UDC 622.73

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# QUALITY CONTROL OF THE GRINDING PRODUCTS

*Annatation. The article is devoted to the development of a quality control system for jet grinding products based on the acoustic signal analysis of the mill acting zones. The dependences of the fraction particle size of various materials on the characteristics of the recorded acoustic signals are investigated. At the particle size analysis the maximum amplitude, characteristic frequency and its dispersion were taken into account. A three-stage algorithm for monitoring and controlling the product size based on the acoustic monitoring results has been developed.*

*Keywords: gas-jet mill, acoustic signal, size, product quality, algorithm.*

**Introduction.** Currently, there are several ways for automatic control and optimize the process, in particular, on the basis of the ball mill active drive power setting and the jet mill productivity on the loaded material, monitoring the temperature differential or vacuum over the jet mill path. These methods have disadvantages, for example, a significant error in indicator determining of the grinding process, as well as the delay in determining the temperature at the material loading and the lack of regulation accuracy. The product quality has a great influence on the efficiency. In jet grinders, a slight change in the classification mode may cause a violation of product quality and further the need for re-grinding. This all leads to the material and financial resource overrun.

**Analyses of previous publications.** A method of process acoustic monitoring has been developed at the Institute of Technical Mechanics of the National Academy of Sciences of Ukraine and the State Space Agency of Ukraine (ITM). Conducted studies [1-2] made it possible to establish connections between the technological and acoustic parameters in the jet grinding process. The analysis of the material size in the stream and the recorded signals showed a stable links between the acoustic signal amplitude and the material particle size, the presence of signal characteristic frequencies, their dispersion, determining the quantitative value of material fractions in the stream [3]. These facts became the basis for the control algorithm development of the grinding product size.

**The purpose** of the work is to develop an algorithm for monitoring and control the grinding material size to improve the product quality.

The task of any grinding process is to reduce the particle size of the initial material to a certain content percentage of the control class and finer one in the ready product. The change in the particle size distribution of the material takes place in the mill chamber. Then after the classifier, the ready material is removed from the gringing cycle, and the undersized material as a circulating load is fed back into the chamber for grinding. For example, fig. 1 shows the change in the quartz size composition during grinding.

