Minimising Particulate Emissions of Sinter Plant Operations

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1. INTRODUCTION

The principal for the long-term future of the Tata Steel integrated steel plant in Port Talbot is reliant on efficient and stable operations. However, increased production levels and stringent environmental demands have pushed the sinter plant main stack to its limits with respect to particulate emissions.

Sinter is a critical feedstock for the blast furnaces to aid the production of liquid iron for the conversion to steel. The objective is to understand the effects of chemistry of the sinter blend upon performance, product output and environment emissions. Laboratory simulation with current and modified blends with the aim to optimise accelerants and raw materials will be analysed. Full scale plant trials that results in minimised particulate emissions to comply with the new emission limit value of 40mg/Nm^3 will determine if this project is successful.

2. PROJECT OBJECTIVES

- Effects of chemistry upon performance, focusing on reduced chlorides by treatment of reverts, effects on sinter quality and implementing new cutting-edge sinter process technology.
- Pilot sinter pot studies with modified blends, optimising accelerants to improve fuel performance, analysis of the emissions from the pot and testing sinter quality.
- Full scale plant trials that results in minimised particulate emissions.

3. DATA ANALYSIS

Analysis of a decade of data from the sinter process, raw materials and particulate sampling was carried out. Certain criteria were defined (Figure 1) and were applied to find stable operations which resulted in a range of particulate emission levels for certain days.

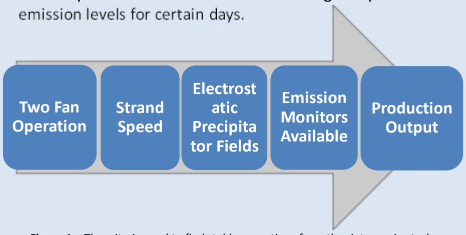

Figure 1 – The criteria used to find stable operations from the sinter main stack, TATA Steel Port Talbot

Figure 2 illustrates the key levers for particulate matter emissions from sinter plant operations and exhibits that changing from one to two fan operations causes the greatest influence with a - 31% decrease in standard reference method results, which are sampled from the sinter main stack isokinectically. Suction from the north and south wind-box when below the sinter plant's target of 75 mbar decreases particulate emissions by 26% and 27%. An additional key lever is moisture when above the average of 6.1%, this results in a decrease of particulate emissions by -9%. Since 2018 when the average inlet temperature is below the average of 149.9°C results in a 21% decrease in particulate matter emissions.

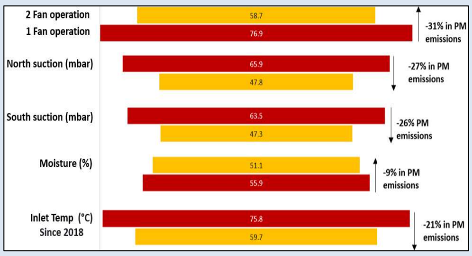

Figure 2 – Key levers for particulate matter from sinter plant operations

4. EXPERIMENTAL PROCEDURES

4.1 Sinter Pot Testing

To simulate a full-scale sintering process, a pilot-scale sinter pot was used with a raw sinter mix capacity of 8.0 kg, a bed diameter of 100 mm and a height of 150 mm as displayed in Figure 3. The sintering blend is charged into the sinter pot and ignited by an ignition burner above the bed and the hood supplying simulated flue gas was lowered simultaneously after the two-minute ignition. A suction fan is used to draw the flue gas through the sinter as the flame front is propagated simultaneously. When the temperature of the exhaust gas reaches the set temperature, the hood is moved aside, and fresh air is drawn through the bed.

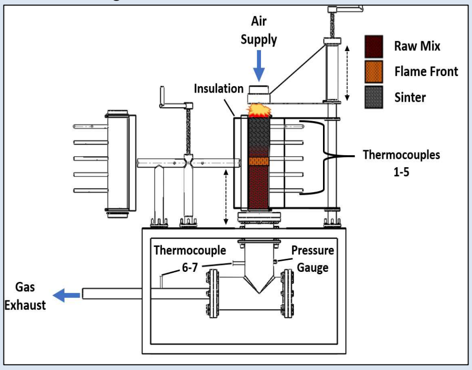

Figure 3 – Schematic diagram of a laboratory sinter pot

4.2 Measurement of Particulate Matter

Previous scientific research captured PM by the use of a particle impactor device. A novel and more feasible technique was designed and installed on the sinter pot to capture particulate matter emissions (Figure 4). The design criteria to collect particulate matter included: The previous cap end was replaced with a removable door including chamfered locks with gaskets for a sealed door. A tray was welded to the new removable door to capture heavy deposited dust which does not enter the air stream. Use of a borosilicate glass filter 110mm Ø which can withstand high temperature and pressure changes and fit in a filter holder which allows the airflow through. The location of the filter had to be positioned above the process dew point (100 °C) to avoid water vapour to protect the filter. from damage.

