Proof of Concept: Dynamic Model of Koniambo's Ferronickel Ladle Refinery Using ChemApp and M4D-GCI Library

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- The main objective is to develop an application to simulate the ferronickel refining step at Koniambo Nickel SAS (KNS)
  - The main interest is in accurately predict the desulfurization.
- An offline application was built and is considered as proof of concept to implement a similar approach to real-time process monitoring for KNS ferronickel refinery.
- A subsequent objective is to validate that the application can be converted to an online model with the plant control system, in a future phase.

- The case consists in the refining of Ferronickel in a ladle furnace. During the process, the metal before treatment is analyzed to determine the initial chemical composition and determine the amount and batches of reagents needed to reduce impurities. The liquid metal is treated with or without a quantity of recycled metal/alloy (Revert). The reactants are added to the ladle furnace following gas stirring and heating procedures.
- All the steps are considered in the form of time-depenndent streams in the thermodynamic model.
- The model is built according to the system of components and constituents verified in different partial equilibrium at different temperature ranges. The details of the constituents will be presented in the section related to the input files.

Modelling approach

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Liquid metal @1450 [C]

Chemical composition [kg]:
S, Si, C, P, Ni, Al, Fe, Cu, Co, Mn, Cr, Zn

+

Reverts @1100 [C]

Chemical composition [kg]:
Fe:C, Fe:Va, Ni:C, Ni:Va, FeS, Ni_2Si, Ni_5P_2, Al_2S_3

➡

Stream 1:
Aluminium

Stream 2: Reagents
FeSi Si, $FeSi_2$, $FeAl_3$, SiC, AlP, Al_2S_3
Lime CaO, MgO, Fe_2O_3, Al_2O_3, SiO_2
Dolomite CaO, MgO, Fe_2O_3, Al_2O_3, SiO_2
Spath CaF_2, SiO_2, S, H_2O

Stream 5:
Carbon addition from electrodes

Stream 6:
Nitrogen stirring and oxygen infiltration

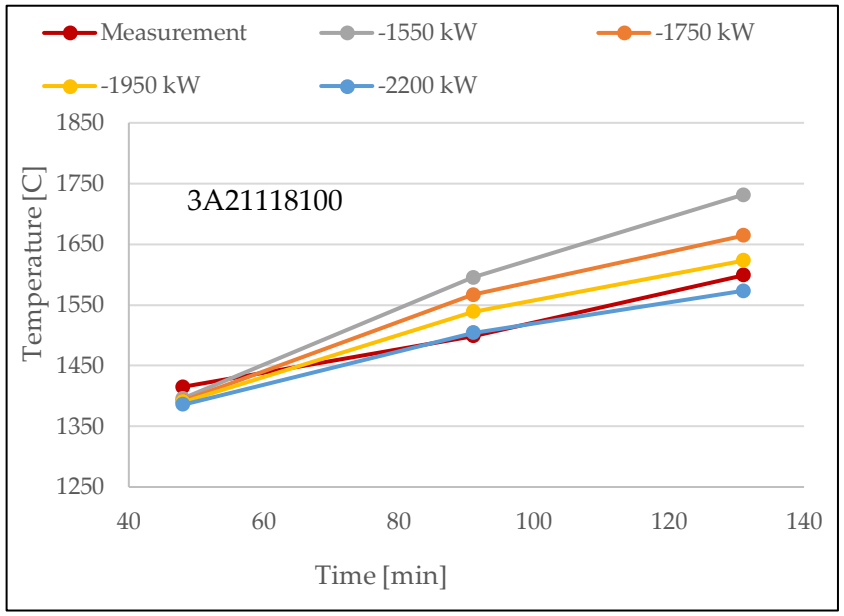
Equilibrium Conditions:
Enthalpy target = Heating and heat losses

