Dynamic Simulation of Batch Copper Converting Using SysCAD with ChemApp

Tanai Marin, Kevin Heppner

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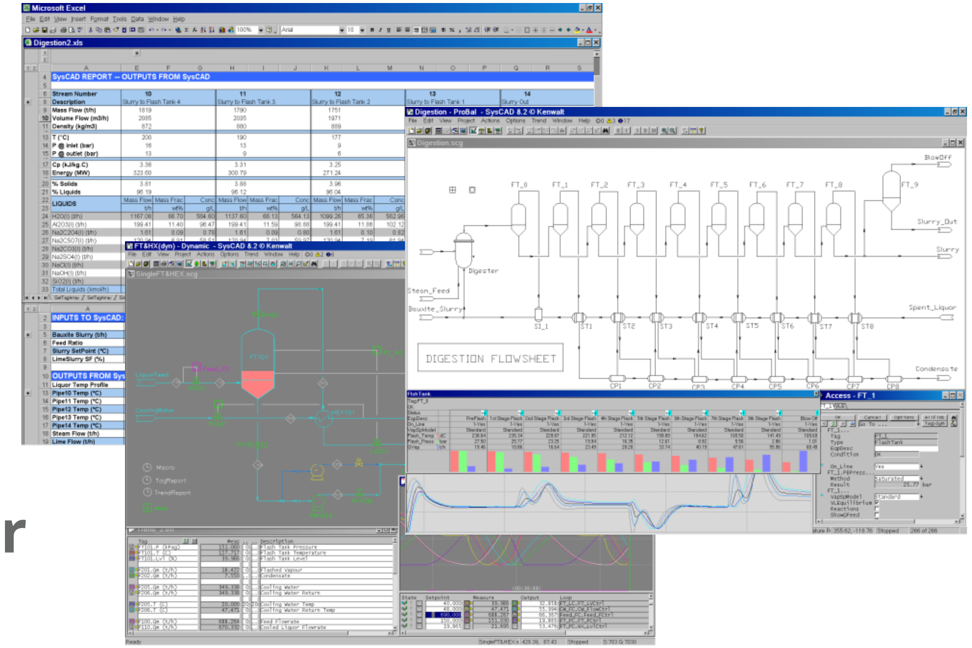
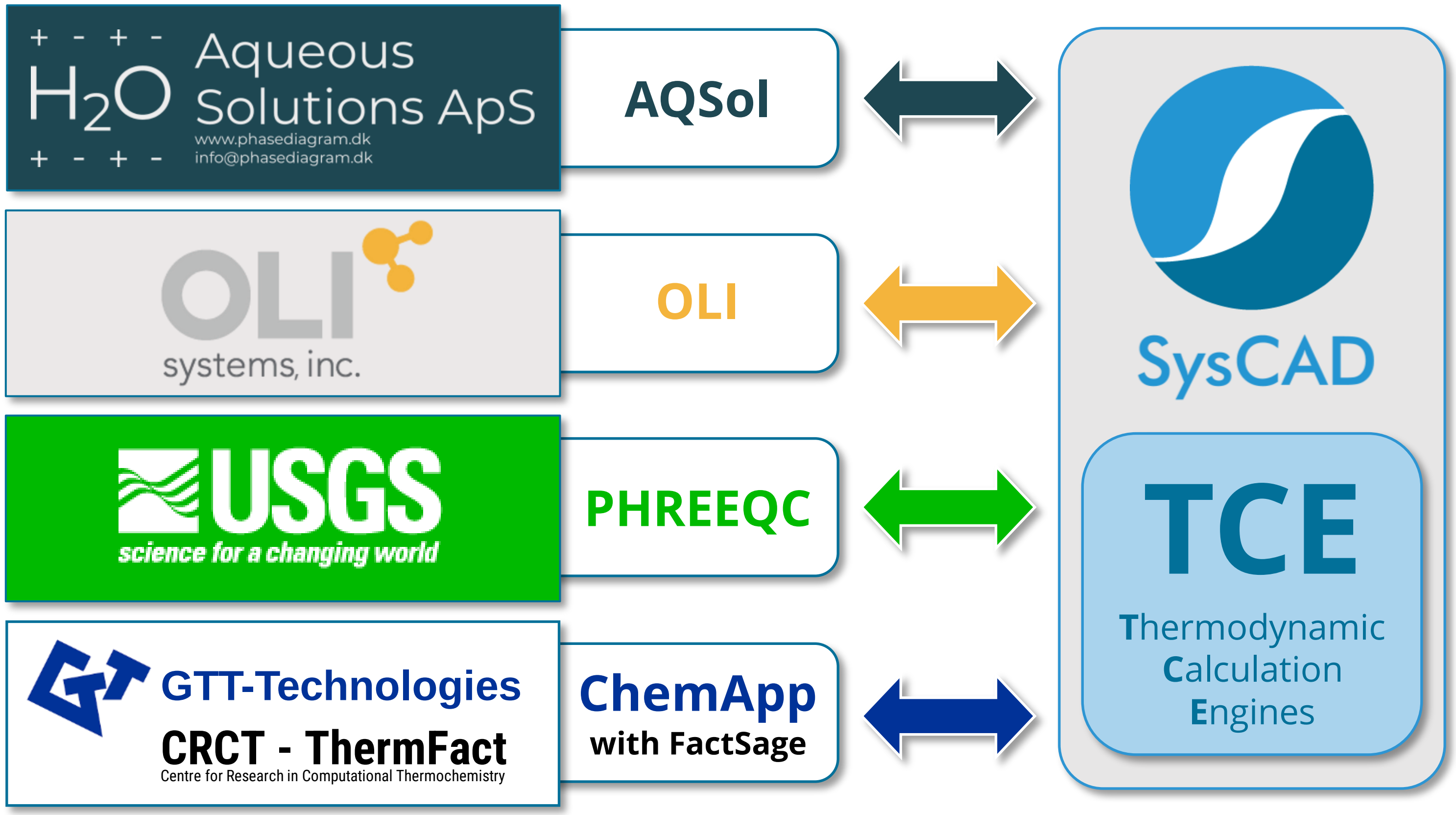
What is SysCAD?

