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Real-time monitoring of efficient grinding and blending of petroleum coke

Abstract

Calcined petroleum coke is an essential component of carbon anodes. The chemical composition of petroleum coke can be measured by means of X-ray fluorescence spectroscopy (XRF). Pressed coke pellets used for XRF are prone to break apart. It is therefore essential that the sample is well blended with binding aid during grinding in a disc mill. Here, we show that real-time monitoring of the grinding vessel acceleration allows the automatic evaluation of blending efficiency.

Key words

• **Petroleum coke** • **Real time monitoring** • **Grinding** • **Disc mill** • **Blending**

Introduction

Carbon anodes used for, e.g., smelting aluminium consist of calcined petroleum coke, coal tar pitch and anode scrap. The major component is the petroleum coke being used as filler in the production of carbon anodes. Anodes account for a substantial part of the costs in the electrolyzing process. Therefore, quality control of the anode constituents is of great importance for quality and economy of the whole process.

Numerous trace elements including silicon, iron, vanadium, alkali metals and sulfur may accumulate during the production process of petroleum coke and have great influence on the properties of petroleum coke and its derivates. Among these substances vanadium is the most undesirable impurity as it might cause significant increase in anode consumption rate and decrease in current efficiency. The chemical composition of coke can be determined by using different methods including atomic-absorption, atomic-emission and X-ray fluorescence spectrometry (XRF).

The XRF is a procedure which is simple to carry out and delivers reliable quantitative results of the element content in coke. It requires a thorough sample preparation including sample grinding, blending with binder and pelletizing into steel rings. Here, we show that evaluation of the grinding vessel acceleration is a valuable tool for real-time monitoring of the sample preparation process in an automatic mill. In particular, we demonstrate that the technology allows the automatic evaluation of blending of sample and binding aid.

Method

All trials were carried out on an automatic combined disc mill/ pelletizer of the type HP-MP using a 100 ccm tungsten carbide grinding vessel. The acceleration sensor used for monitoring of the grinding efficiency was mounted on the swinging aggregate and connected to the PLC of the machine. For analysis of the grinding vessel motion the root mean square (RMS) of the acceleration in the x- and y-direction was calculated and plotted over time for evaluation. All data were recorded and automatically evaluated using the HERZOG PrepMaster Analytics software. The method has been described in more detail in a previous application note [1].

In all trials we used petroleum coke from the same material lot. We pulverized 8 g sample material for 60 s at a rotation speed of 1000 rpm. As a binding aid, cellulose and wax in pill form was automatically added during the grinding process. In order to obtain a stable pressed pellet the sample material has to be completely mixed with the binding aid. In some cases, however, the grinding set might be blocked in the grinding vessel preventing the efficient blending of binder and sample. These events are probably due to gain of sample volume caused by the decrease of grain size during milling. The increased sample volume can wedge ring and stone in the grinding vessel.

As previously described [2] periods with efficient grinding can be easily distinguished from grinding blockage by acceleration measurement. Efficient grinding is characterized by an acceleration signal with a high standard deviation (SD) while grinding blockage is associated with a significantly lower SD.

Results

In our test series, we found two different signal patterns during milling of petroleum coke. In the first pattern (Figure 1, A and B), the efficient grinding behavior prevailed with a relatively high acceleration SD (green dots in the left graph of Figure 1, A and B). We found only brief interruptions (red dots) which were associated with a decrease of the acceleration SD from values of approx. 7 m/s^2 to approx. 2 m/s^2 (right graph of Figure 1, A and B). The first grinding pattern led to a pelletizing process enabling the

