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Development of process models for copper production, processing and recycle

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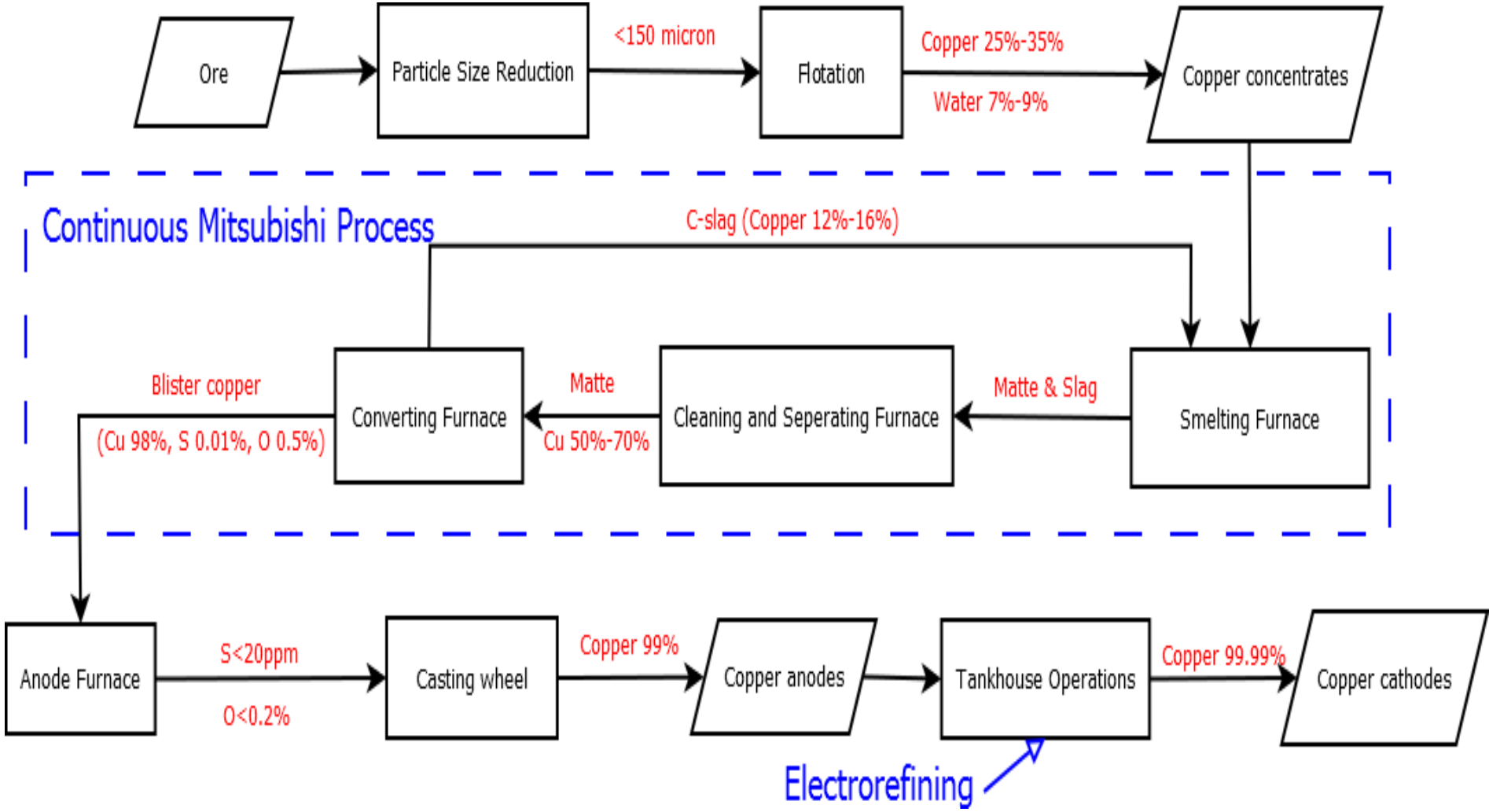
Motivation

Implement a modelling and optimization tool for demand side management, higher purity of copper cathodes (>99.99%), lower energy consumption and environmentally friendly process.

Focus currently

- Establish process flowsheet

- Simulation of Smelting furnace


Ore
Particle Size Reduction
<150 micron
Flotation
Copper 25%-35%
Water 7%-9%
Copper concentrates
Continuous Mitsubishi Process
C-slag (Copper 12%-16%)
Blister copper
(Cu 98%, S 0.01%, O 0.5%)
Converting Furnace
Matte
Cu 50%-70%
Cleaning and Seperating Furnace
Matte & Slag
Smelting Furnace
Anode Furnace
S<20ppm
O<0.2%
Casting wheel
Copper 99%
Copper anodes
Tankhouse Operations
Copper 99.99%
Copper cathodes
Electrorefining

Main parts for copper process

- From ore to copper concentrates

  Grinding and Flotation

- From copper concentrates to copper cathodes

  Continuous Mitsubishi Process → Smelting Furnace

- From copper anodes to copper cathodes

  Electrorefining

Simulation of Smelting Furnace

- Main reaction

  $CuFeS2 + O2 + SiO2 \rightarrow (Cu,Fe,S)(matte) + FeO \bullet SiO2(slag) + SO2$

- T = 1230C P=1atm
- Predict product composition and distribution in multiple phase (matte/slag/gas)

Simulation of Smelting Furnace

- Method: Gibbs Energy Minimization

$$\mathrm{G} = \sum_{p=1}^{\phi} \sum_{i=1}^{N} n_{i,p} \left(\Delta G_{fi}^{0} + RT ln f_i^p \right) \qquad (1)$$

- Constraints:

  Reaction equilibrium : atom balance

  Multiphase equilibrium : phase balance

  Nonideal liquid mixture : interaction of molecule

Simulation of Smelting Furnace

- Thermodynamic approach:

  Gas: Ideal gas mixture.

  Liquid: Modified Quasichemical formalism

- Data sources:

  Thermodynamic Database for the Cu-Fe-O-S-Si system in FACTSAGE

Preliminary results:

Assumption: Ideal solution

Substance	inlet mole flow (kmol/hr)	Outlet mole flow (kmol/hr)
Main reactants		
CuFeS2	489.1304	67.605
O2	1000	0
SiO2	500	300.455
Matte		
Cu2S	-	211.633
FeS	-	24.176
Slag		
Fe2SiO4	-	199.835
FeO	-	0.0002804
Cu2O	-	0
Off gas		
SO2	-	610.723
N2	1000	1000
Min Gibbs = -8.654E02GJ		

Trade off!

Conversion of CuFeS2 = 86.18%

Future work

- Simulate Smelting furnace based on nonideal solution
- Address models of remaining major units
- Complete mass and energy balance of entire process
- Determine prediction of power consumption

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Thank you!