- **Powerful & versatile Process Plant simulator**
- **Steady State or Dynamic mode**
- **Simulate simple to complex full plant operation**
- **An invaluable process design tool that will help users gain tremendous insights into their process operation**
  - Good process knowledge aids better decision making
  - Improved plant operation performance
  - Cost saving
  - More efficient and knowledgeable operators



Thermodynamic Calculation Engines (TCE)



- Detailed thermodynamics applied *as needed*
- One SysCAD model, multiple TCEs and chemistry models
- Parallel processing
- User-friendly features

Batch Cu Converting

Process Description

Process Description

- **Cu converting is traditionally carried out in Peirce-Smith converters.**
- **It is a batch process receiving furnace matte. Mainly consisting of two distinctive steps**
  - Slag blows → removal of Fe to slag to produce white metal ("Cu_2S")
    - Depending on initial matte grade
    - Could consist of 2 or 3 slag blows, each receiving fresh furnace matte and skimming slag at the end of the blow
    - Fe end-point might be higher for initial blows
  - Cu blow → removal of S from Cu to produce Blister Cu
    - Longer blow, needs cold charge (high grade reverts) for temperature control
    - Transition through Cu-S miscibility gap
  - In a converter aisle, several 2-4 converters typically operate in staggered sequence, with one in Cu blow (high and continuous SO_2 stream) whereas other converters are in slag blow, or down for rebrick.

Thermodynamic System

Cu-Fe-S-O-Si+ System, Definition of thermodynamic ChemSage input file

ChemSage Input File

A thermodynamic input file consisting of:

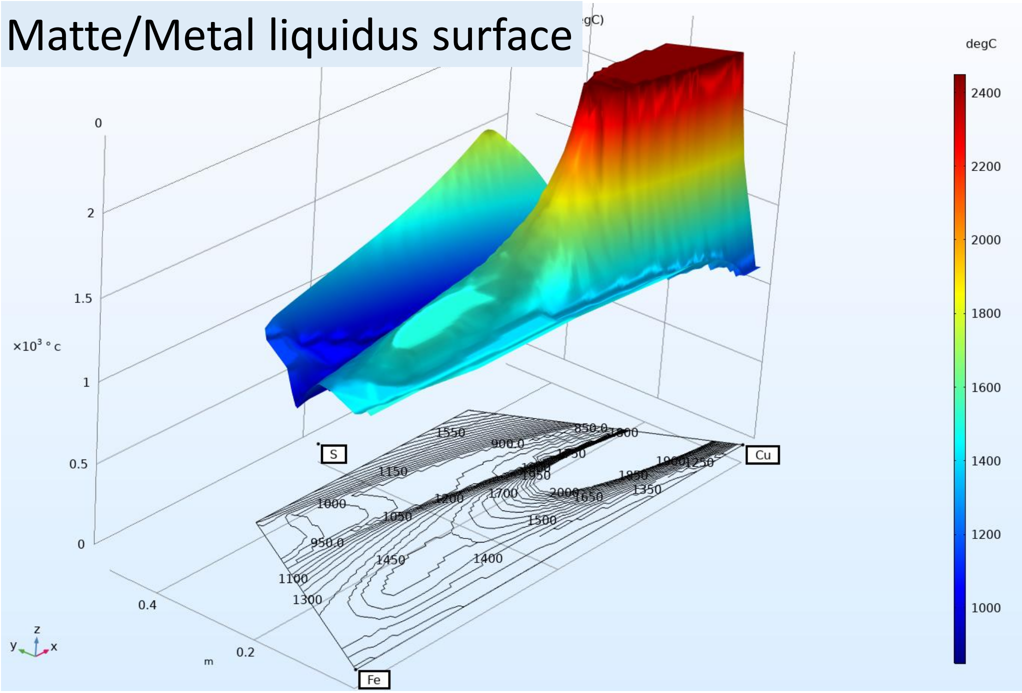
- 7 System components (plus electron):
  - Cu-Fe-S-O-N-H-Si-e
- 9 Solutions:
  - gas_ideal, Spinel, Monoxide, Liq(Matte_Metal)#1#2, fcc#1#2, Slag#1#2, etc.
- 39 Pure Components:
  - Fe_2O_3, CuO, Cu_2O, $CuFeO_2$, S, FeS, FeS_2, CuS, Cu_2S, $CuFeS_2$, $H_2O_{(l)}$, SiO_2, Fe_2SiO_4, etc.
- Built from published thermodynamic parameters[1-9]

