

Mining and Metallurgy.

THE METALLURGY OF COPPER.

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II.

Continental Method.—MANSFELD PROCESS.—The extraction of copper as practised at Mansfeld will serve as an example of the Continental methods.

The ore which is found and so extensively worked at Mansfeld is principally copper pyrites with Malachite or Native copper, Blend Galena, etc. occurring in a bituminous shale, this tends to save fuel, the consumption of fuel being only $\frac{1}{4}$ that used at Swansea.

The ore here treated contains from four to five per cent. of copper and about 25 per cent. of silver, and there are not less than nine operations in connection with the extraction of the copper and silver, the following are the processes:

1. *Burning* in heaps to drive off water and bituminous matter.
2. *Smelting* in furnace for coarse metal.
3. *Roasting* coarse metal in stalls to drive off sulphur and oxidize iron.
4. *Fusion* for fine metal products copper 65 per cent with silver also, rich slag going to No. 2.
5. *Grinding* or granulation of fine metal.
6. *Roasting* ground fine metal to transform copper into cuprous oxide and silver into a sulphate.
7. *Solution* of silver sulphate in warm water and precipitation of silver with metallic copper.
8. *Smelting* residue in Cupelo furnace to produce blister copper or rich matt and poor slag.
9. *Refining* black copper either in a reverberatory furnace or in a German hearth.

1. *Burning.* The burning takes place in the open air upon a platform of stone from 200 to 300 ft. long, by 30 to 40 ft. wide. This is covered with faggots leaving air passages; the ore being piled on top and the wood ignited. Although the time necessary to complete this operation is from two to four months from 300 to 900 tons of ore are roasted, thus more work is done in two to four months than one ore furnace at Swansea could complete in a year.

Another consideration is that not more than ten pounds of fuel is used per ton of ore.

II. *Fusion.* The charge of roasted ore is fused with fluorspar and carbonate lime to slag of the oxide of iron, etc., and with oxide of copper to decompose the sulphide of iron and remove it in the slag. This operation was carried out until recently in a shaft furnace (Fig. V and VI), from 15 to 20 feet high and three to four feet in diameter, furnished with a pair of tuyers placed about two feet from the bottom to supply the hot blast heated to a temperature of 280° Fah. The fluid slag and regulus are run into basins C C lined with charcoal and clay through the channels O O. The fuel employed is charcoal, or a mixture of charcoal with gas coke, and is charged in alternate layers with the ore as in iron smelting. The chemical reactions which take place resemble that of the Welsh method No. 2: the liquid matter in the basins divides into two layers, slag at the top and copper and iron sulphides at the bottom. The slag is removed by ladles into moulds to be subsequently used for building purposes and the regulus removed in crusts as it solidifies.

The furnace used at present is a blast furnace 25 to 30 feet high, and six feet in diameter, lined with fire brick and supported by an iron collar on eight iron pillars. It has eight tuyers which conduct the hot blast under a pressure of two pounds per square inch to the furnace, the fuel used is coke and the slag runs continually off at one side into moulds, while the regulus is drawn off at the other side into water for granulation. This furnace will smelt a charge of 13 to 15 tons of calcined ore in 24 hours with 25 to 30 tons of fuel, the resulting product being coarse metal or "Rohstein" containing 30 to 40 per cent of copper.

III. *Roasting* in stalls (Stadeln.) The stalls are six in number built with a flue running up the back (Fig. VII.) to contain 200 to 300 cubic feet of coarse metal with fuel. The floor of these stalls are first covered with wood, then the coarse metal is introduced which after ignition of the fuel remains 10 to 12 days before the completion of the operation losing meanwhile from 15 to 20 per cent. by weight.

The ore is next placed in vats where the sulphate of copper formed by oxidation of the sulphide, is dissolved out in water. The sulphate of copper thus obtained by evaporation is sent into commerce whilst the dried matt is again roasted.

IV. Fusion of roasted coarse metal.

The matt from last process containing oxide of iron and sulphide of copper is treated as in Welsh method for the removal of iron by fusion with silica and production of fine metal.

The charge is:

Roasting coarse metal	200 Cwt.
Slag from No. 2 and silicious sand	2½ "

These fusions are made in reverberatory furnaces; until recently, however, shaft furnaces were employed. The matt is tapped into water for subsequent treatment.

V. *Grinding.* The matt containing 67½ copper and 35 per cent silver is ground between granite mill-stones.

VI. *Roasting* ground matt. The ground matt from No. V is roasted in a double bedded furnace 18ft. + 8ft. to oxidize copper and convert sulphide of silver into sulphate.

VII. *Solution of Silver.* In this process the sulphate of silver is dissolved out from the matt in large vats with water and subsequently precipitated with metallic copper.

VIII. *Fusion* The matt from No. VII. is mixed with a sufficient quantity (eight per cent.) of clay to enable its formation into balls about 4" in diameter; these are placed in a blast furnace with 10 per cent. of sand, 5 per cent sulphide of iron or gypsum, 10 to 15 per cent. slag, and from 1 to 2 per cent regulus from same operation. The resulting product is Black or blister copper containing 65 to 66 per cent. of copper.

IX. *Refining.* The Blister Copper is refined in a reverberatory furnace (Fig. VIII and IX) the hearth of which is lined with charcoal and clay upon which the copper is fused by the flame of a wood fire in the grate F and air is thrown upon the surface from two tuyers T T removing the sulphur as sulphurous anhydride and the foreign metals as oxides. When the refining is complete, as ascertained by testing a sample, the copper is run into the basins B B and removed in rosettes by throwing water upon the surface and removing the crusts formed.

The rosettes contain a large quantity of cuprous oxide which has to be removed by treatment in a German furnace (Fig. XXI.) consisting of a basin C 16" wide, lined with fire clay and charcoal and furnished with a blast pipe.

The copper is placed on glowing charcoal in the basin, covered with charcoal and fused by the hot blast and kept in a state of fusion until it is tough pitch owing to reduction of the oxide of copper, when the reduction is complete the refined metal is ladled into ingot moulds.

Wet Process is divided into three parts as follows:—

1st. *Extraction* of copper from solution in mine and other waters.

2nd. *Solution* of ores with acids (sometimes after roasting), and precipitation of copper with iron.

3rd. *Wet and dry combined.*

I. This process is carried out by allowing the water containing copper in solution to pass through tanks containing scrap iron which causes the copper to be precipitated in a metallic state.

II. As an example of this process the German hydrochlorine acid process is taken. It is worked in "twist" in Waldic and consists in the treatment of sandstones impregnated with carbonate of copper, containing 1 to 1½ per cent. of copper, with dilute hydrochloric acid. The solution for precipitation is pumped into vats containing scrap iron where the copper is precipitated in an insoluble gangue.

III. Dry and wet process.

There are many processes under this heading including those of Longmaid, Bankart, Birkmyre, Henderson, Hunt and Douglas.

The latter is considered one of the best, and will, therefore, be used as an example of the wet and dry methods.

The Hunt and Douglass process is for the extraction of copper from oxidized compounds whether they are natural or obtained by roasting sulphuretted ores.

The oxidized ores are acted upon by an aqueous neutral solution of ferrous chloride and zodic chloride whereby the oxides of copper are converted into cuprous and cupric chlorides while iron separates in form of hydrated peroxide. The presence of