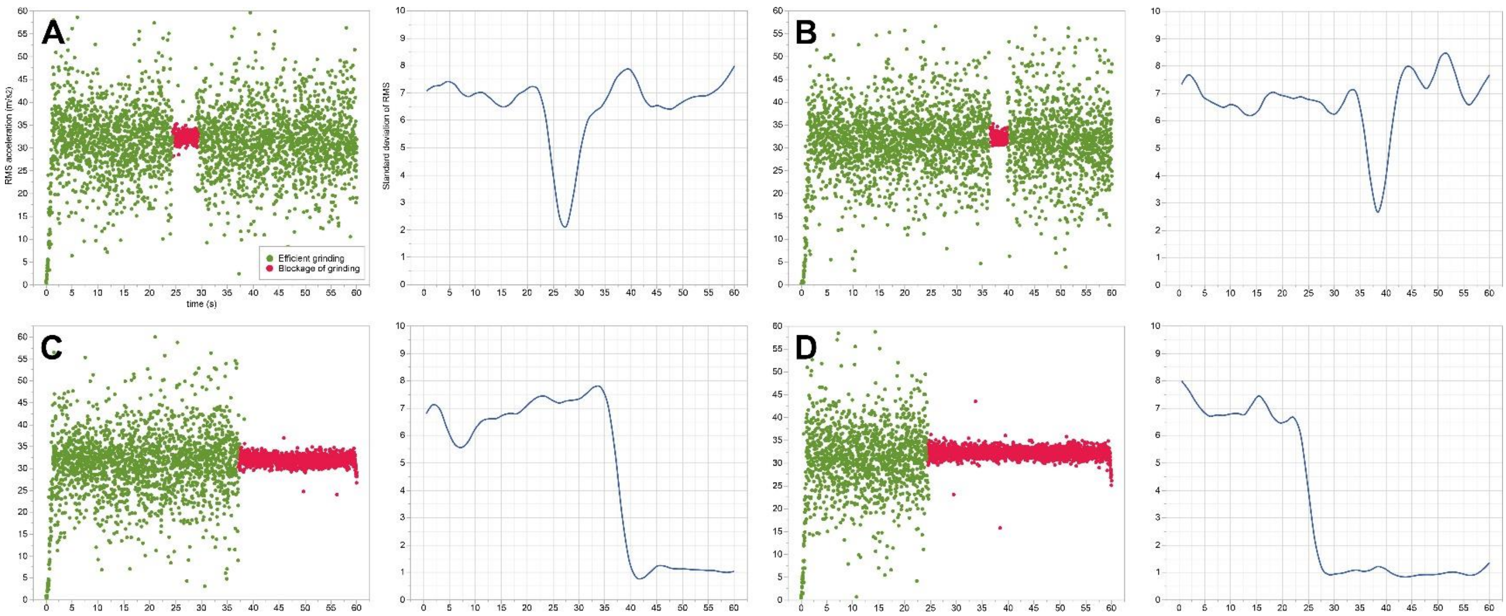

Figure 1: The left graph shows the plot of the RMS acceleration values with phases of efficient (green dots) and inefficient grinding/ blending of the sample within the grinding vessel of the HP-MP. The right graph displays the standard deviation of the RMS acceleration over time. (A, B) Examples of efficient grinding trials with only short periods of grinding blockage. (C, D) Examples of inefficient trials with extended blockage periods exceeding 25 s.

the production of stable pressed pellets optimally suited for XRF analysis (Figure 2, A).

By contrast, the second grinding pattern was accompanied with longer sections of grinding blockage exceeding 25 s (Figure 1, C and D, left graph). During these blockage periods, the acceleration SD decreased to a value of approximately 1 m/s^2 (Figure 1, C and D, right graph). This grinding pattern was associated with unstable pressed pellets tending to break apart at the bottom (Figure 2, B).

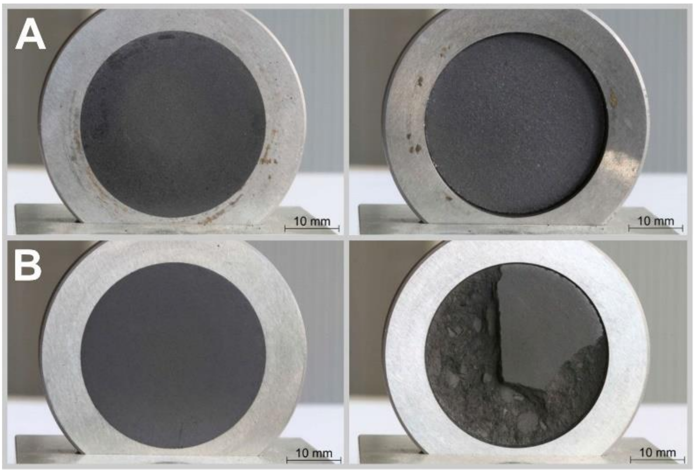

Figure 2: *Condition of the pressed pellet after grinding and pelletizing using the HP-MP. (A) shows the example of a complete and solid pressed pellet after an efficient grinding process. (B) shows the condition after inefficient grinding with material loss on the bottom side.*

Discussion

By using the acceleration sensor signal of the grinding vessel, it is possible to evaluate the grinding and blending process of petroleum coke. Based on the calculation of the acceleration SD, periods of efficient grinding can be clearly delimited from periods of inefficient grinding. This allows the reliable prediction whether a stable pressed pellet can be produced from the ground sample. A crumbling pressed pellet can have unfavorable consequence as it might cause contamination of the XRF analyzer requiring extensive cleaning.

The areas of application for this technology are different. It can be used for application development aiming at determination of the optimal preparation steps for each specific material. The online monitoring of the grinding process considerably shortens the time required for identifying the most suitable parameters. Furthermore, the technique can be applied for online monitoring of grinding efficiency in routine operation. If the PrepMaster Analytics detects an insufficient grinding trial an alarm can be triggered or appropriate measures can be automatically taken in order to release the grinding set and prolong the grinding time.

References

[1] HERZOG Application note 30/2020: Real-time monitoring of grinding efficiency in disc mils by acceleration measurement

[2] HERZOG Application note 31/2020: Real-time monitoring of efficiency in quicklime grinding

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