Main Solutions

Liquid Metal/Matte

SUBG model

Cu, Cu^{2+}, Fe, Fe^{2+}, S and O

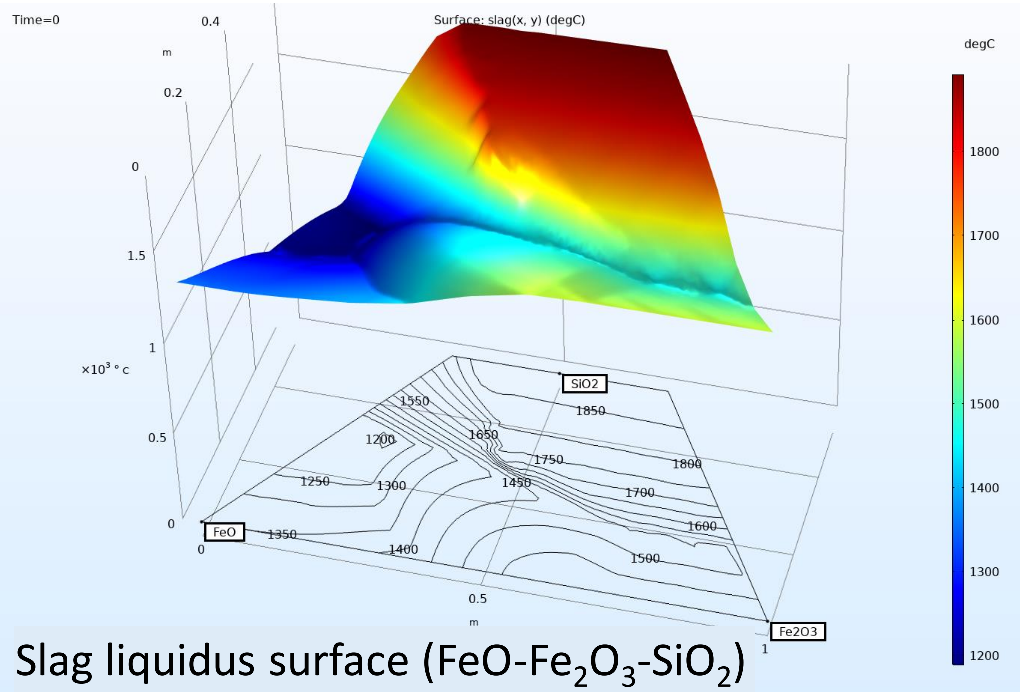


Matte/Metal liquidus surface

Slag

SUBG model

SiO_2-FeO-Fe_2O_3-Cu_2O



Slag liquidus surface (FeO-Fe_2O_3-SiO_2)

