ABSTRACT

In order to use non-coking coal and fines, several fundamental investigations have been carried out in recent past to explore the possibility of cold setting iron ore-coal composite pellets to reduce it directly to sponge iron. In the present study composite pellet is investigated as a potential raw material in the tunnel kiln, for the first time, to explore tunnel kiln's efficacy with composite pellets. Both organic and inorganic binders have been tested for preparing composite pellets. Pellets prepared using 1% bentonite was found to be optimally placed for use in experiments. The total stoichiometric coal has been partitioned as internal and external coal in the tunnel kiln. Optimum internal coal for maximum reduction efficiency of such pellets has been studied in laboratory muffle furnace and is found to be 6% in the pellets. Experiments performed in a sample kiln (50kg capacity) and shuttle kilns (12 ton capacity) were directed to find the time of reduction of such pellets in the industrial crucible of diameters greater than 20cm by measuring the evolution of temperature between the surface and centre of the loaded container through thermocouple measurements. It is observed that approximately 12 hours are required for such temperature equalization. Experiments were then scaled to bigger gas fired batch furnace with tested crucible to check stabilization of furnace temperature considering the large thermal mass of the containers as well as the material inside it, and it is found to take around 20 hours. Metallic iron of the reduced mass is found to be of the order of 85% and composite pellets are found to produce more metallic iron compared to composite mixture. With the success of composite pellets in shuttle kiln, a pilot tunnel kiln (7.0 tpd) used for ceramic heating is modified to fix up the firing temperature, speed of trolley to reduce fines of iron ore-coal mixture and composite pellets. Experiments with seven material systems (composite pellets, briquettes, simple raw and indurated iron ore pellets, loading of separate concentric layers of iron ore and coal fines, ore fines-coal fines mixture) are carried out in some specially marked containers along with other containers. Parameters evaluated include metallization, reduction efficiency, carbon efficiency and energy efficiency. The metallization, thermal and chemical efficiency for the composite pellets appears to be highest among all other material systems studied. After the optimisation of parameter in 7.0 tpd pilot tunnel kiln, 50tpd tunnel kiln experiments were carried out. Chemical and thermal efficiency of 50tpd kiln is found to be higher than that of 7.0 tpd kiln based on detailed mass and energy balance of the system, as a result of better heat utilisation in the larger kiln.

Key words: Tunnel kiln, iron ore-coal composite pellets, thermal efficiency, chemical efficiency, metallization, sponge iron