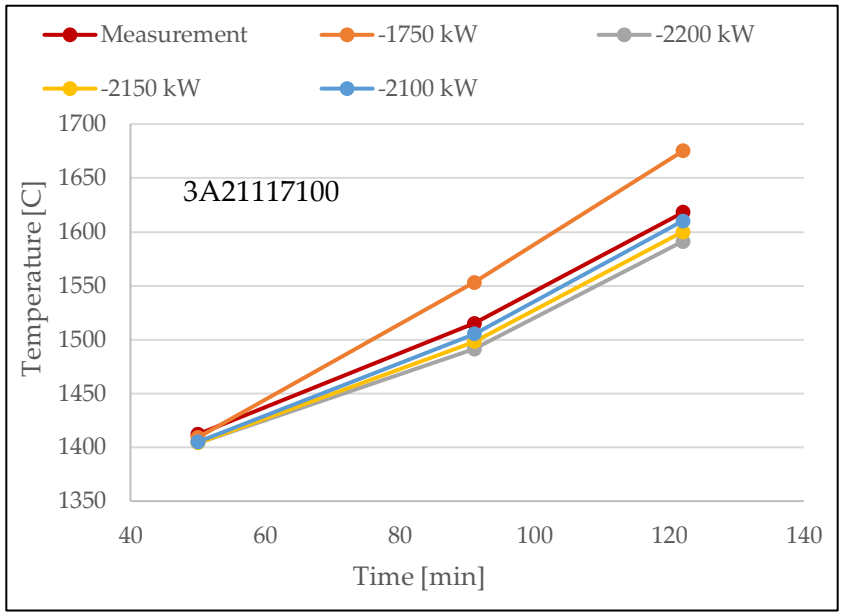
➡

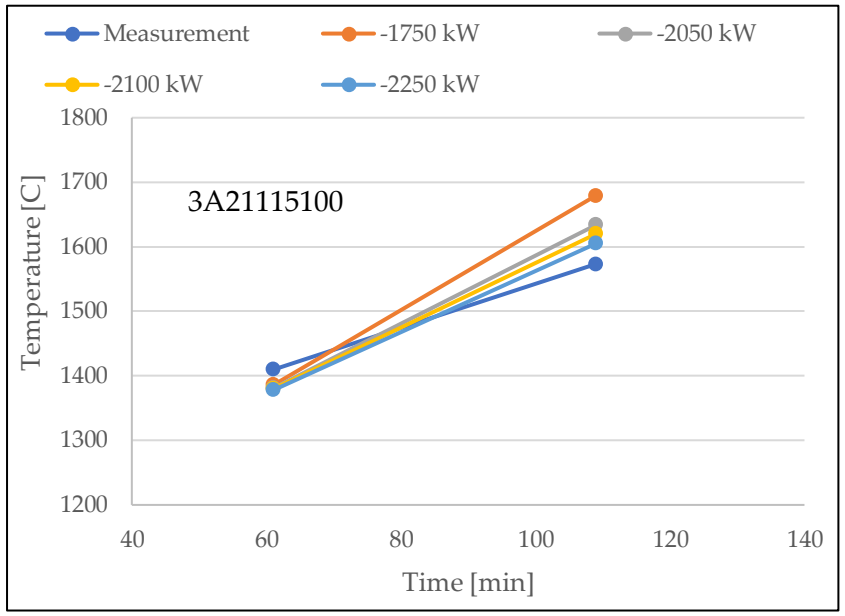
Desulfurized Ferronickel
+
slag

Results

Heat losses calibration runs

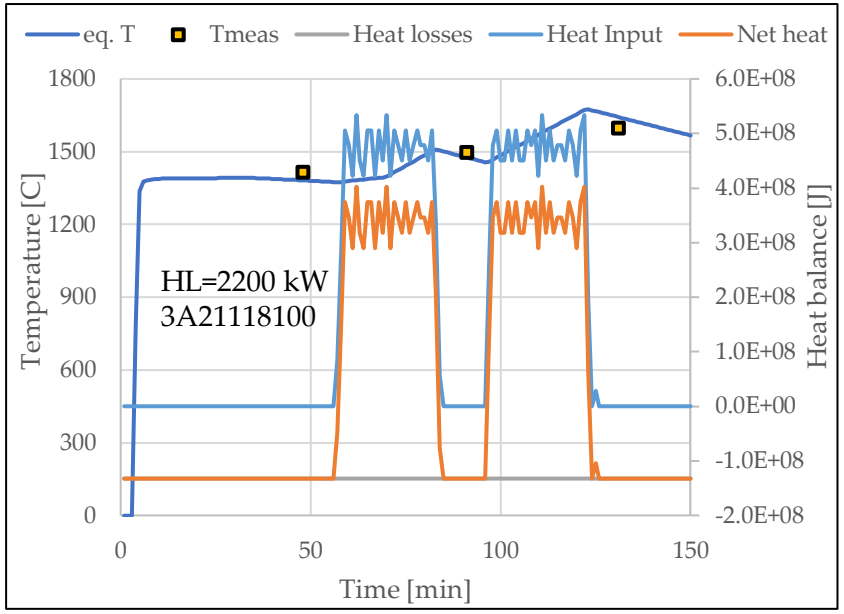


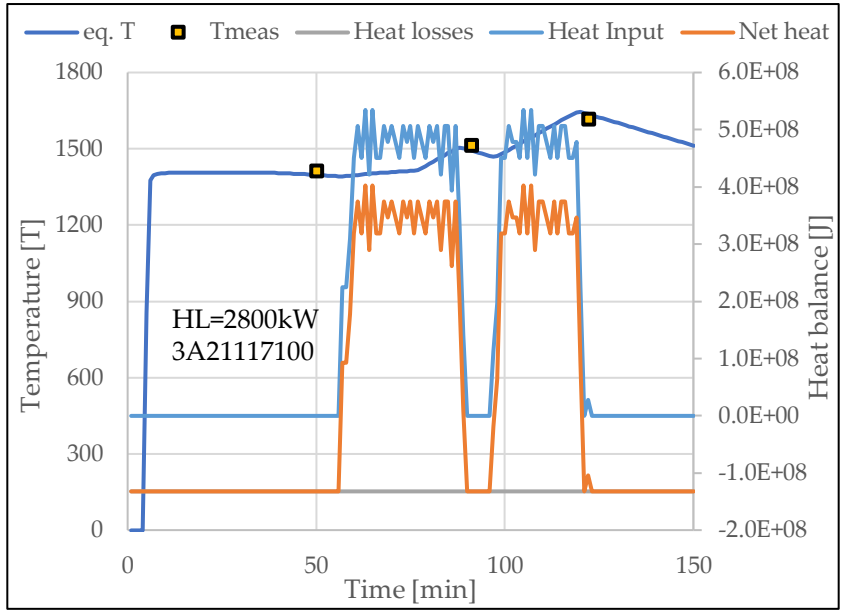


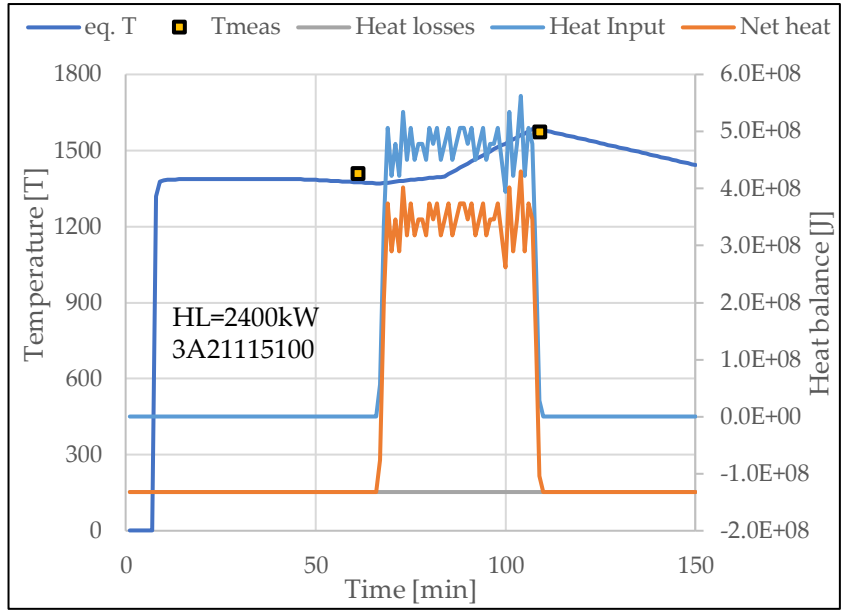


Results

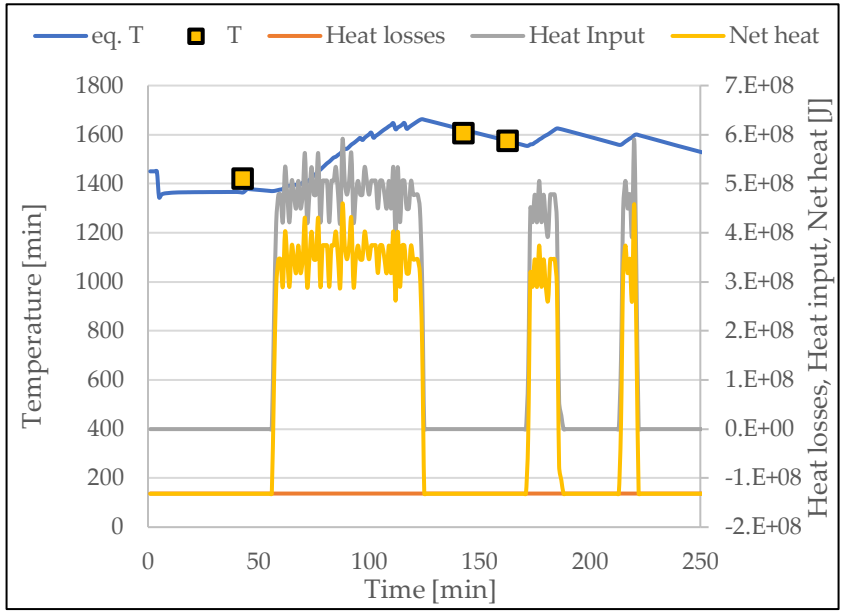
Heat losses calibration runs

