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Original Article

Agglomeration behaviour of steel plants solid waste and its effect on sintering performance

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ABSTRACT

Recycling has been the fascinating topic among the researchers for all times. The present study shows the recycling of steel plant's solid wastes as blast furnace flue dust and sludge towards agglomeration and their use in the production of sinter. These wastes consist of metal oxides and coke fines as a valuable material with some alkali oxides. Using these wastes as it is in the form of fines exacerbate the further processing. Pellets of these wastes are prepared with three types of binders as molasses, dextrin and bentonite. The result reveals that properties as compressive strength, shatter strength, are better in the case of bentonite binder having the productivity of the disc pelletizer machine as 75. After that, these macro pellets used for sintering with iron ore and other ingredients in pot type, down draft laboratory grade sintering machine, which shows very high productivity and good mechanical properties of the sinter as well. The microstructural analysis reveals the presence of re-oxidized hematite and a little bit of a magnetite phase with some slag phases, which confirmed later by XRD analysis. Results also show the decrease in coke rate, i.e. coke consumption to produce sinter and at the same time, this process is highly eco-friendly.

1. Introduction

Blast furnace sludge and blast furnace flue dust are the hazardous metallurgical waste generated in the iron making plants [1]. The flue dust and sludge is a mixture of oxides expelled, whose major components are iron oxides and coke fines. It also contains silicon, calcium, magnesium and other minor elemental oxides in lesser amounts. The recovery of these valuable metals and carbon from this flue dust and sludge becomes very important, due to the increase in the price of coke breeze and the decrease of the primary resources of the raw materials. Moreover, it makes the environment safer by decreasing pollution.

The fact that it is not possible to recycle this dust and sludge directly or to reject it as landfill because it will contaminate the soil badly, so it is necessary to consider the recovery of the valuable elements contained in it and to obtain a non-hazardous residue that can be stored without problem or can be used in agglomeration units in iron-making industries [2,3].

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Although utilization of these wastes as it is from the plant for the production of sinters is a recirculation technique [4] but at the same time, it adversely affects the property of sinter, which is not up to the mark for use in blast furnace. In this study, we made the pellets [5–8] from the blast furnace waste and then used these pellets for preparing of sinter, which results in sintering properties such as sinter strength increases with using the waste made pellets, at the same time the productivity of the sinter machine also increases [9–11]. It also decreases the fuel rate in the sintering process [12]. The results were found that the presence of bentonite binder up to 4% provides the shatter index of the pellets less than 20, whereas molasses and dextrin gave the significantly high shatter index means very low strength. Hence, the 4% bentonite binder gave the optimum condition for the pelletizing machine. Thereafter, these pellets are used for sintering results in a decrease of coke consumption from 60 to 30 kg/ton of sinter, utilizes 25% of waste. At the same time, this much of waste addition also decreases the lime addition to maintaining the basicity. The productivity of sintering machine was found to increase up to 5.2 at 27% waste for the basicity of the sinter as 2.2.

2. Materials and methods

2.1. *Material used for pelletization*

The raw materials (blast furnace flue dust and sludge) were used for pelletization, obtained from the Durgapur Steel Plant (India). The chemical composition and sieve analysis are shown in Tables 1–3.

The waste sample shows the abnormal accumulation of iron as well as very fine carbon. At the same time, these also contain a high percentage of alkali, so it cannot be reused directly in the sintering process. The optical emission spectroscopy studies (OES) of these samples indicated that iron is present in very high amounts in comparison with the other elements. The X-ray diffraction (XRD) study shows the associated phases of iron metal, gehlenite ($Ca_2Al_2SiO_7$), magnetite, hematite, quartz and wustite in order of abundance. The XRD pattern of flue dust and sludge is shown in Figs. 1 and 2.

A number of organic and inorganic binder materials used as an additive in agglomeration technique are being reported in the literature. Here bentonite an inorganic, whereas molasses and dextrin (organic binders) are used for pelletization. The chemical compositions of bentonite and molasses binder are listed in Tables 4 and 5.

Table 1 – Chemical composition of blast furnace sludge.

Element	Weight %, by mass
Fe	30.82
CaO	8.95
SiO_2	11.59
MgO	3.83
Al_2O_3	3.6
Na_2O	0.09
K_2O	0.29

Table 2 – Chemical composition of blast furnace flue dust.

Element	Weight %, by mass
Fe	39.92
CaO	6.28
SiO_2	6.95
MgO	2.01
Al_2O_3	4.0
Na_2O	0.51
K_2O	0.29

Table 3 – Sieve analysis of blast furnace ferruginous waste material.

Sieve size (μm)	Weight % of flue dust	Weight % of sludge
1000	20	30
500	10	25
300	20	25
150	30	20
75	10	–

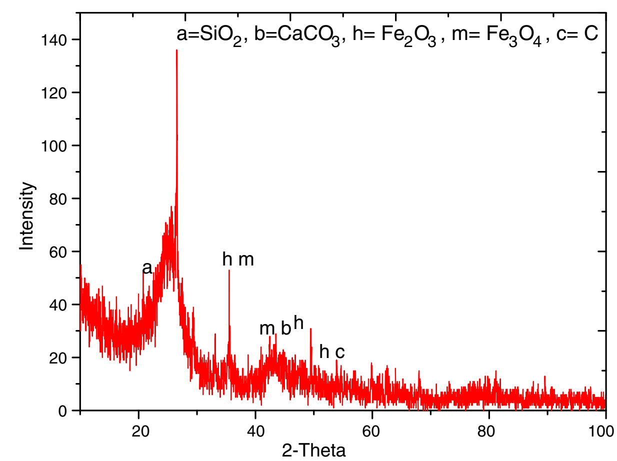

Fig. 1 – X-ray diffraction pattern of blast furnace flue dust.

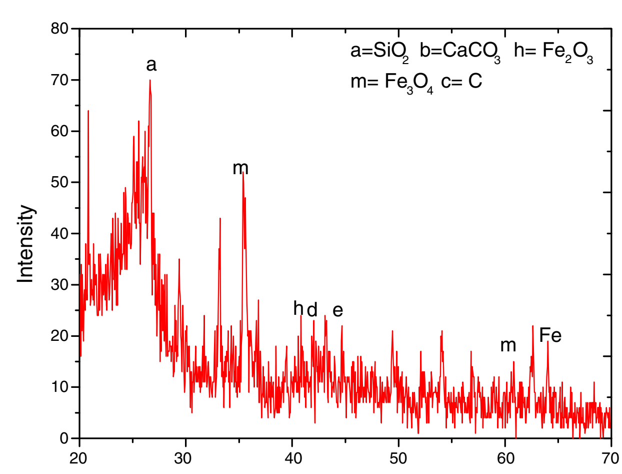

Fig. 2 – X-ray diffraction pattern of blast furnace sludge.

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