Title: IMPROVING TECHNOLOGICAL PROPERTIES OF MOLD FLUXES USED IN CRACK SENSITIVE STEEL GRADES CASTING.

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Abstract
Physico-chemical properties of mold fluxes greatly influence fundamental processes as lubrication of strand and heat transfer control between the strand and the mold wall. Balance of these effects should be achieved for better quality and smooth casting operations of crack sensitive steel grades. Design special fluxes matching such critical requirements has been definitely a stiff problem. In this work a viable solution of such technological puzzle is discussed. Some experimental evidences strongly support the effectiveness of the proposed approach to the problem.
In recent literature attention is focusing on properties of solidifying liquid slag. It seems that traditional data on melting behavior of mold fluxes (softening, melting and flowing point) should be replaced by measured value of solidification temperature and estimation of crystallization tendency of liquid slag [1]. These characteristics are ‘key-parameters’ in controlling the lubrication of strand and the heat flow between the strand and the mold wall [2]. Balance of these effects should be achieved for better quality and smooth casting operations of crack sensitive steel grades. Therefore, the optimization of solidification temperature and amount of crystal phases in slag film is a fundamental step in developing/selecting suitable mold fluxes in connection with specific steel grades and operation parameters. The design of special mold fluxes, showing an optimal balance among strand lubrication and control of mold/strand heat transfer is considered a great achievement in mold fluxes technology.

Trying to solve this problem, one can consider some different solutions. It is possible to decrease the crystallization tendency of a mold flux forming crystalline slag by decreasing CaO/SiO₂ ratio [3], F content or increasing B₂O₃ content [4]. On the other side, it is possible to modify the heat transfer properties of a mold flux forming glassy slag by transition metal oxide doping, as Cr₂O₃, Fe₂O₃ and NiO [5].

Several examples of application of these strategies have been discussed in open literature. However, it can be observed that still it is very difficult to obtain a reliable balance between these technological properties. Actually, crystallization tendency changes stepwise from almost glassy phase to fully crystalline phase as ‘Non-Bridging-Oxides / Bridging-Oxides’ ratio reaches a specific critical value [6]. Moreover, estimated extinction coefficient for some transition metal oxide doped glasses results to be significantly lower than estimated extinction coefficient for crystalline layers [5].

Studying this problem a novel approach has been disclosed. It has been found that crystallization tendency of a mold flux forming crystalline slag can be adjusted by doping the flux with suitable transition metal oxides, giving a slag with more effective lubrication capability [7].

Preliminary screening on effects of several metal oxides pointed out that most suitable doping compound contains MnO. Indeed, other effects on viscosity and solidification temperature due to MnO content of slag are well-known, being already investigated by many researchers. In particular, it is important to stress that MnO has been found to have no effect on increasing heat flow control in a mold flux forming glassy slag [5].
Different samples were prepared from parent material ‘A’ at increasing extent of MnO doping (ranging from 1% in Sample B up to 5% in Sample D). Modification on physico-chemical properties induced by MnO addition are summarized in Figure 1.

Some comparative DTA measurements of sample A through D are shown in Figure 2. Typical sharp peak in cooling segment of a DTA curve due to a crystallizing slag, as depicted for parent material ‘A’, is shown in Figure 2 (see for example curve of Sample A). Measured value of crystallization temperature is $T_{\text{cry}} = 1417$ K This case represents a traditional basic powder with high basicity index and high crystallization temperature. From DTA analyses of samples B-D shown in Figure 2, it is evident that adding MnO to sample A produces some relevant effects on crystallization behavior of slag resulting from molten doped materials. In particular it is possible to evidence following observations:

1. nature and/or crystallization kinetic of crystalline phase seems to change significantly from sample A to sample D;
2. as consequence of observation at point 1 $T_{\text{cry}}$ seriously decreases from sample A to sample D, $\Delta T \sim 100$ K.
These results show that it is possible to tailor the crystallization tendency of a mold flux giving a slag with more effective lubrication capability.

Although, more research work is needed for better understanding of mechanism involved in MnO doping, present results strongly support the validity of the proposed solution of the problem of managing physico-chemical properties and/or technological properties of mold fluxes.

References