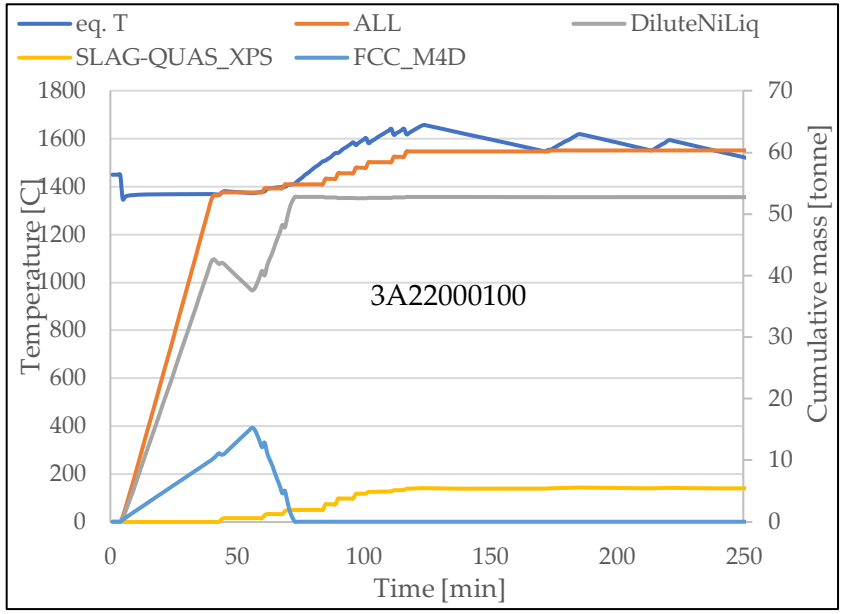


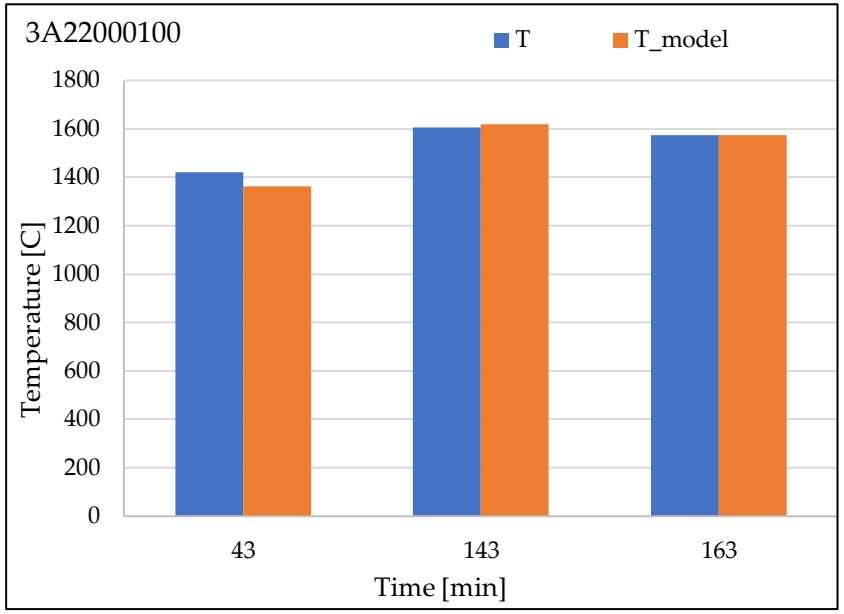




Discussion


eq. T
T
Heat losses
Heat Input
Net heat
Temperature [min]
Heat losses, Heat input, Net heat [J]
Time [min]


eq. T
ALL
DiluteNiLiq
SLAG-QUAS_XPS
FCC_M4D
3A22000100
Temperature [C]
Cumulative mass [tonne]
Time [min]


3A22000100
T
T_model
Temperature [C]
Time [min]

