N E W S
OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN
SERIES CHEMISTRY AND TECHNOLOGY
ISSN 2224-5286 **https://doi.org/10.32014/2018.2518-1491.32**
Volume 6, Number 432 (2018), 102 – 108

D.I. Chyrkun[1], A.E. Leudanski[1], V.G. Golubev[2], D. Sarsenbekuly[2], S.A. Kumisbekov[2]

[1]Belorussian State Technological University, Minsk, Belarus;
[2]M. Auezov South Kazakhstan State University, Shymkent, Kazakhstan
email: alex_levdansky@mail.ru *nii_mm@mail.ru* alex_levdansky@mail.ru serik_argin@mail.ru

ANALYSIS OF INDUSTRIAL DRUM MILLS' OPERATION AND WAYS OF THEIR IMPROVEMENT

Abstract. There has been done the analysis of existing industrial drum mills, which has permitted to reveal their design imperfection. In order to increase the intensity of heterogeneous processes, it is proposed to aim at increasing the surface of contacting phases, involved in the process. For this purpose, it is necessary to combine such processes as grinding, activation, classification, mixing and chemical synthesis in the grinding device, which enables to intensify the subsequent operations for processing of dispersed compositions.The efficiency of mill operation in a closed cycle can be further improved, if to provide a highly efficient classification of ground products, removed from the mill. It is proposed to divide the whole drum of the mill along its length by lattice partitions into a large number of chambers, with a certain distance between the chambers of about $1,5 \div 2$ meters; to install two lattice partitions between the chambers, with a distances of $0,25 \div 0,4$ meters between the partitions; to fix the blades to the drum wall in the space between the partitions, similar to the drum dryer. It is recommended that in order to reduce energy costs, there should be provided a rational organization of the grinding process with optimal process conditions for industrial mills, applied in cement milling, with the air speed in the free drum space having to be within $0,7 \div 1,4\ m/\mathrm{sec}$.

Keywords: industrial drum mills, continuous classification of ground products, particles, process intensification, material cooling energy, specific energy costs, designs.

Introduction. Improving production efficiency is an essential part of the economic strategy of the country and, finally, is shown in increasing the output of high quality products at lowest costs. This is achieved through technical re-equipment, wide introduction of advanced technologies and equipment.

To increase the intensity of heterogeneous processes, it is necessary to aim at increasing the surface of contacting phases, involved in the process. Therefore, at present, many products for most industries are obtained in a fine-disperse state, with the requirements for powder dispersity continuously growing.

The modern direction in the development of technological production equipment is a combination of technological processes. The combination of such processes as grinding, activation, classification, mixing and chemical synthesis in the grinding device enables to intensify the subsequent operations for processing of dispersed compositions.

Grinding of various materials to the particles of less than a tenth of a millimeter is the most important technological process in the production of cement, lime, ceramic products, ore dressing, etc. [1-4].

Methods of research. To carry out the research, there were used analytical and numerical methods with the computers applied.

Results of research. As is known, the main drawback of the milling process is high energy intensity, although directly on the material grinding there is spent a small part of the energy, consumed by the machine.

In modern large-tonnage production there are mainly used drum mills for grinding. However, a very low-efficiency coefficient of these mills forces the researchers to work on their improvement, as well as to develop and apply mills of other designs. Such mills as medium-speed, impact, impact-centrifugal and others are beginning to find more and more application in the processes of fine grinding [5,6].

Drum mills are hollow rotating drums, in which there are grinding bodies (in most cases, steel balls), and just here the material is fed for grinding. Grinding is carried out by impact, crushing and attrition. These mills have been used in industry since the beginning of the twentieth century. The reason for such a long life of this mill is in reliability and simplicity of its design, and due to these characteristics, being very important for production, it is still out of competition in comparison with other designs. Therefore, it is necessary to remember that the newly created designs of mills can move from the development phase to the implementation phase only when they will be comparable by reliability to the drum ones. During the long period of their application, the drum mills have undergone some design changes that have enabled slightly to reduce energy losses, but they still remain very high.

