ABOUT MATHEMATICAL MODEL OF SLAG FOAMING IN CONVERTOR

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Annotation. The main factor of the foam formation in oxygen convertor is gas blowing so the aim of this work is to find an optimal amount of injected gas avoiding overflow of the convertor. Researches and experiments can be very expensive in plant conditions. On the other hand such experiments give important data about real process. A mathematical model can considerably decrease costs of mentioned process prediction and helps in finding of rational parameters. However for a good adequacy the model needs to take into account melt flow and gas movement. Conservation laws of impulse and mass are used in form of Navier-Stokes equations and convection-diffusion equation. Cylindrical coordinate system fits geometry of problem and axis symmetry can be used to simplify the model with two-dimensional statement (r-axis and z-axis).

Keywords: NAVIER-STOKES EQUATIONS, CENTRAL DIFFERENCE METHOD, OXYGEN CONVERTER, GAS-SLAG FOAM.

Introduction. Slag foaming are considered by many authors in their works [1-3]. Oxygen convertors are widely used in metallurgical plants. A hazardous problem is overflow of convertor by gas-slag foam, which is rising up during gas blowing using injection and gas bubbles formation due chemical reactions inside melt. In the beginning of blowing slag layer is thin, however, in the end the layer thickness grows because gas bubbles are significantly slower inside slag then they are in molten iron. Costly laboratory and plant experiments can be replaced by a cheaper mathematical model implemented in a computer program. To check correspondence of the model and real process a comparison of numeric experiment results and data of monitoring can be done.

Main material. Assumptions for the mathematical model are following:

1. Geometry of convertor is cylindrical.

2. For this case there is axial symmetry, which simplifies a model.

3. Molten steel and slag are viscous Newtonian fluids– continuums, which exchange its speeds at a flat interface.

4. Top surface of the slag layer is flat and has time dependent vertical speed, which is calculated using speed field of slag.

5. Gas bubbles are continuum, which interpenetrates melts and causes vertical motion due local gas concentration variation.

Gas injected into the melt by top-inserted blowing lance, which is placed on the axis of the convertor.

Stated problem can be considered as the one that has explicit border between phases like Stefan problem. Let gas bubbles leave the surface *G* with speed of flotation and be incompressible by above layer. Then a current position of the border can be defined by height *h* of gas-slag layer and amount of injected gas per unit of time Δt as well as volume of gas leaved the surface *G*:

$$\frac{\Delta h}{\Delta t} = \frac{1}{A}\left(q\frac{T_m}{300K} - \sum_{i=1}^{k} \alpha_i V_i\right) \qquad (1)$$

$$V_i = \Delta A_i w^c_\alpha \qquad (2)$$

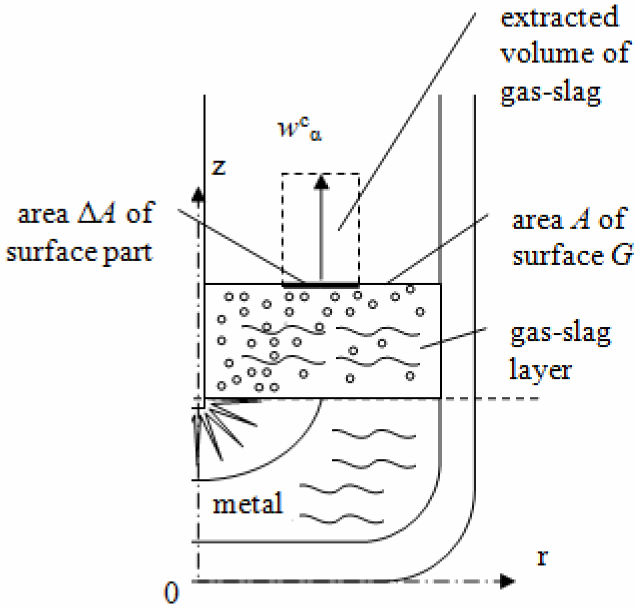

Figure 1 – Axial cross-section of converter

where A – area of surface G, m^2; q – volume of gas injected per unit time Δt, m^3/s; T_m – temperature of melt for ideal gas expansion, K; w^c_α – speed of gas flotation, m/s; α_i – fraction of gas on the surface part ΔA_i; k – number of area A divisions; V_i – extracted gas-slag volume per unit time. Let`s check dimensional equality of left and right sides of (1):

$$\frac{m}{s} = \frac{1}{m^2}\left(\frac{m^3}{s}\frac{K}{K} - \sum_{i=1}^{m} m^2 \frac{m}{s}\right) \tag{3}$$

Conclusions:

1. Proposed mathematical model of slag foaming takes into account gas inlet from top-inserted tube and gas outlet from free surface of gas-slag layer, which allows finding of optimal technological parameters.

2. For conducting numerical experiments the mathematical model can be implemented in computer program using widespread programming language. The application should have friendly user interface to input parameters and should save results of an experiment. Also visualization of the results is an important feature for technologist to see dynamics of process.

References

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