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STUDY ON THE SYNTHETIC FLUX VISCOSITY USED AT THE CONTINUOUS CASTING

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ABSTRACT
In the steel continuous casting process, the mould lubrication has a very important technological role, with direct effects on the continuous cast blank quality. The lubrication process is directly influenced by the synthetic flux viscosity (slag thickness), which is determined on its turn by the chemical composition and the temperature.
The researches made aimed to establish some correlation relationships between the viscosity, chemical composition and temperature, analytically and graphically expressed, by processing the data in the Matlab program. Based on these correlations the best chemical compositions of the lubrication fluxes are established.
Keywords: viscosity, steel, continuous casting, mould, flux.

1. INTRODUCTION
The surface quality of the continuous cast blanks is influenced by the casting powder characteristics too, besides a series of technological factors. The casting powders used at the continuous steel casting have a complex role, having to provide: preventing the steel reoxidation at the continuous casting; trapping and keeping the non-metallic inclusions from the hot steel; heat insulating; heat transfer and lubrication between the solid steel crust and the mould wall.
In order to fulfil these requirements the continuous casting powders shall be analysed, taking into account the following characteristics: fusibility, viscosity, surface and interface pressure, inclusion absorption capacity. These proprieties, at their turn, are greatly determined by the chemical and mineralogical composition, the grain size distribution and the physical and chemical humidity of the powder, respectively of the casting powder slag.
However the real behaviour of the casting powder represents the resultant of the action of all these characteristics, it is necessary to study each of them apart and then the interferences among them. [1]
From the chemical composition point of view, the powders or more precisely the slag of continuous casting powder are within the reducing metallurgical slag range, that means within the SiO_2 - CaO - Al_2O_3 system. Besides the three basic oxides, the continuous casting powders also contain MgO, Na_2O, CaF_2, C, MnO, Fe_2O_3, B_2O_3, etc. The presence of these components modifies the resulted characteristics from the SiO_2 - Al_2O_3 - CaO system; each of them influencing differently the other proprieties of the slag resulted from the powder melting. [2]
The mineralogical composition of the slag and its characteristics are modified function of the oxide addition and the temperature.

2. EXPERIMENTAL RESEARCHES
The researches made had in view to establish some dependences between the viscosity and the chemical composition [3].
In order to establish of best dependences between temperature, MgO and Al_2O_3 quantity and CaO/SiO_2 from slag, we are obtain a lot of experimental data from powder made after our recipes and

another industrial powder, used in continuous casting industry. This dates it was processed in MATLAB software and was established graphical and analytical dependences.
Using a multiple correlation conduct to obtain optimal values for temperature MgO, CaO/SiO_2 and Al_2O_3 that should determine to obtain a viscosity within a certain range.
Because these hyper-surfaces cannot be represented in the 4-dimension space, we resorted to replace successively an independent variable with its average value. These surfaces, belonging to the 3-dimension space, can be represented and interpreted in a technological sense.

The regression surface equations:

$\eta=2,2 \cdot CaO/SiO_2^2+0,01 \cdot Al_2O_3^2+2,06 \cdot 10^{-5} \cdot T^2-0,46 \cdot CaO/SiO_2 \cdot Al_2O_3-0,0009 \cdot Al_2O_3 \cdot T+0,01 \cdot T \cdot CaO/SiO_2-23,2 \cdot CaO/SiO_2+1,53 \cdot Al_2O_3-0,06 \cdot T+53,99$

$\eta=1,79 \cdot CaO/SiO_2^2-0,11 \cdot MgO^2+2.25 \cdot 10^{-5} \cdot T^2-5,14 \cdot CaO/SiO_2 \cdot MgO-0,00018 \cdot MgO^* T+0,018 \cdot T \cdot CaO/SiO_2-26,32 \cdot CaO/SiO_2+4,71 \cdot MgO-0,08 \cdot T+70,34$

In fig. 1-6 there are shown the regression surfaces of the viscosity function of the temperature and the chemical composition.

$$\eta[CaO/SiO_2med]=0,01 \cdot Al_2O_3^2+2,06 \cdot 10^{-5} \cdot T^2-0,0009 \cdot Al_2O_3 \cdot T+1,12 \cdot Al_2O_3-0,05 \cdot T+35,21$$