In paper [7, p.17-18] there is given an approximate balance of power consumption items in the drum ball mill:

1. Formation of new surfaces	– 0,6%
2. Losses in the transformation of electricity into the kinetic energy of ball lifting	– 12,3%
3. Heating of the drum	– 6,4%
4. Heating of the medium	– 31%
5. Heating of the material	– 47,6%
6. Other losses	– 2,1%

The balance shows that the main energy losses are related to heating of the material, the medium and the drum itself. Heat in the mill is released as a result of friction between the particles, the friction of the particles on the grinding bodies and the drum wall, as well as due to the volumetric and plastic deformations. Often, high specific energy consumption in fine grinding is explained only by strength change. The smaller the particles, the smaller the internal defects in the material, the stronger they are and, therefore, their grinding requires more energy costs. This explanation is true, but far from being exhaustive. In grinding, part of the particles, having reached the desired size, remaining in the whole mass of the material, take over them the part of acting forces, dissipate them, are over-ground and slow down sharply the process in the right direction. With increasing the dispersity of particles, the effect of interaction of the particles between each other also increases. As a result, there is observed the formation of very small particles' coagulation structures, the destruction of which consumes a significant portion of the energy, supplied to the particle.

The main ways of reducing the energy losses and improving the efficiency of grinding in a drum mill are as follows. By grinding method, the drum mills can be dry and wet grinding. Wet grinding is used in those cases, when the material to be ground is further processed in the form of suspensions, for example, in mineral processing by flotation or extraction of certain components by chemical means.

The advantages of wet grinding, compared to dry grinding, are as follows:

1. less energy consumption per 1 ton of the material;
2. higher grinding capacity of the mill (approximately by 15%), absence of dust and, accordingly, aspiration ventilation and air purification systems;
3. facilitation of transportation and distribution of the material: the hydraulic transport can be used;
4. wet classification is more effective than air classification

The energy consumption reduction in wet grinding and the growth of mill capacity are explained by the fact that the liquid penetrates into cracks and causes tensile stresses that contribute to the destruction of the material, in addition, the friction force between the particles of the ground material decreases.

However, if after grinding the material, the further technology requires its use in a dry form, the dry grinding appears to be more feasible economically due to the large heat consumption for drying.

By operation principle, the drum mills are subdivided into batch and continuous. Batch mills are working by wet method. These mills are not used for operation by dry method because of great difficulties, arising in their discharge. A major drawback of batch mills is a large loss of energy to the mill operation at the end of the grinding cycle, when a very small amount of underground material is left in it. Batch mills are operated very much at the enterprises of the Republic and in order to reduce energy costs they are to be replaced by continuous mills.

To improve the process and to reduce energy costs per unit of the ground material in long drum mills, for example, tube ones, is possible by dividing them along the length into several chambers by installing lattice partitions.Since the size of the material to be crushed is decreasing while it is moving from the charging spout to the discharge one, in accordance with this, each chamber should be charged with grinding bodies, the size of which corresponds to the size of the material to be crushed. The largest bodies will be in the first chamber and the smallest bodies - in the last one.

To increase the grinding capacity and to reduce the energy costs substantially when grinding in a drum mill is possible by converting its operation from an open cycle to a closed one.

The open cycle operation circuit, when all the material to be crushed is passed through the drum once, is simpler. In this operation circuit there are no devices, providing the finished product selection, and therefore all the material is in the mill until it is completely crushed, as a result of which there will be observed the finished product grinding heterogeneity, part of the material will be over-ground. Naturally, in the open cycle operation there will be low grinding capacity and high specific energy consumption for grinding. However, it should be noted that the mills, working by open method, are simple in design and are not difficult to operate, which ensures their application up to the present time.

