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Wear progress and mechanisms in high temperature sieves

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ABSTRACT

Sieves for high temperature (HT) environment are necessary for screening of iron oxide sinter in steel industry. Sinter is produced at temperatures of ~1000 °C, crushed and screened for usage as raw material in blast furnaces. To determine the critical cause that leads to sieve cavity widening and subsequent productivity loss of the steel plant, a comprehensive damage analysis was undertaken. Sieves are equipped with plates covered by a hypereutectic hardfacing for wear protection. Cavities are cut by oxygen plasma cutting. Long-term wear investigation was done using replica samples taken from cavities after defined time intervals during the sieve's lifetime. Thereby differences in wear progress due to asymmetric material flow, position and alignment of cavities were studied. Additional temperature measurements were conducted via thermography of the sieve while in operation to identify service temperatures. Furthermore cross-sectional and microscopic analyses were carried out after end-of-life of the sieve to investigate wear mechanisms and microstructural changes.

It was found that plasma cutting of the sieve cavities leads to a wide range of cavity widths. Continuous investigation of wear progress showed that the first interval resulted in significant blunting of edges. After this period of running-in, the ongoing wear loss at the edges became less pronounced. Significant wear was found descending up to 1.5 mm in depth along the cavity sidewalls. Furthermore, large break-outs could occur at any time due to cracks in the microstructure and fatigue. Nevertheless, blunting and cavity widening limited the lifetime of the sieve. Wear losses were more distinct on top of the sieve at the beginning of the sinter flow. No significant influence of the angle of the cavity positions in respect to the material flow was found. Cross-sections showed microstructural changes due to the thermal cutting process. Microstructure changed from hard hypereutectic structure to softer hypoeutectic microstructure, which is less wear resistant.

1. Introduction

Sieves are necessary components within many industrial applications to separate material fractions of varying size. A special application are sieves for high temperature (HT) use, e.g. for processing of iron ores. This work will concentrate on HT sieves used for screening of hot iron oxide sinter within the pig iron production chain. Sinter is produced by the Dwight-Lloyd process [1] at temperatures in the range of roughly 1000 °C. The sinter is then broken by a crusher to obtain particles usable in the blast furnace. The fine fraction needs to be screened by the HT sieve and is subsequently returned and recycled to the sinter process, while still at high temperatures (Fig. 1). As the sieve cavities wear out, the fraction of returned material increases leading to a decline of productivity of the sinter process. Hence, wear resistance and geometrical stability of the sieve cavities are essential for excellent productivity and reduced requirements on HT sieve maintenance.

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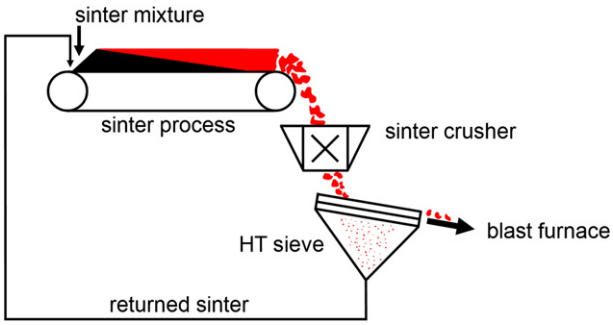

Fig. 1. Schematic of HT sinter sieve.

Edge stability and blunting, respectively, are scarcely investigated in literature, especially at elevated temperatures. High temperature abrasive and erosive wear are investigated in more detail [2–4]. It is well known that temperature has a crucial influence on present wear mechanisms and wear loss. Critical temperatures for cost efficient Fe-based materials are in the range of around 500 °C [5–7]. For highly loaded surfaces, hardfacing is a common wear protection, especially in HT environment. There is a wide range of possible solutions although, mostly Fe-based alloys are preferred due to significantly lower costs than Ni- or Co-based [7,8]. In abrasive environment, carbide-rich hardfacings show beneficial behaviour [2,8–10]. For HT applications, high amounts of HT strength stabilizing elements like W or Mo are added. Nevertheless, temperature limits for these high alloyed Fe-based hardfacings are mostly in the temperature range of 700-800 °C, because of matrix softening and tungsten carbide oxidation [4,7,11]. Hence, it is of high importance to know exact process parameters, especially temperatures, present in the wear zone to identify wear mechanisms and subsequently make an optimal choice in material selection. Furthermore, wear evolution over time is particularly important when dealing with highly loaded edges and blunting, since blunting may cause essential loss in operability [12].

The aim of this study is to characterize the wear progress of the HT sieve in use during its lifetime operation. Additionally, a detailed failure analysis will be carried out after application. In order to choose optimal materials for this application, wear mechanisms need to be identified and a wear progress model will be suggested.

2. Experimental

2.1. Field data acquisition

In order to gain information about real temperatures within the sinter, sieve temperature measurements were carried out. Thereto two methods were applied: a) thermal imaging of the hot sinter material and the sinter sieve applied from the top and b) temperature measurement of sieve elements by thermocouples from the bottom.

Thermal imaging was carried out with a FLIR SC7600 single-wavelength infrared camera, with a filter for 300 °C - 1500 °C measurement range. Frame rate was set to 100 Hz to capture the fast sieving process in more detail. Images were taken from a maintenance door on top of the sieve with normal view on the flowing sinter from ~2 m distance. It has to be mentioned that results may be affected by the large amount of dust in the HT sieve nevertheless, temperature distribution of the sinter over a time period can be captured.

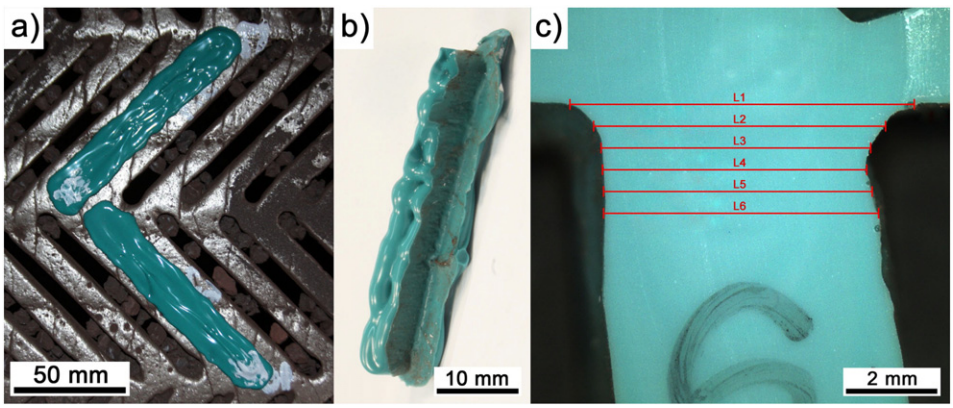

Fig. 2. Wear observed in real application by replica method: a) general view of replicas taken from the sieves; b) shape of one replica after being removed (bottom side up); c) cross-section of the replica revealing the sieve cavity's profile.