11-13 September / Eylül 2014
TÜYAP Fair, Convention & Congress Center, İstanbul
7th International Ankiros Foundry Congress
7. Uluslararası Ankiros Döküm Kongresi

«Inoculation of Grey and Ductile Iron»

«Gri Dökme Demir ve Duktil Dökme Demir Aşılama Uygulamaları»

Kenza Soulas
Michael Koch
(Zenmet)

2.Oturum: Döküm Teknolojileri Demir - Çelik

2nd Session: Casting Technologies Iron - Steel

Oturum Başkanı/Session Chairman: Hüseyin Yumak (Trakya Döküm San. Tic. A.Ş.)

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INOCULATION OF GREY AND DUCTILE IRON

Kenza Soulas
Michael Koch

SUMMARY

- Understanding of inoculation
- Effect of inoculation
- Inoculation materials
- Practical experience

summary

- **Understanding of inoculation**

- **DEFINITION OF INOCULATION**

Certain materials added in small amounts to liquid cast iron, reduce the tendency to form « chill », enhance solidification under Iron-carbon system by promoting sufficient nucleation sites

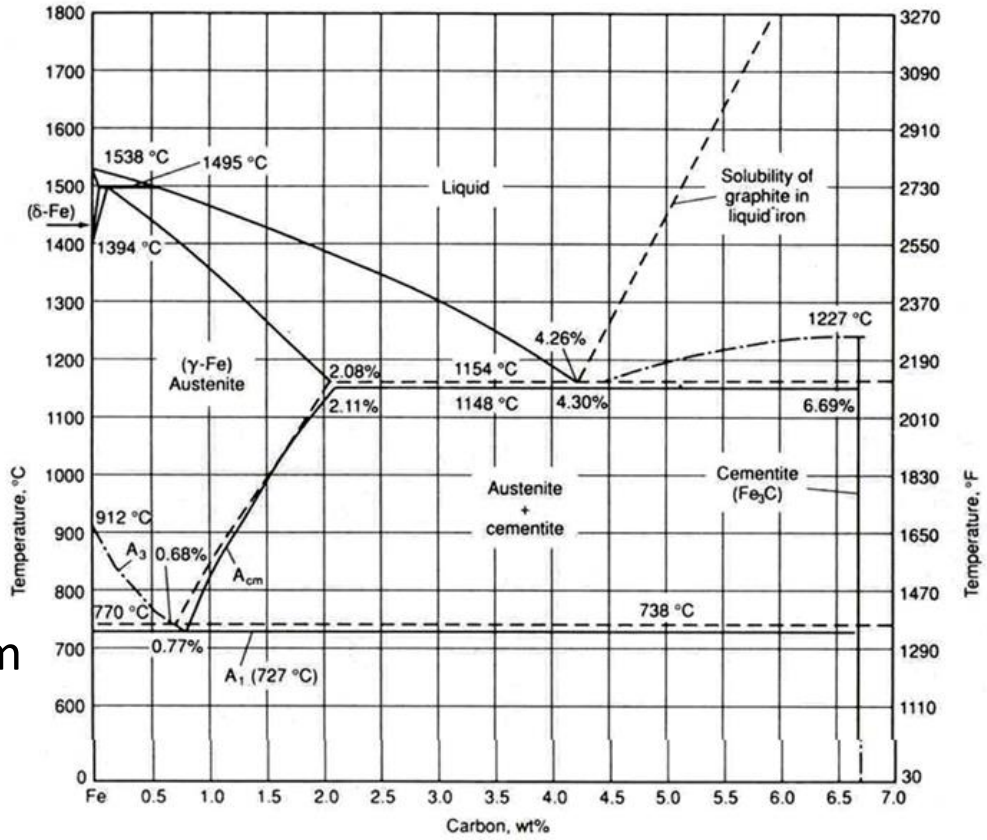
This practice is called :

INOCULATION

- **What happens during solidification ?**

  - carbon can solidify under two forms :
    - graphite
    - bound carbon

  - This corresponds to two cases :
    - Fe-graphite : stable diagram
    - Fe-Fe3C : metastable diagram



