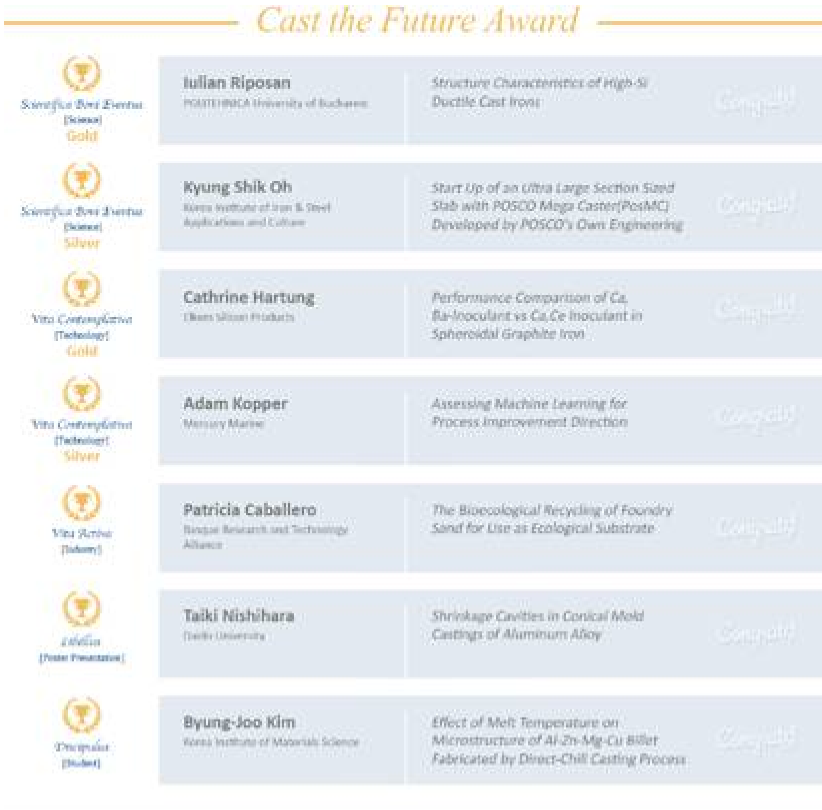
Cette journée a été couronnée par la Nuit des fondeurs combinée à la cérémonie de clôture du Congrès. Ce tout premier congrès hybride s'est avéré très fructueux techniquement, à l'image des récompenses distribuées au cours de la cérémonie de clôture aux lauréats dans les catégories « Meilleur article scientifique » et « Meilleur article technique ».

Vous trouverez l'article d'Elkem dans ce ***TECH News** **FONDERIE**, écrit par Cathrine Hartung qui a reçu le très convoité « Best Paper Gold Award Technology ». L'article décrit les avantages en termes de performance des inoculants spécialisés au cérium par rapport aux produits de base à base de calcium et de baryum pour produire des pièces en fonte ductile de haute qualité.*

Le dernier jour du congrès a été consacré à des visites techniques, permettant aux participants de se familiariser avec les capacités de l'industrie Coréennes de la fonderie et ses installations scientifiques et de recherches.

Guillaume ALLART //////////
Président de l'ATF



Performance comparison of Ca,Ba-inoculant vs Ca,Ce inoculant in spheroidal graphite iron

Cathrine Hartung[1], Leander Michels[1], Eivind G. Hoel[1]

[1]*Foundry Innovation – Elkem Silicon Products (ESP) – Fiskaaveien 100, NO-4621 Kristiansand Norway,*

>>> ABSTRACT

In the present study, the performance of Ca, Ba-inoculant has been compared against Ca, Ce-inoculant in spheroidal graphite irons (SGI). In the study, the addition rate for the two inoculants was varied in order to understand what the minimum addition rate would be to ensure carbide free castings and to evaluate the effect of increasing inoculant addition on carbide level, graphite structure and thermal analysis characteristics.

