The Couple of Advanced Thermal Analysis and Casting Simulation to Predict the Component's Soundness Directly on the Pouring Line and Before Shaking Out. The Kasandra® Method

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Abstract: The use of powerful computers has led to develop complex simulation solidification software's that go beyond the use of Chorinov rules. Nevertheless, this huge advance in the comprehension of solidification phenomena the problem has not been solved completely. Some remaining residual soundness scrap appear randomly after production, given rise to an expensive unitary control to detect the castings that do not fulfill the quality requirements. This extra control generates a lack of productivity, extra cost, etc.

The use of commercial solidification software's cannot predict the variations on metallurgical quality during the production, and this is the reason why unexpected micro shrinkages appear in some castings given rise to the extra unitary control.

With the aim to solve this important problem a new tool coupling the thermal evolution are and the measurement of metallurgical quality in the production line has been developed given an instantaneous picture about castings soundness.

Keywords: Simulation software, Thermal analysis, LFA (last to freeze areas), Micro shrinkage prediction, WIP (working in process)

1 Introduction

Cast Iron is a unique alloy that depending on the nucleation capacity can solidify following the stable Fe-C-Si diagram with graphite formation as well in an intermediate state with presence of graphite and cementite or with fully presence of carbides and austenite. These three-solidification behaviours determine the final properties of the castings.

Nowadays the classical casting foundry design in ductile, compact or gray iron where the thermal evolution goes to the risers as a final solidification element has not place, due to the highest competitiveness introduced by globalization. It is imperative design models that reduce the number of risers, increase the pattern yield, lower the energy consumption, reduce the amount of master alloys and the number of final controls on the castings and avoiding operations that do not add any value, such as degating, trimming, fleeting, producing castings in a lean way without WIP.

The only way to obtain soundness castings with high yield is combining thermal evolution with the capacity to form graphite. The isolated thermal pockets detected by the study of thermal evolution in the LFA and the corresponding contraction due to the residual liquid must be counteract by the graphite formation in these areas. The Kasandra® software combine the study of thermal evolution of the casting pointing out the isolated pockets and the capacity of graphite formation during solidification to predict directly in the production line the soundness of the poured components avoiding the further triage of the casting to scrap parts with porosity because of micro-shrinkage presence.

3 Experimental procedure

Caliper castings for automotive brakes systems were produced in a vertical molding machine (Disamatic 230 type Z) with six cavities per mold and a pattern yield of 70% in D.I quality GGG 50-7. The melting shop of the foundry is composed by three induction medium frequency furnaces 25 ton of capacity each and the material of charge is 50% steel scrap from automotive stamping, 40% foundry returns and 10% of pig iron.

Some graphite and CSi was added to adjust the chemical composition. Spheroidization treatment is performed by 1.2% of Mg master alloy with 5-6% Mg 1.2% of RE following the sandwich method in a ladle of 2-ton capacity. The metal is introduced in a pouring unit with heating of 15-ton capacity. Every 20 minutes a new ladle is introduced into the pouring unit. The metal is poured into the mold by means a rod-stopper system and the flow rate is guided by automated laser system.

The chemical composition is highlighted in table 1.

Table 1. Composition of Alloy

C	SI	Mg	P	S	Cu
3.65	2.30	0.040	0.002	0.006	0.35

The inoculation is performed in the liquid stream during the pouring in 0.2%. Grain size 0.2-0.6 mm. The composition of inoculant is the following.

Table 2. Composition of Inoculant

Si	Ca	Al	RE	Fe	
70-75	0.7-1.2	0.7-1.2	1.5-2	5.01	6.01

The range of pouring temperatures is 1390-1410ºC and the pouring time is around 8 sec.
The metallurgical quality of the poured melt is measured by Thermolan® thermal analysis system
The lay out shows that the casting is fill and fed only for one riser and the thermal evolution is pointed out in Figure 1. It is of interest to remark the different liquid fractions inside of the isolated pockets

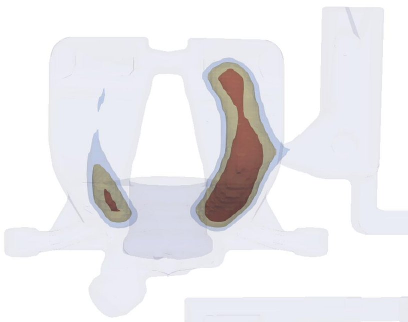

Figure 1. Lay out of filling and feeding system.

4 Result and discussion

The prediction of Kasandra® software who integrate in its calculations the metallurgical quality of the metal treated and inoculated in terms of capacity of graphite formation along all the solidification period paying special attention at the final end (latest fraction liquid to solidify) show that it is possible to produce this casting with appropriate quality in terms of soundness and mechanical properties if the metallurgical quality is classified as “premium” with good capacity to form graphite till the latest states of solidification otherwise the prediction forecast defects in both sides of the isolated area.

Figure 2 shows how, during the production, it is possible to produce good castings with the appropriate metallurgical quality as it is shown by Thermolan® and Kasandra® prediction.

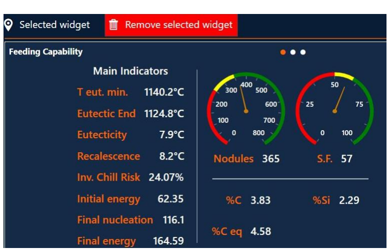

Figure 2. Picture taken from Thermolan® showing the main features of the cooling curves as well as the prediction knowledge

Figure 3. Image of the casting analysed by tomography.

Conclusion

1.A new software which integrates filling, thermal evolution of the castings as well as the implementation of metallurgical quality of the metal to be poured into the mold have been developed.

2.This software can be used well in the technical department to design the lay out the new project as well as to calculate the final cost for RFQ proposal and also directly in the shop floor together with the thermal analysis to predict the soundness of the products that are producing. In such a way it is possible well reduce the xR control of the parts or eliminate this costly control.

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