Figure 4 – Design & installation of a particulate matter capturing device on the laboratory sinter pot

5. RESULTS & DISCUSSION

5.1 Sinter Pot Testing

Figure 5 displays the different characterises of particulate matter during sinter pot testing which range from various zones, forces and transformation paths. The release of particulate matter from the sinter pot is understood to be impacted directly from the different zones; combustion zone, drying zone & wet zone. (Debrincat, 2006)

The break-down of particles due to thermal shock or calcination is likely to weaken interparticle adhesion and lead to their entrainment in the gas stream or can be deposited down in the wet zone of the bed. The main transformation paths include minerals melting, escaped fine fuel fly ash, chlorination reactions and forming sulphate. *(Zhiyun, 2017)*

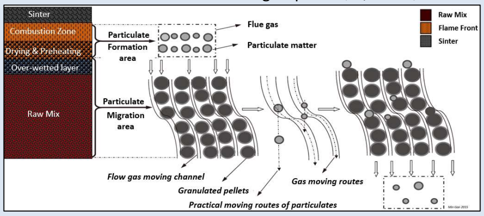

Figure 5 – Characteristics of the release of particulate matter during sintering (Gan 2015)

5.2 Measurement of Particulate Matter

Validation using a base blend was repeatedly tested on the sinter pot and the concentration of particulate matter on the filter are displayed in Figure 6. The percentage deviation was 12% which gives the installed particulate matter capturer technique confidence in results. Further analysis of ICP-OES is used to determine the chemical composition and SEM images and mapping of typical Fe–Ca–Al–Si–O-related particles is used: (a) Fe–Ca–O-related particles (b) Al–Si–O-related particles; (c) Ca–O–S-related particles in Figure 7.

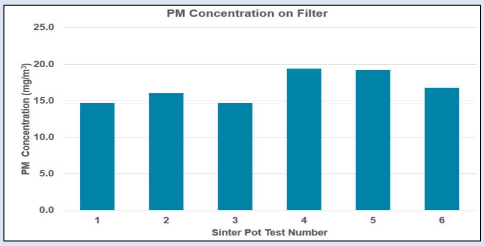

Figure 6 – Concentration of particulate matter collected from a laboratory sinter pot

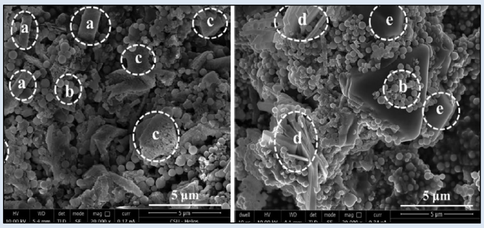

Figure 7 – SEM images of $PM_{2.5}$ released from sintering process. (a) Polyhedron-like particles; (b) Sphere-like particles; (c) Square-like particles; (d) Flake-like particles; (e) Bulk-like particles (Zhiyun 2017)

6. CONCLUSION

Since validation, the sinter pot now has the capabilities to measure concentration and chemical analysis of the particulate matter. Utilising the literature review (gaps in scientific knowledge), data analysis (key levers of particulate matter) and deliberations with sinter and environmental specialists has steered an experimental plan which focuses on having the largest impact on minimising particulate emissions from sinter operation. Planned experiments are:

1. **Modification of the particle size distribution (ultra-fines) of an iron ore**
2. **Controlled addition of Potassium Chloride**
3. **Displacement using different ratios of two iron ores** *(Collaboration with Ryan Davies, SaMI)*
4. **Water washing on electrostatic precipitator dust** *(Collaboration with Matthew Wilcox, EngD student)*
5. **Micro-pelletising of iron ores & reverts** *(Collaboration with Tariq Al-Haji, TATA Steel)*
6. **Plant trials using different plant blends**

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