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USING OF FLUIDIZED-BED JET MILL TO A SUPER FINE COMMINUTION OF STEEL COMPOSITE

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In many industries the demand for very fine material increases. In the metallurgical industry, for example, there is increasing use of the production of high density metal elements with the use of metallurgical powder composites. The use of powder composites requires prior their grinding. Unfortunately, the very fine grinding is not an easy process. The using for this purpose fluidized-bed jet mill was proposed in the paper. The attempts of grinding of metallurgical powder were carried out in the fluidized-bed jet mill. After the experiment analyses of particle size distribution of grinding products were performed. The results are presented in graphs. Analyses of the obtained results concluded that the grinding of very fine metallurgical composite is possible and produces positive results.

Key words: metallurgy, grinding, steel composite, fluidized-bed jet mill, fine material

INTRODUCTION

Intensive development of science has caused interest in technologies, which so far have been treated as not promising or totally unrealistic in terms of the implementation. And so for example. the development of research in the field of solid mechanics contributed the use of a range of innovative solutions in the metallurgical industry, automotive, aerospace and energy. An example of this may be metals connection with Friction Stir Welding (FSW) [1]. It relies on creation of connection without changing state of concentration of element, i.e. solid state. This is possible because a small amount of heat supplied to the connecting zone. This is due to the replacement of the mechanical pressure force the combined elements of impact force of the rotating tool, operating in the environment of the emerging joint. The tool causes the “mixing” of particles assembled elements. Such a method of joining metal provides a high strength connection.

Another example of innovative technology can be a solution, which uses very fine grained materials [2 - 4]. In the metallurgical industry, for example, there is increasing use the production of high density metal elements with the use of metallurgical powder composites [2, 3]. Is obtained in such cases, a much lower power consumption and a much better use of raw materials. This is particularly important in the era of discussion about reducing the consumption of energy and materials. An important factor in favor in favor of powder metallurgy is that the elements of the final shapes can be produced immediately after the sintering process. It avoids the costly of initial performing -rolling, sanding, milling, etc. Thus the raw material utilization rate grows, and eliminates the need for further processing steps result in energy savings.

The source of very fine metallurgical components can be recycling [5]. This is especially important today, when it seeks to make the best use of raw materials. Material recycling can be achieved by eliminating all kinds of material losses in industrial processes.

In the metallurgical industry produces various types of dust waste. These wastes contain ingredients essential for further use by material recycling or energy. A lot of irons bearing waste materials, including dusts or sludges, are used as iron feed components in the sinter mixture, for the production of sintered iron ore or for the production of plastics with specific metallurgical characteristics and properties.

However, the recycling process does not always ensure a sufficient amount of components. In such cases, the fresh material must complete lack of raw material.

THE PROCESS OF SUPER FINE GRINDING

The use of powder composites generally requires prior their fragmentation. Unfortunately, the grinding in terms of very fine grains is no easy technological process. In this case, the surface force interactions between grains begin to counteract the grinding process. There is a process of agglomeration of very fine grains, which is the source of dissipation of delivered energy.

Forces acting on the crushed grains can generally be divided into mass and surface forces [6]. Mass forces interact across all volume of grains and are proportional to their weight. These are mainly the forces: gravity, centrifugal force but also the magnetic field. Surface forces are the result of direct impact of the environment

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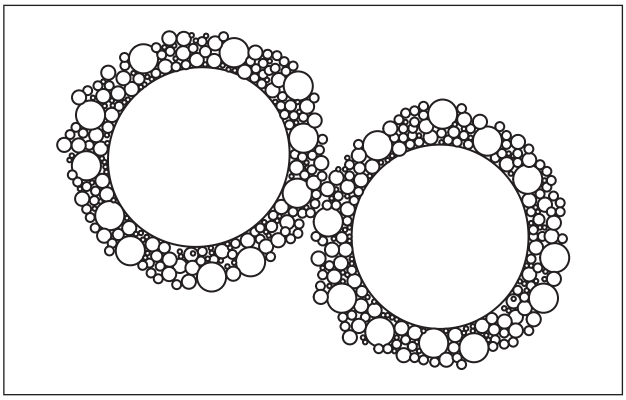

