UDC 622.232.72:004.942

N. S. Pryadko, A. D. Yhnatev, H. M. Shevelova, K. V. Ternova

Gas mass flow control in jet equipment

Institute of Technical Mechanics
of the National Academy of Sciences of Ukraine and the State Space Agency of Ukraine
15 Leshko-Popel St., Dnipro 49005, Ukraine; e-mail: ai2325434@gmail.com

Based on a numerical simulation of gas flows in an ejector unit and an analysis of grinding chamber acoustic signals, this paper shows ways to increase the efficiency of jet grinding. To prevent ejector speed-up tube wear and to obtain a ground product without impurities, the effect of feeding an additional energy carrier flow on the flow pattern in the speed-up tube of a jet mill was studied. A comparative analysis of the ejector flow pattern as a function of the presence of an additional feed and the speed-up tube shape was carried out. It was shown that the use of a conical nozzle offers a more uniform flow at the ejector outlet. The additional energy carrier feed provides a uniform increase in flow speed and reduces speed-up tube wall wear. The acoustic signals of the mill working zones were related to the jet grinding process parameters, around which a ground product quality control method was developed. The paper presents a technique for determining the material particle size in the energy carrier flow from the results of acoustic monitoring of the process. The technique uses the established relationship between the dispersion of the acoustic signal characteristic frequency and the mass of the corresponding fracture of the mixture in in-flow material transportation. The technique speeds up material particle size determination and improves the finished product quality. An automatic system was developed to control the grinding process by controlling the loading process according to the characteristics of the grinding zone acoustic signals. An operating model of a controlled hopper of a gas jet mill was made. The operability of the control system was verified on a simulation model, which includes a control objet (mill) model and a control system model. It was shown that the system of mill loading automatic control by the characteristics of the grinding zone acoustic signals offers an up to 10 percent increase in mill capacity, which was verified in industrial conditions at Vilnohorsk Mining and Metallurgical Plant.

Keywords: *gas jet mill, nozzle, ejector, acoustic signals, efficiency, control*

1. Zhao X., Zhu H., Zhang G., Tang W. Effect of superfine grinding on the physicochemical properties and antioxidant activity of red grape pomace powders. Powder Technol. 2015. No. 286. Pp .838-844.
https://doi.org/10.1016/j.powtec.2015.09.025

2. Pryadko N. S., Ternova K. V. Acoustic monitoring of jet grinding. Akademperiodyka, 2020. 192 pp.
https://doi.org/10.15407/akademperiodyka.409.192

3. Ali M., Lin L. Optimisation and analysis of bead milling process for preparation of highly viscous, binder-free dispersions of carbon black pigment. Prog. Org. Coat. 2018. No. 119. Pp. 1-7.
https://doi.org/10.1016/j.porgcoat.2018.02.007

4. Pryadko N., Muzyka L., Strelnikov H., Ternova K. Acoustic method of jet grinding study and control. Essays of Mining Science and Practice. 2019. Pp. 1-11.
https://doi.org/10.1051/e3sconf/201910900074

5. Sheveleva A. M. Methods for finished product quality improvement in jet grinding, Zbahachennia Korysnykh Kopalyn. 2018. No. 69 (110). Pp. 86-94. (in Russian).

6. Kong F., Kim H. Analytical and computational studies on the performance of a two-stage ejector diffuser system. Int. J. Heat Mass Transf. 2015. V. 85. Pp. 71-87.

https://doi.org/10.1016/j.ijheatmasstransfer.2015.01.117

7. Barakovskikh D. S., Shishkin S. F., Shishkin A. S. Particle motion in a jet mill speed-up tube. Vestnik Belgorodskogo Gosudarstvennogo Tekhnicheskogo Universiteta im. V. G. Shukhova. 2017. No. 5. Pp. 82-88. (in Russian).

8. Rao S. M.V., Jagadeesh G. Novel supersonic nozzles for mixing enhancement in supersonic ejectors. Applied Thermal Engineering. 2014. No. 71. Pp. 62-71.
https://doi.org/10.1016/j.applthermaleng.2014.06.025

9. Ameur K., Aidoun Z., Ouzzane M. Modeling and numerical approach for the design and operation of two-phase ejectors. Applied Thermal Engineering. 2016. No. 109. Pp. 809-818.
https://doi.org/10.1016/j.applthermaleng.2014.11.022

10. Barakovskikh D. S., Shishkin S. F. External-pressure ejector jet mill. Industrial Production and Metallurgy: Proceedings of the International Scientific and technical Conference. 2020. Pp. 14-19. (in Russian).

11. Ihnatev O. D., Shevelova H. M. Effect of the location of a gas flow control element in an ejector unit on the flow pattern. Teh. Meh. 2020. No. 3. Pp. 54-63. (in Ukrainian).
https://doi.org/10.15407/itm2020.03.054

12. Sheveleva A. M., Ihnatev A. D. Calculation of the ejector velocity field with an additional energy feed along the speed-up tube axis. Zbahachennia Korysnykh Kopalyn. 2019. No. 73 (114). Pp. 92-98. (in Russian).

13. Zhiyong Gaoa, Ruiying Fana, John Ralstonc, Wei Suna, Yuehua Hu Zhiyong Gaoa, Ruiying Fana, John Ralstonc, Wei Suna, Yuehua Hu. Surface broken bonds: An efficient way to assess the surface behaviour of fluorite. Minerals Engineering. 2019. No. 130. Pp. 15-23.
https://doi.org/10.1016/j.mineng.2018.09.024

14. Tkachev V. V., Bublikov A. V. Simulation Study of a Cutter Loader Automatic Control System. National Mining University, 2015. 182 pp. (in Russian).

15. Reshmin B. I. Simulation Study and Control Systems. Info-Inzheneriya. 2016. 74 pp. (in Russian).

Received on June 7, 2021,
in final form on November 23, 2021