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Improving the efficiency of fluidized bed comminution of limestone samples

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Introduction

The process of grinding is a technological process of mechanical degradation of materials (both organic and artificial) into smaller pieces. The grinding of the working material happens because of external factors, that cause tension stronger than the maximum material's strength. When the grinding takes place, the shape of grains changes and the surface area of the material expands. The aim of the grinding process is to achieve an optimal size grade that meets the specifications of the technological process (used when further processing requires feed of specific grain size), create a product of a set maximum grain size, separate the product from unwanted materials. The process of grinding requires large intakes of energy but is widely used everywhere, therefore there is a great need to find a more effective and cheaper solution. Because of its complexity, the fluidized bed comminution process depends on many parameters.

Fig. 1. Limestone sample.

Limestone was used during the research of the comminution process because of it is characteristics: low hardness, brittleness, abrasibility, low absorption, high cold resistance, and numerous uses. Various branches of economy use limestone in it is many forms: limestone powder, burnt lime and hydrated lime. Nowadays, because of the norms that restrict the emission of fumes, it is important to use limestone sorbents to desulfurize flue gases. The negative impact of industry on the environment brings about the implementation of increasingly more demanding policies restricting the pollution of fumes.

Research methodology

The tests of the grinding process on limestone samples was carried out in a laboratory fluid mill that was adapted for fine grinding of granular substances with the grain size of the product below 100 µm. The research was carried out before and after the modification of the grinding chamber, which was extended by 17 cm. Grinding of limestone samples was carried out in the laboratory fluid-bed mill. The process of each trial was similar. A sample with a mass of 1500 g and a grain size of 800 - 1200 µm was fed using gravity from the hopper into a cylindrical grinding chamber, where it underwent intensive fluidization. Working air with a regulated mass flow was supplied from a system of three converging nozzles (diameter 2 mm) arranged concentrically on the perimeter of the chamber, and a fourth nozzle of the same diameter, mounted on the bottom of the grinding chamber. The volume of the air mass stream was regulated by setting the appropriate value of the working medium overpressure, which also depended on the speed of the flowing air. The air flowing out of the nozzles expanded, creating a rise of high-energy fluidized layer, enabling comminution of the tested material.