SysCAD Implementation

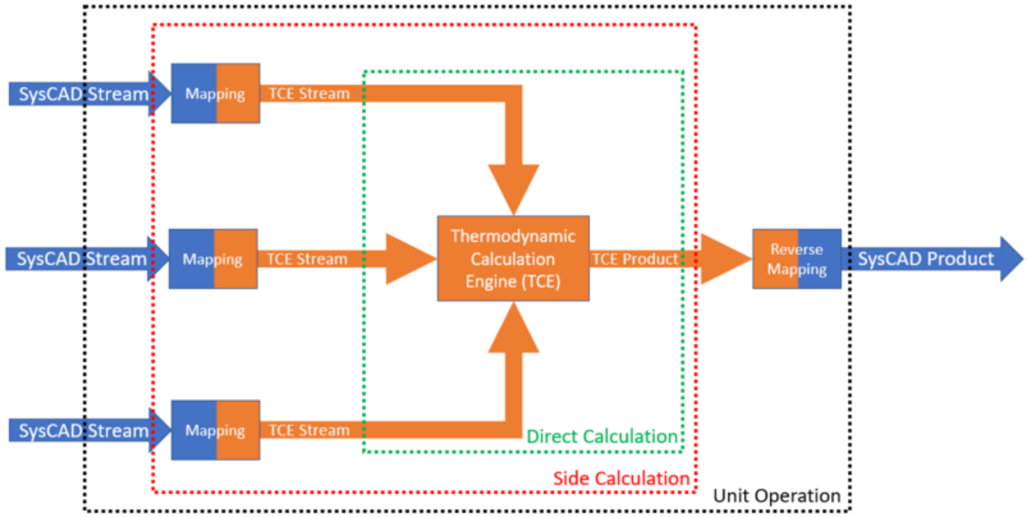
Dynamic Converter Model

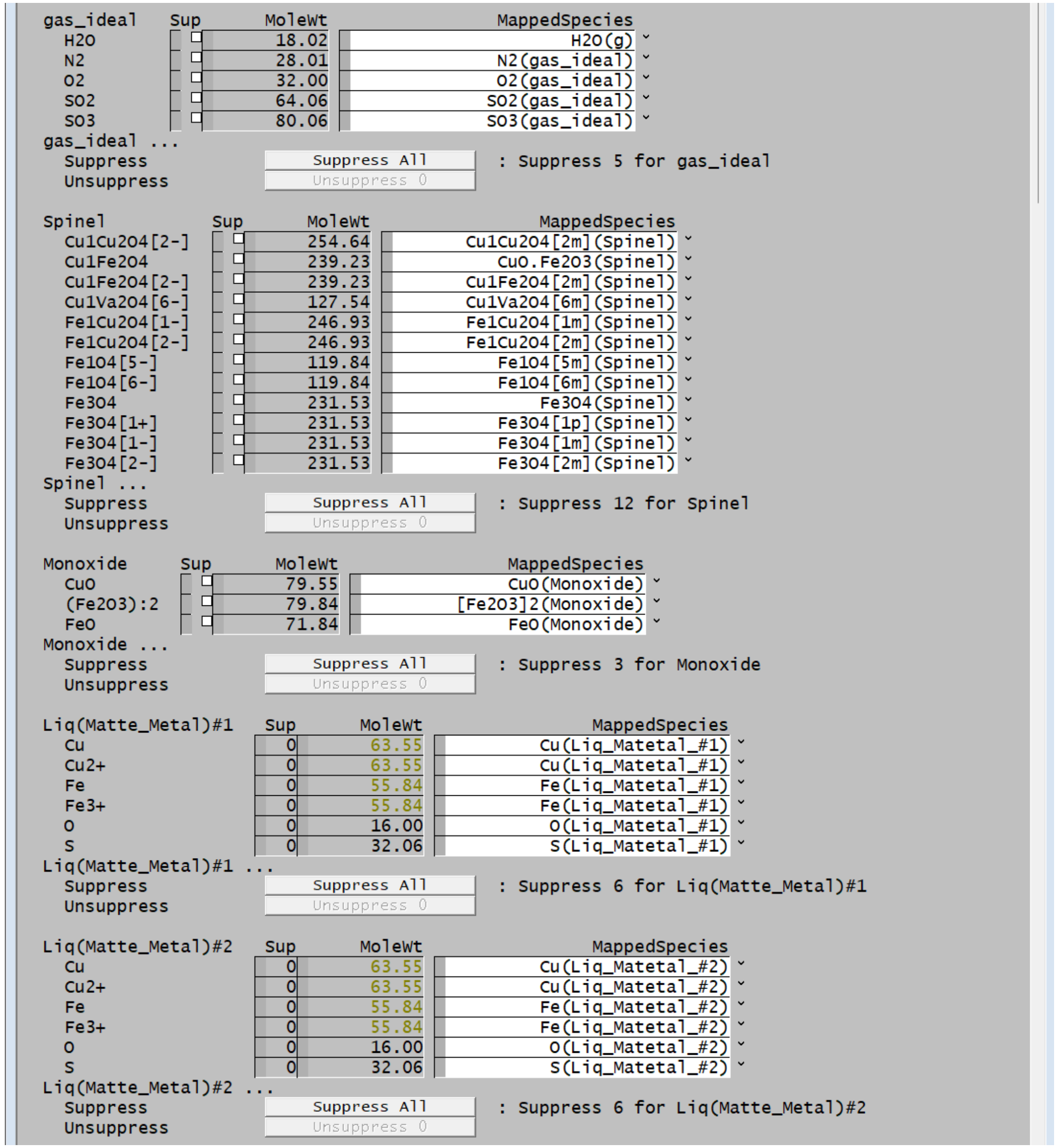
Species Mapping

ChemApp species are mapped to SysCAD species

Mapping process is automated but also allows user customization

Species/Phase suppression is supported





Dynamic Model Structure

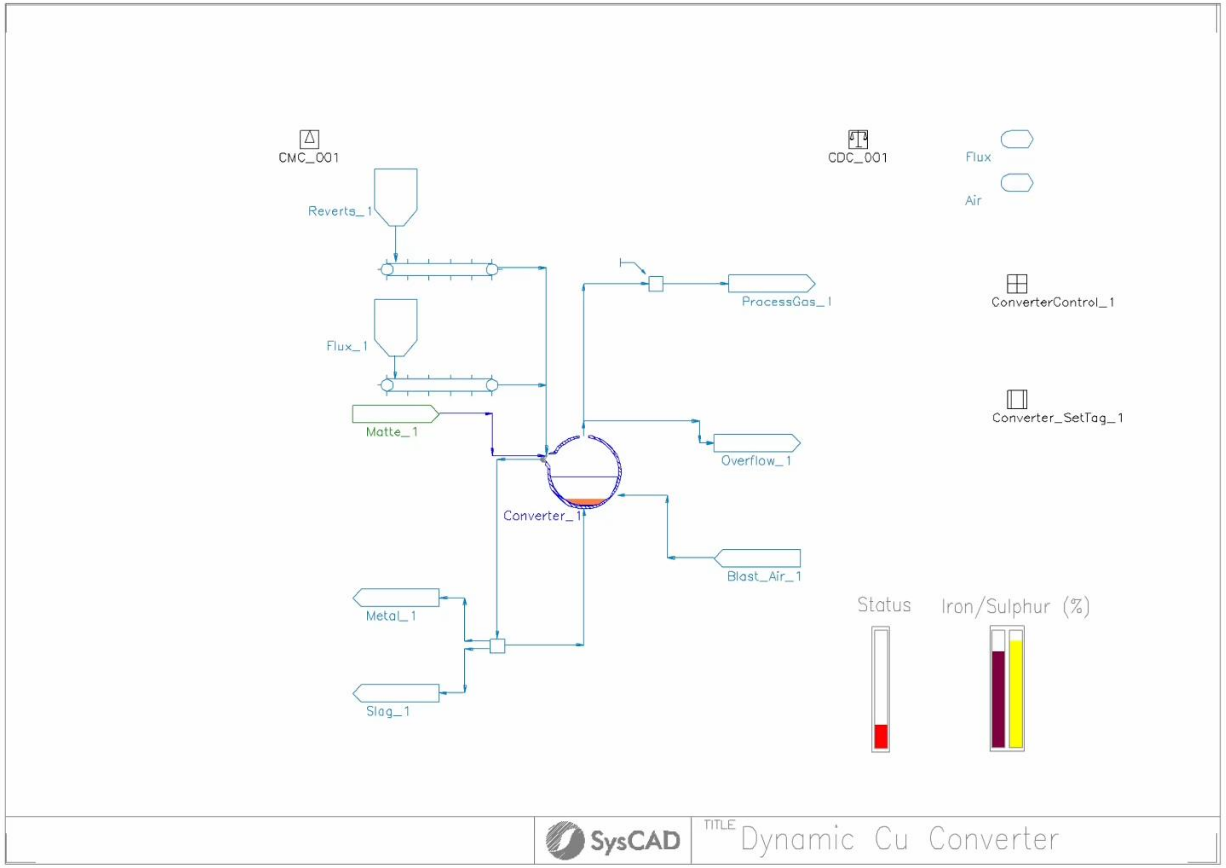
The model centers around a generic "ChemApp Tank" unit model

A converter class was build to simulate the batch process

- Status: Idle, loading, Slag blow, Skimming, Cu Blow, Casting and Maintenance
- Each status has a defined behaviour and set point

A "slag blow" subclass was defined to allow creating multiple slag blows, each with its own settings and configuration