In a closed grinding cycle there is no aim to bring the whole material to the desired grinding fineness, and at the exit of the mill it is sent for separation to the separator, when using a dry grinding method, and to the screens or hydrocyclones, when using wet grinding. After separation, the fine fraction as a finished product is removed from the circuit, and the coarse fraction is sent again to the mill for re-grinding. The fresh and underground material is charged into the mill through the second hollow spout or the finished product - through the hollow spout, while the underground material is charged through a special hole in the middle part of the drum wall. Andreyev S. Ye. [8, p. 330-338] proved theoretically that grinding capacity of the mill, working in a closed cycle with a classifier is proportional to the content of coarse size grains in it. At the same time, it is easy to prove that the content of coarse size grains in the mill is directly proportional to the frequency rate of the circulating load. However, the increasing frequency rate of circulation results in the increased energy costs at the stage of classification and transportation of the material under the scheme: mill $\rightarrow$ classifier $\rightarrow$ mill. The conditions are considered to be optimal, when the material makes three to six passes through the mill [9, p. 94-95]. The mill's grinding capacity here increases, in comparison with the open cycle, by 20%, with a decrease in energy costs by $15 \div 20\%$; in addition, the specific consumption of grinding bodies is reduced and the service life of the lining is extended.

Taking into account the advantages of a closed grinding cycle, in most countries in cement production and other large-tonnage industries the drum mills are converted to a closed cycle of operation, and only in recent years, such reconstruction has begun to be carried out at some enterprises of our Republic.

The efficiency of closed cycle mills can be further improved, if to provide a highly efficient classification of ground products, removed from the mill. Many researchers, on the basis of evaluation of the existing industrial separators [10, p.130-135; 11, p.42-43], note that the applied designs have low separation efficiency and about $40 \div 70\%$ of the finished finely ground material, having not separated in separators, return again to the mill. The use of screens and hydrocyclones in the wet grinding method also does not provide a high-quality classification, since these devices can work well on low-concentrated suspensions [10, p. 34-35].

Thus, the classification problems in grinding are very acute and need to be solved.

Practice [12, p. 3-6] and studies [13, p. 12-16; 14] show that the air blowing of a drum mill has a positive effect on the grinding process by dry method. Moreover, it was found that with increasing intensity of aspiration to a certain limit, the mill's grinding capacity increases substantially. Thus, monograph [7] gives the graphic dependence, obtained on the basis of the drum mill's industrial testing, which shows that due to active blowing it is possible to increase the mill's grinding capacity by 25%.

The increase of the mill's grinding capacity when blowing it with air can be explained by several factors, the degree of influence of each of which on the process has not yet been determined. Some researchers [13, p. 12- 16; 14; 15, p. 6-8] believe that the improvement of tube mills' grinding capacity with their intense aspiration occurs due to removal of the crushed material's fine fraction from the grinding area, which results in the increase of the coarse fraction portion and the increase of the relative grinding velocity.

It is also known that in fine grinding there are observed aggregation and sticking of small particles on grinding bodies and lining, which has a negative influence on the process. Examination of industrial mills in clinker grinding shows that with increasing the intensity of aspiration, the temperature in the mill is reducing by $35 \div 40°C$, the aggregation and sticking of fines fractions of the material to the grinding bodies and lining are reducing, and in milling a relatively cold clinker ($60 \div 70°C$) there is no sticking at all. The particle sticking occurs due to the action of electrostatic charges on the surface of particles. Water vapors, contained in the air, washing the small particles of the material, form temporary "bridges", which are a kind of conductors, through which the neutralization of electrostatic charges is carried out.Thus, aggregation and sticking are eliminated and due to this the grinding process is intensified.

The grinding degree increase with increasing air speed in the mill is explained by some researchers [16, p. 38-45] not only by the removal of fine fractions of the material from the grinding zone, but also by the influence of the environment on the grinding process. Adsorption of water vapors, which in this case are surface-active substances, from the air, passing through the mill, facilitates the deformation and destruction of the solid body. The effect of adsorption strength reduction is determined primarily by the fact that surface-active substances, reducing the material's surface energy, contribute to the development of various defects at lower stresses. To adsorption influence there are primarily exposed the surface defects of structure – weak points that are always present in any solid body and even in the most well-formed crystals. Into the defects of structure - the micro-cracks, being present in a solid body and appearing in the process of its exposure to the grinding media, with air, there penetrate the water vapors, covering the surface, available to them inside the deformed body, with a uniform adsorption layer. When the liquid comes to the mouth of a micro-crack, its molecules are distributed on both surfaces of the micro-crack up to the narrowest places, where their further penetration is prevented by the size of the molecules themselves. The adsorption layer of water molecules prevents the closure of the micro-cracks and thus reduces the hardness of the material to be ground.

