Nickel Flash Smelting

Abstract:
The two commercial classes of nickel ore (sulfide ores and silicate oxides) are produced in the highest quantities in Canada and Russia which equates to approximately 20-25% of the world's production.
Using nickel flash smelting technology it is possible to process sulfide nickel concentrate and produce nickel matte and slag in a relatively efficient process. Any materials resulting as smelting and converting slags are recirculated in the electric furnace and recovered where possible as nickel matte.

Nickel (Ni) is a silvery-white, hard metal. Although it forms compounds in several oxidation states, the divalent ion seems to be the most important for both organic and inorganic substances, but the trivalent form may be generated by redox reactions in the cell. Nickel compounds that are practically insoluble in water include carbonate, sulfides (the main forms being amorphous or crystalline monosulfide, NiS, and subsulfide Ni_3S_2) and oxides (NiO, Ni_2O_3). Water-insoluble nickel compounds may dissolve in biological fluids. Particles of the same chemical entity (oxides and sulfides) have different biological activity depending on crystalline structure and surface properties.

There are two commercial classes of nickel ore, the sulfide ores (pentlandite and pyrrhotite) and silicate-oxide. Most nickel is produced from the sulfide ores, and the two largest producers, Canada and the Russian Federation, account for

20–25% each of total annual production, which was 784.82 thousand tones in 1988.

In Nickel Flash Smelting technology, sulfide nickel concentrate is processed in the Outotec® Flash Smelting Furnace to produce nickel matte and slag. The matte is transported to the Peirce-Smith converters where it is blown to high-grade matte. The metal values in the smelting and converting slags are recovered in the electric furnace as nickel matte. The matte is then circulated to the Peirce-Smith converters.

The dried feed mixture, oxygen-enriched process air and distribution air are mixed in the concentrate burner to assure an even distribution of the feed in the reaction shaft suspension. As the dried charge flows downwards in the reaction shaft, the concentrate particles dissociate, ignite and undergo controlled partial oxidation generating a large amount of heat, which results in the melting of the material into fine droplets. In the settler, the immiscible slag and matte phases separate and form two layers according to their specific densities.

The process gas flows upward through the uptake shaft and then to a heat recovery boiler for cooling. Part of the flue dust is separated from the gas stream in the boiler. The gas flows onward to an electrostatic precipitator where the remaining fine dust is recovered. The dust collected under the boiler and precipitator is returned back to the furnace.

The produced slag is tapped from the Flash Furnace and directed along with the converter slag into an electric slag cleaning furnace before being granulated and discarded. Reduction is carried out batch-wise using coke as a reducing agent. During the settling period, reduced metal droplets and mechanically trapped matte droplets are settled through the slag layer to the bottom of the electric furnace to form the matte layer. Immiscible slag components with a much lower density stay at the top of the bath and form the cleaned slag layer.

The mattes obtained from the flash smelting furnace and from the electric *Outotec® Slag Cleaning Furnace* are converted in Peirce-Smith converters with oxygen-enriched air, which is blown through tuyeres into the converter. For slag forming purposes, some silica flux is added. The produced high-grade matte is granulated and further treated in the refinery. The waste slag is also granulated and transferred to the slag disposal area.

A typical flash smelting furnace is shown schematically in Figure 1. The refractory-lined furnace vessel is composed of three sections: reaction shaft, settler and uptake shaft. In the flash smelting process, a sulfidic feed mixture is distributed through the top of the reaction shaft by a concentrate burner, where the correct design is vital to furnace operation. The concentrate burner consists of several concentric ducts through which the process gas and the concentrate are blown and mixed in the furnace. The main task of the burner is to produce an optimal suspension of solid particles and oxygen-enriched process air in the reaction shaft.

Individual particles heat up as they fly about in the furnace and after ignition they start to combust with oxygen in the process gas. The combustion reactions with fine (<100μm) sulfides are very rapid and a substantial amount of heat is released, which leads to the complete melting of the combusting particles, as well as that of the other materials introduced in the feed mixture. The molten particles flow downstream and they are collected in the settler, where silicate slag and sulfidic matte layers are separated. The off-gas (mainly an SO_2-N_2 mixture) flows through the uptake to the waste heat boiler, where it is cooled down and its heat content is recovered as steam.