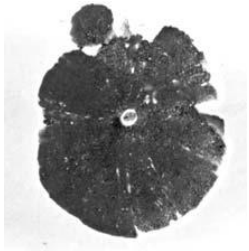
- **Inoculation mecanisms**

Alkaline Earths from Inoculant

+

Liquid Iron "O + S "

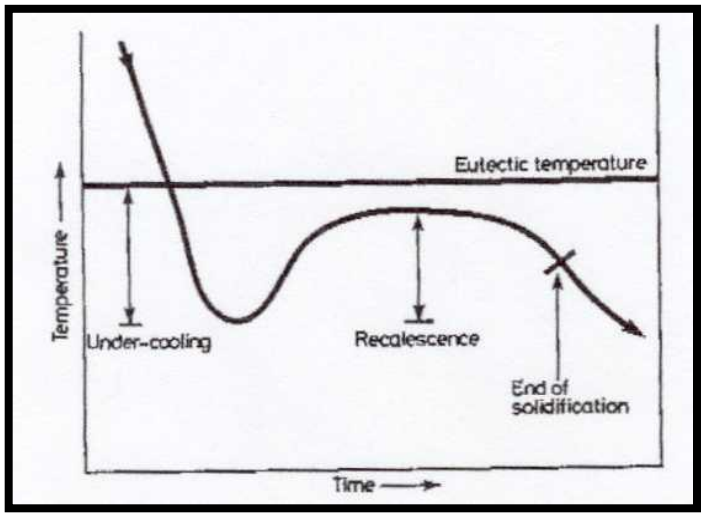
=

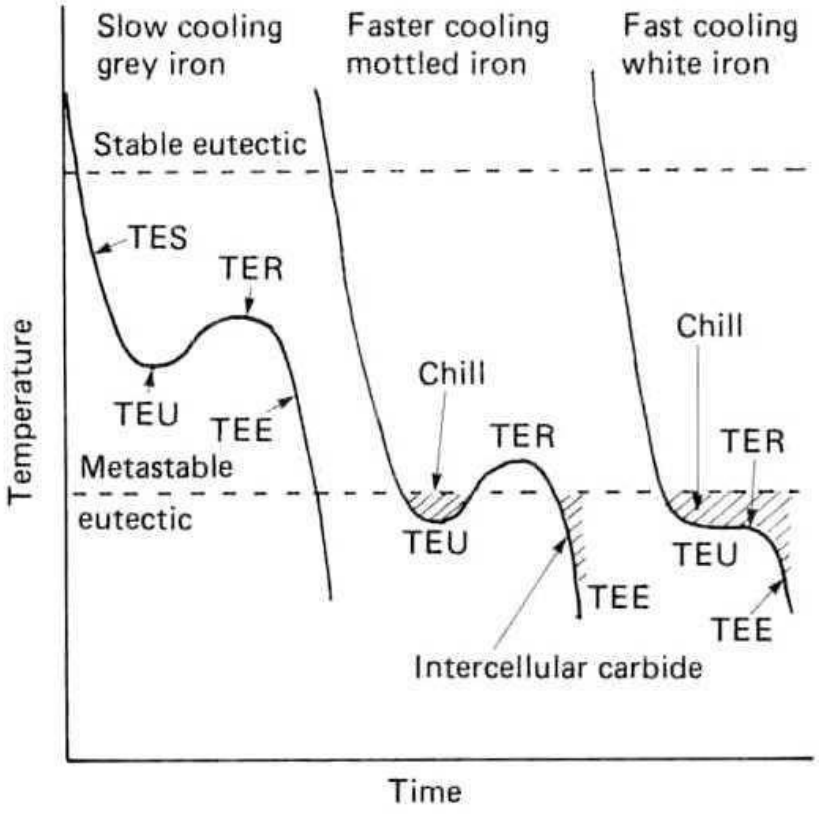


Heterogeneous Nuclei
(carbides, sulfides, oxides)

- **Minimizing the undercooling phenomenon**

At the eutectic temperature, there is a degree of undercooling followed by a recalescence before solidification is completed.