Code is generic allowing use for multiple converters in a flowsheet



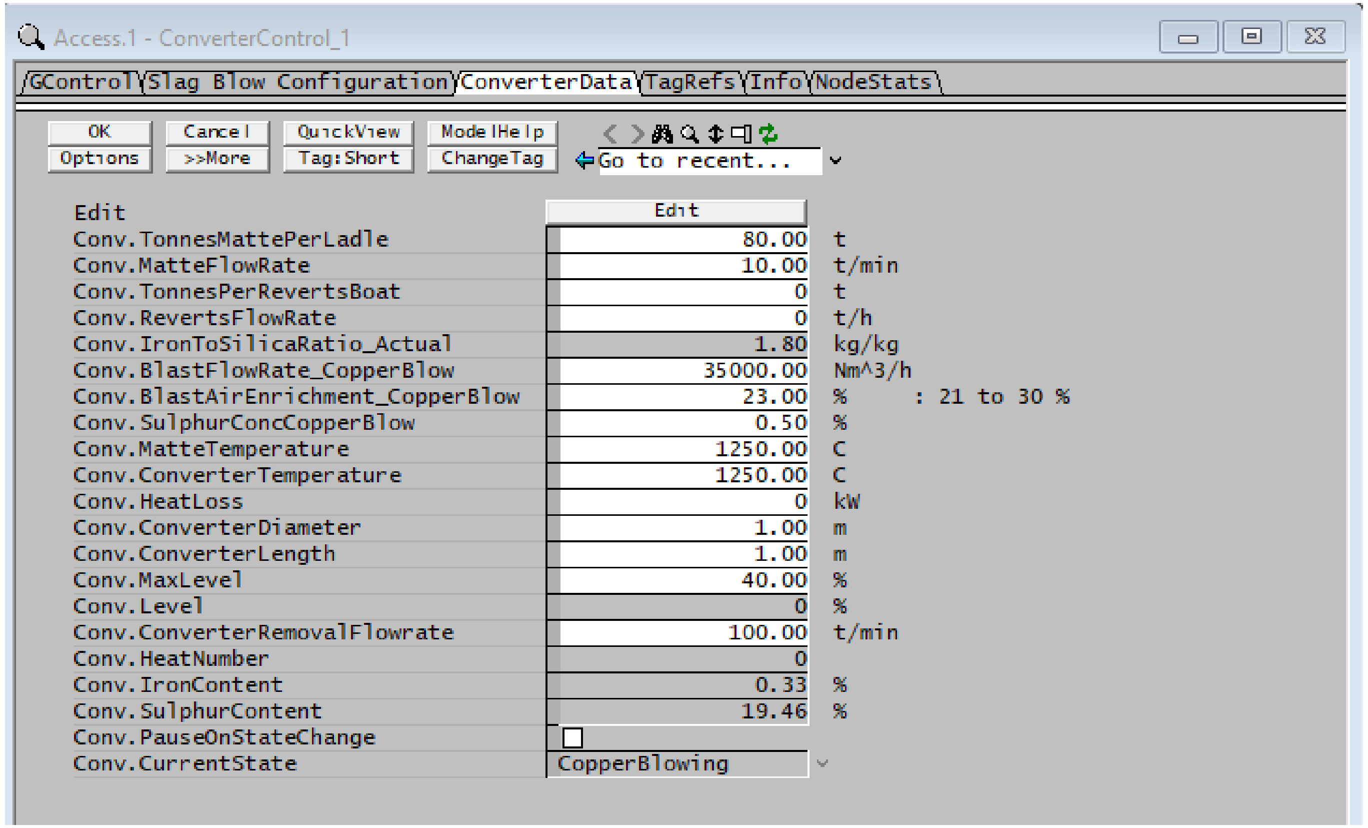
Main Class Settings

General settings for the overall converting process are defined by a custom interface

The user input interface is created with each "converter" instance

General Parameters:

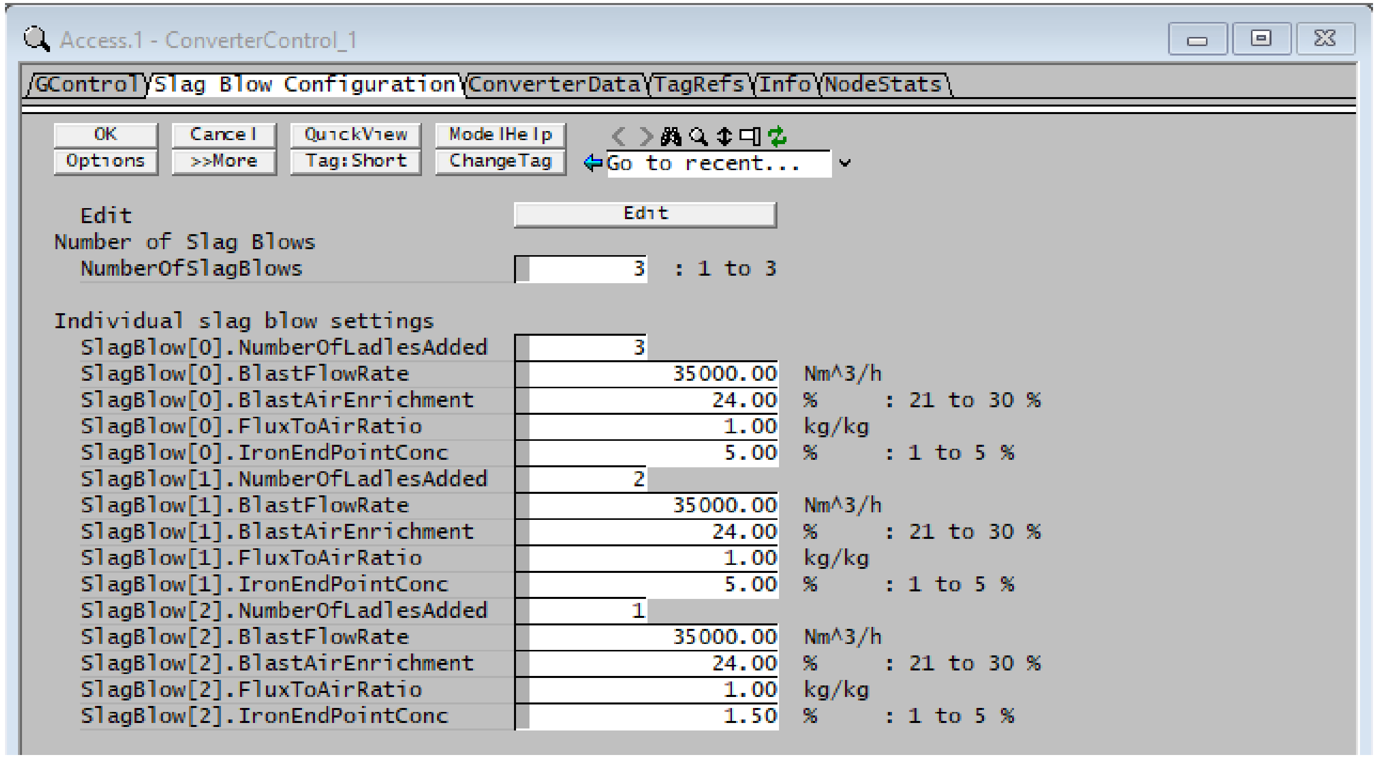
- Ladle size (capacity)
- Loading flow rate
- Furnace and converter T (iso-thermal mode)
- Information variables: Fe/SiO_2, %Fe, %S, State, etc.