Article info
Keywords: *SGI, Inoculation, Chill control, Fading*

>>> INTRODUCTION

For SGI, Mg-treatment is essential to ensure that the graphite grows in the shape of nodules, while inoculation is critical to ensure nucleation of graphite and provide a high nodule count, which will help to reduce the risk for carbides and increase the as-cast ferrite content ***[1]***. Inoculation can be done in different ways, but the best effect is achieved by adding the inoculant close to pouring ***[2]*** to reduce the risk of fading ***[3, 4]***. Majority of inoculants are Fe-Si based, but there are many different types ***[5]***. They will all work, but some are more potent than others at the same addition rate, while for some the effect fades faster. These inoculants will all contribute with Si, leading to a higher carbon equivalent (CE). In SGI the CE is normally kept high at 4.3-4.5 ***[6]*** to have the maximum amount of graphite precipitated during solidification and the lowest possible requirement for feeding. The cost of Si-units increases with proximity to pouring as there will be more requirements for sizing and chemistry. A more effective inoculant will thus allow for late and lower addition, which leave room for more Si- units to be added to the charge where the cost is lower. A high Si-level in the induction furnace is beneficial for reducing lining wear. The purpose of this study is to show how Ca,Ce-inoculant can provide better inoculation at lower addition, thus leaving more room for the addition of Si-units to the furnace charge and having minimal impact on CE.

>>> EXPERIMENTAL PROCEDURE

Base iron (3.6%C, 1.7% Si, 0.012%S) was melted in coreless induction furnace and tapped out at 1500°C into a tundish ladle where 1.20 wt% MgFeSi (6.0% Mg,1.8% Ca, 0.5% Al). Inoculation was done by placing the

inoculant in alumina crucibles filled with 32 kg liquid iron and held 60 s prior to casting. The two different inoculants tested were Ca,Ba-inoculants (73.1% Si, 1.4% Ca, 2.6% Ba, 1.5% Al) and Ca,Ce-inoculant (73.1% Si, 0.97% Ca, 1.67% Ce, 0.88% Al). The addition rate for the two inoculants were varied between 0.05 and 0.20 wt%. A compensation for Si was made to the alumina crucibles with pure Si-metal to have the same final Si for the different addition rates.

>>> RESULT AND DISCUSSION

Below the chemical composition for the two heats can be seen showing that the chemistry for both heats were in line with target and the same for both heats.

	C	Si	Mn	P	S	Mg
Target	3.5	2.5	0.2	<0.030	0.008	>0.040
Ca,Ba12.5 inoculant	3.55	2.6	0.2	0.013	0.007	0.052
Ca,Ce12.5 inoculant	3.54	2.6	0.2	0.013	0.007	0.052

Table 1: *Actual final iron composition versus target.*

Microstructure results from the 30 mm tensile bar show in ***figure 1*** that nodule density increases with increasing inoculant addition for both inoculants, but that higher nodule density is achieved with Ca,Ce-inoculant for all addition rates. A minimum of 40% higher nodule density is achieved with Ca,Ce-inoculant compared to with Ca,Ba-inoculant at same addition rate.

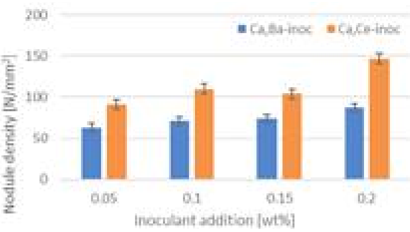


Figure 1: *Effect of inoculant addition on nodule density for the two inoculants compared.*

With regards to nodularity a consistent nodularity of ca 80% is seen for Ca,Ce-inoculant regardless of addition rate, while the nodularity for Ca,Ba-inoculant varies from 60 to 75% and increases with increasing addition rate.

When it comes to the ferrite content minor difference is seen between the two inoculants at the lowest inoculant addition rate as can be seen in ***figure 2***, but as the nodule density increase with increasing inoculant addition the ferrite content increases with both inoculants. However while a ferrite content of 50% is achieved with 0.20 wt% of Ca,Ba-inoculant, 65% or 30% higher is achieved with Ca,Ce-inoculant.

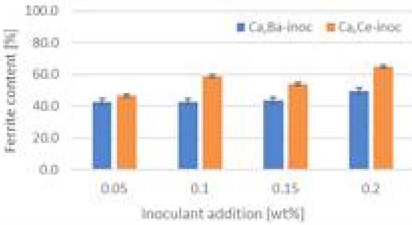


Figure 2: *Effect of inoculant addition on ferrite content for the two inoculants compared.*

In ***figure 3*** below the cooling curves for the two inoculants are shown versus the uninoculated.

