

REVERBERATORY SMELTING AT THE QUEEN BEE COPPER MINE, NEAR COBAR.

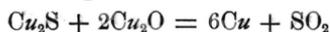
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OUTLINE OF THE PRINCIPLES OF REVERBERATORY SMELTING.

The reverberatory process of smelting copper ores consists, like the blast furnace process, of successive oxidations and fusions. The ores are, for the most part, mixtures of sulphides of iron and copper, with silica, lime, etc., and perhaps a certain proportion of oxidised copper ores, such as carbonate and oxide. During the roasting a certain amount of the sulphur in the sulphides is eliminated, producing oxides of iron and copper, with evolution of SO_2 . In the subsequent fusion the copper present, owing to its greater affinity for sulphur, combines with sufficient of that element to form the sulphide Cu_2S , with the result that there is not enough sulphur left to unite with all the iron. Such iron sulphide as is formed unites with the Cu_2S to form a matte, while the rest of the iron, which is in the form of oxide, unites with the SiO_2 and bases of the charge to form a slag, which is skimmed off and either thrown away, or re-smelted if it contains enough copper to pay for re-treatment.

This process is repeated until all the iron has been eliminated. On roasting further, the sulphur is driven off as SO_2 and Cu_2O forms. This Cu_2O reacts with the remaining Cu_2S producing metallic copper and SO_2 , according to the equation.—



These reactions do not adhere to the order given, but go on simultaneously to a certain extent, the products inter-acting with one another; also a certain amount of sulphates form during the roasting, and this further complicates the reactions.

The advantages of this method of smelting are as follows:—

- (1). It is particularly suited to a small concern such as the Queen Bee Mine, with only a small output of rich ore, owing to the fact that its working is intermittent and the capacity of the furnaces small. Even one small blast furnace, to be worked economically, would require as much ore per day as the reverberatory furnaces treat in a week.
- (2). The siliceous nature of the ore requires either a very siliceous slag or else expensive fluxes. The siliceous slag would be too infusible and viscous for a blast furnace, and would carry over a large amount of valuable matte, but in the reverberatory furnace, owing to the length of

time the slag is in contact with the matte, the products can separate themselves by gravity, even when the slag is very viscous.

- (3) Wood fuel can be used in a reverberatory furnace, and this is plentiful at the Queen Bee Mine, while the coke necessary for a blast furnace plant would have to be brought from Newcastle or Rix's Creek.

SITUATION AND GENERAL DESCRIPTION.

The Queen Bee Mine is situated about thirteen miles south of Cobar, and is reached by road, the railway only extending as far as the Peak, a distance of five miles. The plant consists of winding plant, rock-breaker, sorting table, saw mill, weighbridge, three reverberatory furnaces capable of putting through 600 tons of ore per month, a dam of 3,000 yards capacity and a brick-making plant. About £3,500 has been spent on the plant. The mine is being worked in the oxidised zone, and the ore assays from 10 per cent. to 15 per cent. *Cu*, although there are several patches which run as high as 50 per cent.

ROASTING.

Owing to the highly oxidised nature of the ore very little preliminary roasting is necessary. Such roasting as is done is performed in heaps, which usually contain forty to fifty tons. In constructing the heaps a layer of fines is first put down as a bed. Above this wood is laid for a depth of ten to twelve inches, and above the wood the ore is laid. The finished heap is about 20 ft. square and 3 ft. high. The wood is ignited and the roasting takes two weeks. Care must be taken that the heat does not rise sufficiently to fuse the ore, as this prevents the expulsion of the sulphur. When much sulphur is present this fusion is likely to happen. The result of the roasting is that the sulphur in the ore is reduced from 37 per cent. to 14 per cent., and it is also said to make the SiO_2 easier to smelt.

ORE FURNACES.

The ore is concentrated to a matte in two "ore furnaces." The charge for these furnaces is made up of oxidised and sulphide ores, or oxidised ore, roasted sulphide and raw sulphide ores. The copper contents are roughly 10 per cent., and this is concentrated to a matte containing 48 per cent. to 53 per cent. The sulphur in the charge is 10 per cent. to 14 per cent. The hearth of the smaller furnace is 17 ft. by 25 ft., and the other is slightly larger. They are both lined with 9 ins. of firebrick, and are provided by a stack 75 ft. high and 9 ft. square, also lined with firebrick and joined to the furnace by a flue about 30 ft. long, 4 ft square, and with an upward slope of one in twenty-five, supported by two iron rails at about 8 ft. from the ground.