Thus, the air purging of the drum mill chamber can have a positive effect on the grinding process for the following reasons:

1. Due to continuous removal of a fine fraction from the grinding zone;
2. Due to removal of electrostatic charges from the surface of very fine particles and thus, reduction of their aggregation and prevention of sticking to the grinding media and lining;
3. Due to adsorption effect of the air moisture on the particle defective structures and thus, reduction of the material's strength.

All these factors, undoubtedly, have a positive influence on the grinding process, and it is very difficult to give preference to any of them. One thing is clear that the closer contact will be in the mill between the air and the particles of the crushed material, the more effective will be the influence of these factors on grinding.

If we consider the movement of flows in the drum mill in the cross section, we shall see that in the operating state all the grinding bodies and the material occupy a little more than 50% of the section (the bottom and side part along the way of the mill's movement).

If we supply air to the mill, it will move in its free space without a sufficiently good contact with the material. Of course, during the rise and fall of the grinding media and the material there will be their intensive mixing and, naturally, a certain part of the fine-disperse material will be thrown into the free space, where the fine particles will be picked up by the air flow and carried away to the separator. However, there will be no good air purge of the whole mass of the material in the existing structural design and therefore the bulk of the crushed material will be in the general flow.

When solving the problem of a close contact between the material and air in a drum mill, it is necessary to take into account the recommendations of Andreyev S. Ye. and Sidenko P. M. [16, p.337; 16, p.26-41], who repeatedly note that in a drum mill it is not advisable to conduct a process with a high degree of grinding in one chamber. It is more economical to conduct it in several serially mounted chambers with the necessary intermediate selection of fractions that do not need grinding in the next chamber. It is also important that to the grinding chamber there came the material with a narrow size range, and the frequency rate of destruction in it was minimal. So, Andreev S.Ye. notes that, from the theoretical point of view, the perfect one there would be a method of grinding in a series of ball mills, each operating in a closed cycle with a classifier and so short that the material, passing through the mill, would be subjected to a limited number of ball impacts and all the resulting finished product would be immediately removed from the classification cycle.

On the basis of the above, we offer a more perfect version of the drum mill. The whole drum of the mill along its length should be divided by lattice partitions into a large number of chambers, with a distance between the chambers, being, for example, $1,5 \div 2$ meters; to set not one lattice partition between the chambers, but two, with a distance of $0,25 \div 0,4$ meters between the partitions; to fix blades to the drum wall in the space between the partitions, similar to the drum dryer, as shown in Fig. 1.

In this case, the material is crushed in the chamber, passes through the first lattice partition and, falling on the blades, rises up and falls down from above. Since there are many blades, the falling particles will fill almost the whole cross section of the mill. The air, moving in the longitudinal direction, will enter the flow of falling particles, cool them and, depending on the speed, will pick up the particles of certain sizes and carry them away with it.This separation process will be observed after each chamber. The air velocity must be such that the near-mesh size particles, picked up by the air flow before they settle, could fly over the whole length of the chamber.