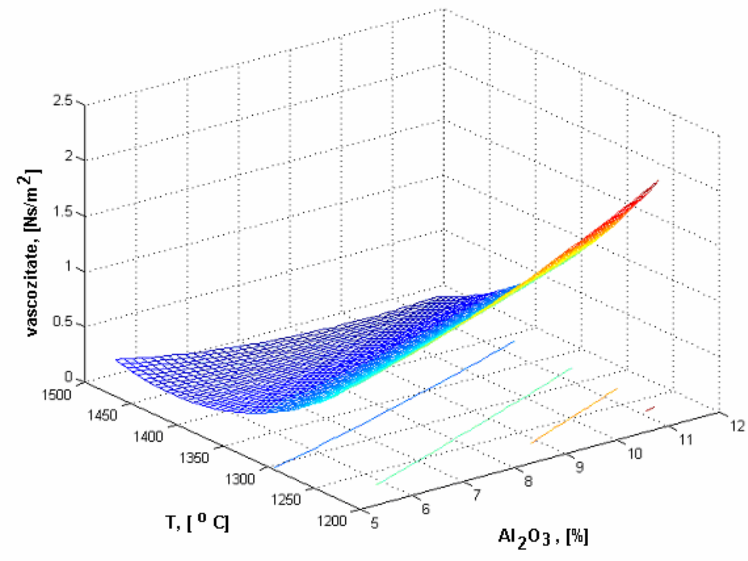

Figure 1. Surface regression η = f(CaO/SiO₂med, Al₂O₃,, T)

$$\eta [Al_2O_3med]=2 \cdot 10^{-5} \cdot T^2+2,2 \cdot CaO/SiO_2^2+0,015 \cdot T \cdot CaO/SiO_2-0.074 \cdot T-26,98 \cdot CaO/SiO_2+67,01$$

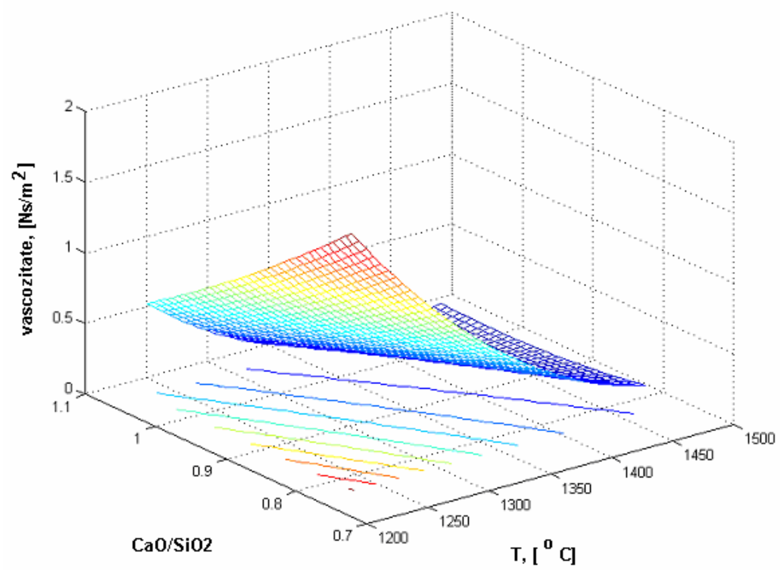

Figure 2. Surface regression η = f(CaO/SiO₂, Al₂O₃ med, T).

$$\eta\ [Tmed]=2{,}20 \cdot CaO/SiO_2{}^2+0{,}01 \cdot Al_2O_3^2-0.46 \cdot CaO/SiO_2 \cdot Al_2O_3-2{,}69 \cdot CaO/SiO_2+0{,}32 \cdot Al_2O_3+1{,}18$$

