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STUDY ON THE SURFACE PRESSURE IN THE SLAG SYSTEMS USED AT THE CONTINUOUS CASTING

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ABSTRACT
The intensity of the gas absorption processes (oxygen, nitrogen, hydrogen, sulphur, etc.) from the furnace environment, the assimilation of flux additions and of inclusions, the slaf foaming are greatly influenced by the surface pressure.
The slag surface pressure is influenced by its components, an influence that is transmitted upon the slag-steel interface pressure too.
The researches aimed to establish some correlation relationships between the surface pressure, temperature and chemical composition of the slag, analytically and graphically expressed, by processing the data in the MathCAD program. The best chemical compositions of the lubrication fluxes are established based on these correlations and by comparing them with those obtained for the viscosity variation.
Keywords: surface pressure, steel, continuous casting, mould, slag.

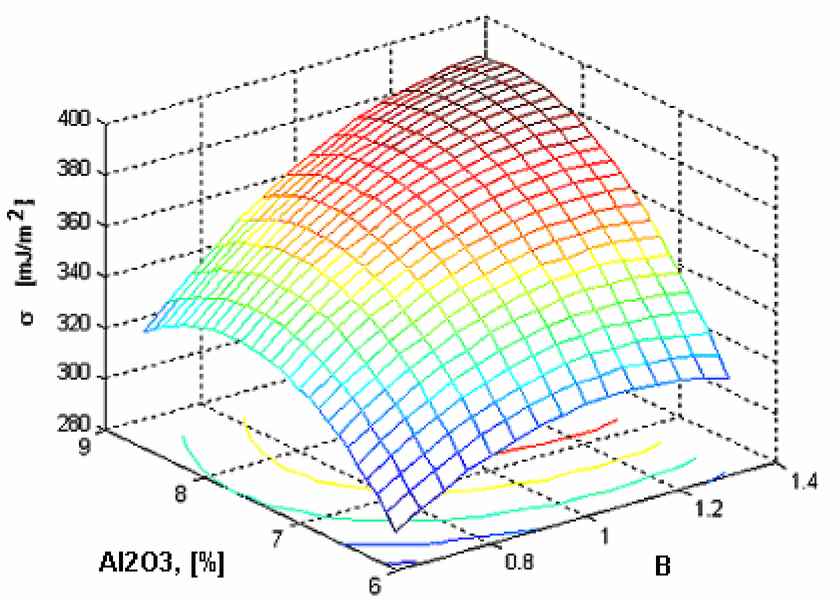
1. INTRODUCTION
The molten metallurgical slags being ionic melts have relatively high (300-600 mJ/m^2) surface pressure, but several times less than the metal one.
It is considered that the surface pressure of the pure oxides in melted condition depends on the electrovalence link weight, being known that it varies from an oxide to another, function of the difference of electronegativity between the cation (basic ion) and anion (acid ion). Function of it the surface tension of the pure oxides varies too, decreasing from CaO to Al_2O_3 and SiO_2. This rule, though it is scientifically founded, is not verified integrally in practice, because of the miss of sure values of the surface pressure of the pure oxides.
In the melts of two or several oxides the surface pressure is determined by the fact that the particles (ions) from the superficial layer are not subjected to some preponderant attractions of the phase where the slag is and that is why its value depends on the connection energy of the particles from the superficial layer with the neighbour particles from the same phase. The oxygen concentration in the superficial layer of the melted slags is approximately constant and the influence of replacing an oxide from the slag with another upon the surface pressure is explained by the appearance of some new cations - having another connection energy with the oxygen - in the superficial layer. The values of the connection energy in CaO, MgO, MnO and Al_2O_3 are close and that is why their reciprocal replacement shall not lead to essential changes of the surface pressure, while introducing SiO_2, B_2O_3, P_2O_5, Na_2O, having smaller connection energy values shall lead to the decrease of the slag surface pressure, fact that is confirmed into practice.
The surface pressure shall provide an optimal meniscus shape. This is function of the chemical composition of the slag, of the steel being cast and of the temperature.