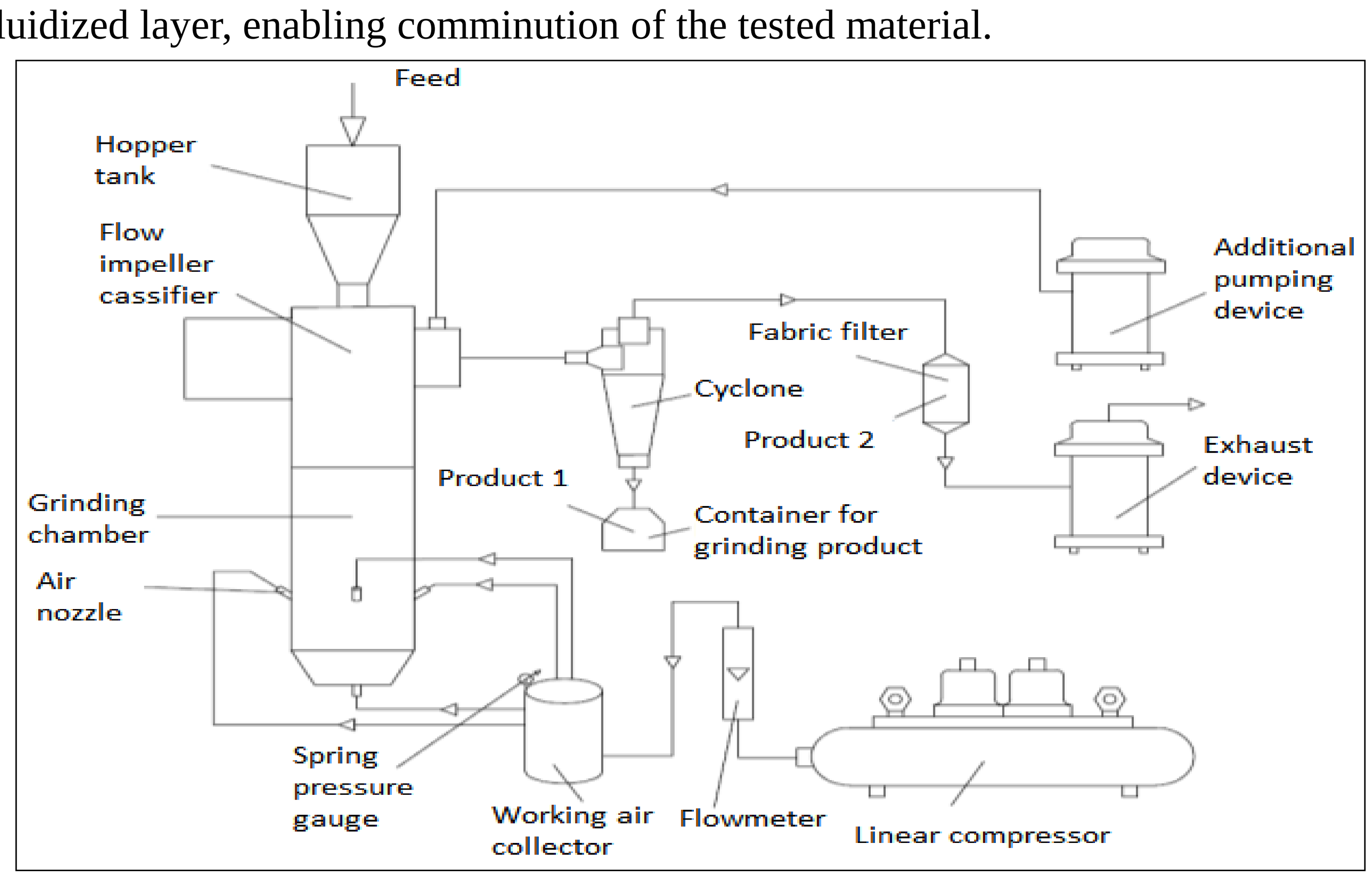

Fig.2. The schematic diagram of the test stand.

Analysis results

During the research the following parameters were checked, before and after the modification of the test stand:

- rotation speed of the classifier rotor was set on three different levels 100 (N-100), 200 (N-200), 250 (N-250) [1/s],
- similarly, working air pressure was set on three levels 100 (P-100), 300 (P-300), 500 (P-500) [kPa],
- Before indicates the results before the modification of the grinding chamber,
- After indicates the results after the modification of the grinding chamber.

