Direct Reduction: The Flash Steel Process

A new slant on the old problem—this process is dependent upon fluid dynamics in a high-velocity gas column.

by J. J. Burke

A 72-year old independent inventor is making a bid for that most elusive of all jackpots: a successful direct reduction process. F. W. DeJahn, for many years employed at the Mines Experiment Station at the University of Minnesota, has received a patent on what he calls the *Flash Steel Process*, whereby pellets of sintered ore float down through a stream of rising gas, producing molten 1 pct C steel.

A general outline of the process is given in the simplified flow-sheet below. Pellets from $\frac{3}{8}$ to $\frac{5}{8}$ in. in diam and of specified strength and porosity are preheated to 1400°F in a rotary kiln and fed into the top of the reactor. A reducing gas of approximately 70 pct CO and 30 pct H₂, made by burning soft coal in oxygen, is fed into the bottom of the reactor.

The pellets are bouyed up by the gas stream, but as they are reduced and finally liquefy, they fall to a hearth at the bottom of the reactor. Undersize pellets and dust are blown out of the reactor, caught in a cyclone, and returned. Lime may be added to the molten bath in the reactor or, alternately, self-fluxing pellets may be used. The sensible heat in the gases leaving the reactor is used in the rotary kiln for preheating. Each pellet should remain in the gas stream from 25 to 30 min before liquefying and dropping into the hearth. Recent experiments have indicated that larger aggregates, in the form of briquettes, perform much better in the reactor.

These briquettes, manufactured by the Dravo Corp. in Pittsburgh, have the advantage of perfectly uniform size, shape, and weight. Containing no binder, the briquettes are strong, porous, and cost

less than pellets. Tests have shown that they are just as reducible as the pellets.

The molten steel product must be finished in an electric or open-hearth furnace.

Physical properties and dimensions of the pellets—their strength, porosity, and size—are critical factors. Porosity determines the pellet's ability to be completely reduced while in the reactor . . . size determines the length of time a pellet will remain in the gas stream . . . and strength is necessary so that the pellet does not break up before liquefying and get blown out of the reactor. Another important parameter is the density of pellets in the column. A certain amount of gas must pass each pellet while it is in the reactor in order to be completely reduced; if there are too many pellets in the column at one time, reduction will be incomplete. Briquettes show a further advantage in this regard, since only 100 are required per cu ft, as opposed to 1600 pellets per cu ft. This cuts down collisions between particles.

Control of these parameters and the fluid dynamics of a large high-velocity gas column are certainly Mr. DeJahn's biggest problem. From the thermodynamic and economic points of view, the process is very attractive indeed.

On the basis of a 1300 tpd plant, he estimates that installation cost would be \$20 to \$25 per annual ton of steel. Total production cost would be well below \$50 per ton.

The process is said to be adaptable to present blast furnaces, although considerable alteration would be necessary. Mr. DeJahn envisions that a 2200 tpd blast furnace, while costing \$50 million to convert into a flash steel furnace, would produce 7000 tpd using the process.

He estimates that 0.64 tons O₂ and 0.62 tons coal would be needed per ton of steel produced. Heat balances for the kiln and the furnace are given in the accompanying table.

Mr. DeJahn is currently engaged in further studies on the process using a model set up at the US Bureau of Mines Experiment Station in Pittsburgh as a cooperative project. The Bureau's interest is limited to studying the fluid dynamics of the system.

Simplified flow sheet for the Flash Steel Process.

Heat Balance of Flash Steel Process, Million Btu

Rotary Kiln		Flash Steel Furnace	
In		In	
Gas from furnace	2792	Gas	4953
Out		Pellets	823
Exit gas	575	Reaction	161
Pellets discharged	823	Total	5937
Heating pellets	914		
Reduction (partial)	80	Out	
Radiation	400	Fe	1500
Total	2792	Gas	2792
		Heating to 2511°F	370
		Slag	675
		Radiation	600
		Total	5937