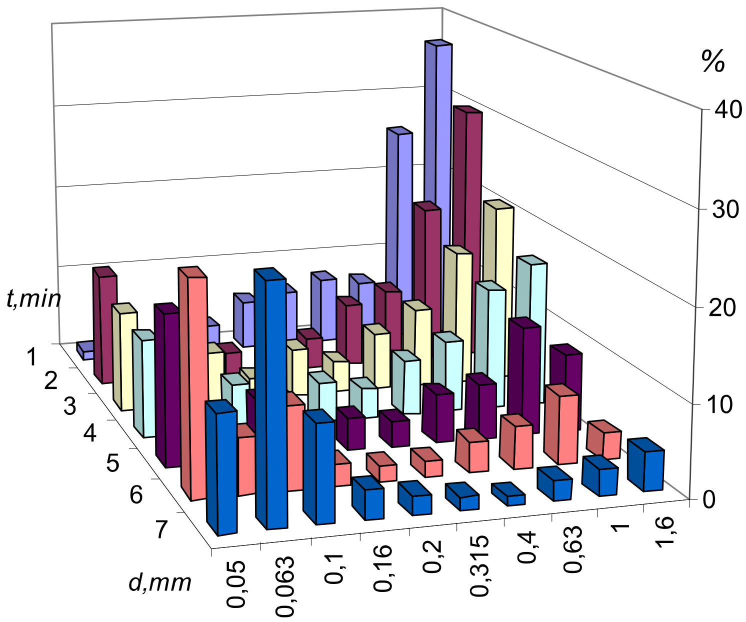


Figure 1 – Kinetics of quartz granulometric composition during jet grinding

**Methods.** Experimental studies on the product size control were carried out on the ITM jet mill with a capacity of 20 kg / h. At the experimental studies the compressed air pressure was P = 0.3-0.5 MPa and the mill classifier rotor speed was *n* = 600-3000 $c^{-1}$. Materials of various densities and sizes from 0.0063 mm to 2,5 mm were considered, the specific surface of the ground product was 0,48 – 0,72 $cm^2$ / g. Acoustic signals in the chamber and in the zone behind the classifier were transmitted through a waveguide connected by a sensor to an ADC and further processed and analyzed on a computer. Figure 2 shows the recordings of the acoustic monitoring signals of the mill chamber during the various fireclay fractions grinding: a) -0.315 mm + 0.2 mm; b) -0.4 mm + 0.315 mm; c) -0.63 mm + 0.4 mm.

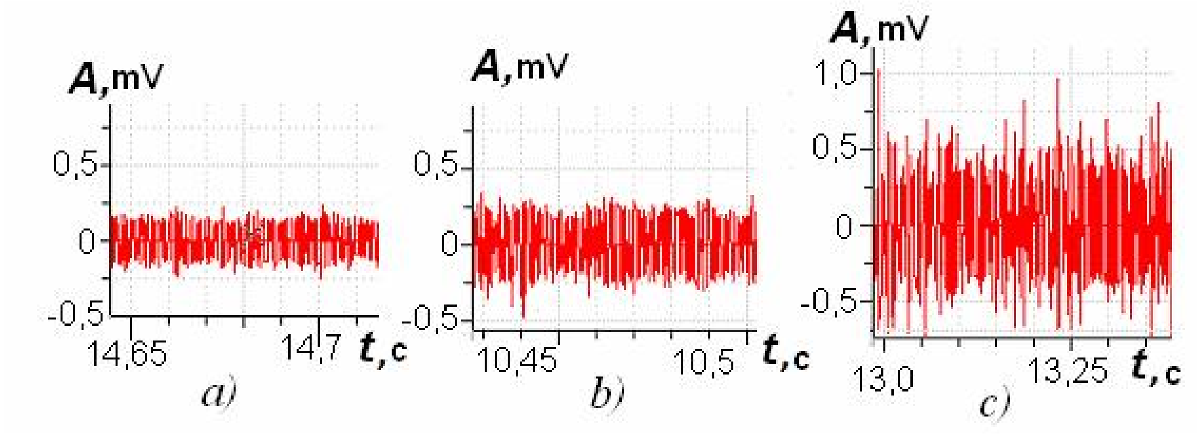


Figure 2 - Amplitude acoustic signal characteristics of fireclay various fractions

**Results and discussions.** It has been established that at other equal, technological parameters the maximum signal amplitude depends on the material properties, its particle size, strength, grind ability, etc. In particular fig. 3 shows the dependences of the maximum amplitude on the material particle size for various material properties - slag and quartz.

