

Refining Unit Process Stage

The refining process begins with nickel matte or crude nickel products' delivery to the refining stage and ends at the gate to delivery of the finished nickel products. The following sections provide more detail of the technologies, processes, and modeling.

Matte refining into Class I Nickel

Matte refining into class 1 nickel begins with crushing, leaching, and separation of matte. One questionnaire is sent for the crushing-leaching-separation stage due to the metal-containing coproducts. The subsequent four stages, concentration of iron and cobalt, purification, and electrolysis, also each are their own black box.

A mass allocation of the metal in the coproducts is made for each black box. The SO_x allocation rule applies to the leaching/separation stage.

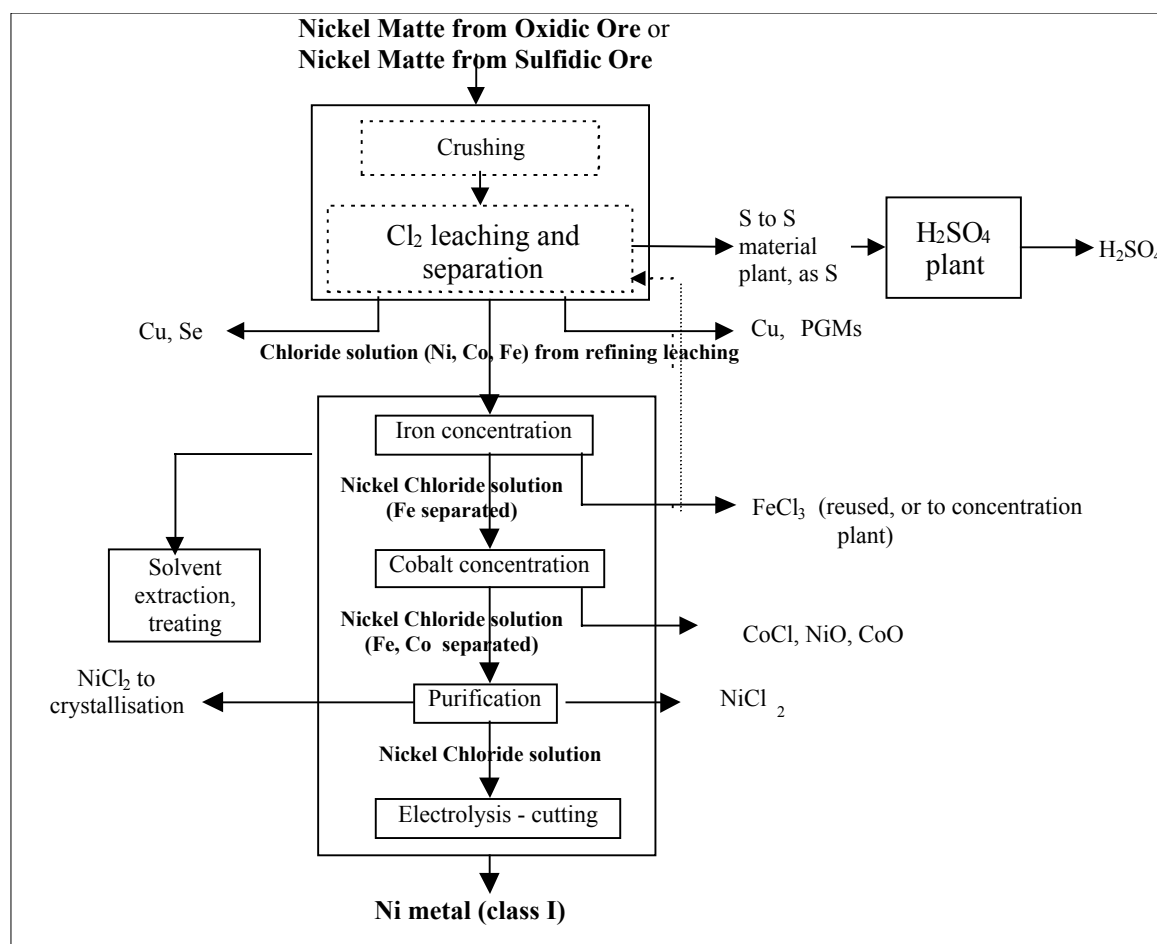


Figure 29 Refining: Class 1 Ni Production from Matte (Integrated Facility)

Some facilities' processes are not as integrated as those in Figure 29. Matte here may be leached (producing coproducts), and then undergoes electrolysis to produce Class 1 nickel.