2. EXPERIMENTAL RESEARCHES
In MathCAD it was obtaining dependences between superficial tension and chemicals composition for slags in $CaO-SiO_2-Al_2O_3$ system. Also is presented in fig.1-3 equations in analytical and graphical form. [1, 2]

In the specialty literature there are not presented any correlations between the surface pressure, the temperature and the chemical composition for the lubrication slags from the continuous casting of the steel. As a result, in order to establish some dependences of the above-mentioned kind, we have processed the data from several lubrication powder grades (lubrication slags) from the continuous steel casting in the calculation program MathCAD.

Next there are presented the resulted obtained both analytically and graphically.

$$\sigma = -651,9122+118,7269\cdot B+236,0594\cdot Al_2O_3+26,4803\cdot B\cdot Al_2O_3-128,9917\cdot B^2-16,4141\cdot Al_2O_3^2$$



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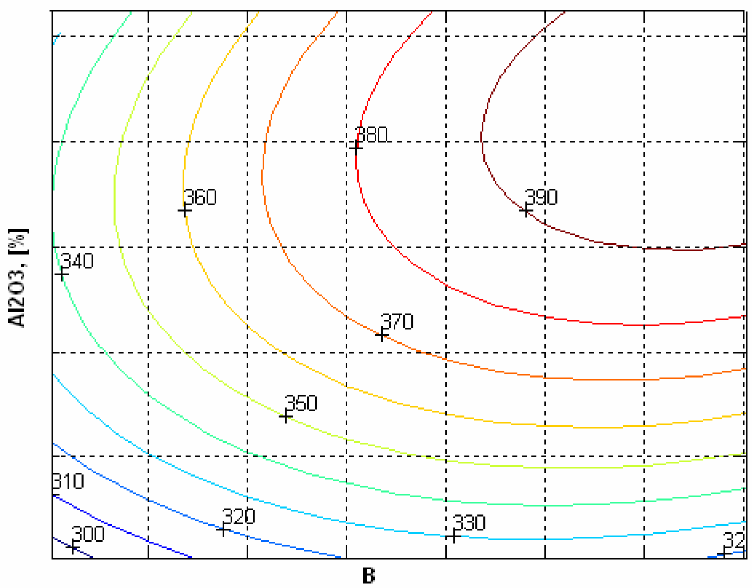

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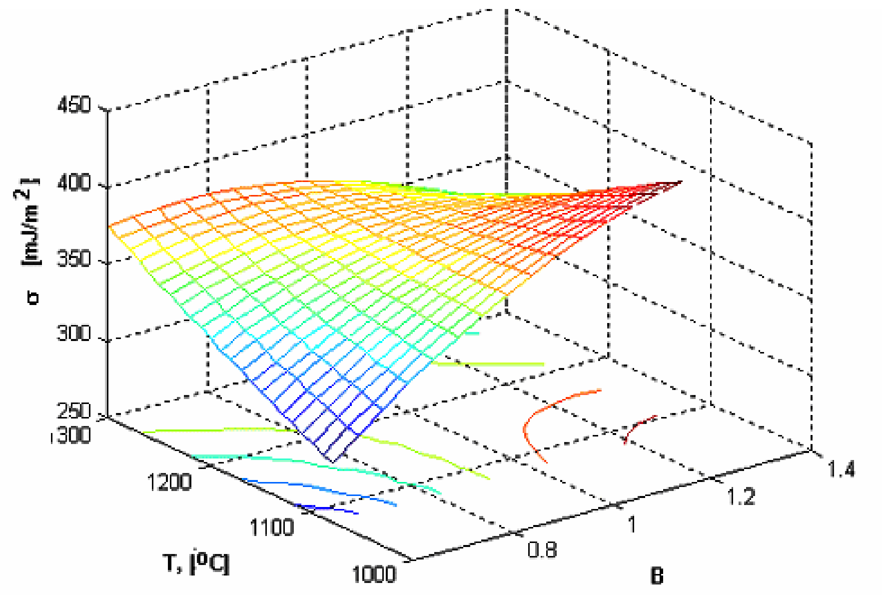
Figure 1. Surface regression(a) and contour lines (b) for $\sigma = f(B, Al_2O_3)$