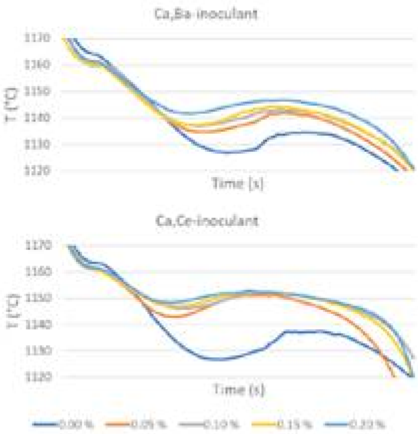


Figure 3: *Cooling curves for the two inoculants compared versus uninoculated.*

Both inoculants provide an improvement versus uninoculated, but it can also be seen from ***figure 3*** that there is less undercooling with Ca,Ce-inoculant than with Ca,Ba-inoculant regardless of addition rate.

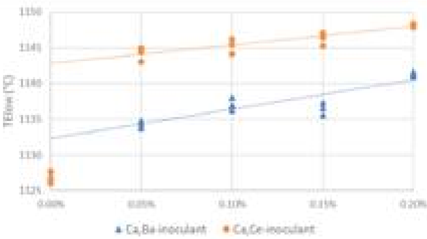


Figure 4: *Effect of inoculant addition on TElow for the two inoculants compared.*

The effect of the inoculant addition on TElow value for the two inoculants is shown in ***figure 4*** and shows that even at 0.20 wt% addition the Ca,Ba-inoculant is not able to provide similar low undercooling as observed with 0.05 wt% Ca,Ce-inoculant.

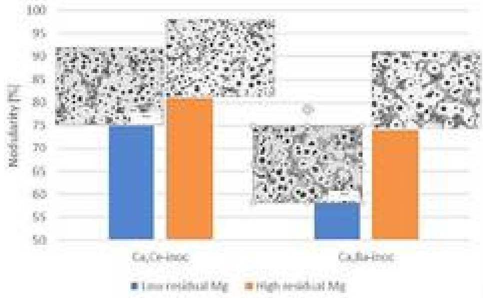


Figure 5: *Effect of residual Mg-level in nodularity and microstructure for the two inoculants compared.*

In ***figure 5*** the effect of residual Mg (0.038% vs 0.050%) on the nodularity along with the etched microstructure can be seen for the two inoculants. No significant effect of residual Mg-level on nodule density or ferrite content, but for both inoculants lower nodularity is observed for lower residual Mg-level. For the Ca,Ce-inoculant the nodularity decreases with ca 7% while for Ca,Ba-inoculant the nodularity decreases with ca 20% .

>>> CONCLUSION

The present study shows that even at 0.05 wt% Ca,Ce- inoculant is providing higher nodule density, higher nodularity and more ferrite than Ca, Ba-inoculant. Working with Ca,Ce-inoculant will allow lower addition rate of inoculant and also allow working with lower additions of MgFeSi and/or lower residual Mg level. Lower inoculant and lower MgFeSi addition will give room for more Si-units in the furnace where the Si-units are cheaper.

Acknowledgments

We would like to thank Emmanuelle Ott and John Hughes for valuable comments.

References

1. *Morgan, H. L. "Inoculation of cast iron", BCIRA Journal 32, pp 339-350 (1984).*
2. *Pearce, J. "Inoculation of cast irons: practices and developments", Foundry Trade Journal, pp 28-32, (2008).*
3. *Hummer, R. "Some aspects of inoculation of flake- and nodular graphite cast iron," The Metallurgy of Cast Iron, B. Lux, I. Minkoff, F. Mollars (eds.), St. Saphorin (Switzerland): Georgi Pub. Co., pp 147-160 (1975).*
4. *Michels, L., Pires, A. J. F., Ribeiro, C. A. S., Kroka, B., Hoel, E. G., Ott, E., & Hartung, C. "Effect of Holding Time on Populations of Microparticles in Spheroidal Graphite Irons." Metallurgical and Materials Transactions B, (2022) 1-12*
5. *Hartung, C, Michels, L, Logan, R. "The History of inocula- tion and evolution of inoculants" AFS Transactions (2021) 21-038-1*
6. *Kanno, T "Effect of pouring temperature, composition, mould strength and metal flow resistance on shrinkage cavities in spheroidal graphite cast iron", International Journal of Cast Metals Research Vol 21 No1-4 2008*