Separate data are collected to allocate the leaching flows to the metal coproducts, and a mass allocation on the metals is made.

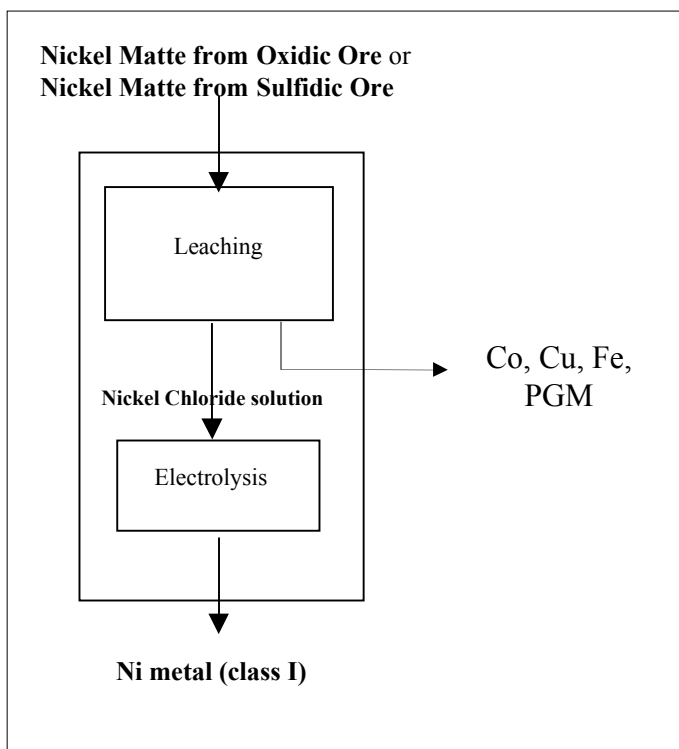


Figure 30 Refining: Class 1 Ni Production from Matte (Less Integrated Facility)

Hydrosulfidic Refining

Case 1

The processes for hydrosulfidic refining include electrorefining and electrolyte purification of nickel matte (or sulfide anodes) to produce CoO and Ni cathodes. Only one black box is considered since the CoO as a coproduct occurs at purification. A mass allocation on the metals is made.

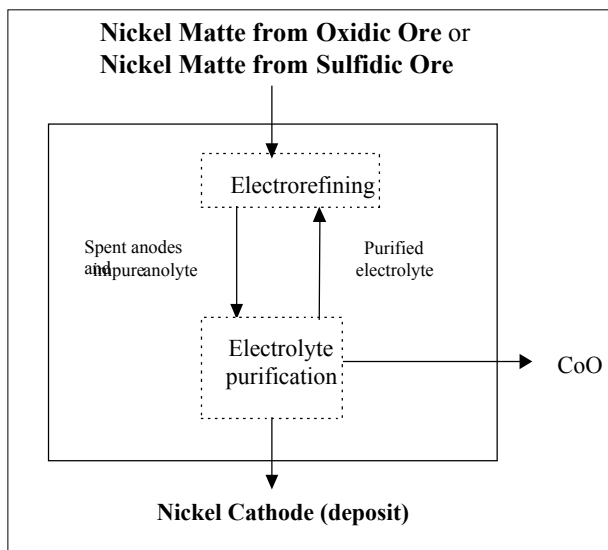


Figure 31 Refining (Hydrosulfidic): Ni Cathode Production from Nickel Matte (Part 1)

Ni cathodes are then shipped to another location which produces nickel products, according to the figure below. Only one black box is needed for this process.