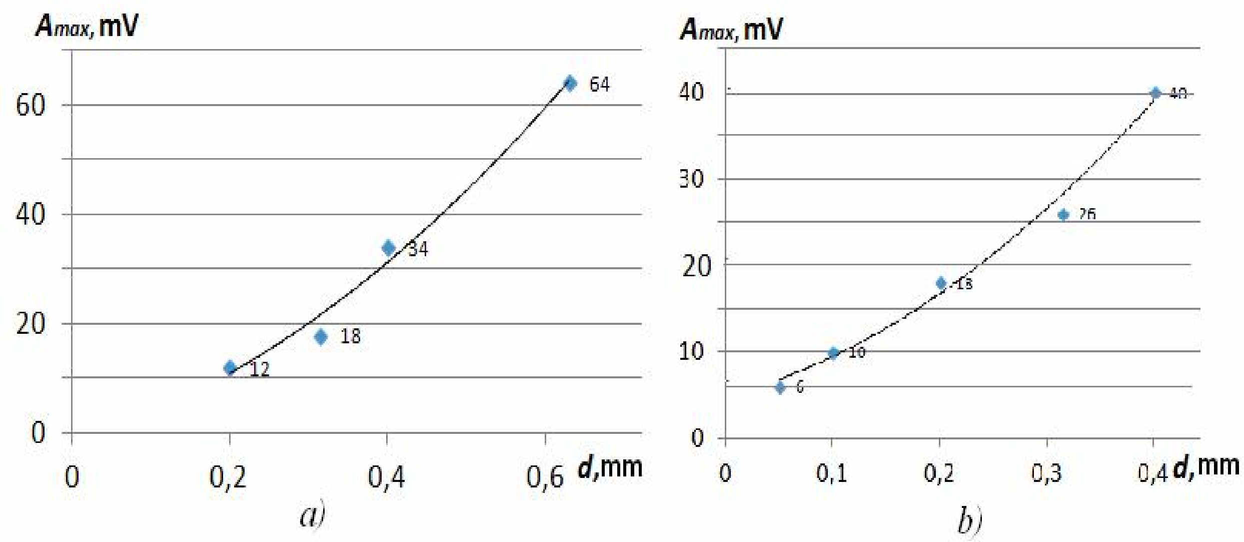


Figure 3 - Dependence of the maximum amplitude on the material particle size at slag (a) and quartz (b) grinding

Dependencies have a similar character, but for size control of various materials in the grinding process, it is necessary to preliminarily establish a quantitative dependence of the acoustic signal characteristics on the control class size.


ISSN 1562-9945

On fig. 4 it's shown the dependences of the acoustic signal average amplitude in the grinding zone on the various materials particle size: slag (1), fireclay (2), carbon black (3) and quartz (4).

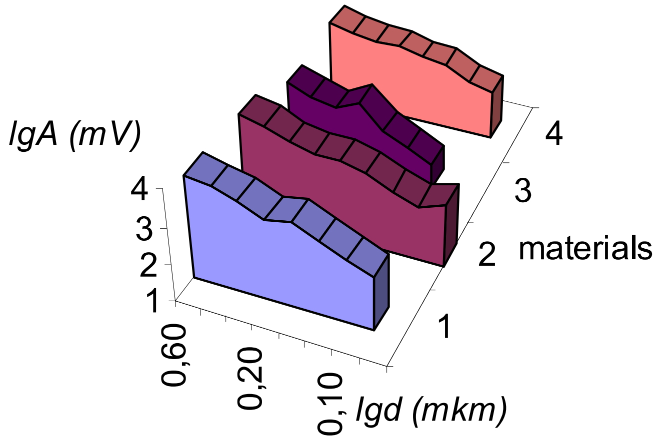


Figure 4 – The dependence of the signal amplitude on the particle size of the grinding material in the logarithmic coordinate system

Knowing the acoustic signal characteristics for individual material fractions, it is possible to control the material size transporting in the zone behind the classifier according to the results of acoustic monitoring. The appearance of signals which amplitude differs from the established amplitude of signals characteristic of the size monitoring control class is a sign of the larger fraction particle presence in the product.

Fig. 5 shows just this case, i.e. detection in the product the particles larger than the control class. This fact is indicated by signals with a frequency of 83 Hz, in which the amplitude reaches 1.0 mV.

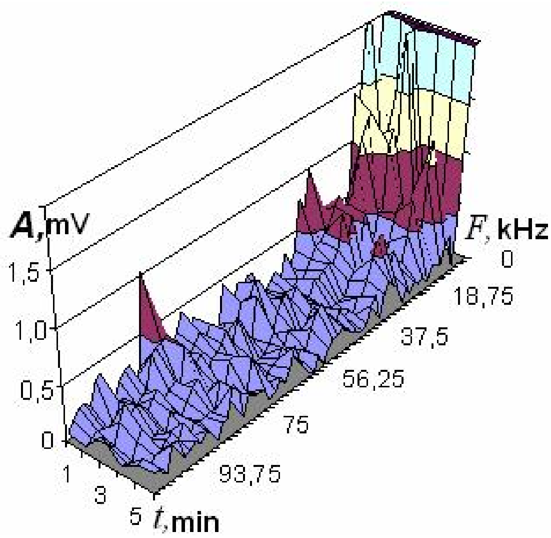


Figure 5 – Kinetics of acoustic signals in the classification zone

At acoustic monitoring of the grinding operation zone in the mill chamber, the signals have larger amplitude than in the transportation zone. However, the established connections are preserved. Fig. 6 shows the characteristic changes of acoustic signals in the mill during quartz grinding.

