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Original Research Paper

# Energy and cement quality optimization of a cement grinding circuit

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ABSTRACT

This study aimed at optimizing both the energy efficiency and the quality of the end product by modifying the existing flowsheet of the cement grinding circuit. As a general application, mill filter stream is sent to the air classifier owing to its coarser size distribution than the desired product. However, the study proved that some further evaluations i.e., quality tests and chemical assays, could make it possible to treat this stream as a final product. Consequently, directing this stream to the final product silo could be considered. Within the study, sampling survey was undertaken initially that was followed by the modelling and simulation works. The calculations implied that the production rate increased by 4.45% that corresponded to energy saving of 4.26%. As the plant decided to change the flow sheet, another sampling campaign was arranged to validate the outputs of the simulation studies. In that case, the real data showed that the increase in production rate was 3.68% and 28 strength of the cement improved by 2.9%. As a result, the simulation outputs were found to be in agreement with the real data hence the efficiency of the cement production, both quality and energy, for a given circuit was improved.





## 1. Introduction

Industrial sector demanding significant amount of energy when the global energy consumptions were taken into consideration. There have been reports compiled to reveal the data explicitly and to emphasize how important to manage the energy efficiently for the economic and environmental reasons. Huang et al. [1] and Madlool et al. [2] indicated that industrial sector account for about 28–70% of global final energy consumption and changed depending on the region. Similar conclusions were drawn by various of the studies as well [3-6].

Among the industries, the non-metallic industry was reported as the third largest energy user and accounted for about 12% of the global energy use [1]. Within this portion, cement industry had the majority of the utilization with 8.5–12% [1,2]. U.S. Energy Information Administration (EIA) [7] named cement industry as the most energy intensive among the manufacturing industries and the projections estimated that, its contribution to energy consumption was expected to be increasing in the following years. International Energy Agency (IEA) [6] in their report set a target to reduce the energy consumption of this industry significantly through to 2025.

Many of the studies focussed on energy assessments of the cement industry to evaluate and then determine the possible energy savings. These reports proved that savings varied between 20% and 50% was attainable by considering the optimization of the existing circuits, evaluation of the possible investments and the changes in the control strategies in the overall production chain [3–5,8,9].

Cement manufacturing is a process that combines varieties of unit operations including raw meal handling, pyrometallurgy and comminution. Comminution in cement manufacturing takes place in both raw meal and finish grinding operations and responsible for about 60% of the whole electrical energy utilization [2–5,8,10]. The global energy assessments also indicate comminution as highly energy utilizing operation and as it is responsible for 2–4% of world energy consumption [10,11]. Since a considerable amount of energy is consumed in this field focus should be given on the reduction where various alternatives could be considered. These can be either through innovating a new product or through a process optimization that can be accomplished by replacing the old technologies or optimizing the operating conditions/flow sheets of the production. IEA 2015 [6] concluded that only the technology shifting was not believed to be enough for energy saving therefore product innovation/improvement or other alternatives were also to be considered.

Energy optimization of a circuit has been subject of many of the studies. Jankovic et al. [12] considered the optimization alternatives of cement grinding circuits. Benzer [13] studied on optimizing the fully air-swept raw mill grinding circuit, Dundar et al.

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[14] reported the optimization opportunities of a cement grinding circuit. Altun [15] improved the energy utilization of the circuit with the aid of simulation studies.

Within the study, it was aimed to optimize both the energy utilization and the product quality of a conventional cement grinding circuit during CEM I 42.5R cement production. In this context, an accurate sampling methodology was applied, which was supported by the computer simulations and the assessments of the quality properties of the finished product. It should be emphasized that within the existing flow sheet, the mill filter stream was sent to the classifier feed that was considered to be sending to the final product silo. As a result of the quality evaluations and the simulation studies, the proposed flow sheet was applied by the plant. As a conclusion, the production rate of the circuit increased from 103.4 t/h to 107.2 t/h while the ultimate strength of the cement was improved from 51.2 MPa to 52.7 MPa. It is thought that the outputs of this research are to be beneficial for the researchers and engineers of cement industry.

## 2. Materials and methods

### 2.1. Experimental studies

Within the scope of the study, experimental studies were commenced with the sampling of the cement grinding circuit at a routine production when the steady state conditions were established. In order to decide whether the whole process is at steady state, time-based trends of the operating conditions are followed for certain period of time. Figs. 1–3 illustrate the simplified flow sheet of the grinding circuit, the sampling points and the trends recorded during the sampling campaign.