Discussion

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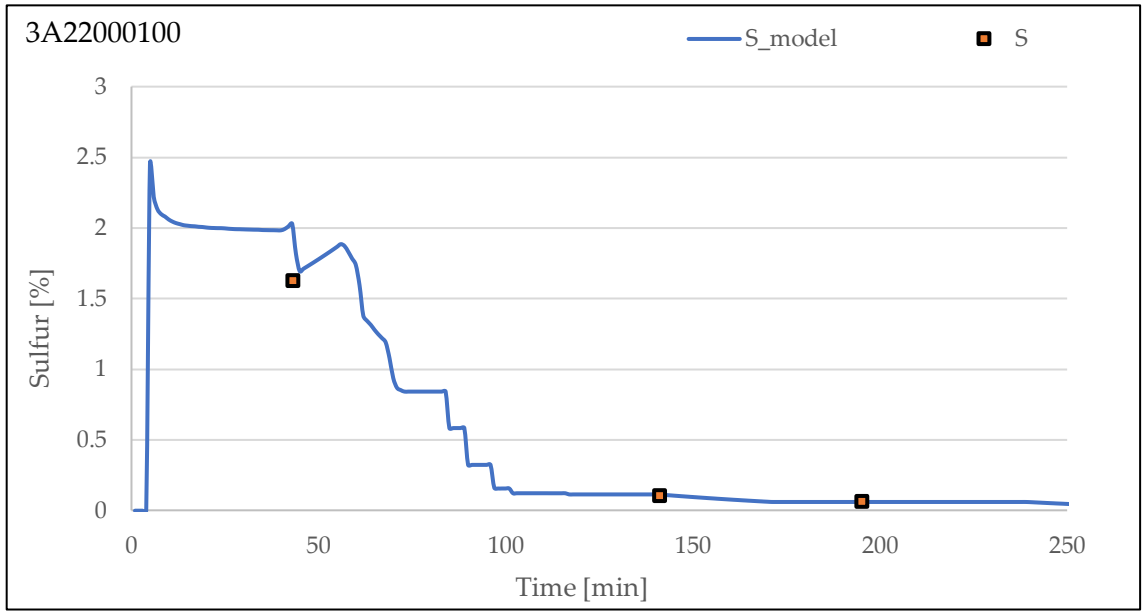
