COPPER SMELTING PRACTICE IN LAKE SUPERIOR REGION.*

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Copper smelting in the Lake Superior district of Michigan comprises the melting of concentrates and mass containing native metallic copper, the refining of the copper, and the smelting of the slag formed during the melting operation to recover the high metal values carried by it. In the simplicity and directness of the methods and processes required the Lake practice differs very greatly from that of any other district and is altogether different from that involved in the treatment of the ores of copper. The absence of roasters, calciners, matte furnaces and converters, and the electrolytic refinery, essential to the smelting of copper sulphides—the usual source of copper in other districts—is apparent at once to the metallurgist; and the very simplicity of the operations has given rise to the widely spread idea that "there is no metallurgy in Lake Superior smelting." The problems here are the effective use of fuel, the efficiency of labor, the avoidance of excessive amounts of metal in the reverberatory slag, the successful smelting of the slag and the prevention of losses in the waste slag; while the operation of refining, for many years regarded as a deeply mysterious proceeding, demands care and technical knowledge to obtain the most satisfactory results.

Summary of Treatment.

Copper occurs in the Lake district practically altogether in native form, either disseminated through conglomerate or amygdaloid rock in sizes vaying from the finest particles to pieces weighing several pounds, or existing in masses running from a few pounds in weight up to several tons. After being hoisted from the mines the rock containing the copper is crushed, stamped and concentrated on jigs and slime tables until the percentage of the metal is brought from its initial figures in the vein rock of from 1 to 3 per cent. to from 60 to 80 per cent., according to the system best adapted to each kind of rock. The mass copper is broken and cut, and cleaned of rock as far as possible. The concentrates, known locally as mineral, and the mass are then shipped to the smelters ready for the furnace treatment.

The mineral and mass are generally, with some exceptions to be mentioned later, charged into reverberatory furnaces and melted down without any fluxes, the slag skimmed off as fast as it is formed and the remaining copper either refined in the same furnace or in a secondary reverberatory furnace into which it is tapped. The refined copper is then either ladled or dipped into moulds to form the several shapes into which it is marketed.

The slag is skimmed usually into conical pots, some metallic copper settling to the bottom in a button, cooled and broken into pieces and transferred to the storage floor or bins at the blast furnace. It is then smelted in a blast furnace with limestone, with the addition of ferruginous or siliceous fluxes as may be necessary, coke being used as fuel for melting and anthracite as a reducing agent. The resulting "cupola" copper is tapped into blocks which are melted in reverberatory furnaces and refined; while the waste slag, low in copper, flows continuously from the slag spouts into pots or into granulating devices for removal to the slag dump.

The Lake Superior smelting industry and its methods had its origin in practice derived from Wales, Welsh refiners having been employed in the works first established 50 years ago in Detroit, Mich., for the treatment of the Lake copper.

The old-time reverberatory furnace, with a capacity of 7 or 8 tons of copper—increased later to as much as 20 tons—had a hearth 11 ft. wide by 14 ft. long, with a fire box 4 ft. square. The sides and roof were laid up with clay fire brick and the hearth was put in with a highly refractory sand carefully baked in layers and seasoned with copper. Furnaces of this sort are still in use at three of the works. They are charged with mineral and mass in the afternoon, the fires are cleaned and built up, and the melting continued during the night, slag being skimmed off at intervals until the gauge has been removed, and early in the morning the charge is ready for the refining operations. The first step, known as rabbling, is to oxidize such comparatively small quantities of impurities as occur, which come to the surface and are skimmed off. Fortunately, these impurities are more readily oxidized than the copper, sensitive though the latter is to the attack of oxygen; but unfortunately suboxide of copper is formed also, some of it being removed with the impurities in the slag, though most of it remains in solution in the molten charge. This then must be reduced back to metallic copper by the introduction of carbonaceous material, poles of hardwood being used for this purpose and buried deep into the copper. During these periods small quantities of slag formed by the oxides are skimmed off. The completion of the rabbling, or the extent to which the oxidation is carried, is indicated to an experienced observer by the character of the crystallization of the copper as exhibited in the fracture of a test button taken from time to time. The coarseness of crystallization which must be attained and the degree of oxidation to which the copper must be subjected depend on the nature of the material being refined and the proportion and kind of impurities present—the time required varying from 2 to 6 hours. The test button is commonly taken with a small ladle 2 ins. in diameter and the button is three-fourths of an inch thick. It is placed in a vise, nicked and broken across the middle so as to expose the fracture and the small hole just under the top. The usual test made when the copper is poled up or refined is for electrical conductivity, and while with cathode copper the button need be only finely granular to assure a conductivity of 100%, to reach that figure with copper refined from the concentrated native mineral the button must be coarsely crystalline. In refining the cupola copper recovered from the slag the button may have the same coarse crystalline fracture and still the conductivity may not be over 70%. The amount of impurities is by no means uniform from one time to another even for the same kind of copper, and no general rule could be deduced to govern all cases because it would be necessary in order to apply the rule to determine precisely the kind and amount of impurities contained in each furnace charge—a proceeding which, for obvious reasons, is entirely out of the question. Rabbling was formerly accomplished by stirring the surface by pushing a rabble—a 4 by 6-in. piece of iron attached at right angle to an iron handle 8 ft. long—back and forth; this laborious operation has been entirely superseded by the use of compressed air either blown through 1-in. iron pipes inserted into the copper or made to impinge on the surface.

The refiner in charge of the furnace having satisfied himself by repeated tests that the copper is sufficiently purified submits a button to the foreman for his judgment; and if this is favorable, the poling is started and carried on until the surface of a test button sets level and without any depression when cold, this being the end of the refining process and the metal being then ready to be poured into

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