Maximising sinter machine productivity through identification & checking of air leakage points

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Introduction

Sintering is a process of agglomerating iron ore fines, along with flux and waste fines. Burning of coke breeze present in the raw mix provides the heat require for incipient fusion to take place and subsequently lumpy product sinter to form.

In a typical continuous sinter machine of Dwight-Lloyd type, top layer coke breeze is ignited under an ignition furnace, afterwards the moving pallet is subjected to under-grate suction and flame front progresses till the pallet bottom. Heat from igniting layer transferred to raw mix layer lying below, mainly due to conductive heat transfer. Rate of air flow through the sinter bed is an important parameter; both the vertical sintering speed and specific productivity are controlled by the air filtration velocity. Air flow through the bed is achieved by creating vacuum at the bottom of the bed with the help of the exhausters of suitable capacity. The assembled part form exhauster to under-grate is called suction track, and each parts are seamlessly designed for preventing air loss.

However, after operating sinter machines over long period, it has been observed that there is considerable loss of vacuum. This loss of vacuum is due to the fresh air leakages at different places in the entire suction track. These fresh air leakages are due to improper pallet sealing system, damaged side plates, expansion joints of wind boxes, wind main and holes developed in the track due to wear and tear.

It is imperative that for increasing productivity, the under-grate suction has to be improved by reducing fresh air leakages into suction track. The various sources of fresh air leakages are already listed above. But without proper scientific aerodynamic evaluation of the entire suction track of the sinter machine, it is difficult to pin- point which source of fresh air leakage is contributing maximum to the drop in suction.

Literature Study

In early 70s, the air leakage of the sinter machine was more than 60%. The air leakage is generally lower for the newly built sinter machines. However, as reported by Japanese with application of all recently developed measures such as the high minus pressure contact air-sealing technology and self-adjustable flexible sealing device, the all-metal soft magnetic sealing device and double plate spring sealing device etc., the air leakage of sinter machine can be reduced to 20-30%[1].

Sinter productivity is determined by the vertical sintering speed which depends on the bed depth and the suction pressure, an increase in suction at the constant bed depth will increase the sintering rate as well as the sinter productivity. Under laboratory conditions, productivity and suction were found to be related by the following relationship[2]:

Productivity = k (suction) ^{n}

Where,

n = 0.705-0.735 (1)

k = Proportionality constant which is a characteristic of the sintering unit

A proper balance between the suction pressure and the bed depth is, therefore, necessary for any given set of raw materials to produce acceptable quality of sinter at the desired productivity level. Higher suctions at relatively low bed depths makes the sinter relatively weak although very high productivities can be achieved.

Reduction of air leakage offers benefits not only in terms of energy saving, such as reduction of blower electrical requirements but also in terms of various operational factors such as improved productivity[3]. It is an established fact that a drop in suction by 100mmwc results in reduction in specific productivity by 8-10%[4]. This is also confirmed by some of the laboratory experiments conducted.

Experimental

Because of the number of points involved in measurement, for convenience sake, the entire suction track of sinter machine can be divided into the following segments:

- Across the sinter mix bed
- Under grate-Wind Legs
- Wind legs – Wind Main
- Across battery cyclones
- Battery cyclones to Exhausters

Visual inspection pointed to improper pallet sealing, damaged side plates, damaged bottom compensators of wind boxes, compensators on wind main, worn out plates of wind main, worn out battery cyclones plates & insulations etc. However, to comprehensively identify the leakage areas along the suction track & most importantly to quantify respective amount of leakages, aerodynamic evaluation of sinter machine wasconducted.

Aerodynamic Study

Two pallets with good grate bars and side plates were identified and chosen for experimental purpose. These experimental pallets were placed, during trials, in the sinter machine in such a way that when one pallet was in forward track and the other in the return track. By this arrangement, it was possible to have the entire time one experimental pallet above the wind boxes. Before starting the experiments, the points of measurements were identified and marked.

As the whole suction track was divided into several segments, the measurements were made segment-wise. In the first segment, gas samples were collected from the experimental pallet and from the wind box which is right under the experimental pallet. In this way, as the pallet moves, gas samples were collected from pallet and the corresponding wind legs till the last wind leg. Also, air filtration velocity into bed, temperature, suction, dynamic pressure was measured in addition to collecting gas samples. Similar measurements were made and also gas samples were collected in wind main, before battery cyclones, after battery cyclones and before exhausters.