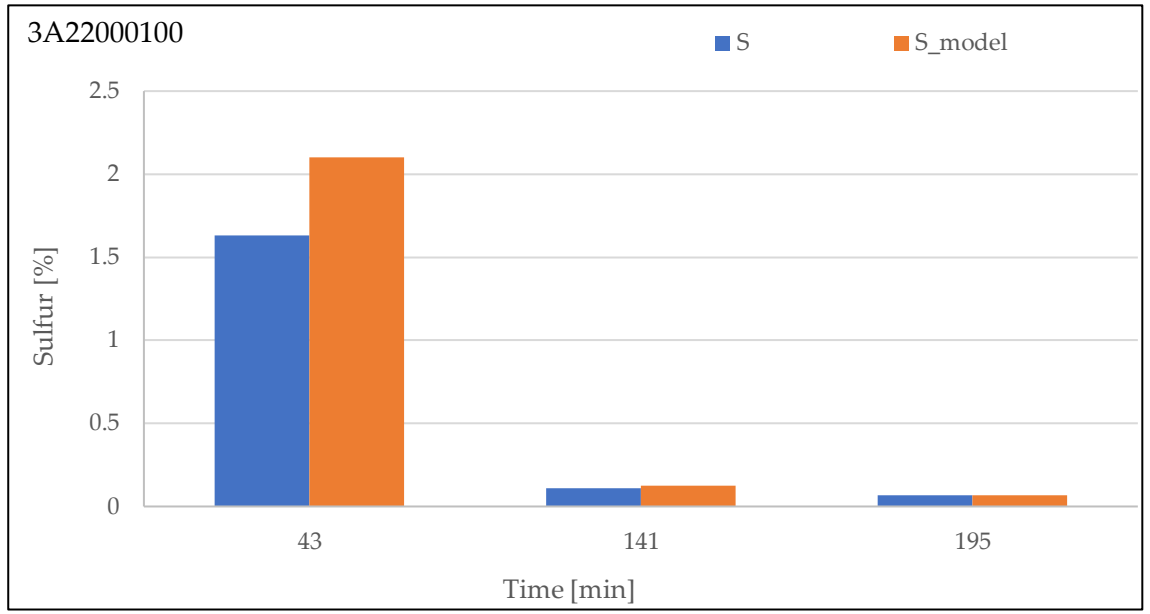
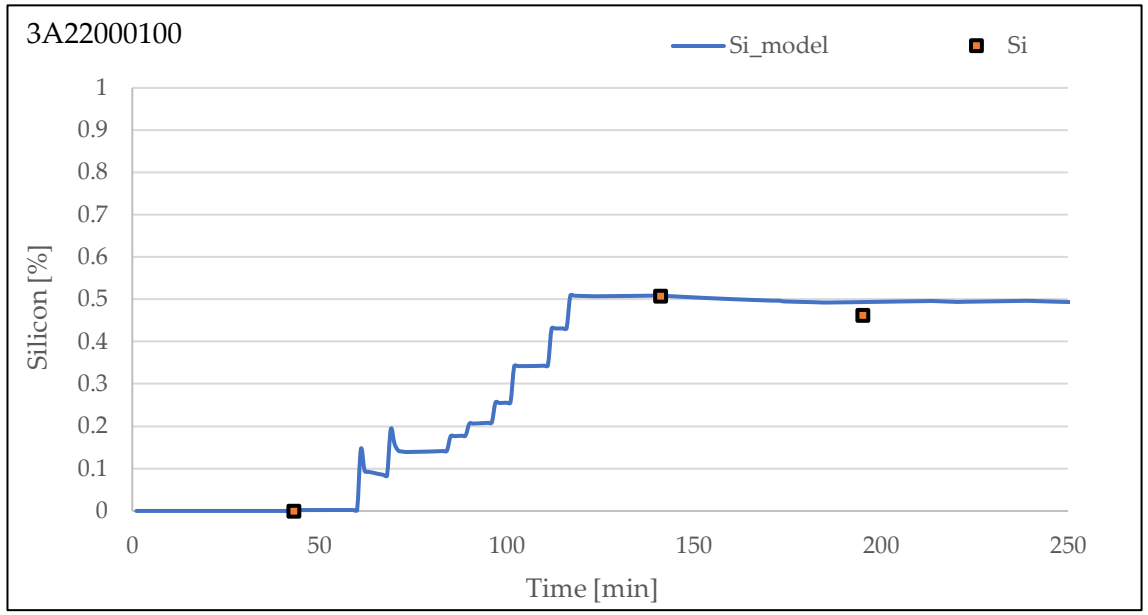
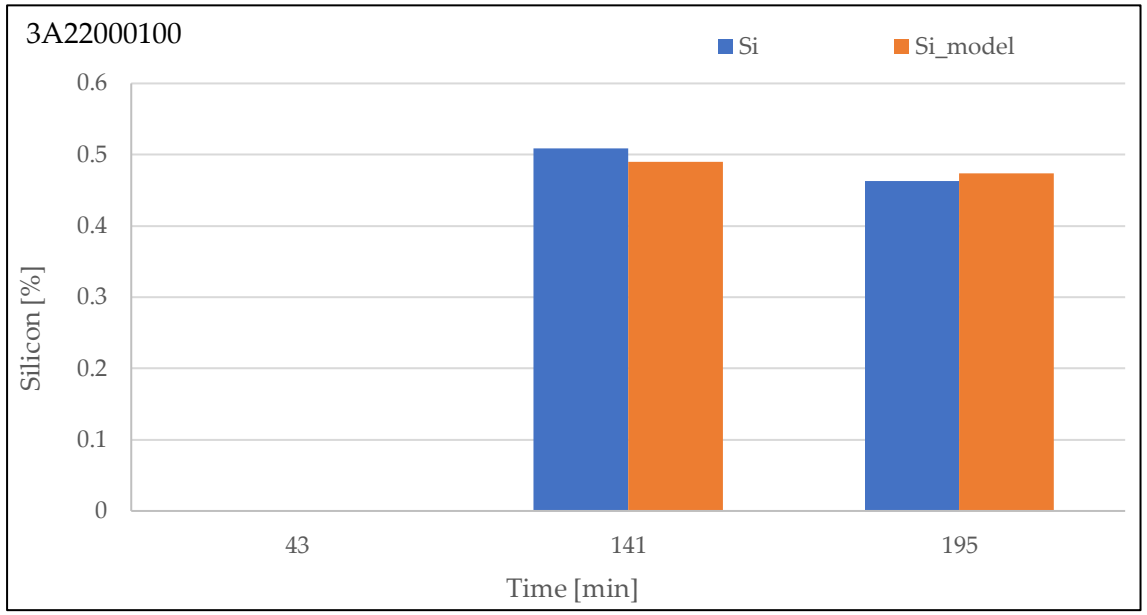





