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K. Deineka[1]
Yu. Naumenko[2]
S. Zhabchyk[2]

CREATION OF INNOVATIVE SELF-OSCILLATING WORKING PROCESSES FOR PROCESSING GRANULAR MATERIALS IN DRUM-TYPE TECHNOLOGICAL MACHINES

[1]Rivne Technical Vocational College of the
National University of Water and Environmental Engineering
[2]National University of Water and Environmental Engineering

Abstract
The report presents an innovative approach to increasing the efficiency of the working processes of drum-type machines when implementing various technological processes for processing granular materials: granulation, reactive process, mixing, grinding, washing, classification, rolling, drying and heat treatment. The results obtained from the application of the established hydrodynamic effect of self-excitation of auto-oscillations of the granular filling of the rotating drum chamber demonstrate the intensification, increase in productivity and reduction in energy consumption of processes by increasing dilatancy and activating the passive part of the filling. This paves the way for a new generation of drum-type machine workflows.

Keywords: drum-type machines, granular material, workflow, rotating drum, intrachamber filling, self-excitation of auto-oscillations

Drum-type machines are a fairly common type of technological equipment and constitute a wide class of multi-purpose machines. The widespread use of drum machines is due to a number of advantages: high unit productivity, reliability, ease of operation, versatility, and cost-effectiveness.

Based on the International Patent Classification, 9 classes of patents for inventions can be distinguished, corresponding to 9 main types of drum-type machines: B01J 2/12 Processes or devices for granulating materials in rotating drums; B01J 8/10, B01J 19/28 Chemical, physical or physicochemical processes moved by rotary drums; B01F 29/60 Drum mixers; B02C 17/00 Disintegrating by tumbling mills; B03B 5/56 Drum classifiers; B07B 1/22 Sieving, screening, sifting, or sorting solid materials using revolving drums; B24B 31/02 Machines or devices designed for polishing or abrading surfaces on work by means of tumbling apparatus. Rotary barrels; F26B 11/04 Machines or apparatus for drying solid materials rotating about a horizontal or slightly-inclined axis; F27B 7/00 Rotary-drum furnaces. The most energy-intensive and common type of such machines are tumbling mills.

The main disadvantage of drum machines is low energy efficiency. It is believed that the mechanical efficiency of such processes is very low and is about 0.1-0.001%. This is caused by significant dissipation, absorption and conversion into heat, of mechanical energy due to internal friction of the granular chamber load. The mass fraction of the active part of the internal chamber filling is only 30-45%.

A paradoxical feature of drum machines is the combination of extreme simplicity of design, on the one hand, and extremely high complexity in describing the behavior of the processed medium, on the other. The latter is caused by the effect on the working environment of both the vertical gravitational and distorted centrifugal inertial force fields of rotation around the horizontal axis.

An innovative direction for dramatically improving the relatively low energy efficiency is the use of the self-oscillating recycling process in drum-type machines of traditional design solutions with a smooth chamber surface. Self-excitation of auto-oscillations allows to bring into periodic pulsating motion and activate the passive part of the intra-chamber filling and significantly increase the intensity of interaction of particles of the processed medium with the working bodies and the surrounding environment.

The first video recording of the self-oscillating mode of motion of a polygranular loading of a rotating drum (Fig. 1) was made in [1]. In [2], a mechanism for implementing the self-oscillating mode of the chamber loading flow was discovered when the stability of the dynamic system of the mill movement was lost [3]. Based on the numerical data visualization method, the effects of the degree of filling of the chamber [4,5], the content of the crushed material in the load [6], and their simultaneous variation [7] on the parameters of the self-oscillating action and grinding characteristics were evaluated.

