Modelling of an industrial submerged plasma zinc fuming process

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ABSTRACT

Fayalite slags produced by secondary copper smelting can be treated using a slag fuming process, where volatile metals such as zinc and lead are separated. A classic slag fuming process uses a significant amount of fossil fuel as energy source, emitting a considerable amount of greenhouse gases. Submerged plasma slag fuming technology overcomes this issue by using electrically powered plasma torches replacing coal-fired jets. It is also an upgrade to the traditional slag fuming technology in terms of process intensification. There is little understanding about how the plasma intensifies the zinc fuming. To understand this behavior, a general dynamic steady state thermodynamic flowsheet model of an industrial submerged plasma zinc fuming process has been developed in FactSage 7.0.

SUBMERGED PLASMA FUMING PROCESS

In this process, compressed air is heated in a non-transferred arc plasma generator to produce air plasma and mixed with natural gas in a tuyere to produce energy-dense reducing gas. This gas is used in the endothermic reduction reaction of zinc oxide and in heating the slag bath. A solid reducing agent is added to enhance the fuming rate. The zinc fumes are post combusted to produce zinc oxide precipitates in a duct by drawing air from the surroundings. The gases and the precipitates are cooled in a spray cooler. The reactor is water cooled (Figure 1).

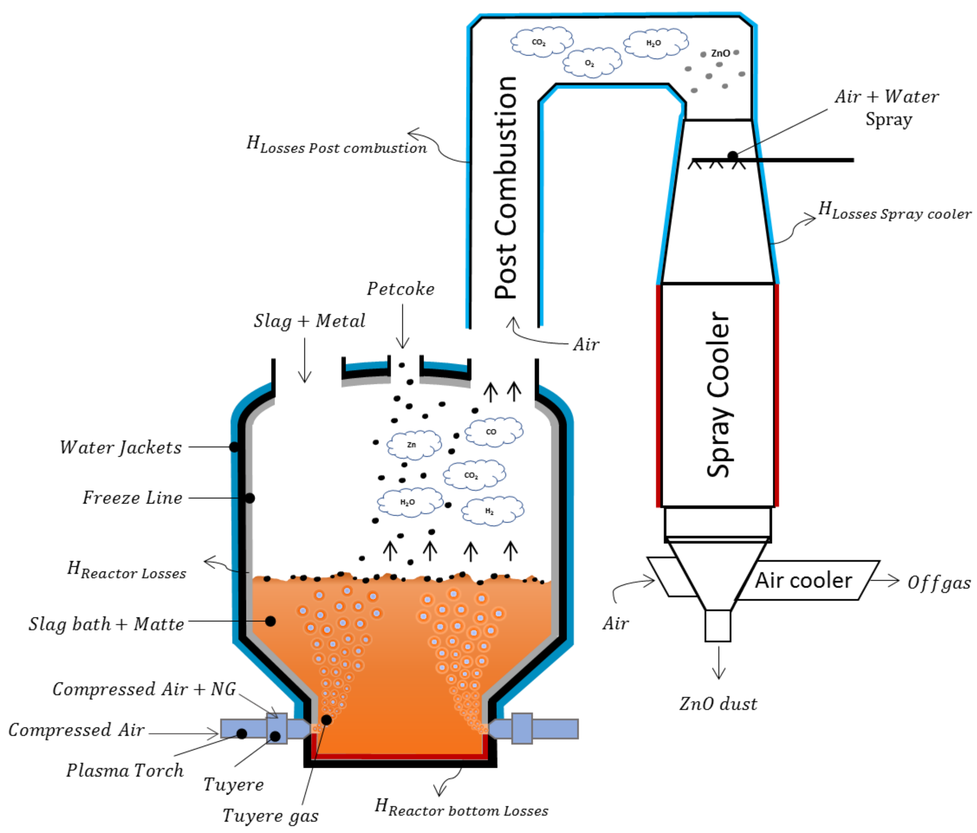

Figure 1: Submerged plasma driven slag fuming process

MODEL DESCRIPTION

- Model based on submerged plasma slag fumer at Metallo Belgium
- Approach : Flowsheet modelling (heat and mass balance)
- Thermodynamics : FactSage 7.0 macro processing and MS Excel
- Assumption : Dynamic steady state process