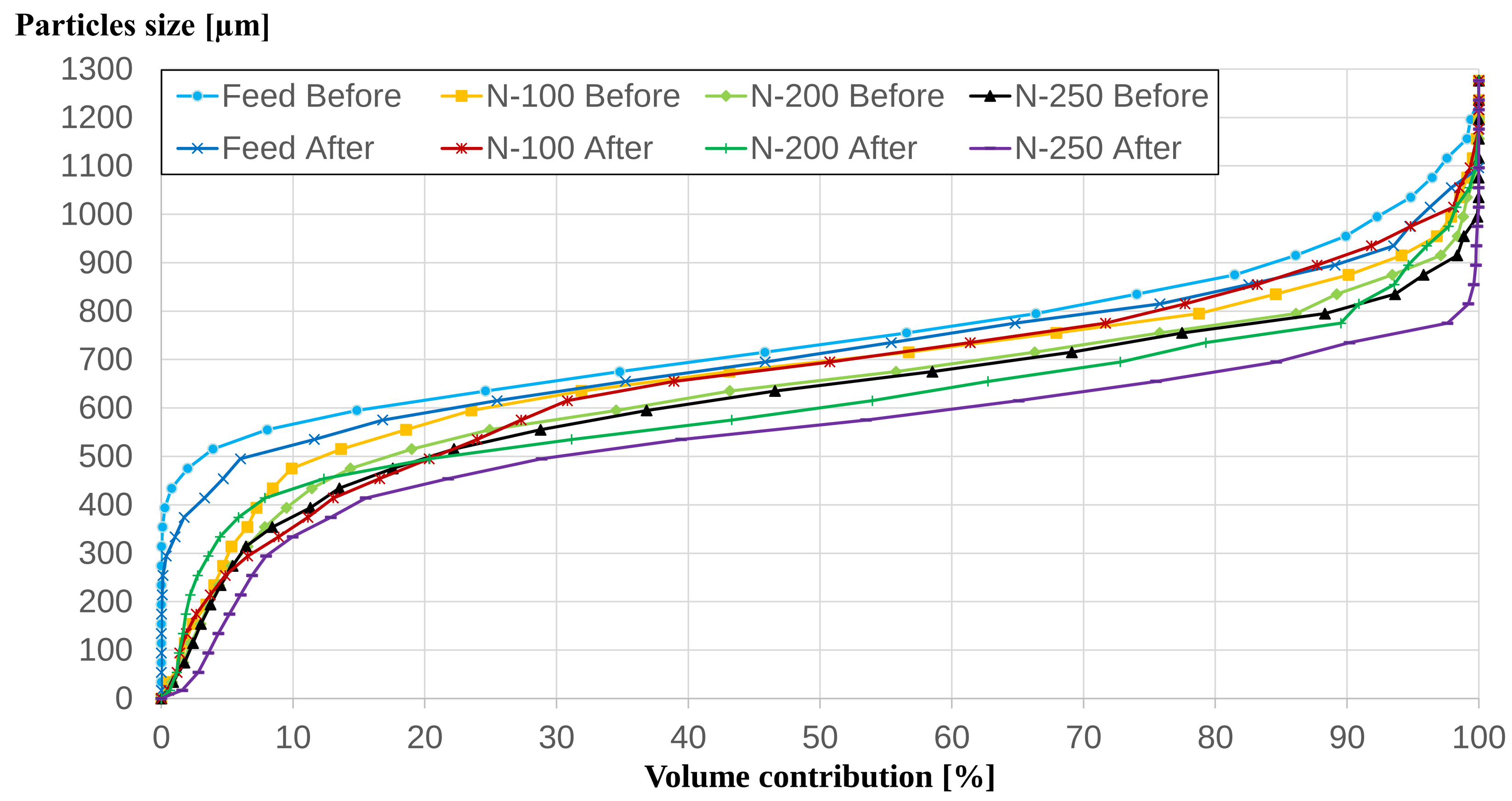

Fig. 3. The influence of rotor speed on the comminution process.