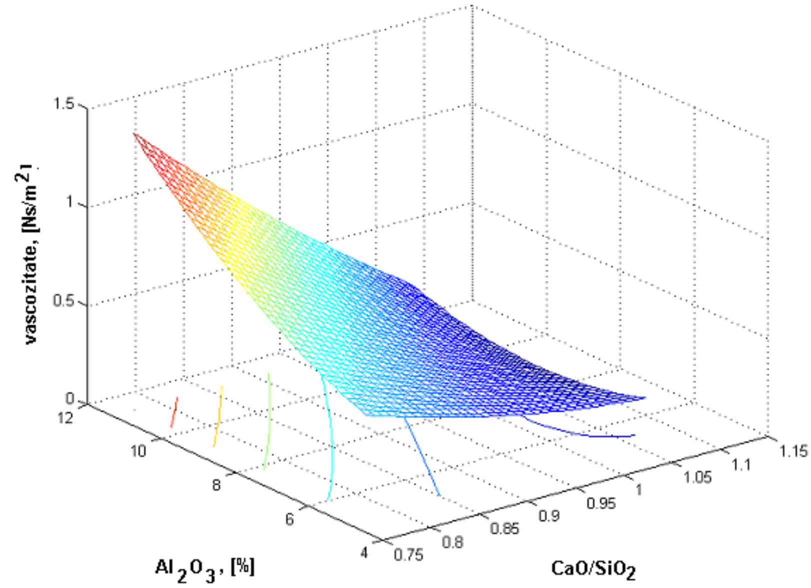

Figure 3. Surface regression $\eta = f(CaO/SiO_2, Al_2O_3, T\ med)$.

$$\eta\ [CaO/SiO_2\ med]=-0{,}11 \cdot MgO^2+2{,}25 \cdot 10^{-5} \cdot T^2-0{,}00018 \cdot MgO \cdot T+0{,}1827 \cdot MgO-0.065 \cdot T+48{,}51$$

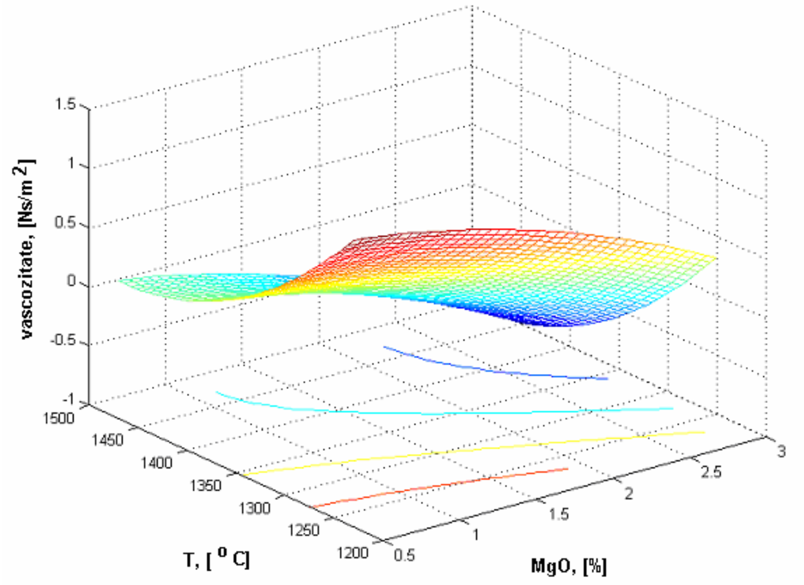

Figure 4. Surface regression $\eta = f(CaO/SiO_2 med, MgO, T)$

Analysing the two equations of the corresponding regression hypersurfaces shown analytically and graphically, the following conclusions result:

- The slag viscosity resulted by melting the lubrication powder decreases at increasing the temperature, the decrease being more pronounced at relatively low temperatures;
- The basicity increase leads to the decrease of the lubrication slag viscosity, as a result of breaking the complex anion chain of Silicon;
- An increase of Al_2O_3 content leads to an increase of viscosity, due to the formation of octahedrons (AlO_6^{9-}) instead of tetrahedrons (AlO_4^{5-}), linking the free ends of the silicate chains or those having the last Oxygen linked by Ca^{2+};
- Regarding the MgO influence on the viscosity, this leads to its decrease, fact corresponding to the data from the specialty literature for slags having CaO/SiO_2 = 0,7-1,1.

