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by

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INTRODUCTION

Softening-under-load and counter-current-reactor experiments were performed on double layered experimental pellets prepared by workers at the University of Toronto. These pellets were prepared by agglomerating a mixture of 30% coke fines and 70% magnetite to form pellets about 7 mm in diameter. The pellets were then surrounded by 100% concentrate by spherical agglomeration to form double layered pellets about 12 mm in diameter. They were then fired over a 3 hour period at a temperature of 1220°C. Pellet materials prepared in this fashion are to some extent prereduced and should therefore require less reductant when charged into the blast furnace.

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METHOD

Six pellets weighing 21-22 g were placed in 100 numbered trays (4.1 cm high) and charged into the counter-current reactor tube. The reactor consists of a vertical stainless steel reduction tube (Figure 1), two inches in diameter. Reducing gas mixture was introduced into the top of the reduction tube and was set so that the C/Fe ratio was 2.20. A furnace consisting of four separately controlled heating elements surrounds the reduction tube. Adjustments to the four heating elements allowed for the establishment of a temperature profile which was thought to be typical for a blast furnace. Inside the reduction tube is a smaller tube (¼ inch) which contains a thermocouple and an orifice to allow for gas analysis at a known temperature. It is situated about 1.5 m from the base of the reduction tube. Gas samples from this orifice and from the base of the reduction tube were analyzed periodically on Lira infrared carbon monoxide and carbon dioxide analyzers. This equipment simulates the gas-solid conditions in the upper zone of the blast furnace. Results are measured from the last furnace length of the tube after the system has reached a steady state.

The Hoogovens method was used for measuring the softening-under-load properties of these double-layered pellets. The procedure involves placing a 500 g burden in a cylindrical tube (75 mm) within a pressure retort. The retort is suspended from a load cell in a high temperature oven and heated to 1050^{o}C while the sample is maintained under a nitrogen atmosphere. The burden is loaded (0.5 Kg/cm^2) using a piston from a pneumatic pressure cylinder. When a constant temperature is obtained the preheated reducing gas (30 l/m of 60:40 N_2 to CO) is passed through the sample bed. The reduction is monitored by recording the EMF output of the load cell. The change in differential gas pressure across the bed (a measure of the permeability) is monitored by the EMF output of a differential pressure transducer. Similarly, the movement of the piston is measured using a linear displacement transducer.

RESULTS

Chemical analysis of the material as supplied gave an analysis of 64.9% Fe^T, 5.8% Fe^{+2}, and 0.9% Fe^0.

The Hoogovens tests at 1050°C gave a reduction rate $\left(\frac{dR}{dT}\right)_{60}$ of 0.78 (% oxygen loss per minute at 40% reduced). No change in differential pressure occurred during the reduction but the sample height had 25.8% shrinkage after 65% reduction.

The experiment with the counter-current reactor gave an efficiency for the reaction of 0.92. The maximum swelling found during the reduction was 16% at a O/Fe ratio of 0.7. The average results of compression tests made on two pellets from several trays indicated a minimum compression strength of 21.7 lbs at an O/Fe ratio of 1.13. The initial compression strength of these pellets was found to be 170 lbs. Pellets (400 g) that had passed completely through the furnace and had therefore been reduced as completely as possible were tumbled for 10 minutes at 30 ± 2 rpm for 300 revolutions. The material was then screened through 6.35, 3.36 and .5 sieves. Results indicated 98.0% was plus 6.35 mm, 98.8% plus 3.36 mm, and 99.1% plus 0.5 mm.

DISCUSSION

It was thought that these double-layered pellets would require less coke for blast furnace operation because they should be partly reduced during their induration period. Chemical analyses suggests, however, that these pellets may have been fired for too long a period as they contain only small amounts of metallic iron. The softening-under-load test indicates that the pellets reduce well under load and show no change in differential gas pressure across the bed. The pellet bed however, shrinks quite considerably (26%) and may be due to the hollow centres found in some of these pellets. $\left(\frac{dR}{dT}\right)_{60}$ was found to be 0.78 %/min. after 40% reduction. This value was somewhat lower than anticipated and may be partly attributed to the lower reducibility of the ferrous iron in these pellets. The experiments in the counter-current reactor gave reduction efficiencies of 0.92 and 0.94 which are intermediate in value to two Canadian made commercial pellets (0.89 and 1.00) measured under similar conditions.

The amount of disintegration of the reduced pellets after reduction in the counter-current reactor is small. It is comparable to the disintegration of pellet type A and less than pellet type B.

These pellets showed maximum swelling during the wustite to iron stage of reduction. The free-swelling index however is below the limiting value of 20% and compares well with the commercial pellets. It is somewhat surprising that maximum swelling occurs at O/Fe of 0.7 as the minimum crushing strength (21 lbs) occurs during the wustite formation. Although the compression strength of the unreduced pellet is much less (170 lbs) than for commercial pellets (> 500 lbs) it appears that their strength during reduction is not significantly different from the two commercial pellets tested (pellet A minimum = 32 lbs, pellet B = 19.5 lbs).

CONCLUSIONS

Double layered iron oxide pellets are of interest because they are pre-reduced during firing. As a result, these pellets should lower the coke rates when used in blast furnaces. The reducibility and mechanical properties of the reduced pellets were found to be similar to those of commercial pellets but the compression strengths of the non-reduced pellets were found to be low. A thorough study is recommended to determine a method of preparing these pellets so that their metallization and compressive strengths are optimized for the fired pellets.