Silesian University of Technology

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Doctoral Thesis

Measurements, modelling and control of flow in grinding installation with electromagnetic mill

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Abstract

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Comminution of raw materials is a massive and large-scale process present in numerous branches of industry. New equipment and technologies are constantly being developed to improve product quality and throughput, and to decrease costs and environmental impact. One of new solutions to ultrafine grinding of hard materials is an electromagnetic mill with its dedicated grinding installation with pneumatic material transport. Being still a new invention, the system requires extensive studies (including experimental research), e.g., on dedicated measurement methods, mathematical modelling of system components, automatic control algorithms.

This thesis proposes some indirect methods for measurement of raw material features, such as flow rate, particle size and moisture content. These experimental methods are fast and contactless, though approximate, and they are based on vibration, acoustic or vision signals.

Secondly, this dissertation presents several steady-state and dynamic models (mainly of black box type), based on experiments carried out on the grinding installation with electromagnetic mill. Some models assess the mutual effects between material moisture and particle classification subsystem. Others describe steady-state and dynamic relationships between positions of air dampers (actuators) and air flows or pressures in key parts of the pneumatic transport system.

Lastly, this work introduces the hierarchical layout of control loops in the grinding installation and focuses on control of transport air flow in the lowest (direct) control layer. The flow of air is a crucial factor as it determines the flow of the processed material, thus affecting particle size distribution of the product, efficiency of the grinding process, and even its stable operation. A simulation framework is prepared to easily test air flow control schemes. Then, several types of control algorithms are tuned, assessed and compared.

The above-mentioned findings help to monitor or control some key parts of the grinding installation with electromagnetic mill, and to do it efficiently. Moreover, some research outcomes — mainly, the methods of indirect measurements — may be utilized also in other plants and processes.