Air Filtration Velocity through Sinter Bed

Air filtration velocity has been measured using a diverging hood and vane type anemometer on top of the sinter bed. Whole sinter cake has been compartmentalized into three sections width-wise and air filtration velocity of each compartment has been measured.

Flue Gas Analysis

The gas samples collected were analysed for O_2 using the Flue Gas Analyser. From the analysis of gas samples from pallet and corresponding wind leg, the fraction of air leaked into this pallet- wind leg segment was estimated by O_2 balance (XO_2) using the formula

$$X0_2 = (O_2wl - O_2p) * 100/(21 - O_2p) \qquad (2)$$

Where,
XO_2 = the % of air leakage into the segment
O_2p = % of O_2 in gas sample from pallet
O_2wl = % of O_2 in gas sample from wind leg.

Using the same methodology, the % of air leakage into other segments was also estimated.

Suction and Temperature Profile

Suction, temperature, dynamic pressure values were measured at various locations, like under grate, wind legs, wind main, before & after battery Cyclones and before exhausters.

Flow Regime

From the average air filtration velocity into the sinter mix bed, the total flow into the bed was calculated. Using temperature and pressure corrections, the flow under the bed was also calculated. Static pressure, dynamic pressure and temperature were measured at all sampling points in wind legs, wind main, before and after battery cyclones and before exhausters. From these measured values flow was calculated at the point of measurement. From this flow regime, leakages occurring in various segments were also calculated.

Primary Results

Air Filtration Velocity into Bed

Generally, the air filtration velocities are higher near side plates compared to middle due to Rim-Zone effect. It is also observed that overall air filtration velocity i.e 0.12 m/s

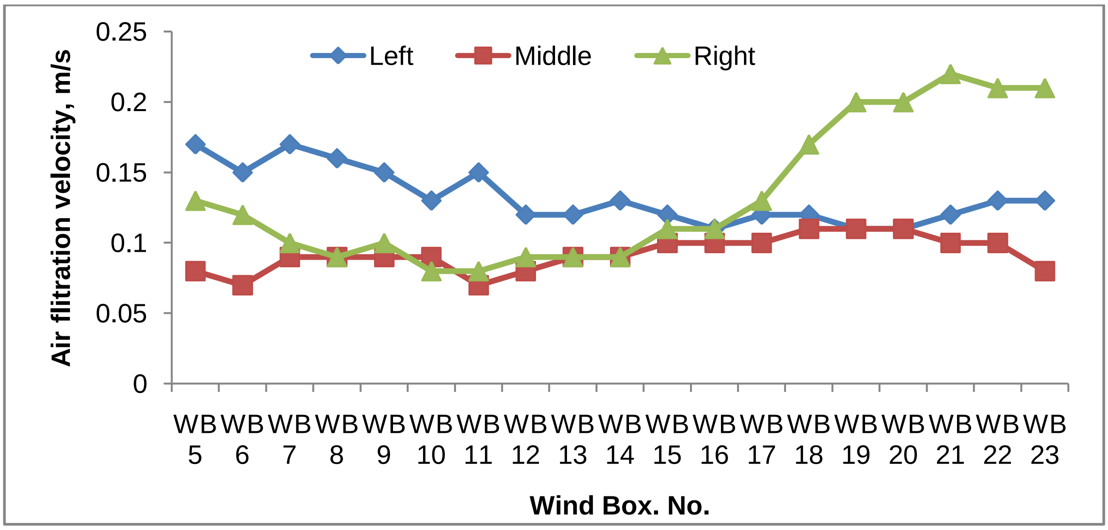

Figure 1: Profile of air filtration velocities through sinter bed

is very much lower than the required average value of 0.3-0.35 m/s. This low overall air filtration velocity is due to very high leakages through track sealing, compensator between consecutive wind boxes & end sealing of sinter machine.

Suction Profile

It can be seen that the suction loss above wind boxes 2, 5-9, 12-13 & 21-23 is substantially high in comparison to suction loss above other wind boxes. This is mainly due to the leakage occurring across the track sealing above these wind boxes.