As can be understood, the circuit is closed circuited and is composed of a two-chamber ball mill, a mill filter, an elevator and a high efficiency air classifier. Within the circuit, the feed is ground in the ball mill initially. Mill filter sweeps the material (blue-coloured line) mainly from the second chamber of the ball mill and non-collected material overflows from the discharge. Afterwards, the two streams (mill product and filter) are combined and sent to the high efficiency classifier via an elevator. The classifier splits the products as fine and coarse while the fines are reported to the final product silo and the coarse ones are circulated back for further milling. The important point in this flow sheet is the mill filter stream on which the focus was given. Owing to its coarser size distribution, this stream is sent to the classifier. However further evaluations proved that it had some improved effects on the production, which are to be explained in the further sections. The technical specifications of the machines and the operating conditions recorded during the sampling campaign are given in Table 1 and Table 2 respectively.

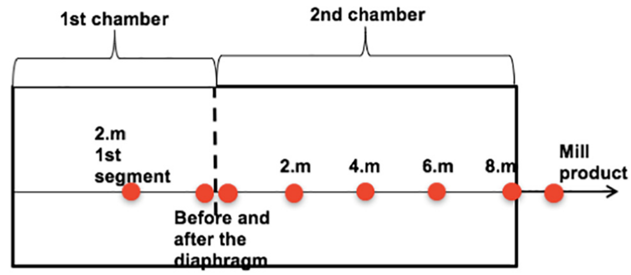


**Fig. 2.** The sampling points of the mill inside.

Following the sampling studies, the collected samples were characterized regarding to their size distributions, Bond work index, chemical assays and strength properties. Size distribution analysis were performed in two stages. Initially all the materials were sieved starting from the top size to 150micron range and below that size laser diffractometry method was applied to conduct further measurements down to 0.5micron range [16]. Bond work index of the feed material was determined as prescribed by Bond [17]. Within the context, only the total feed including clinker, gypsum and limestone was subjected to this characterization work. Finally, the strength tests (2–7 and 28-Days) and the chemical assays of the necessary samples were determined at cement plant by applying the standard procedures [18].

### 2.2. Mass balancing & modelling studies

The mass balancing is the initial processing of the experimental data. The aim is to distribute the errors arisen due to the fluctuations in the system, while collecting the samples and undertaking the measurements. In brief, the experimental data was recalculated and based on that the flow rates around the circuit are determined. If the calculated data is in good agreement with the experimental ones it can be said that they all can be used in the further evaluations i.e., modelling and simulation. In this regard, JK-SimMet mass balance module [19], of which the algorithm is based on Quasi-Newton approach, was utilized. Following the

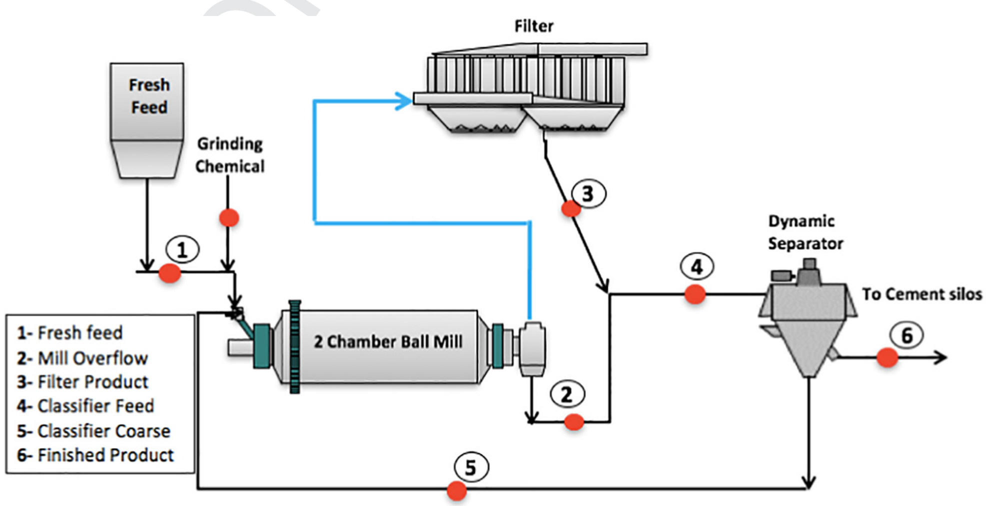


**Fig. 1.** Existing flow sheet of the cement grinding circuit and the sampling points.

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