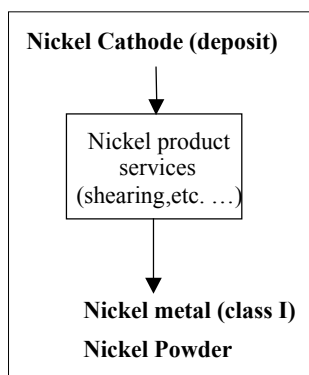


Figure 32 Refining (Hydrosulfidic): Ni Products Production from Ni Cathodes (Part 2)

Case 2a and 2b

Another hydrosulfidic refining process takes nickel cobalt sulfide or nickel matte and goes through the following processes to produce Class 1 nickel products: leaching, cobalt and copper extraction, nickel reduction, sulfide precipitation, and nickel handling, as shown in Figure 33a and b below:

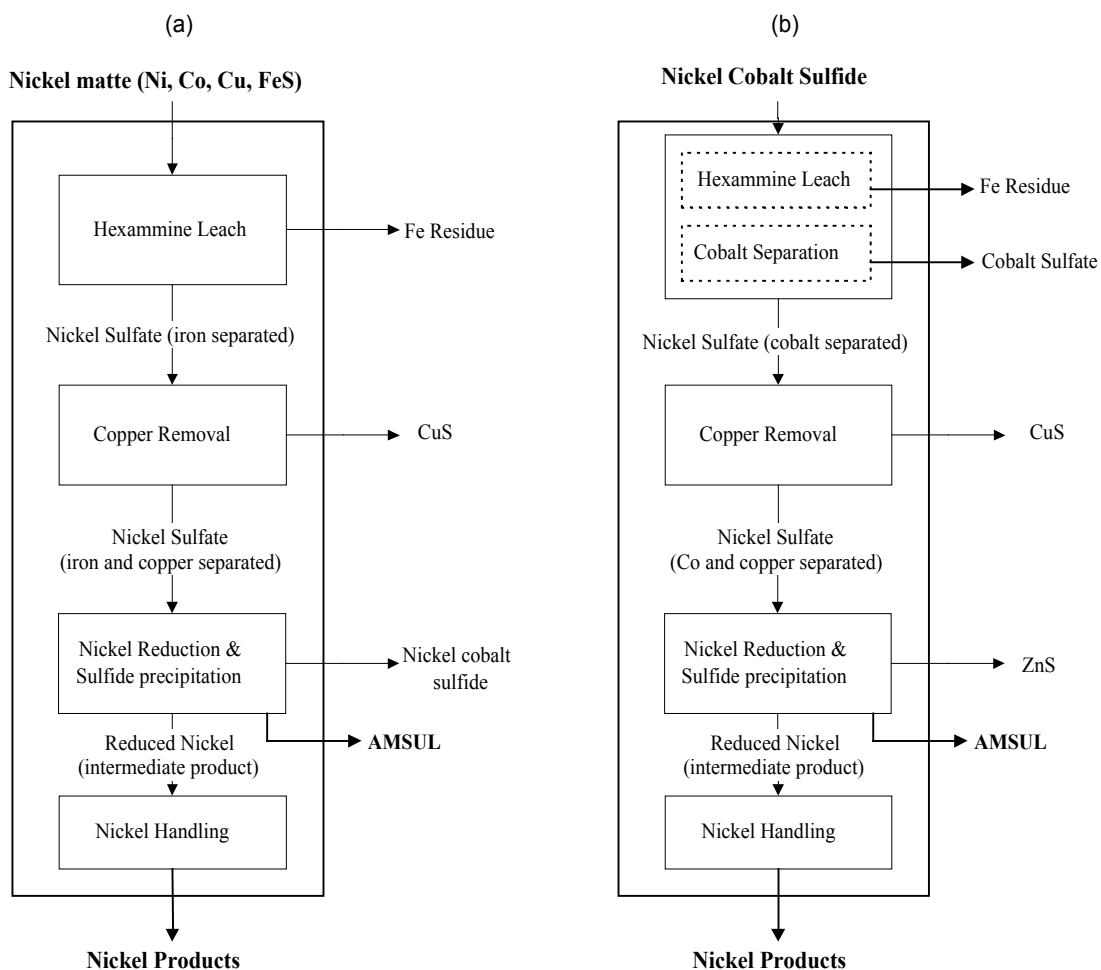


Figure 33a and b Refining (Hydrosulfidic): Ni Products Production from Nickel Cobalt Sulfide and Nickel Matte

