

## Hot metal desulphurisation simulator

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### Introduction

The hot metal desulphurisation (HMD) is conducted typically in a ladle or a torpedo car. In the lance injection process, the desulphurisation reagent is injected pneumatically through an immersed lance [1–2] as show in Fig. 1.

The objective of this work was to develop a mathematical model, which can predict the desulphurisation of hot metal based on available operating and technological parameters.

### Description of the model

The model is based on the assumption that desulphurisation takes place simultaneously at the metal-reagent and metal-slag interfaces. The overall desulphurisation rate is given by

$$\frac{d[\%S]}{dt} = \underbrace{\left(\frac{d[\%S]}{dt}\right)_I}_{\text{metal-reagent reaction}} + \underbrace{\left(\frac{d[\%S]}{dt}\right)_{II}}_{\text{metal-slag reaction}},$$

The rate of the metal-reagent reaction is characterised by transitory phase contact in a dispersed system:

$$\left(\frac{d[\%S]}{dt}\right)_I = - \sum_{k=1}^N \sum_{i=1}^n L_{S,K}^I \frac{V_{p,i,k}}{V_{\text{bath}} t_{\text{res},i,k}} \eta_{M,i,k} ([\%S] - [\%S]_{i,k}^I),$$

macrokinetics
microkinetics

where  $L_S^I$  is the partition ratio,  $V_p$  is the volume of the reagent,  $V_{\text{bath}}$  is the volume of the metal bath,  $t_{\text{res}}$  is the residence time, and  $\eta_M$  is the microkinetic efficiency. The equilibrium sulphur content  $[\%S]^{I1}$  was related to the growth of the CaS layer [3]. The size distribution of the reagent particles was assumed to follow the Rosin-Rammler-Sperling (RRS) distribution. An example of a fitted RRS distribution is shown in Fig. 2.

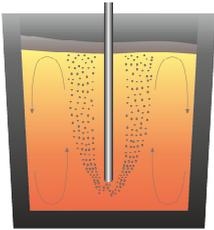


Fig. 1. Schematic illustration of HMD.

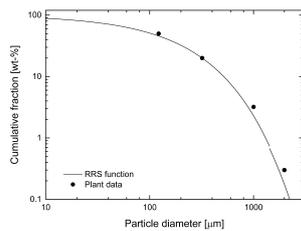


Fig. 2. Size distribution of the reagent.

The microkinetic efficiency of each particle size class is obtained from [4]:

$$\eta_M = 1 - \exp\left[-\beta_{\text{tot}}^I \left(\frac{A}{V}\right)_p t_{\text{res}}\right],$$

where  $\beta_{\text{tot}}^I$  is the overall mass transfer coefficient. The overall mass transfer coefficient is defined by mass transfer resistances within the particle and in the metal phase. The kinetics of the metal-slag reaction is characterised by permanent phase contact in a non-dispersed system [4]:

$$\left(\frac{d[\%S]}{dt}\right)_{II} = -\beta_{\text{tot}}^{II} \frac{A_{\text{slag}}}{V_{\text{bath}}} ([\%S] - [\%S]^{II}),$$

where  $A_{\text{slag}}$  is the cross-sectional area of the slag. The overall mass transfer coefficient is defined by mass transfer resistances in the metal and slag phases [5].

### Preliminary results

In its current state, the model can be applied for injection of lime, calcium carbide and soda, as well as their mixtures. Fig. 3 shows the predicted sulphur content and desulphurisation rate in an example heat, in which a lime-based reagent was employed. For sake of simplicity, only the lime and soda contained by the reagent were taken into account. The predicted final sulphur content is in good agreement with the measured value. The stochastic of the reagent injection become evident from the desulphurisation curve, which is characterised by three stages: *run-up*, *steady-state* and *run-down*.

From Fig. 4 it is seen that the average efficiency of the lime particles is only in the order of few percent. The predicted microkinetic efficiency of soda was of the same order of magnitude. Therefore, the extractive capacity of the reagent is hardly utilised at all.

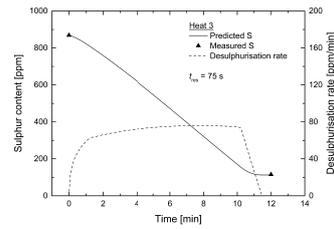


Fig. 3. Predicted sulphur content and desulphurisation rate.

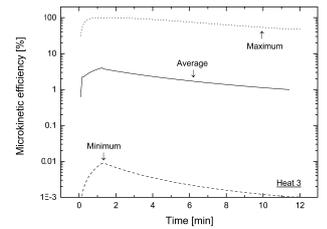


Fig. 4. Predicted microkinetic efficiency of lime.

### Future prospects

The next step of the modelling work is to extend the model for desulphurisation using industrial reagent mixtures. Thereafter, the model will be validated more exhaustively and coupled with a graphical user interface. A journal manuscript is in preparation regarding the scientific results.

The main financial potential of the simulator is related to the possibility of optimising the operating parameters to suit the objectives of a given production strategy. For example, new desulphurisation reagents can be tested cost-efficiently before their adoption into production use.

### Conclusions

The objective of this work was to develop a mathematical model for hot metal desulphurisation. The employed approach is based on thermodynamic-kinetic description of main reaction mechanisms. The preliminary results suggest that the model can predict the final sulphur content reasonably well. The further development of the simulator aims for an easy-to-use support tool for factory use. The main financial potential of the simulation tool lies in the cost-efficient and rapid testing of improved production practices.

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