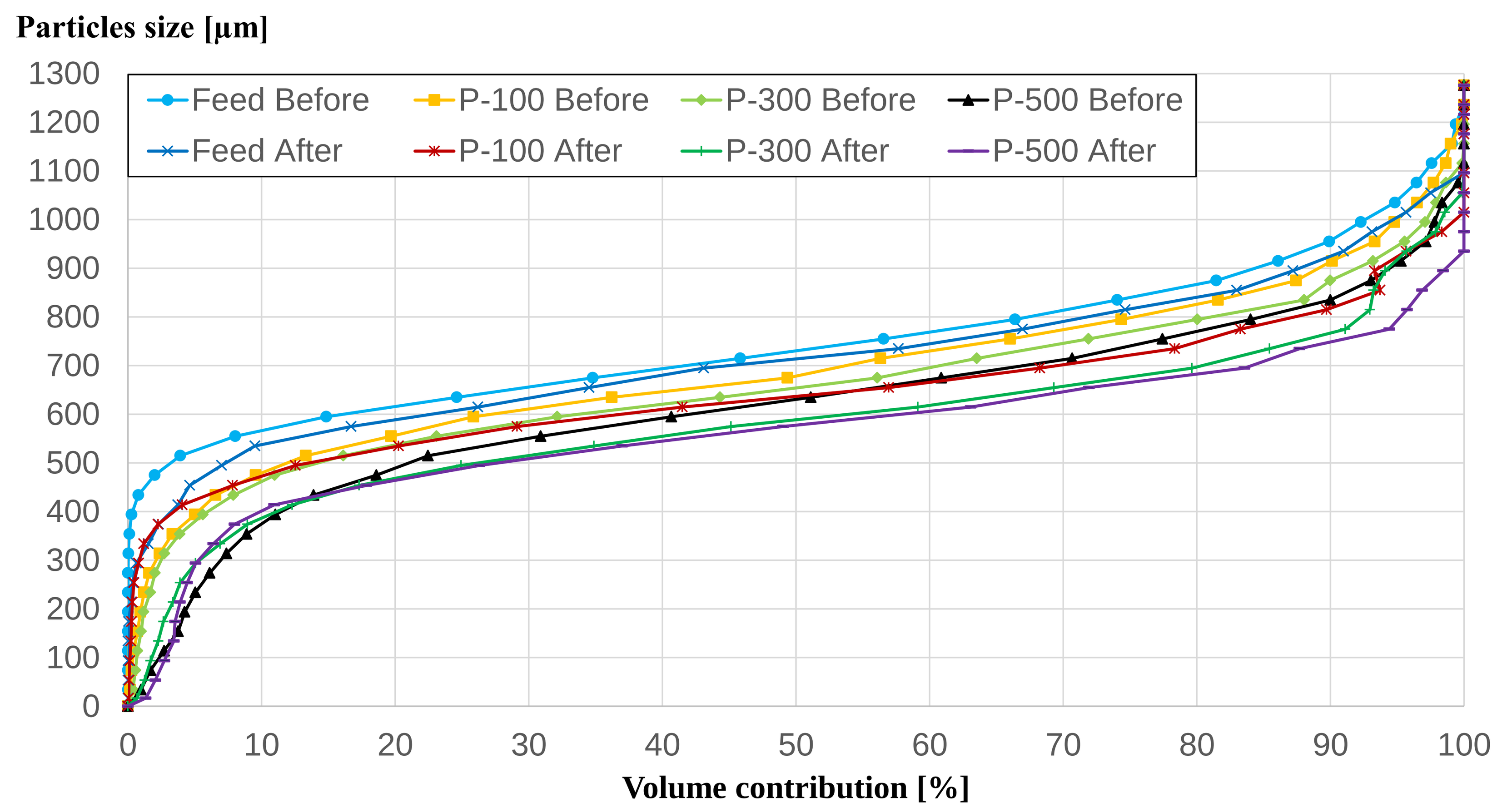

Fig. 4. The impact of working air pressure on the comminution process.

Conclusions

- Increasing the overpressure value forces the larger working air stream, which is supplied to the nozzles from the compressor. Thus, it increases the energy that is transferred to the grains by the air particles in the grinding chamber, which causes an increase in the intensity of the fluidization process. This in turn leads to a shift in the cumulative grain composition curve toward finer grains.
- Higher rotor speed ensures a smaller average grain size characterizing the grinding product. This is caused by the centrifugal force impacting the grains falling into the classifier, which increases with the increasing rotor speed. Under the influence of this force, larger grains are returned to the milling chamber enabling secondary grain material degradation, which is the final product.
- Increasing the working air pressure causes a shift in the cumulative grain composition curve toward finer grains. This is due to the fact that, as the working air pressure increases the air velocity in the grinding chamber also increases, which intensifies the fluidized grinding process. It result in the final product of smaller grain size.
- The introduction of the modifications of the test stand ensured an increase in the volume of the fluidized layer in which the grinding process takes place. As well as a greater gravitational classification, which caused larger grains to be stopped in the grinding chamber and shift of characteristics of grain compositions towards finer grains.

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