Case 3

A third hydrosulfidic refining case occurs by putting nickel matte through the following processes to produce Class 1 nickel and nickel briquettes: grinding and leaching, cobalt removal, and electrowinning and hydrogen reduction, as shown in Figure 34 below:

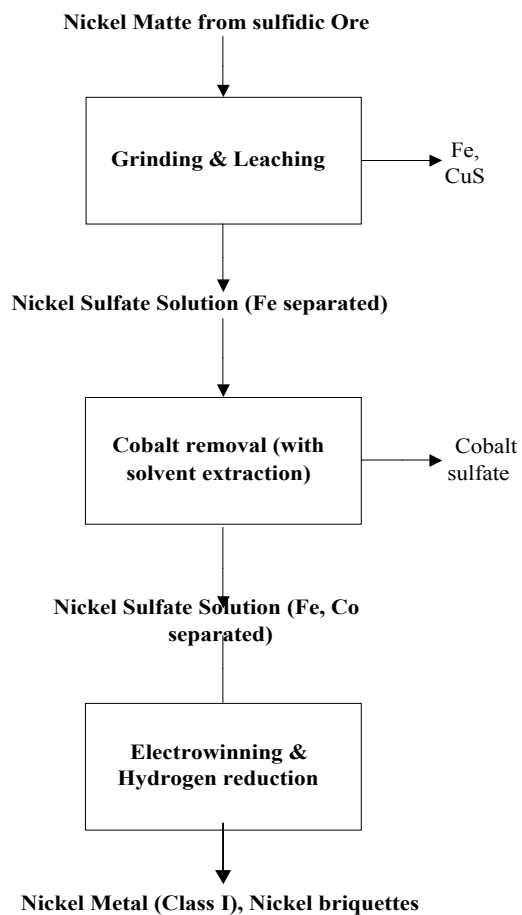


Figure 34 Refining (Hydrosulfidic): Ni Products Production from Nickel Matte

Case 4

A fourth hydrosulfidic refining case occurs by putting various nickel feeds through the following processes to produce Class 1 nickel and a nickel-cobalt slurry: grinding and leaching, nickel purification, roasting, and nickel electrolysis and cutting (see Figure 35).