No kinetics involved in the process

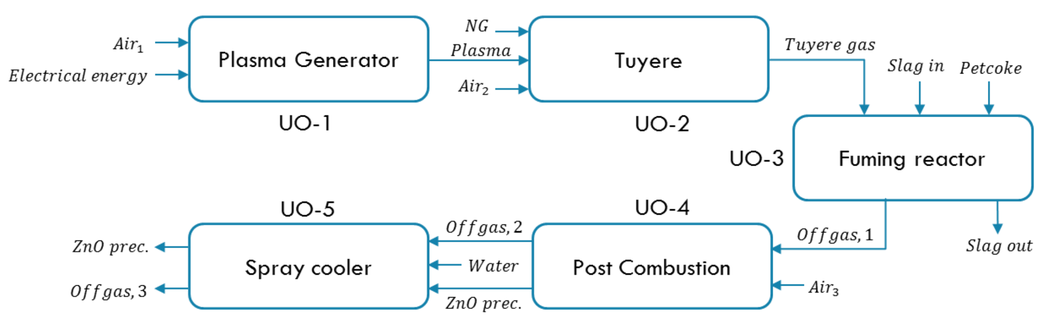

Figure 2: Flowsheet model of the submerged plasma driven slag fuming process

CASE STUDY

- Molten slag amount : 70 tons
- Slag composition : Table 1
- Petcoke feed : 1 t/h
- Energy supply : 9 MWh
- Air : 3000 Nm^3/h
- Natural gas : 430 Nm^3/h

Table 1: Composition of secondary copper smelting slag in the model

Component	FeO	SiO_2	Al_2O_3	CaO	ZnO	PbO	Cu_2O
mole %	44.8	34.1	5.3	3.8	11.1	0.12	0.69

RESULTS

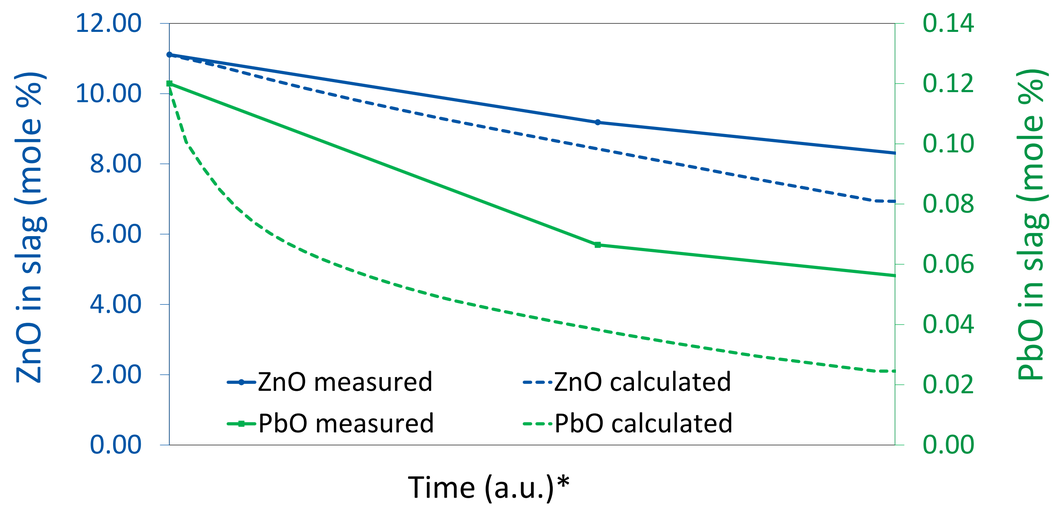

Figure 3: Evolution of ZnO and PbO in the slag bath with time
(*The scale on x-axis is omitted due to confidentiality)

CONCLUSIONS

- ✓ A dynamic steady state thermodynamic process model of the submerged plasma slag fuming process in FactSage 7.0 using FactSage's macro processing and MS Excel based on the industrial scale fuming furnace at Metallo Belgium was developed.
- ✓ The industrial fuming process has kinetic limitations.
- ✓ Reactor heat losses play an essential role in the efficiency of fuming.

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