Characterisation of ESP Dust Sample from Sinter Plant

Moni SINHA,1) R. V. RAMNA,2) Surajit SINHA3) and Goutam BOSE4)

1) Research and Development and Scientific Services Division, Tata Steel, Jamshedpur, Jharkhand, Pin 831007 India. 2) Head, H Blast Furnace, Tata Steel, Jamshedpur, Jharkhand, Pin 831007 India. 3) Head, Pelletisation Plant, Tata Steel, Jamshedpur, Jharkhand, Pin 831007 India. 4) Head, Sinter Plant, Tata Steel, Jamshedpur, Jharkhand, Pin 831007 India.

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1. Introduction

Sintering plant dust arrested by electrostatic precipitator (ESP dust) in an integrated iron and steel company is perceived as a precious secondary material to steelmaking process, due to the presence of important elements to the industry such as, Fe and C with an attractive concentration.1)

In an electrostatic precipitator, a strong non-homogeneous electrical field is generated between a pair of electrodes, under a differential voltage of 50 to 100 kV. Usually, the negative electrode is an assembly of vertical metal wires, while the positive electrode is an assembly of vertical metal plates, which is grounded. Near the negative electrode the electrical field is strong enough to ionise the gas into positive and negative ions. The positive ions travel a short distance towards the negative wire electrode. The negative ions travel a longer path to the positive plate electrode. During this trip, the negative ion may collide with a dust particle, which in turn becomes charged, and moves towards the plate electrode. Periodically, the dust on the plate electrode is removed via mechanical hammering on the plate. This allows the dust to fall down under gravity into the dust hoppers underneath the electrodes.2)

Carbonaceous materials are highly conductive. They are large and light in comparison to other dust particles. Carbon particles readily accept an electrical charge but also lose their charge quickly and are re-entrained. So any change in fuel combustion practice will lead to inefficiency, if there is unburnt carbon or high volatile material. The presence of high volatile matter (VM) content in fuel was probably causing the electrodes to buckle as the temperature was beyond their normal operating limits (120–175°C), this affecting the efficiency. The characterisation of ESP dust was thus necessary to know the reasons for abnormal heating. Based on the findings, the use of high VM fuel in sinter-making was reduced, thus increasing the life and efficiency of the ESPs at sinter plant.

2. Methodology

In the sinter plant, ESPs are located as given in the block diagram below (Fig. 1). All the samples were collected from waste gas ESP location.

There are two ESPs, Waste gas ESP and dedusting ESP. Each has three fields, where the sampling was done. Thus six dust samples from different locations of electrostatic precipitators (ESP), were collected from the sinter plant. The samples were analysed for their chemistry with inductively coupled plasma atomic absorption spectrometer (ICP-AAS), presence of carbon by carbon and sulfur determinator and flash point. XRay Diffraction (XRD) analysis was carried out to check the presence of graphitic carbon. Scanning electron microscope-energy dispersive spectrometer analysis was used for elemental analysis and checking the presence of carbon. To check the reactivity of the ESP dust, Thermo gravimetric analysis-differential thermal analysis (TGA-DTA) was used. Finally Fourier transformation infrared spectroscopy (FTIR) was used for information about the chemical bonding/molecular structure of materials.

3. Results and Discussion

3.1. Chemical Analysis

The carbon content of the dust samples varied from 7 to 13% (Table 1). Iron content is above 40%, Al2O3 is around...
4%, CaO is around 9% and SiO\textsubscript{2} is 4% on an average. This makes ESP dust a good quality recyclable material for sinter plant. However the amount of Sulphur needs to be brought down before using the ESP dust.

### 3.2. XRD Analysis

Though observed in chemical analysis, carbon was not observed in XRD tests in any of the samples, suggesting the presence of carbon in either amorphous state or soot. The major phases detected in XRD\textsuperscript{3,4)} are hematite and magnetite.

### 3.3. TGA-DTA Analysis of the ESP Dust Sample

To check the reactivity of the ESP dust, (TGA-DTA) was carried out for sample \#1. The analysis was carried out in normal atmosphere, with an heating rate of 5°C/min. The quantity of sample used for this analysis was 50 mg.

TGA indicates the weight loss (Fig. 2) during heating, thus loss of volatiles such as combustion of carbon in this case is a probability. At about 200°C there is a sudden down-curve indicating weight loss.

Similarly in DTA analysis (Fig. 2), at around 160°C a sharp increase in the exothermic reactions is observed which could be due to combustion of carbon.

The dust samples had carbon in it which might be combusting. This is indicated by the weight loss as well as a corresponding increase in the exothermic reaction.

To confirm that carbon was indeed combusting at over 160°C in the above study of TGA-DTA, the sample \#1 was heated in air atmosphere at two different temperatures, 150°C and 250°C, with a holding time of 2h. The heated samples were then tested for their chemical composition, especially carbon content (Table 2).

It is observed that there is a significant loss in carbon percentage and a marginal loss in sulfur in heating at 250°C temperatures in comparison to 150°C. This test also indicates that carbon is combusting somewhere between 150°C and 250°C. Thus it can be concluded that the ESP dust samples contained carbon in amorphous form, probably as soot. This carbon is prone to ignition if exposed to higher than 150°C as observed in the tests.

### 3.4. FTIR Analysis of ESP Dust

FTIR Spectroscopy is a qualitative technique that provides information about the chemical bonding or molecular structure of materials, whether organic or inorganic. It is used to identify unknown materials present in a specimen. The instrument used here is Nicolet 6700 FTIR. Analysis is done at room temperature and normal environment. The sample is mixed with Potassium bromide powder (KBr, Spectroscopic grade), in the ratio of 25% : 75% :: Sample : KBr, and total 1 g of sample is used for analysis.

The FTIR analysis of ESP dust (Fig. 3) revealed the presence of organic groups like, carboxylic group, ether, sulphate, sulphonate, alkyl etc. (Table 3). The carboxyl and ethers are generated during combustion of coal/coke. These compounds apparently originated from any raw materials charged on the sintering strand.
4. Conclusion

It was observed that there is a significant loss in carbon percentage and a marginal loss in sulfur in heating at 250°C temperatures in comparison to 150°C. This study indicates that carbon is combusting somewhere between 150°C and 250°C. Thus it can be concluded that the ESP dust samples contained carbon in amorphous form, probably as soot. This carbon is prone to ignition if exposed to higher than 150°C as observed in the tests. The FTIR analysis suggests the presence of organic groups like, Carboxylic group, Ether, Sulphate, Sulphonate, Alkyl etc. in the ESP dust. This it was very likely that the combustion of carbon particles were causing the abnormal heating of electrodes, which may affect the electrodes in the long run. However, based on the findings, the charging of high VM material in sinter-making were monitored and controlled, thus increasing the life and efficiency of the ESPs at sinter plant.

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