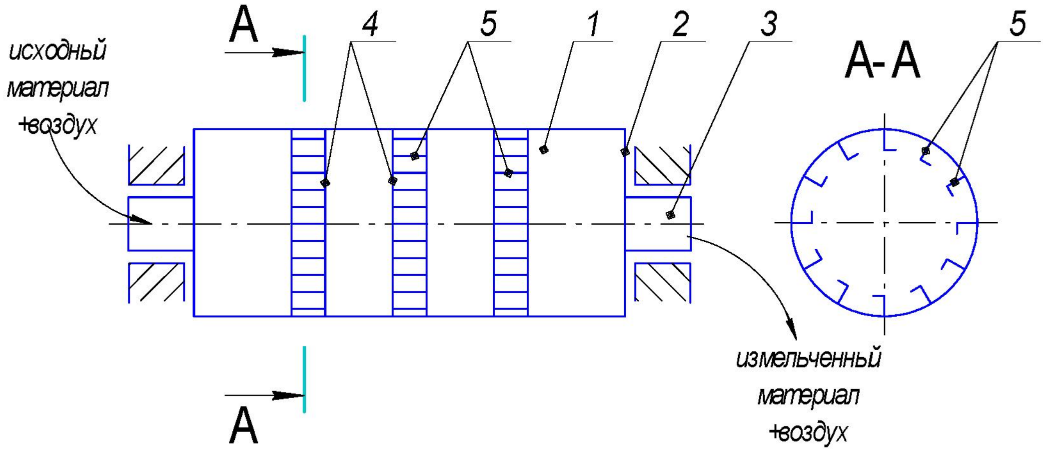

Figure 1. The scheme of reconstruction of the drum mill
1 – the drum; *2* – the end covers; *3* – the spouts; *4* – the lattice partitions; *5* – the blades.

To calculate the air velocity in the chamber, it is necessary to calculate the settling velocity of near-mesh size particles in the drum, using the Stokes formula. Knowing the particle settling velocity and the mill diameter, we determine the particle settling time. During this time, the particle should manage to pass the whole length of the chamber in the horizontal direction.Knowing the length of the chamber and the settling time, we determine the air velocity in the chamber. According to our approximate calculations, for industrial mills, used for cement milling, the air velocity in the free space of the drum should be within $0,7 \div 1,4$ m/sec. [16].

Conclusions. Thus, with the help of such reconstruction, there will be carried out continuously almost complete removal of crushed particles from the mill, there will be intensified the processes of cooling the material and the adsorption of moisture on its surface, which will significantly increase the grinding capacity of the mill, with reducing its energy costs.

However, at the exit of the mill, the ground material must be subjected to a highly efficient classification, so that the finished product could be almost completely removed from the system, and only the underground particles returned back for re-grinding. It is known that there are used medium-speed mills, having much lower energy consumption due to a highly organized grinding process, but having a much more complicated design.

REFERENCES

[1] Bobrova N. V. Influence of the wear of impact elements of crushers on their performance characteristics. //International scientific conference "Actual problems and prospects of the agro-industrial complex development ", Ivanovo, 2007. P. 124-125.

[2] Lapshin V. B., Abalikhin A. M., Bobrova N. V., Bogorodskiy A.V., Kolobov M. Yu. Ways of improving the durability of the centrifugal-impact grinders' operating elements // Repair. Reconstruction.Modernization.No. 8.M.; Science and technology, 2008. - P. 41-44.

[3] Abalikhin A. M., Bobrova N. V., Subbotin K. V. Ways of improving the durability of the impact- centrifugal grinders' operating elements. // Proceedings of the international scientific and methodical conference " Modern problems of the agro-industrial complex development in the works of young scientists and students of the FSEI HPE (Federal State Educational Institution of Higher Professional Education) "Ivanovo SAA (State Agricultural Academy) named after academician D. K. Belyaev"", Ivanovo, 2008. P. 203-204.

[4] Verigin Yu. A., Tolstenev S. V. Synergetic bases of processes and technologies. Barnaul: AltSTU, 2007. 172 p.

[5] Gridchin A. M., Sevostyanov V. S., Lesovik V. S., Gorlov A., Perelygin D. N., Romanovich A. A., Kolesnikov A.V. Energy saving complexes of fine and ultrafine grinding of the materials// IzvestiyaVUZov. Construction, 2006. №11. P. 60-67.

