Sponge Iron Used As a Precipitant for Copper

SPONGE iron as produced at Anaconda is a fine, —35 mesh impure product, about 50 pct metallic iron, obtained from reduction of iron calcine at a temperature of 1850°F using coke resulting from slack coal. Investigation of the treatment of Greater Butte Product, Kelley, ore at Anaconda early showed the desirability of using sponge iron as a precipitant for the copper in solution resulting from desliming of the ore in a dilute sulphuric acid solution.

Anaconda had done considerable work on the production of sponge iron in 1914 for use as a precipitant of copper from leach solutions. Some success and considerable experience were attained at the time. They were indicative that sponge iron might be successfully made by a modification of the process used in 1914, a batch process in which an iron calcine was reduced by means of soft coke, resulting from noncoking coal, in a Bruckner-type revolving horizontal cylindrical furnace widely used 50 years ago.

It was thought that the process, if changed to a continuous one, might work out satisfactorily. These favorable conditions at Anaconda justified the investigation: 1—Sufficient tonnage of good grade iron calcine resulting from the roasting of a pyrite concentrate in one of the acid plants, at substantially no cost. 2—Reasonably cheap natural gas. 3—No need for production of a high grade product. 4—No need for obtaining a consistently high reduction of the iron in calcine.

A small revolving Bruckner-type furnace about 2 ft ID x 4 ft long set up for early pilot work showed that a satisfactory product could be obtained at reasonable cost. It also indicated a marked advantage in preceding the reduction furnace with a furnace of similar size and capacity for preheating and roasting out any residual sulphur from the feed. The small furnace was operated for several months, various details of the process were worked out, and sponge iron was produced to supply a pilot LPF plant which treated 300 lb of Kelley ore per hr. Later a second pilot furnace 5 ft in diam and 12 ft long inside confirmed the data of the small furnace and gave a basis for design of the final plant.

At Anaconda a pyrite concentrate, running about 48 pct S, is recovered from copper concentrator tailings by flotation. This concentrate is roasted to sulphur of 3 pct or less at the Chamber acid plant. The iron calcine containing about 57 pct Fe and 18 pct insoluble is reroasted and preheated in a reroast furnace preceding the reduction furnace. Both are of the Bruckner type. The reroasted calcine is fed into the reduction furnace at 800° to 1000°F along with 30 pct slack coal. In the feed end of the furnace the volatile is burned from the slack, giving a soft coke which readily serves for iron reduction. Hard metallurgical coke will not serve the purpose, since it does not reduce CO_2 readily at a temperature of 1850°F. All indications are that the actual iron reduction is accomplished by carbon monoxide below the bed surface, which is 30 in. deep at center.

Table I. Production of Sponge Iron at Anaconda Copper Mining Co.

Daily Operating Data

Calcine feed, tons	65	Slack coal, tons	20
Final product, tons	45	Return coke, tons	5
Gas	300		
Iron reduced, pct	72		
Bed temperature, °F	1850		

Analyses

	Total Fe, Pct	Metallic Fe, Pct	S, Pct	Insoluble, Pct
Feed	58		0.50*	18
Final product	70	50	0.8	24

* Reroast to reduction furnace.

Apparently there is a constant interchange:

$$Fe_2O_3 + 3CO = 2Fe + 3CO_2. \quad CO_2 + C = 2CO$$

Actually iron oxide is reduced by CO at somewhat lower temperature than the 1850°F used in the process, but this temperature is necessary for a satisfactory furnace production rate. Gas flames from four 3-in. Denver Fire Clay Inspirator burners are played directly on the bed, which is slowly cascaded by the 1 rpm of the furnace. An excess of coke is necessary to assure maintenance of good reducing conditions in the furnace bed.

A satisfactory final sponge iron product involves two steps, production of the iron, and prevention of reoxidation during cooling. The firing end of the furnace is almost entirely enclosed and the product overflows at the firing end into a receiving duct in which raw gas is passed to maintain a reducing atmosphere. The furnace product passes from the duct directly into a Baker cooler where it is cooled from about 1500°F down to about 150°F. The Baker cooler has rotary seals at both ends to exclude air and prevent reoxidation of the sponge iron.

For satisfactory production of sponge iron sulphur content of the feed to the reduction furnace should not exceed 1 pct. A larger amount gives wall accretions, ball formation in the bed, and a dark inferior product that gives a poor efficiency in precipitation of copper.

Both pilot plants indicated the need for a boring bar in a commercial plant. At the 1850°F temperature necessary for satisfactory production from an individual furnace, there is a tendency for the formation of accretions on the walls of the furnace, and it is not feasible to remove these accretions by hand barring. A mechanically operated water cooled boring bar was designed which enables removal of the accretions satisfactorily.

The cooled furnace product requires preparation for use, principally reduction in size to —35 mesh and recovery of excess coke for return to the reduction process. Size reduction is desirable to lower the tendency of sponge iron to sand out in the flotation cells of the LPF plant.

FREDERICK F. FRICK is research engineer, Anaconda Copper Mining Co., Anaconda, Mont.