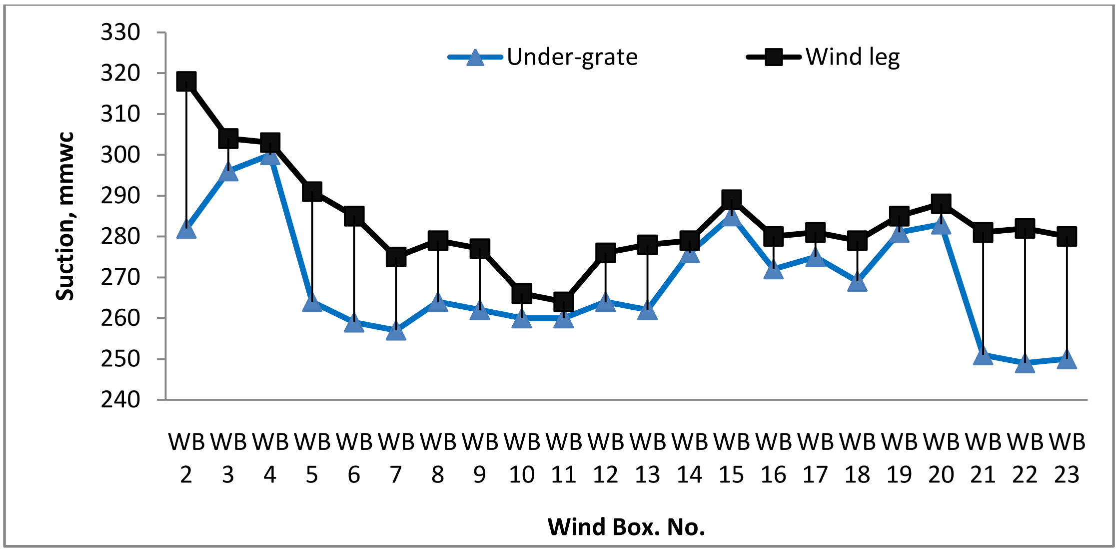

Figure 2: Profile of air filtration velocities through sinter bed

Discussions & Recommendations on Primary Results

1. Due to heavy leakages average air filtration velocity into sinter mix bed was very low at around 0.15 m/s
2. Suction loss from exhauster to under grate was 226 mmwc, which was 59% of generated suction at exhauster end.
3. Out of total gas flow through under grate to wind leg segment 59 % was on account of atmospheric air leaking into the suction track through track sealing, compensator between consecutive wind boxes, worn out plates of wind boxes, end sealing of sinter machine & compensators.
4. It was observed that the suction loss above wind boxes 2, 5-9, 12-13 & 21-23 were substantially high in comparison to suction loss above other wind boxes. This was mainly due to the leakage occurring across the track sealing above those wind boxes.

5. Flue gas analysis also indicated heavy leakage occurring through the "**Track Sealing**" except wind box no. 16 and 20, resulting reduced air filtration velocity through sinter bed.
6. Out of total gas flow through wind leg to wind main segment 33% was on account of air ingress.
7. A major leakage was observed across the battery cyclones. Due to this the suction loss was around 180 mmwc.

Jobs Undertaken

During capital repair period, exhaustive maintenance jobs were undertaken to plug those identified points. Replacing entire sealing plates, repair/replacing of wind boxes, sleeves, Vacuum chambers, wind main, battery cyclone shell and exhauster casing etc. were carried out exclusively to improve upon suction front.

Seondary Results

Air Filtration Velocity through Sinter Bed

Figure3shows comparison of average air filtration velocity before and after capital repair. From thisFigure,it can be summarized that average air filtration velocity through sinter bed has increased from 0.15 m/s to 0.17 m/sec.