[6] Baranov V. F., Weisberg L. A. Trends in the development of technology and technique of ore preparation //"Modern methods of technological mineralogy in the processes of complex and deep processing of mineral raw materials".- Proceedings of the international meeting "Plaksinsky readings – 2012", Petrozavodsk, September 10-14, 2012. p. 12 - 16.

[7] Lowrison G. Crushing and grinding. London, Butterworth's, 1974, V.1.

[8] Andreyev S. Ye., Perov V. A., Zverevich V. V. Crushing, grinding and screening of minerals. Moscow: Nedra, 1980. 415 p.

[9] Sapozhnikov M. Ya. Mechanical equipment of the enterprises of building materials, products and structures. Moscow: Higher school, 1971. - 382 p.

[10] Deshko Yu. I., Kramer, M. B., Krykhtin G. S. Grinding of materials in cement industry. M.: Ed. liter. on construction, 1966. 274 p.

[11] The trend of development of hammer mills with separators. Review.Power engineering, 1976. - 62 p.

[12] Cherep I. L., Belkoskiy G. V. Increase of the cement mills' capacity. Cement № 3, 1956. P. 13-14.

[13] Krykhtin G. S. Influence of ventilation on the main indices of tubular cement mills' operation. / Proceedings of NIICement, Issue 12, 1959. 86 p.

[14] Apimakh Ye.V. and etc. Promising directions of reducing specific energy costs in grinding // News of the academy of sciences of the Republic of Kazakhstan. Series chemistry and technology, No5 (431), 2018. P.32-41. https://doi.org/10.32014/2018. 2518-1491

[15] Tovarov V. V. Ways to improve the grinding capacity of mills.// Cement № 2, 1962. P. 16-17.

[16] Khodakov G. S. Physics of grinding. - Moscow: Science, 1972. 256 p.

[17] Levdanskiy A. E. Scientific and practical bases of applying the flowing currents for intensification of classification and grinding processes: dis. ... Dr. Techn. Sciences: 05.17.08 / A. E. Levdansky. Minsk, 2004. 272 p.

Д. И. Чиркун [1], А. Э. Левданский [1], В.Г. Голубев [2], Д. Сарсенбекулы [2], С.А. Кумисбеков [2]

[1] Белорусский государственный технологический университет, г.Минск, Беларусь;
[2]М.Әуезов атындағы Оңтүстік Қазақстан мемлекеттік университеті, Шымкент, Қазақстан

ӨНЕРКӘСІПТІК БАРАБАНДЫ ДИІРМЕНДЕР ЖҰМЫСЫН САРАПТАЛАУ ЖӘНЕ ОЛАРДЫ ЖЕТІЛДІРУ ЖОЛДАРЫ

Аннотация. Олардың конструкциялық жетілдірілмегендігін анықтауға мүмкіндік берген қолданыстағы өнеркәсіптік барабанды диірмендердің жұмысына сараптама жүргізілді. Гетерогендік процесстердің қарқындылығын жоғарылату мақсатында процесске қатысатын түйісуші фазалардың беттерін ұлғайтуға ұмтылу ұсынылады. Бұл үшін дисперсті композизияларды өңдеу бойынша кейінгі операцияларды қарқындастыруға мүмкіндік беретін ұсақтау, активация, классификация, жылжыту және аппараттағы химиялық синтез сияқты процесстерді біріктіру қажет. Егер диірменнен шығарылатын ұсақтау өнімдерін жоғары тиімді классификацияны қамтамасыз ететін болса тұйық цикл бойынша диірмен жұмысының тиімділігін тағы көбірек жоғарлатуға болады.

Диірмен барабанын ұзына бойы торлы қалқалар мен үлкен камераларға белгілі бірарақашықтықта камералар арасы шамамен 1,5÷2 метр бөлу ұсынылды. Камералар арасына қалқалар арасының қашықтығы 0,25÷0,4 м болатын екі торлық алқалар орнатылсын. Қалқалар арасындағы кеңістікте барабан қабырғасына барабанды кептіргіштегідей күрекшелерді орнату. Энергия шығындарын төмендету үшін цементті ұнтақтауда қолданылатын өнеркәсіптік диірмендер үшін процесс өтуінің оңтайлы шарттарымен ұсақтау процесін ұтымды ұйымдастыруды қамтамасыз ету ұсынылады, барабанның еркін кеңістігіндегі ауа жылдамдығы шамамен 0,7÷1,4 м/с болуы қажет.