3A22000100
Si_model
Si
Silicon [%]
Time [min]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150
200
250


3A22000100
Si
Si_model
Silicon [%]
Time [min]
0
0.1
0.2
0.3
0.4
0.5
0.6
43
141
195

Discussion

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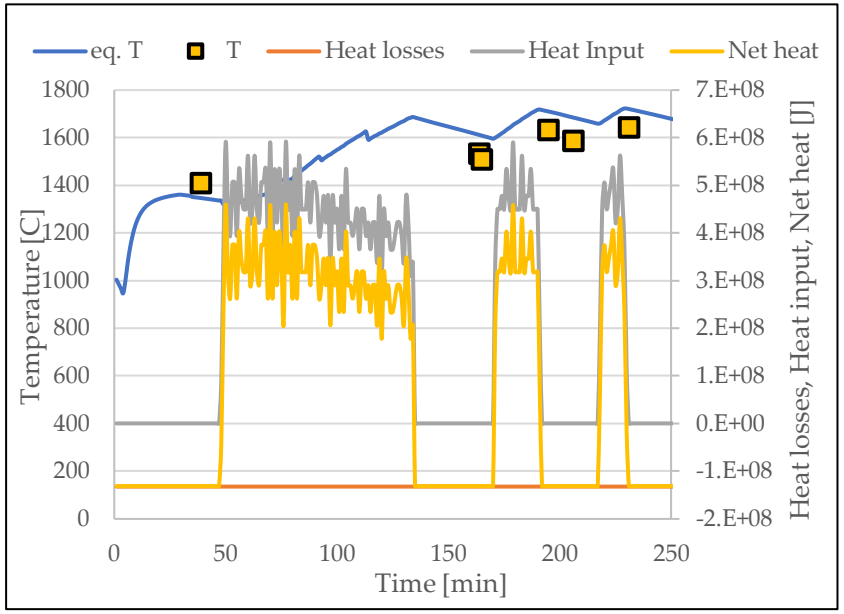
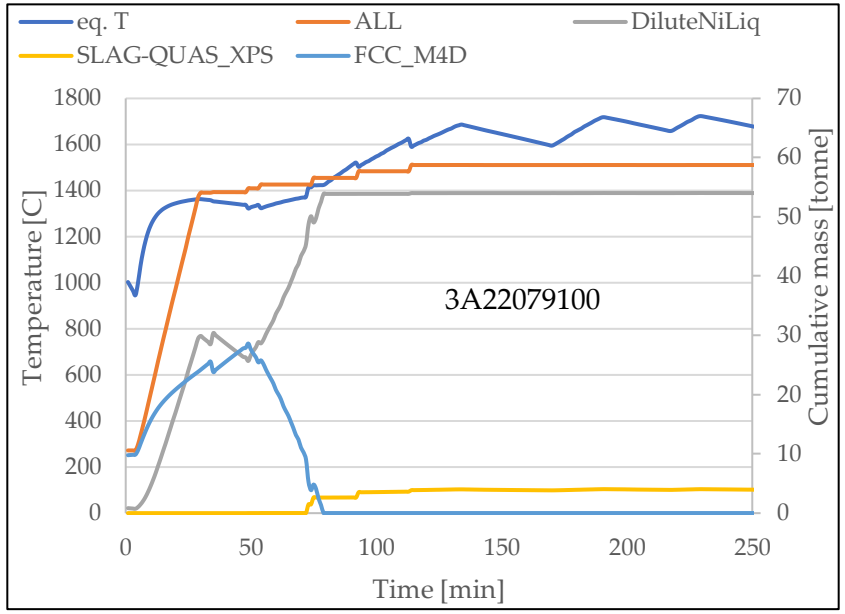
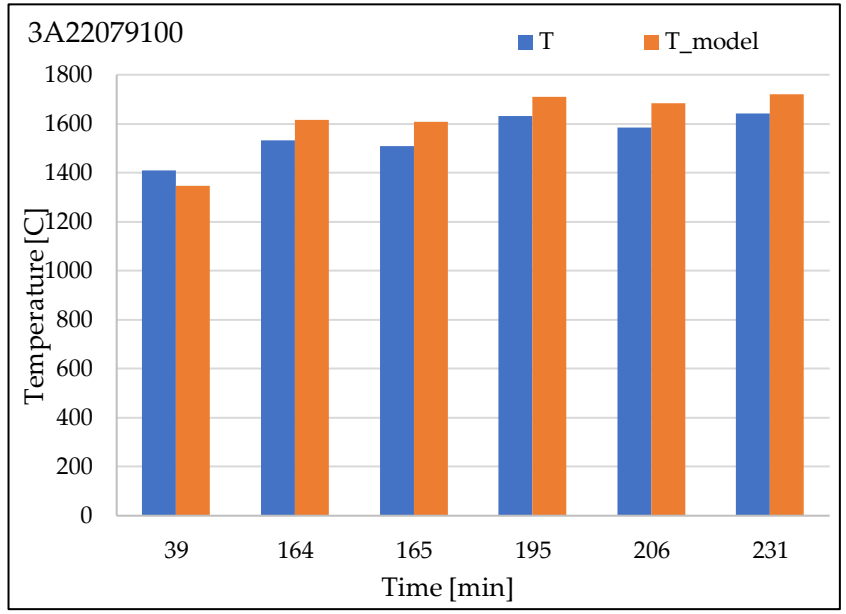
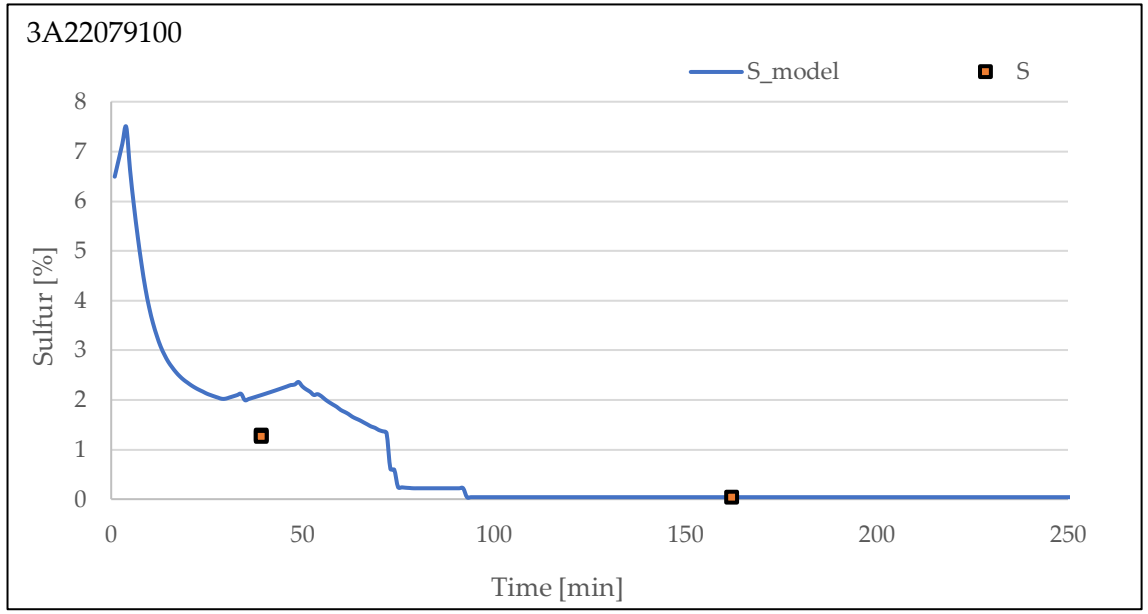
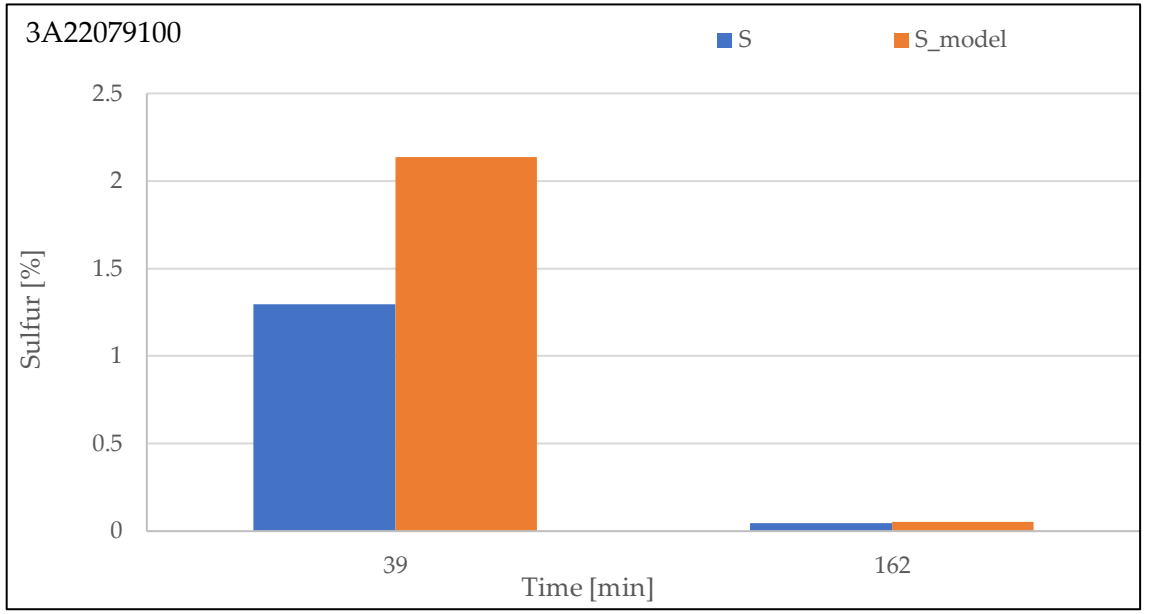