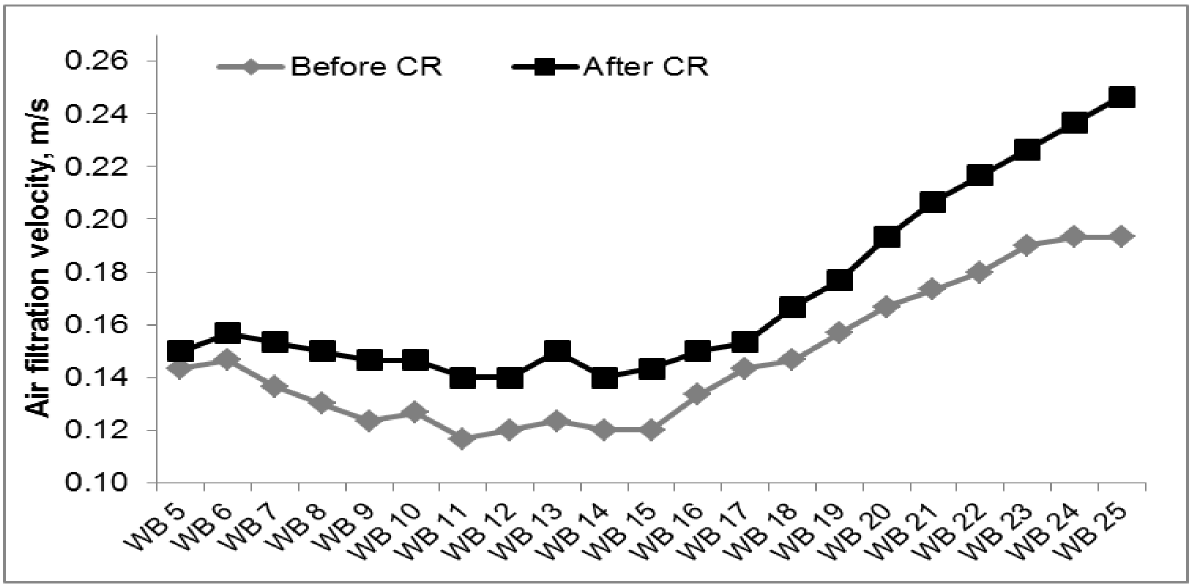

Figure3: Profile of air filtration velocities through sinter bed

Suction Profile

Suction, temperature, dynamic pressure values were measured at various locations. The total suction map as shown in Figure 4 clearly indicate that the under grate suction has improved by 108 mmwc, from 294 to 402 mmwc.

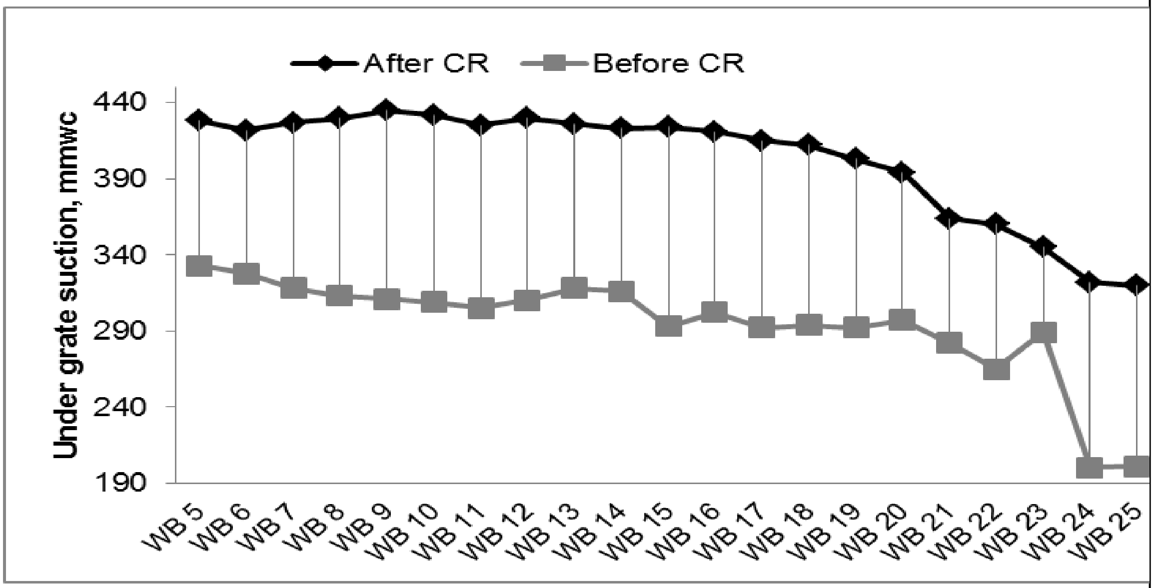

Figure 4: Profile of under-grate suction

Conclusions

The aerodynamic evaluation of the suction track of sinter machine provided the basic tool to identify and quantify the leakages. By paying proper attention to the identified major areas of leakage and incorporating the modifications required to stop leakages the suction under grate can be increased. From the results of the aerodynamic evaluation the following conclusions can be drawn:

- Leakages in sinter plant suction track should be identified qualitatively & quantitatively at regular interval. Afterwards, rectification measures to plug those should be carried out.
- Significant improvement in under-grate suction values has been observed after capital repair; suction loss from exhauster to pallet bottom reduced to 34%.
- After capital repair average air filtration velocity through sinter bed has increased from 0.15 m/s to 0.17 m/sec and the under grate suction has improved by 108 mmwc.
- Sinter machine productivity increased from0.98 t/m²/h to 1.04 t/m²/h.

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