Түйін сөздер: Өнеркәсіптік барабанды диірмендер, ұсақтағыш өнімдердің үздіксіз классификациясы, бөлшектер, процесті қарқындастыру, материалды салқындату энергиясы, меншікті энергия шығындар, конструкциялар.

УДК 621.926.4

Д. И. Чиркун [1], А. Э. Левданский [1], В.Г. Голубев [2], Д. Сарсенбекулы [2], С.А. Кумисбеков [2]

[1]Белорусский государственный технологический университет, г.Минск, Беларусь;
[2] Южно-Казахстанский государственный университет им.М.Ауэзова, г.Шымкент, Казахстан

АНАЛИЗ РАБОТЫ БАРАБАННЫХ ПРОМЫШЛЕННЫХ МЕЛЬНИЦ И ПУТИ ИХ УСОВЕРШЕНСТВОВАНИЯ

Аннотация. Выполнен анализ работы существующих барабанных промышленных мельниц, который позволил определить их конструктивное несовершенство. С целью повышения интенсивности гетерогенных процессов предлагается стремиться к увеличению поверхности контактирующих фаз, участвующих в процессе. Для этого необходимо объединение таких процессов, как измельчение, активация, классификация, смешение и химический синтез в аппарате – измельчителе, позволяет интенсифицировать последующие операции по обработке дисперсных композиций. Эффективность работы мельниц по замкнутому циклу можно еще более повысить, если обеспечить высокоэффективную классификацию продуктов измельчения, выводимых из мельницы.

Предложено весь барабан мельницы по длине разделить решетчатыми перегородками на большое количество камер, с определенным расстоянием между камерами, порядка 1,5÷2 метра. Между камерами установить две решетчатые перегородки с расстояниями между перегородками 0,25÷0,4. В пространстве между перегородками к стенке барабана закрепить лопасти, аналогично как в барабанной сушилке. Рекомендовано, что для снижения энергозатрат должна обеспечиваться рациональная организация процесса измельчения с оптимальными условиями протекания процесса для промышленных мельниц, применяемых для помола цемента, скорость воздуха в свободном пространстве барабана должна быть в пределах 0,7÷1,4.

Ключевые слова: барабанные промышленные мельницы, непрерывная классификация продуктов измельчения, частицы, интенсификация процесса, энергия охлаждения материала, удельные энергозатраты, конструкции.

Information about the authors:

Chyrkun Dzmitry Ivanovich - Candidate of Technical Sciences, teacher of the Department "Processes and Apparatuses of Chemical Production", Belorussian State Technological University, e-mail: alex_levdansky@mail.ru
ORCID: 0000-0003-0195-2575;

Leudanski Aliaksandr Eduardovich - Doctor of Technical Sciences, Associate Professor of the Department "Processes and Apparatuses of Chemical Production", Belorussian State Technological University, e-mail: alex_levdansky@mail.ru
ORCID: 0000-0003-2684-7771;

Golubev Vladimir Grigorievich - Doctor of Technical Sciences, Professor of the Department ofOil & Gas Business, M.Auezov South Kazakhstan State University, e-mail: nii_mm@mail.ru.
ORCID: 0000-0001-7370-3872;

Sarsenbekuly Didar - PhD, teacherof the Department of Technological Machines and Equipment, M.Auezov South Kazakhstan State University, e-mail: nii_mm@mail.ru.
ORCID: 0000-0003-0595-4375;

Kumisbekov Serik Arginbaevich - Candidate of Technical Sciences, Associate Professor of the Department of Technological Machines and Equipment, M.Auezov South Kazakhstan State University, e-mail: serik_argin@mail.ru
ORCID: 0000-0003-4440-5520.