From the correlation analysis $\sigma = f(Al_2O_3, CaO/SiO_2)$ and $\sigma = f(T, CaO/SiO_2)$ it results that an increase of the basicity index within the studied interval of chemical composition leads to an increase of the surface pressure, increase firstly determined by the increase of the CaO content, oxide having a high value for the surface pressure (620 mJ/m^2 in comparison with 400 mJ/m^2 in the case of SiO_2 and a weight of the electrovalent link of 80%). An increase of the Al_2O_3 content in the slag at the same basicity leads at the beginning to an increase of the surface pressure (up to 7-9% Al_2O_3) and then at its decrease.

The increase of the surface pressure at lower concentrations of Al_2O_3 is due to the increase of the weight of an oxide with higher values for the surface pressure (720 mJ/m^2) and its decrease as a result of forming complex anions of the type $Al_2SiO_7^{4-}$, these complex anions being pushed to the surface, fact reducing the slag surface pressure.
Regarding the temperature for the studied slags it is found out a decrease of the surface pressure attributed to the fact that the firmness of the link among the ions decreases at the temperature increase. On the other hand, in some subsystems (of silicates, phosphates) the surface pressure increases, fact that can be explained by the weight of the electrovalent link at the temperature increase at the compounds from the respective subsystems.

$$\sigma = -713{,}8+1611{,}4\cdot B+0{,}5\cdot T-1{,}1\cdot p\cdot T-148{,}5\cdot B^2$$



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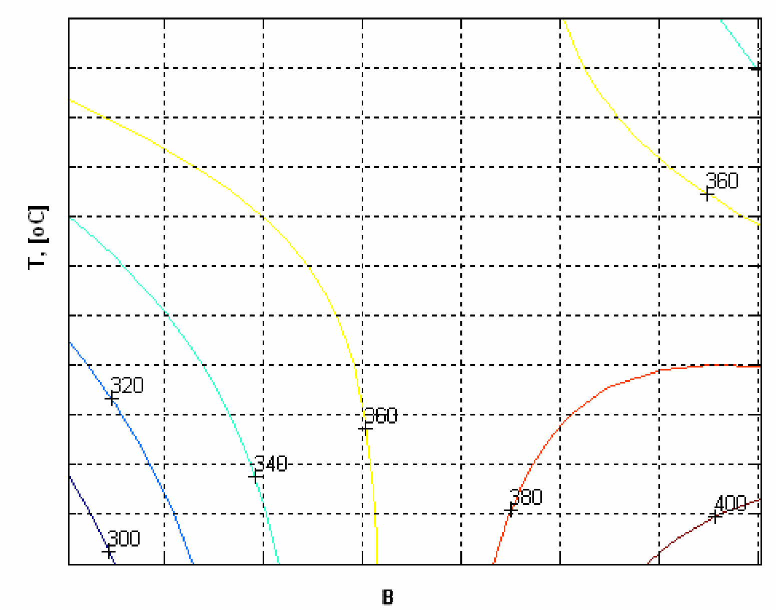
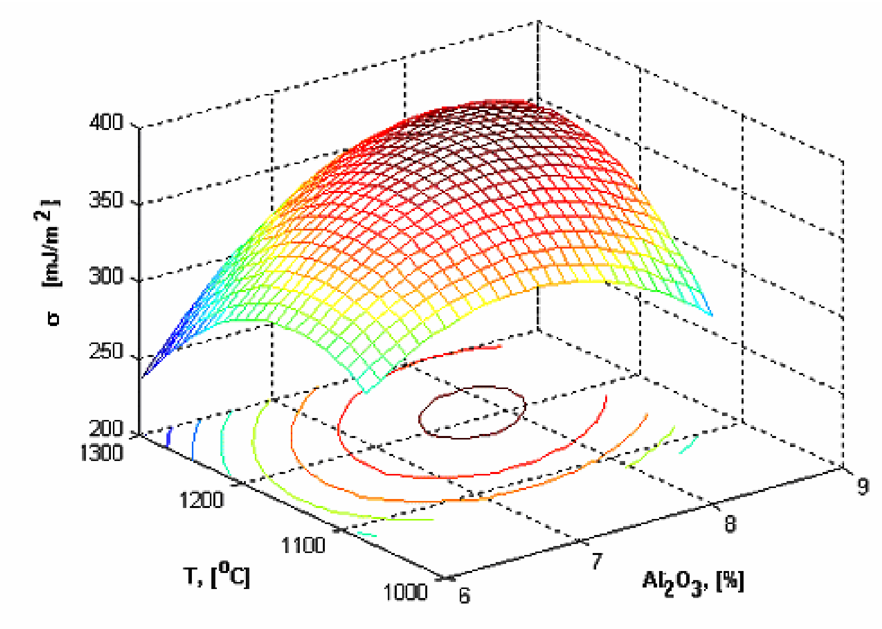


