STUDY ON THE MECHANICAL WORKING OF BLAST FURNACE FLUE DUST – IRON OXIDE – GRAPHITE COMPOSITE BRIQUETTE MADE WITH FLY ASH AS A BINDER

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of

Doctor of Philosophy

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July, 2022

ABSTRACT

Integrated steel plants and mini steel plants produce iron bearing waste materials in the form of fines and ultrafines. Thermal power plants also produce a huge amount of fly ash, which is used in chemical industries, construction material other than landfilling. A small amount of iron bearing industry wastes is used for sintering and pelletizing. It can be considered as a secondary source of iron oxide and carbon with some alkali oxides as detrimental matter. Several studies have been carried out to use these fines in the form of pellets and micropellets. However, previous studies have been primarily limited to use of the waste for recycling in the mainstream.

In this present study, a fixed quantity of blast furnace flue dust (30wt %) and laboratory grade Iron ore fines (65wt %) are mixed with different binders such as bentonite, lime, sodium silicate, fly ash, starch, molasses, pitch and dextrin. The strength of composite briquettes made with different binders was measured at the green, dry and cured conditions. The strength of fly ash briquettes is found to be superior to other inorganic/organic binders. In addition to this, the effect of variation of binder quantity, binder particle size, briquetting pressure, and curing temperature on the compressive strength for cured composite flue dust briquettes was also determined. The optimized parameters fly ash quantity of 5 wt%, fly ash particle size of 75μm (200mesh), briquetting pressure of 95 MPa, and curing temperature of 300° provide maximum strength to the briquettes. Moreover, the presence of the different phases in the fly ash added composite briquettes after curing at 250°C, 300°C and 350°C was identified by X-ray and FESEM based EDS analysis. It is observed that fly ash is a better binder compared to the other conventional binders for briquetting. Furthermore, the response surface model (RSM) technique was used to optimize the variables such as fly ash quantity, fly ash particle size, briquetting pressure, and curing temperature to achieve the maximum compressive strength of briquettes using MINITAB20. The optimized fly ash quantity, fly ash particle size, briquetting pressure, and curing temperature are 7wt%, 50 μm, 121 MPa, and 316°C, respectively.

Subsequently, composite briquettes were produced using blast furnace flue dust (≤75μm), laboratory grade Fe_2O_3 fines (purity ≥ 98%, ≤75μm), fly ash (≤75μm) and pure graphite (≥ 99%, ≤150μm), where fly ash has been used as a binder. The effect of flue dust concentration on the reduction behaviour of the developed composite briquettes at different temperature namely 1073K, 1173K, 1273K, 1373K and 1473K under nitrogen atmosphere for 2 hours was studied. It

is found that the reducibility of the cold composite briquette with a definite amount of blast furnace flue dust increases with temperature and time in the temperature ranges of 1073K to 1473K. The modified unimolecular reaction kinetic model has described the reduction mechanism of the cylindrical briquettes. In addition to that, the activation energy for the reduction increases with an increasing amount of blast furnace flue dust in the sample. Furthermore, optimization was carried out for the process parameters such as flue dust quantity, and reduction temperature over a specified range to maximize the reduced fraction of the briquettes using RSM techniques.

The reduced briquettes were crushed into fines. Reduced fines ($\leq$75μm) mixed with 0.5 sodium silicate was compacted at different pressures such as 75, 90, and 100MPa. The maximum green density of 5341.6 kg/m^3 is achieved at 100MPa pressure. The samples possessing maximum green density were sintered at different temperatures of 1100°C, 1150°C and 1200°C each for 60 min, 90 min and 120 min respectively. The density, compressive strength and hardness were measured after sintering of the samples. The sample sintered at 1150°C for 120 min has achieved a density of 6111.4 kg/m^3, compressive strength of 238.72 MPa and hardness of 109.34 VHN.

The briquettes sintered at 1100°C and 1200°C were extruded at varying pressure of 175MPa and 240MPa respectively. The extrusion ratio is 1.56. The effect of temperature, time of heating and compaction pressure on the physical and mechanical properties such as density, compressive strength, hardness and microstructure of the final product were measured and reported. Quantitative and qualitative metallography analysis and mechanical properties of the extruded product were carried out. The product achieves a density of 7571.6 kg/m^3 after extrusion with 240 MPa extrusion pressure at 1200°C. Furthermore, the compressive strength and hardness values are 336.67MPa and 117.42VHN respectively when the extrusion pressure is maintained at 240 MPa and heat treated at 1200°C. The achieved density and mechanical properties of the extruded product matches with that of low carbon steel.