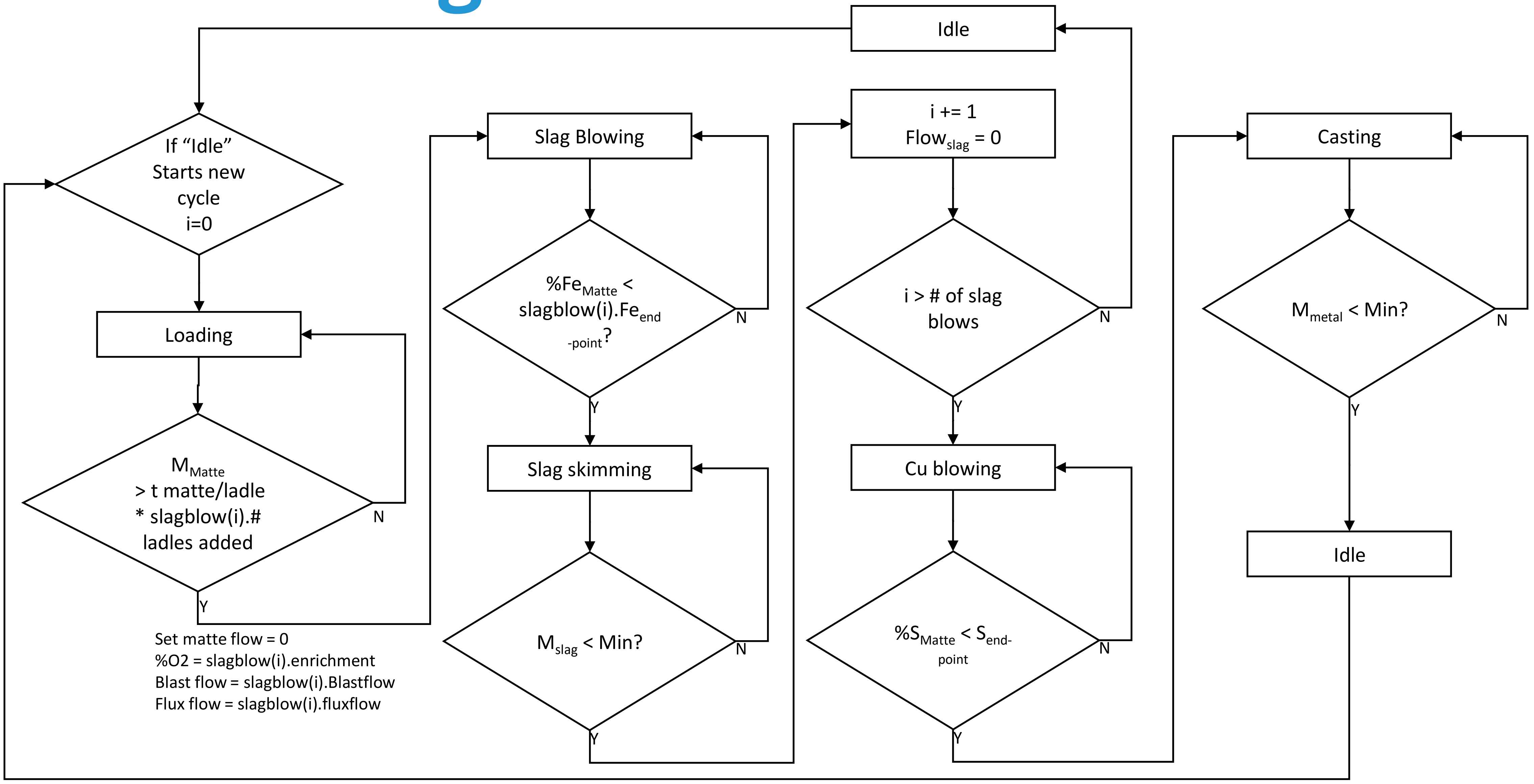
Slag Blow Class Settings

The Slag Blow subclass allows to define specific process conditions for each slag blow

- Number of ladles per blow
- Blast flow rate
- Enrichment
- Silica to O_2 ratio
- Fe end point