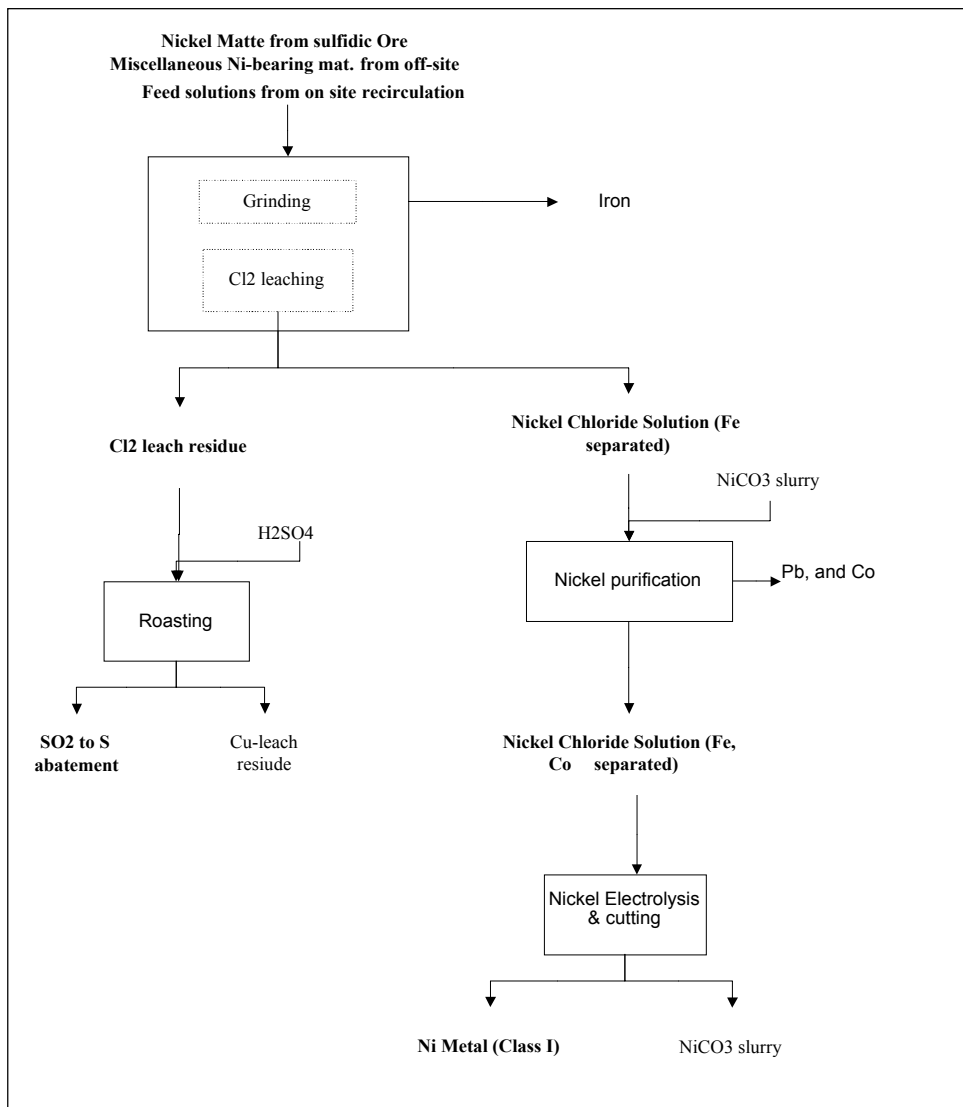


Figure 35 Refining (Hydrosulfidic): Ni Products Production from Various Nickel Feeds

Caron Process

For this process, nickel cobalt liquor undergoes solvent extraction to separate the nickel and cobalt into different product streams. The nickel liquor is then converted to a slurry and refined to produce Class 1 nickel metal and nickel oxide. The cobalt liquor is further refined and then precipitated to produce cobalt oxide hydroxide (with a mass allocation made on the metals content in the two products). The slurry is then reduced to produce Class 1 nickel metal and nickel oxide. A total mass allocation is made for these two nickel products.

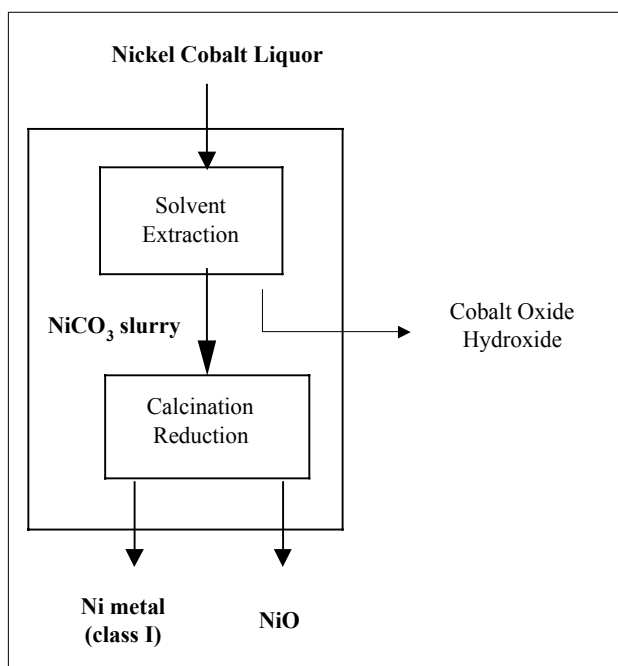


Figure 36 Caron Process: Ni products Production from Nickel Cobalt Liquor

Carbonyl Process

The carbonyl process involves processing nickel and copper metallics and nickel oxide to produce crude liquid carbonyl, which is further processed into Class 1 nickel and ferronickel. A mass allocation is made between the mass of the nickel content in the crude liquid carbonyl and the metals contained in the Integrated Pressure Carbonyl (IPC) residues in the first process box, considered a black box. A total mass allocation is made on the Class 1 nickel and ferronickel produced at the end.