Figure 1 Fine grains embedded on the larger grains [7]

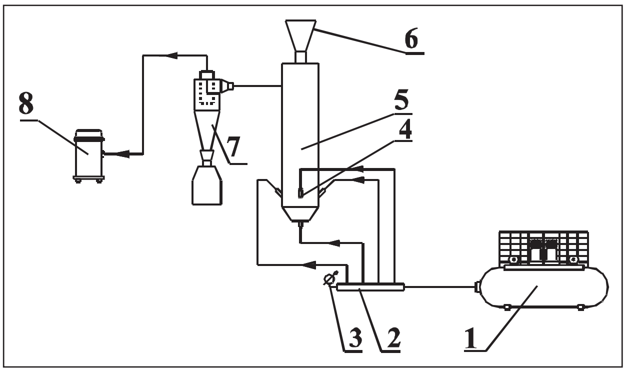

Figure 2 Schematic test stand: 1 – a piston compressor, 2 – a working air collector, 3 – a spring pressure gauge, 4 – air nozzles, 5 – mill chamber, 6 – a feed hopper, 7 – cyclone, 8 – a suction unit

on grain. The nature of these interactions can be varied - from the retention of grains on the mill divisions, by the impact of hydro-or aerodynamic center, and - the most important for very fine grain - interaction of electric fields, determined by the energy state of the surface.

In the process of super-fine grinding the relationship between mass and surface forces is completely different compared to the grinding of large grains. Grinding of large grains is characterized by the dominance of mass forces. In the case of very small grains - the order of micrometers and less - change of this relationship of forces causes the surface interaction is becoming a significant part of the balance of forces.

Increase surface interaction causes “connection” small grains with each other or with larger grains (Figure. 1).

Fine grains form a resilient coating around the larger grains, which neutralize the force of grinding. Energy dissipation occurs and grinding is inefficient. In order to be effective, the conditions of the process must be created to ensure the mechanical activation of fine grains [7, 8]. In this case, the surface interactions between the fine grains are neutralized and separation can take place.

GRINDING IN FLUIDIZED-BED JET MILL AS A MECHANICAL ACTIVATION OF FINE GRAINS

As mentioned earlier, in Authors study demonstrated that the use of a fluidized-jet mill allowed neutralizing the effects of surface forces and achieving a satisfactory comminution effect [7]. In the case of fluidized-bed jet mill comminution is caused to form collisions outbreak of air streams in a stationary bed of granular material, causing turbulent fluidization state. Air streams allow the mutual collisions of grains. And besides the fluidized bed intensifies movements of grains. Grains rub each other. As a result of these interactions, fine grains are separated from the coarse grains. Delivered energy is not dissipated by the by the action the resilient coating around the coarse grains. Fine grains are separated from the coarse grains and raised in the classification zone of the mill. In contrast, coarse grains devoid of the resilient coating of fine grains are loaded with energy and may be fragmenting.

THE TEST STAND

The schema of the fluidized-bed jet mill is shown in Figure 2.

The air is compressed in the compressor 1, after which it is directed by the collector compensatory 2 to four Bendemann nozzles 4. The first nozzle is located vertically from the bottom, and the other three - distributed over the circumference of bottom part of the mill column. To measure the air pressure spring gauge 3 was mounted. Comminuted material is fed to the grinding chamber 5. The comminution occurs as a result of produce of the fluidized bed and collision of speeding grains. Fine grains are moving in the classification zone. There separation takes place on the product stream and a recurrence stream. The product stream flows into the cyclone 7, where the separation of air from the stream of grains occurs. The grain of the product shall be received in the bottom tank of the cyclone. In contrast, the air is suctioned by the suction unit 8. In the filter of suction unit the separation a super fine grain product occurs. Those grains have not been separated in the cyclone. Recurrence stream separated by mill classifier is directed to back to the grinding zone.