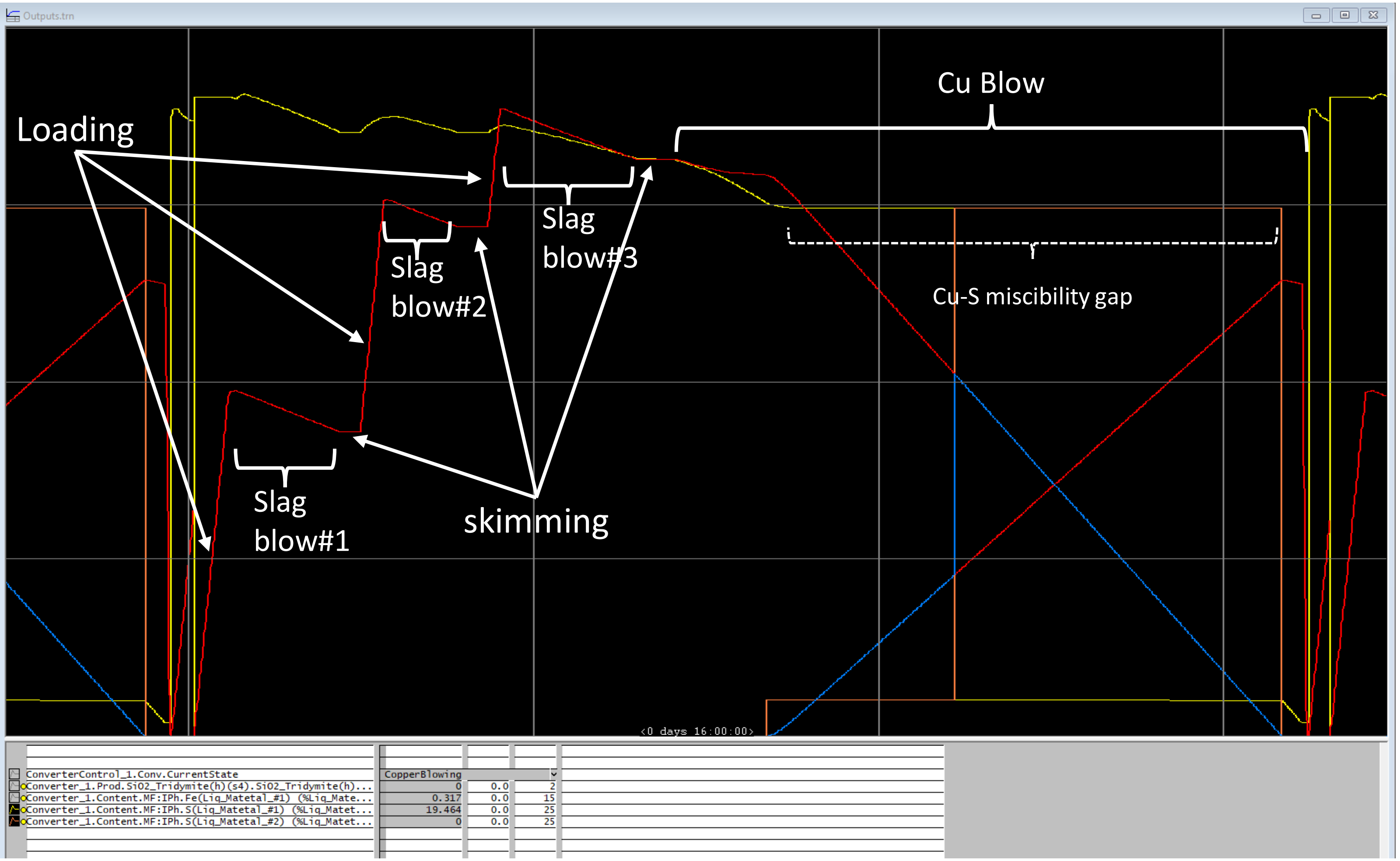
Process Logic



Results

Isothermal Case – Dynamic Model

Results



Selected Trends vs time:

Liquid #1(matte): red

Liquid #2 (blister): blue

S wt% in liquid #1: yellow

S wt% in liquid #2: orange

SysCAD Design I Operate I Optimise

Summary

- **A Batch Cu Converter model was implemented in SysCAD**
- **The model uses SysCAD dynamic solver**
- **ChemApp TCE was used to simulate the converter**
  - The model centers on a generic ChemApp Tank unit model
  - A thermodynamic input file including matte, metal, slag, spinel and other phases was prepared in-house for this model
- **A flexible and modular approach using a converter class definition was chosen to allow future expansion of the model**
  - A sub-class for slag blows was also implemented

Next Steps

- **Enthalpy target run (Heat balance and cold charge)**
  - Automate addition of reverts and cold charge
  - Update tank discharge function (for individual phases)
- **Oxygen efficiency**
  - Use Constrained Free Energy to limit oxygen extent of equilibrium, particularly as a function of S concentration during late stages of Cu blow
- **Multiple converters in parallel**
  - Simulate converter aisle dynamics
- **Upstream/downstream units**
  - Add constraints originated from furnace, oxygen plant, off-gas handling system, acid plant, etc.
- **Expand/Enhance thermodynamic system**
  - Add additional impurities, expanding system of applicability

Thank you!

Questions?

Please Contact:

- tanai.marin@syscad.net
- kevin.heppner@syscad.net
- info@syscad.net

More Information:

- syscad.net
- help.syscad.net

Thermochemical Data References

References:

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