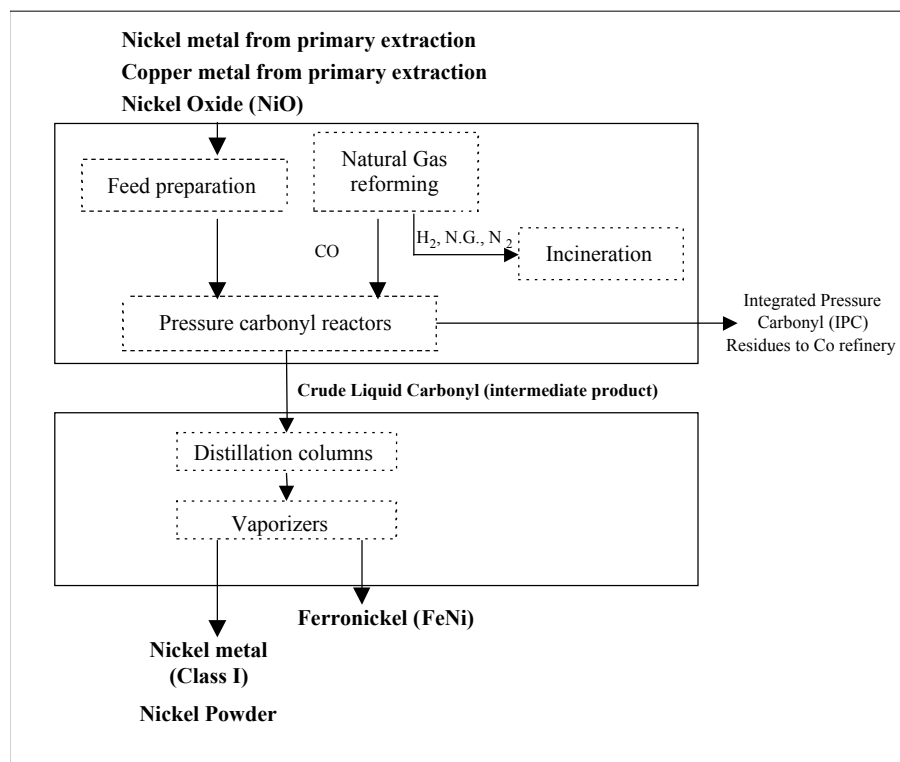


Figure 37 Refining: Class 1 Ni and FeNi Production with Cu/Ni Metallics and NiO (Carbonyl Process)

Pyrometallurgical Refining of NiO

Pyrometallurgical refining of nickel includes reduction of nickel oxide and subsequent volatilization into Class 1 nickel and nickel sulfate. A mass allocation is made on the nickel content of these two products. One black box is considered for this process.

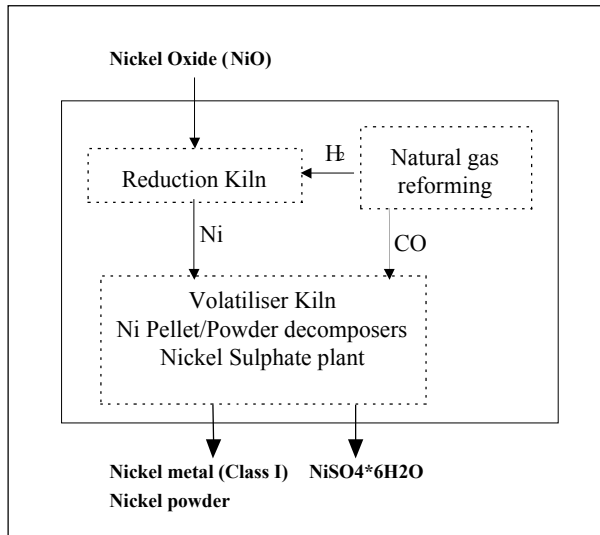


Figure 38 Refining (Pyrometallurgical): Class 1 Ni Production from NiO