METALLIZED PELLETS FROM ORE-COKE MIXTURES

A possible blast-furnace feed?

by J. A. Innes

Some initial investigations into the processes governing the formation of metallized pellets from mixtures of iron ore and coke breeze are reviewed. The effect of such variables as the nature of the raw materials; size distribution of the iron ore and coke breeze, size of the pellet, composition of the surrounding gas, reduction time, and reduction temperature are discussed in detail.

The burdening of ironmaking blast furnaces is currently receiving considerable attention, and the use of both sinter and pellets has led to big productivity gains. During the sintering and pelletizing processes it is customary to add solid fuel, usually as fine coke breeze, to the mix. In the presence of excess air, this fuel ignites to provide the necessary heat for agglomeration. Although the resultant product may be in a more desirable physical form, little or no reduction beyond magnetite takes place. The prospect of achieving considerable reduction during agglomeration with very little increased difficulty over that required for sintering is currently being widely investigated. By carrying out the necessary reactions under suitable conditions and increasing the percentage of fuel in the mix, it seems likely that existing agglomerating equipment can be modified to produce a highly reduced, strong, and uniformly sized material, suitable either as a blast-furnace feed or as a substitute for scrap in open-hearth and basic oxygen steelmaking vessels.

This paper reviews some initial investigations conducted in the Central Research Laboratories of the Broken Hill Proprietary Co. Ltd. into the processes governing the formation of metallized pellets from mixtures of iron ore and coke breeze.

Although it is considered likely that an alternative fuel, probably non-coking coal, could best be suited to the economics of manufacture, early experiments with coke breeze have been done to provide some standard for later evaluation of these cheaper fuels.

In contrast to allied investigations in which agglomeration and partial reduction is achieved by fusion of coal particles during carbonization to create the necessary bond, the bond in the metallized pellets described in this paper is provided by the sintering of reduced iron particles at elevated temperatures. Unlike iron-coke pellets, which require coking coal as a major constituent, metallized pellets can be produced with several low-cost carbonaceous fuels, including non-coking coals.

When intimately mixed finely ground materials are heated, reactions proceed more rapidly than is the case with separated lump components. Reaction between iron ore and coke breeze will take place even in an inert atmosphere if at a sufficiently high temperature. The overall metallization reaction can be controlled by either the oxidation of the particles of carbon or by the reduction of the particles of
size of pellet, (4) composition of the surrounding size distributions of iron ore and coke breeze, (3) gas, (5) reduction time, and (6) reduction temperature.

Some CO. or CO in the surrounding atmosphere can agglomerating characteristics of the iron and coke faces. It has been observed that considerable variation can arise when using other ores and fuels. The natural size distributions of the iron ore and coke breeze were considered to be the most convenient on which to proceed with initial investigations. It was found that pellets made from mixtures of these two materials screened at 18 mesh had reasonable green strength. The size-consist of the components is given in Table I.

Three levels of coke breeze addition were selected: 12.5, 17.5, and 22.5 pct. The majority of the investigations were at the 17.5 pct level which provided 1.07 times the stoichiometric requirement for complete reduction of the iron and gave a pellet of low residual carbon after firing.

Three sizes of pellets were studied: $-\frac{3}{4} + \frac{3}{8}$ in., $-\frac{3}{8} + \frac{1}{2}$ in. and $-\frac{1}{2} + \%$ in. The intermediate size was considered best for rapid reduction, ease of pellet formation, and development of strength; consequently the major part of the investigation was at this size level.

Nitrogen as an inert surrounding medium was used in most tests, but mixtures of this gas with CO were also used, since these are more likely to be encountered in any commercial application.

Reduction times were not in excess of 30 min, and reduction temperatures did not extend beyond the fusion point of the reduced pellet—usually no higher than 1350°C.

Experiments were carried out in a small laboratory tube furnace. The pellets were inserted on ceramic boats, and gas at the rate of 2 liters per min was passed over them during firing, the tube being sealed to prevent inleakage of air. Mixing arrangements were provided for N₂ — CO₂ atmospheres.

The degree of reduction was taken as the ratio of metallic iron to total iron. For this determination the samples were reduced in size to $-200$ mesh and subjected to chemical analysis. Metallic iron determinations were carried out in 10 pct CuSO₄ solution. Some variance exists between results using this method and X-ray fluorescence analysis results, but the trends are identical.

**Results**

Early tests revealed that pellets made from mixtures of very fine components produced, upon firing, iron oxide. This is demonstrated by the observations of Russian workers who found that the presence of some CO₃ or CO in the surrounding atmosphere can accelerate reduction, but that the particle size of the iron ore has a much greater effect than that of the fuel. During reduction, the carbon monoxide released from within the pellet presumably forms an envelope preventing re-oxidation on the outer surfaces.

Agglomeration and development of strength in metallized pellets takes place over a specific temperature range. This is a result of sintering reduced iron particles and their shrinkage into the void spaces left by the reducing agent.

**Experimental work**

The variables likely to affect the reduction and agglomerating characteristics of the iron and coke mixtures are: (1) nature of the raw materials, (2) size distributions of iron ore and coke breeze, (3) size of pellet, (4) composition of the surrounding gas, (5) reduction time, and (6) reduction temperature.

Table 1. Size Distributions of Raw Materials

<table>
<thead>
<tr>
<th>Mesh B.S.S.</th>
<th>&quot;Iron Prince&quot; Hematitic Ore</th>
<th>Coke Breeze</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>36</td>
<td>90.4</td>
<td>71.4</td>
</tr>
<tr>
<td>72</td>
<td>82.3</td>
<td>43.7</td>
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<td>150</td>
<td>71.8</td>
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<tr>
<td>200</td>
<td>65.5</td>
<td>16.6</td>
</tr>
<tr>
<td>300</td>
<td>55.3</td>
<td>11.9</td>
</tr>
</tbody>
</table>

Fig. 2—Effect of particle size variation on the structure of metallized pellets. Left—minus $\frac{3}{16}$ in. ore mixed with minus $\frac{1}{2}$ in. coke; Right—minus 72 mesh ore mixed with minus 72 mesh coke.

The fine hematitic iron ore studied in this investigation contained 64.2 pct total iron and 2.6 pct SiO₂, while the coke breeze contained 76 pct C, 0.7 pct H₂, and 19.7 pct ash. It has been observed that considerable variation can arise when using other ores and fuels. The natural size distributions of the iron ore and coke breeze were considered to be the most convenient on which to proceed with initial investigations. It was found that pellets made from mixtures of these two materials screened at 18 mesh had reasonable green strength. The size-consist of the components is given in Table I.

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