An important parameter in the material size control with the acoustic method is the frequency of the recorded signals. For the frequency spectra studying of acoustic signals at narrow fraction transporting of different size material (quartz, slag, fireclay) in the flow, characteristic frequencies are determined, which are determined by the particle size of these fractions. During the study of material size connection with acoustic signal parameters, there were obtained signal amplitudes with corresponding characteristic frequencies for a certain particle size [3].

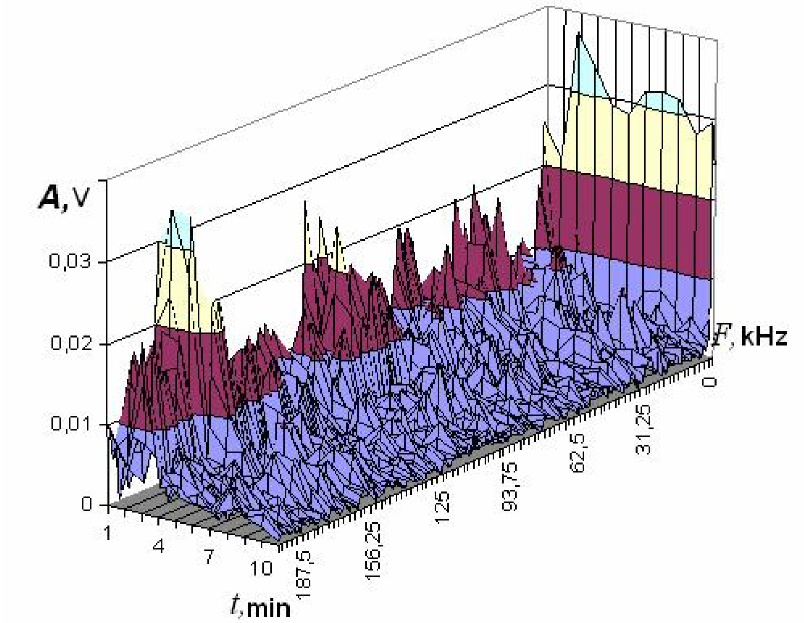


Figure 6 - Kinetics of quartz grinding in the acoustic signal characteristic terms

As a rule the grinding material is a mixture of certain fractions. To study the material fractional composition, we used the dispersion analysis of signal characteristic frequencies during acoustic monitoring process. A preliminary result analysis allows setting the existing dependence of the dispersion of the acoustic signal characteristic frequency on the corresponding fraction mass in the mixture during material transportation in the gas stream. The information presented in fig. 7 allows making the conclusion that the dependencies are linear, and their coefficients depend on the particle size of the fraction and the material properties.

 ISSN 1562-9945

The established connections between the dispersion of the jet mill grinding material and the acoustic signals of the grinding zone made it possible to propose an algorithm for monitoring and control the grinding product quality.

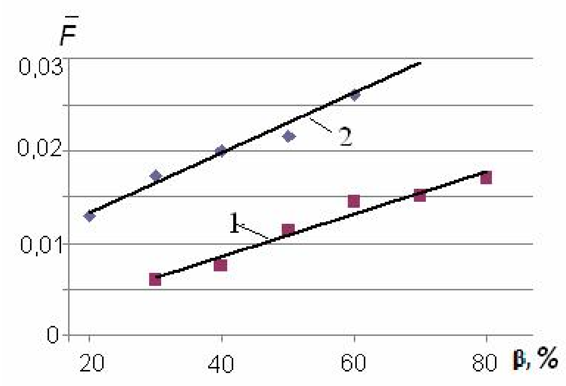


Figure 7 – Normalized signal frequency dispersion for transporting of quartz sand different fraction masses: 1- (-0.4 +0.315)mm, 2- (-0.315 + 0.2) mm

Fig. 8 shows a three-level algorithm for monitoring and control the material size in the grinding operation zone.