$$\eta\ [MgOmed]=2,25\cdot 10^{-5}\cdot T^2+1,79\cdot CaO/SiO_2{}^2+0,018\cdot T\cdot CaO/SiO_2-0,08\cdot T+-31,07\cdot CaO/SiO_2+74.60$$

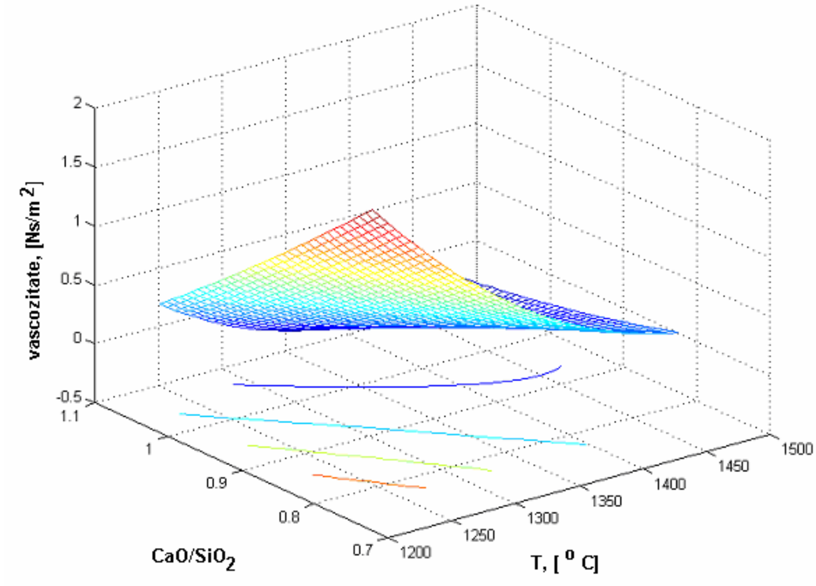

Figure 5. Surface regression $\eta = f(CaO/SiO_2$, MgO med, T)

$$\eta\ [Tmed]=1,79\cdot CaO/SiO_2{}^2-0,11\cdot MgO^2-5,14\cdot CaO/SiO_2\cdot MgO-2,32\cdot CaO/SiO_2+4,47\cdot MgO+1,27$$

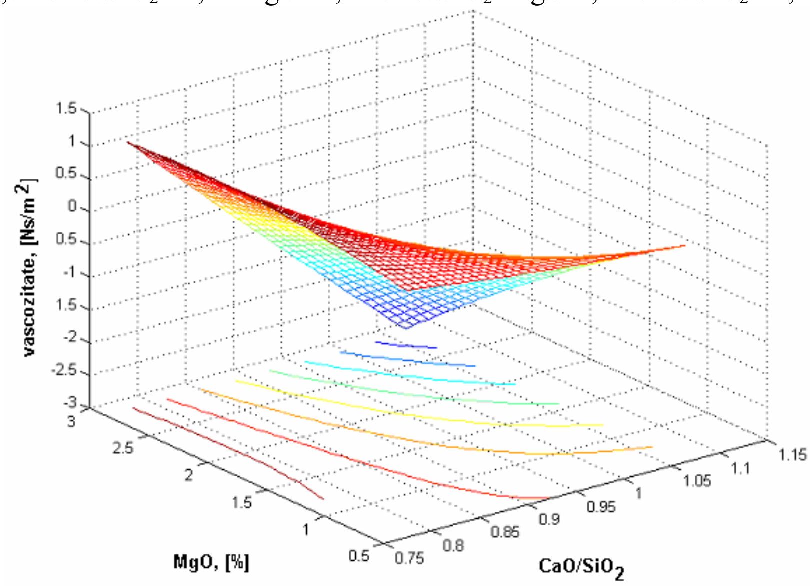

Figure 6. Surface regression $\eta = f(CaO/SiO_2$, MgO, T med)

3. CONCLUSIONS

Knowing these correlations and especially the graphic representations is very useful for the current practice because it allows to choose a casting powder having a viscosity corresponding to the relation $\eta\cdot v = 0,98$, where v is the drawing speed. Also, knowing the dependence between the viscosity and the chemical composition allows the producer of lubrication powders to test some new recipes (formulae) and to replace some components.

4. REFERENCES

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