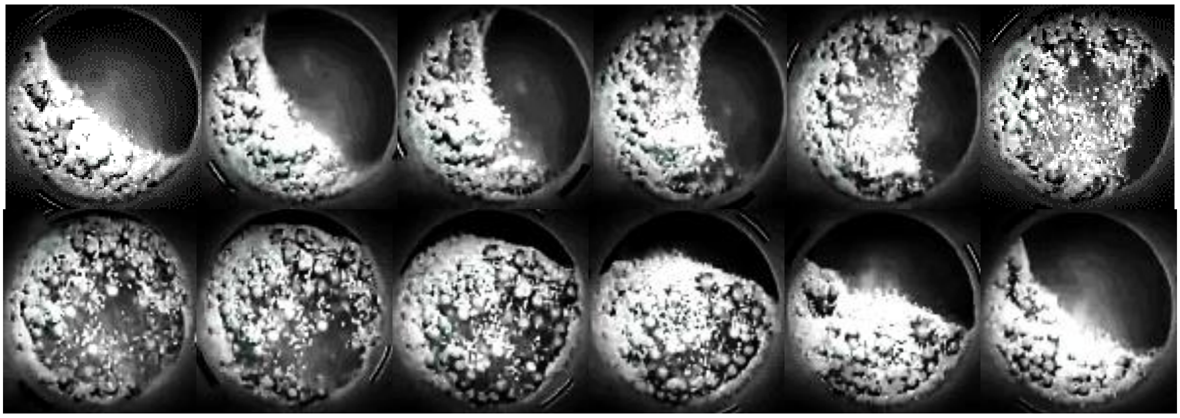

Fig. 1. Sequential pictures of the self-oscillating mode of motion of the intra-chamber filling of a laboratory ball mill for one oscillation period (according to [1])

A general dynamic effect of self-excitation of auto-oscillations of the granular loading of the rotating drum chamber was revealed: a decrease in the particle size and activation of the passive part, an increase in the fraction of the shear layer near the free surface, increased liquefaction of the layer, increased dispersion (dilatation), an increase in the velocity gradient between individual layers and an increase in the intensity of mutual intersection of the trajectories of particle motion, an increase in the frequency of mutual collisions of particles, a significant increase in the surface area of particle contact, improved contact between the solid, which is in a suspended pulsating state, and the gaseous or liquid phases, and prevention of the formation of a central core of particle size segregation.

Based on the results obtained, 9 self-oscillating processes for processing granular materials in drum machines were patented [8-16].

In the future, it is advisable to clarify the influence of different modes of self-excitation of auto-oscillations of the intra-chamber loading due to the loss of stability of motion on the efficiency of the implementation of processes for processing granular materials in drum-type machines.

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Deineka Katerina, Candidate of Technical Sciences, Higher category lecturer, Rivne Technical Vocational College of the National University of Water and Environmental Engineering, k.yu.deineka@nuwm.edu.ua
Naumenko Yurii, Doctor of Technical Sciences, Associate Professor, Professor of the Department of Civil Engineering, Road and Reclamation Machines, National University of Water and Environmental Engineering, y.v.naumenko@nuwm.edu.ua
Zhabchyk Serhii, 4th year student, Basic Science Mechanical Institute, National University of Water and Environmental Engineering, zhabchyk_m21@nuwm.edu.ua

Створення інноваційних автоколивних робочих процесів обробки зернистих матеріалів в технологічних машинах барабанного типу

Анотація
У доповіді представлено інноваційний підхід до підвищення ефективності робочих процесів машин барабанного типу при реалізації різноманітних технологічних процесів обробки зернистих матеріалів: гранулювання, проведення реактивного процесу, змішування, подрібнення, промивання, класифікації, галтування, сушіння та теплової обробки. Отримані результати застосування встановленого гідродинамічного ефекту самозбудження автоколивань зернистого завантаження камери обертового барабана демонструють інтенсифікацію, підвищення продуктивність та зниження енергоємність процесів шляхом посилення дилатансії та активізації пасивної частини завантаження. Це відкриває шлях до створення нового покоління робочих процесів машин барабанного типу.
Ключові слова: машини барабанного типу, зернистий матеріал, робочий процес, обертовий барабан, внутрішньокамерне завантаження, самозбудження автоколивань

Дейнека Катерина Юріївна, кандидат технічних наук, викладач вищої категорії, Рівненський технічний фаховий коледж Національного університету водного господарства та природокористування, k.yu.deineka@nuwm.edu.ua
Науменко Юрій Васильович, доктор технічних наук, доцент, професор кафедри будівельних, дорожніх та меліоративних машин, Національний університет водного господарства та природокористування, y.v.naumenko@nuwm.edu.ua
Жабчик Сергій Вікторович, студент 4 курсу, Навчально-науковий механічний інститут, Національний університет водного господарства та природокористування, zhabchyk_m21@nuwm.edu.ua