Advanced Metallurgical Modelling of Ni-Cu Smelting at Xstrata Nickel Sudbury Smelter

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Business Objective

An independent business providing high-end technical services to the metallurgical industry including:

- Providing strategic operational and technical support to significantly impact the efficiency and growth of Xstrata
- Identifying, developing and transferring technology of high value to Xstrata businesses
- Providing high value services to external customers
Outline of Presentation

1. Introduction

2. Brief review of smelter process with regard to model development

3. Modelling approach

4. Applications of the model

5. Conclusions
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Aerial view of the Xstrata Nickel Sudbury smelter
Falconbridge, Ontario, Canada
Introduction

- Xstrata Nickel’s Sudbury smelter is located at Falconbridge township some 15 km northeast of Sudbury, Ontario, Canada.

- The plant has been in operation since 1930. It has undergone a number of expansions and modifications since that time. The present plant consists of fluid bed roasters, an electric furnace and converters, together with an acid plant.

- The plant typically processes 550,000 tonnes/year of nickel-copper concentrate material producing about 67,000 tonnes/year nickel in the finished matte shipped to Norway for final refining.

- Currently the smelter is reviewing environmental performance and capacity aspects and a new comprehensive process model was desirable.

- This paper discusses the development of this model.
Process Operations: **Roaster**

One of the two, 6.1 m diameter fluid bed roasters at the plant.

The fluid bed roasters were modeled using a standard heat and mass balance module.

Controllers were used to set the target degree of sulphur elimination.
Interior of the single 45 MW electric furnace sized 10 m by 30 m

Electric furnace smelting requires a large amount of input heat energy. Reliable modelling requires good knowledge of slag and matte properties. A molecular approach was adopted to model the liquid phases in the present work.
Process Operations: **Converter Aisle**

The present converter aisle includes four vessels.

Experimental data were incorporated into METSIM to allow for reliable modelling of the converter operations.
Process Operations: **Acid Plant**

View of the acid plant used to treat roaster off-gas

The acid plant was not modeled in the present phase of the work
Modelling approach
METSIM model - I

- Validation with existing plant data
- Emphasis on reliability, accuracy and robustness
1. To model the slag and matte phases, conventional “molecular theory” was applied:

- Adequately accounted for first “nearest neighbor pairs”

- With a careful selection of high temperature minerals and/or “pseudo-components” using FACTSAGE, the heat balance can be calculated with the required accuracy

2. FeS, NiS, Cu$_2$S, Ni, Fe and Co were chosen as the components considered to model the matte phase (the matte is partly metallized)
3. Thermodynamic data for a number of components in slag and matte were cross-checked between FACTSAGE and METSIM. Agreement was generally good.

4. For the slag phase, “pseudo-components” like Fe$_2$SiO$_4$, Mg$_2$SiO$_4$, MgSiO$_3$, Ca$_2$SiO$_4$, CaSiO$_3$ etc. were chosen.

5. Thermodynamic data were not available in METSIM for certain “pseudo-components”, hence data were taken from FACTSAGE.

6. Heat capacity of slag and matte phases were verified with FACTSAGE and experimental data to ensure reliable heat balance.

7. The gas phase was assumed to follow ideal behavior.
METSIM and FACTSAGE model development

**Inputs**
- Feed data (feed rate, chemical and mineralogical data)
- Operating data, heat losses, etc.
- Experimentally determined data
- FACTSAGE output (liquidus)

**Outputs**
- Process data (slag, matte and off-gas data)
- Consumables (coke, oxygen, power, natural gas...)
- Emissions (CO$_2$ and SO$_2$)
METSIM model: Roasters

Process Parameters

- Degree of sulphur elimination
- Slurry density
- Oxygen enrichment
- Calcine temperature
METSIM model : Electric Furnace

Process Parameters

- Melt and freeboard temperatures
- Matte grade
- Slag and matte partition coefficients
- Coke behavior
- Sulfate decomposition in free board
- Magnetite level in slag

(3 site reaction)
METSIM model : Peirce-Smith converters

Process Parameters

- Temperature
- Magnetite level in slag
- Fe/SiO₂ ratio
- Slag and matte partition coefficients
- Fe level in finish matte
- Degree of matte entrainment

All unit operations are linked together for mass and heat flow
METSIM model: Example of dynamic data exchange
Applications of the model
Applications of the model

The model has been used extensively at the Xstrata Nickel smelter for:

- Scenario planning (shut down/maintenance, equipment availability, dealing with feed changes, removing or adding new vessels.)

- Environmental aspects (CO$_2$ and SO$_2$ emissions)

- Alternative operating options (technical and economic feasibility studies)

Helping to identify potential options for piloting
Metallurgical modeling
In addition to the case study discussed here (Nickel smelter), XPS is/has been involved in advanced metallurgical modeling work in a number of different projects:

- Nickel and PGM smelting (Africa)
- Copper smelting (Canada and Chile)
- Ferronickel smelting (world-wide)

Techno-Economic modeling
By linking Metsim (and FACTSAGE) with economic data, for example, an Excel sheet/file, a powerful techno-economic tool becomes possible.

XPS is currently building such models for the Xstrata smelters and External smelters.
Conclusions

- An accurate, reliable and robust process model of the Xstrata Nickel smelter was built and used for exploring different operating scenarios.

- The approach of incorporating FACTSAGE information, when required, into METSIM makes it a very powerful modeling tool reflecting overall operations.

- XPS is ready to assist you with modeling work.
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Any questions........