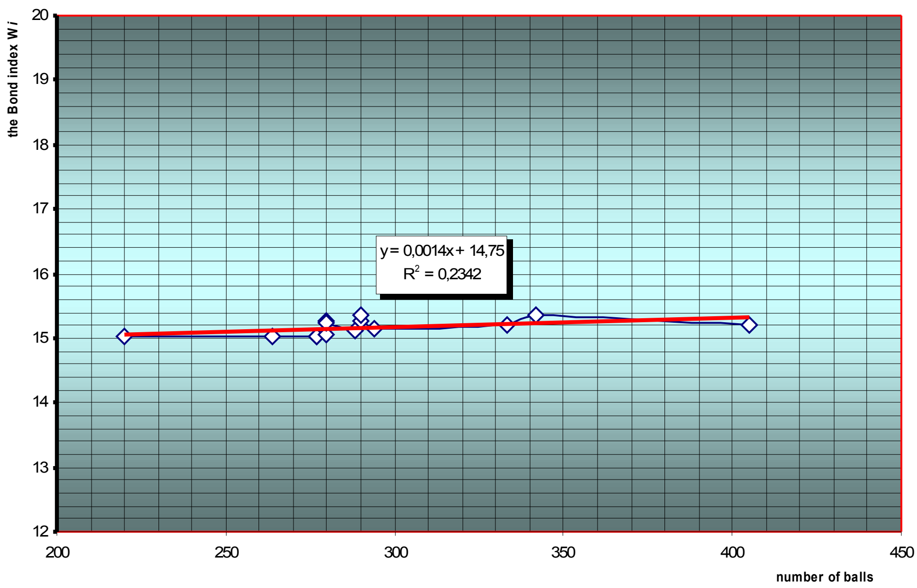
It come out that at the same standard diameter with a ball charge near the standard average value, resulted index is higher than obtained with standard charges, but the variation is insignificantly.

In figure 7 is presented a correlation also, depending on ball number out of mill (at the same charge weight) and come out the same index value insignificant variation. It come out that the index value weakly increases with ball number and go on an flattening.

Rather standard charge is used in Bond index establishing, experiment four result being the nearest value from the optimum possible to obtain for each material if take account of maximum size imposed in feed material of testing mill and of granule strength at impact. That what we said is existence of a granulometric distribution of charge able to produce the process bettering, but such obtained value there is close by those obtained using standard charge, the differences being insignificantly.

Concluding, it come out that ball charge granulometry does not significantly influences the Bond index value, differences being below ±2%.

Fig. 6. The Bond index value variation with the number of balls in the load



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