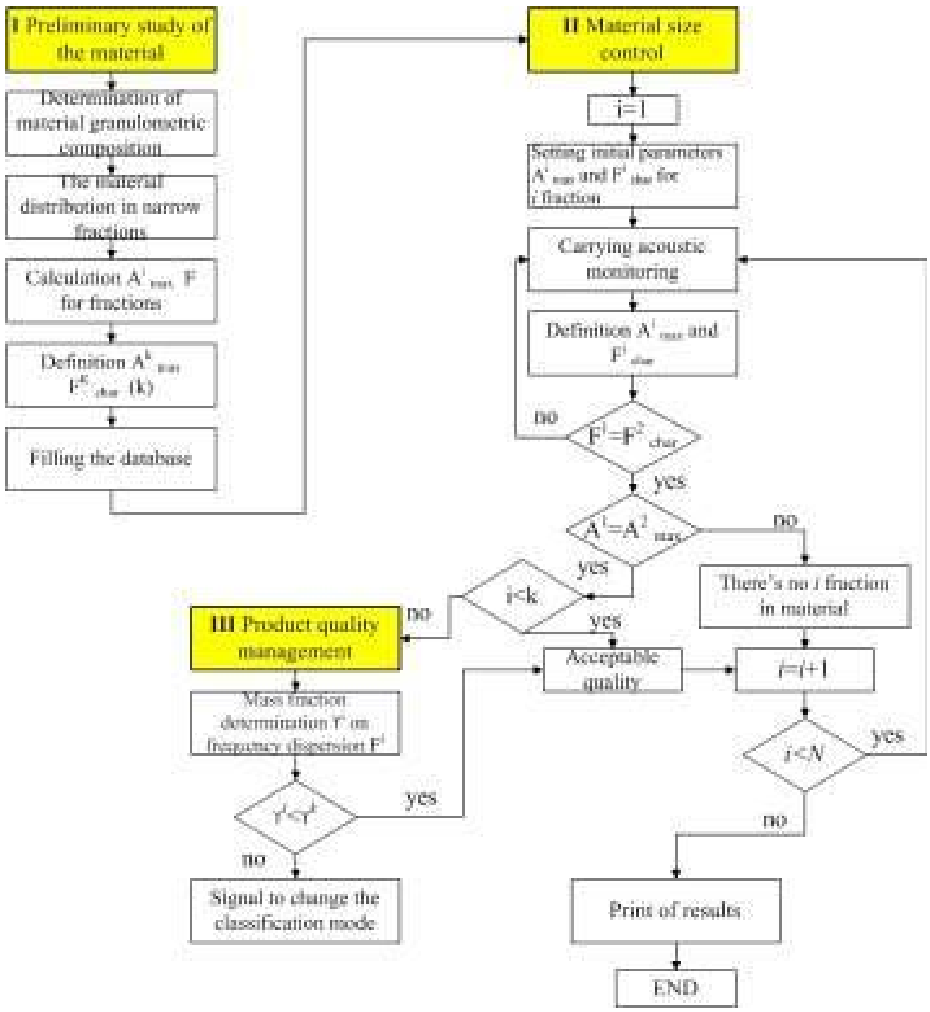


Figure 8 – An algorithm for monitoring and control the material size

The first stage is a preliminary analysis of the material size and the grinding product, the control acoustic parameter establishment. The second stage is the material size control based on the acoustic monitoring results. The final step is the quality control unit of the grinding product. The third stage joined and starts to operate in detection case of a substandard product by size. This makes it possible to respond on-time the appearance of the spoilage and reduce its occurrence probability to a minimum.

**Conclusion**

The possibility of determining the grinding product size with the help of signal analysis of the jet mill operating zones is substantiated. A system for monitoring and controlling the jet grinding mill product quality based on the results of the continuous acoustic monitoring has been developed.

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 ISSN 1562-9945