RESEARCH METHODOLOGY

The tests have been grinding metallurgical component with the following chemical composition:

- C – 5,66 %;
- FeO – 21,14 %;
- Fe – 47,01 %;
- S – 0,086 %;
- CaO – 3,68 %;
- SiO_2 – 9,41 %;
- Al_2O_3 – 5,29 %;
- P_2O_5 – 0,095 %.

Determinations of chemical composition were performed using the method: gravimetry, acid-base titration, measurement of absorption, chromate determination, complexometry.

Sample of 500 g metallurgical component was subjected to grinding. Pressure of working air was 4 bars; time attempt – 10 minute, speed of the flow classifier - 200 r/s.

Before beginning research into the chamber of the mill grinded material was filled. Then compressed air was adjusted to the chamber nozzles, vacuum exhaust is enabled at the same time. After the experiment materials of the respective elements of the system are obtained – mill chamber, cyclone, filter suction device. The amount of downloaded components were weighed.

After conducting tests, samples of the grinded materials were taken purpose of determination of particle size distribution. Grain analysis was performed using an electronic analyzer grain composition IPS [9].

TEST RESULTS

The grinding test results are shown in the work. The experiment was performed for a pressure of 4 bar.

The total mass of the feed was 500 g. After the test carried it was received:

- amount of mass remained in the mill chamber – 246,8 g;
- amount of mass received from the cyclone – 229,1 g;
- amount of mass retained in the filter of exhaust unit – 24,1 g;

Already on the basis of the analysis of material obtained in the individual components of the laboratory, it can be concluded that a jet mill is separated from coarse grains of fine. In other types of mechanical mills, such a situation is generally impossible to achieve. The separation from fine grains of coarse grains enables efficient load energy of coarse grains and their fragmentation.

Samples of materials were analyzed after grinding. The results of the grains analyses are shown in Figure 3.

The particle size distribution of the feed is characterized by a significant presence of relatively coarse grains. In the mass obtained in the grinding chamber of the mill finer grains are present. Already the grains are grinded. In samples separated in the cyclone and filter fine and very fine grains are dominating, there is no coarse grain.

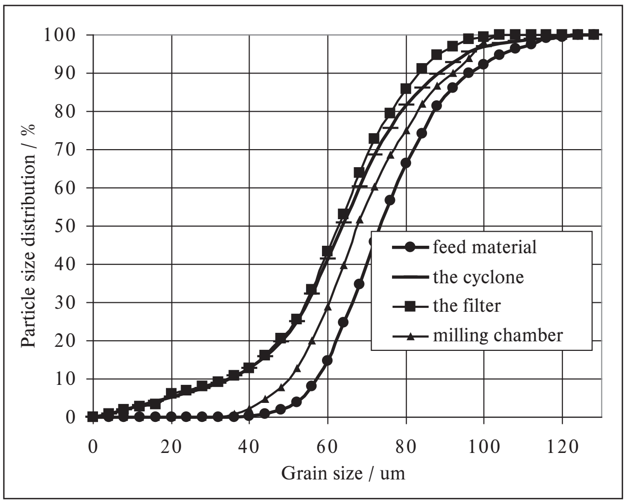

Figure 3 The particle size distribution of grinded materials

SUMMARY

The presented results confirm the possibility of achieving satisfactory results of super-fine grinding substances in fluidized-bed jet mill. The use of this type of mill can neutralize the dissipative impact of the coating of the fine grains embedded in the larger grains. This enables the supply of energy to the large grains of the grinding material, and thus achieves size reduction.

The achieved results allow involve high hopes of using this kind of milling to obtain very fine metallurgical components. It should be remembered that the components are very fine metallurgical materials. Grinding of such materials causes the flow of significant amounts of very fine grains to the exhaust system and precipitating it in the fabric filter. This in turn causes clogging of the filter, which can significantly reduce the power of exhaust units. Further size reduction may be required to enable the next sequential units or increase exhaust power.

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Note: The professional translator for English language is Czesław Grochowina, Studio-Tekst, Poland