Discussion


3A22079100
S_model
S
Sulfur [%]
Time [min]
0
1
2
3
4
5
6
7
8
0
50
100
150
200
250


3A22079100
S
S_model
Sulfur [%]
Time [min]
0
0.5
1
1.5
2
2.5
39
162

Discussion

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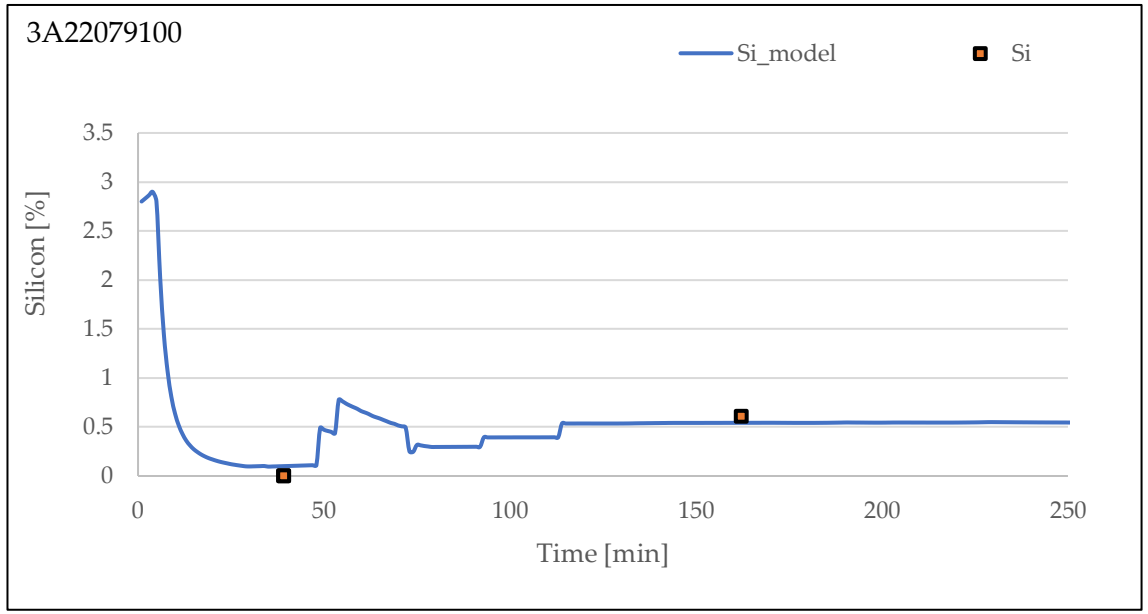

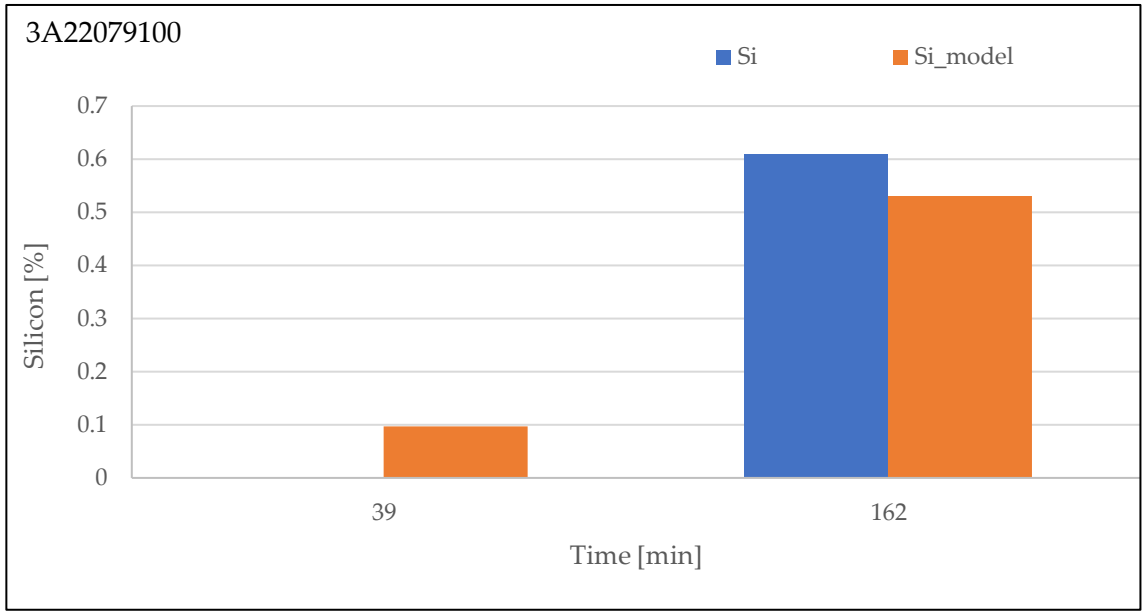

- The input plant data must be adjusted and formatted manually so that the model can read it as a script,
- More measurements must be taken during the process and further automate the acquisition of information to avoid missing data and recalibrate the model dynamically,
- The model is capable to predict the desulfurization process,
- The model can be converted to an online Digital Twin model in the future allowing KNS to use it as a Decision Making Application.