b.

Figure 2. Surface regression(a) and contour lines (b) for σ = f(B, T)

$$\sigma = -4144{,}8+124{,}9\cdot Al_2O_3+6{,}7\cdot T+0{,}2\cdot Al_2O_3\cdot T-25{,}4\cdot Al_2O_3^2$$



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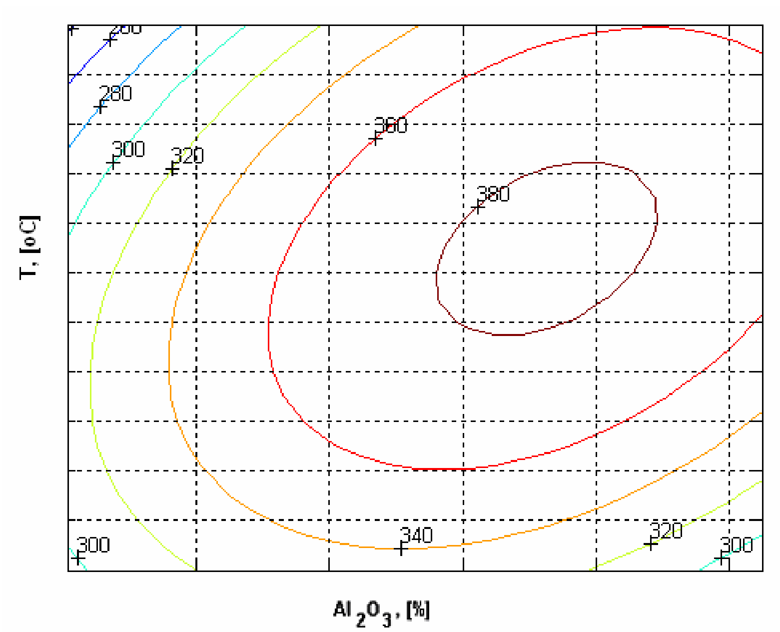

b.

Figure 3 Surface regression(a) and contour lines (b) for $\sigma = f(Al_2O_3, T)$

3. CONCLUSIONS

From the study made it results the following conclusions: correlation equations can be obtained on subranges of the chemical composition, basicity index, temperature, that can represents the real situation as exactly as possible; knowing the surface pressures besides other characteristics, firstly the viscosity, is a really useful for the continuous casting practice of the steel (both for the producer and for the user of lubrication powders).

4. REFERENCES

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