METHOD OF WORKING.

The ore is brought to the furnaces by means of a tramway running from the ore bins and is charged in. The furnace is then closed up and the charge melted down. The oxide of iron combines with the silica to form a slag, which also contains most of the other bases, while the copper, sulphur, and part of the iron form a matte which sinks to the bottom of the charge. Two tons of slag are obtained from

from each charge, and this slag contains 0·8 to 0·9 per cent. of copper. It is skimmed off through a door on one side and runs into sand moulds. Any buttons of matte which come with it are caught in the first one or two moulds. The slag in these first few moulds is known as "plate slag," and is re-smelted. The "sharp slag" or rich slag from the "matte furnace" is also re-smelted as a flux in this furnace. The fuel consumed is one hundred tons of wood per week, and this smelts fifty to sixty tons of ore. The matte is tapped from the ore furnace at a door on the opposite side to the slag-skimming door, and is allowed to solidify in sand moulds.

MATTE FURNACE.

It is then conveyed in barrows or trucks to the "matte furnace," where it is worked up by successive oxidations to a "blister copper" or impure copper assaying 97 to 98 per cent. Cu . The method of working is as follows:—The matte is charged in twenty to twenty-five ton charges, with a little carbonate or oxidised ore. The furnace doors are closed and the charge melted down, the progress of operations being watched through a peephole left in one of the doors. When the charge is melted down two portholes 12 ins. square in front of the furnace are opened to admit air. Oxidation takes place with the formation of FeO and SO_2 . The FeO combines with silica in the charge to form a slag. After about four hours the furnace is closed up again to heat up the slag, which is then skimmed through a door in the back of the furnace. The slag skimmer is assisted by two men who stand at the portholes at the front of the furnace and push the slag back to the skimming door with rabbles.

After skimming off the slag the product in the furnace is a rich matte, but it still contains iron and silica, so the furnace is left open for another four hours, then closed to heat up the slag, and skimmed as before. This operation must be repeated several times before the iron and silica are removed. Finally only copper sulphide is left in the furnace. The furnace is then left open for ten hours while Cu_2O is forming. This reacts on the Cu_2S as already explained, and forms "blister copper," which is tapped off and cast in moulds of sand. The time of the whole operation of smelting from 50 per cent. matte to 98 per cent. "blister copper" in the matte furnace is fifty to sixty hours, and the copper produced per charge is about fifteen tons.

LABOUR.

The labour required on the second or matte furnace is one captain and one mate per shift and one wood staker per day.

DETAILS.

The hearth of the matte furnace is 23 ft. by 13 ft., and the height from the fire bridge to the roof is 2 ft. The spring of the roof is 1 in. to 1 ft. The grate is 4 ft. 4 in. by 4 ft. 6 in. by 5 ft., being very deep owing to the fact that wood fuel is used. The length of the grate is in the same direction as that of the furnace, and the ash-pit is transverse to it, the reason being that the force of the flame is greatest when the draught is in the same direction as the length of the logs. With coal fuel the arrangement is the reverse. The bridge is protected

from corrosion by the molten charge by an air-cooled iron plate which is in contact with the metal. The roof lasts for about two years with continuous work, but for a shorter time if the work is intermittent. The firebrick for lining the furnaces is brought from Newcastle, and contains 90 per cent. SiO_2 . The ordinary bricks are made at the Mine.

The bottom of the furnace is in two layers, known as the block and the bottom, each of which is 9 in. thick. The block is the lower layer. They are each composed of quartz containing 90 per cent. SiO_2 , which has been ground to pass a sieve of ten meshes to the inch. This quartz is put into the furnace, calcined, and then flattened out with clappers, which are round discs of $\frac{1}{4}$ in. iron, 1 ft. diameter, on the end of a long handle 1 in. square. A bottom lasts three or four years in the ore furnace with an acid charge, but only eighteen months in the matte furnace with its very basic charge.

After each charge is drawn the furnace bottom and sides are fettled with quartz made into balls with just enough clay to make it set.

The furnace is stayed with $\frac{3}{4}$ in. iron tie-rods, with eyes at the ends passing over 70 lb. rails.

The draught is provided by a stack similar to that for the ore furnace, and stayed with iron rods. The flue to the stack leads off from the furnace just above the slag-skimming door at the opposite end of the furnace to the grate.

Cost.

The approximate cost of erecting such a furnace, together with stack and shed is £800.

Note :—The paper was illustrated by photographs, and by specimens of ore and of the smelting products.