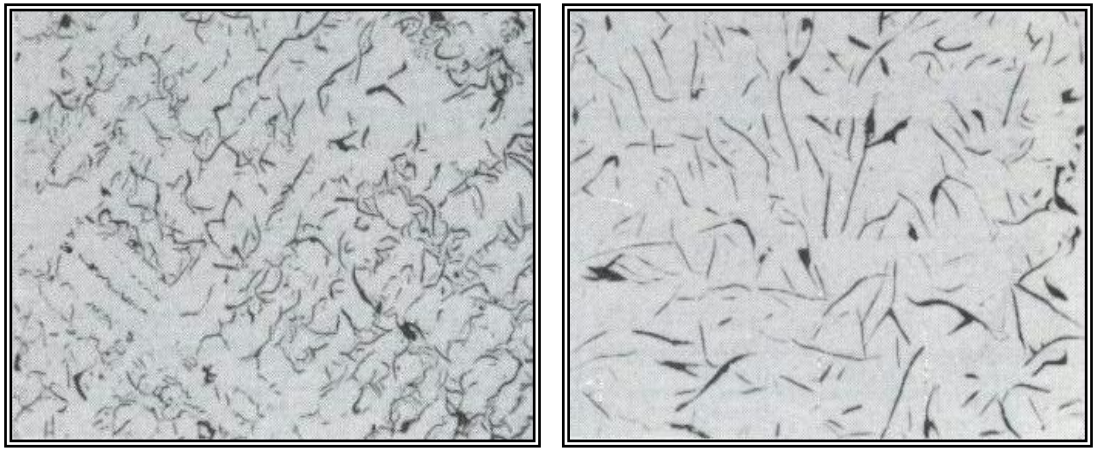


summary

- **Effect of inoculation**

- **Effect of Inoculation on Grey Iron**

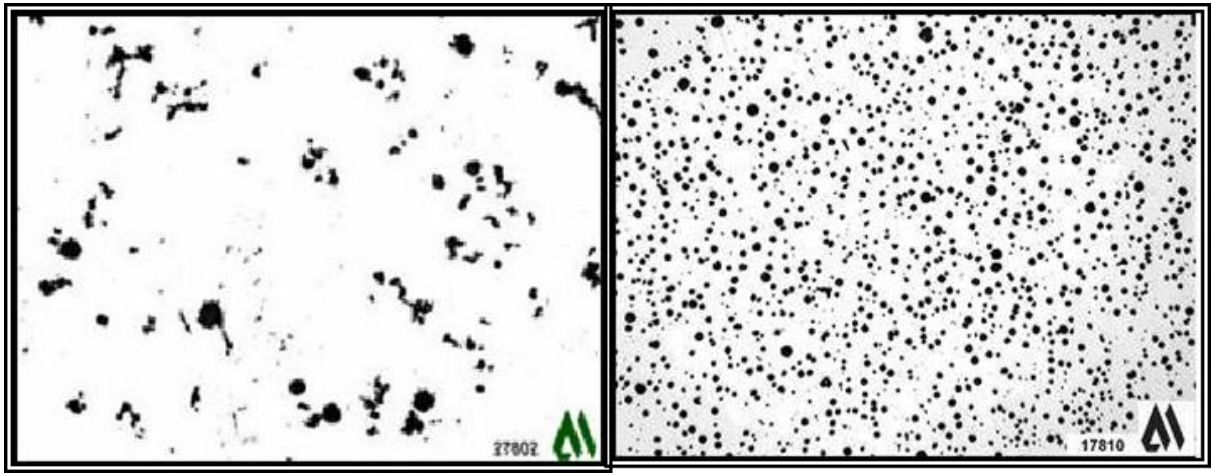
- reduces chill and promotes graphite formation
- reduces the formation of fine graphite
- correct Inoculation leads to the desired Graphite size
- promotes uniform structures in various sections
- improves mechanical properties
- improves machinability



Structures of poorly and well inoculated grey irons

- **Effect of Inoculation on Ductile Iron**

- reduces tendency for chill
- increases the nodule count
- promotes the formation of fully spheroidal graphite
- Ferrite structure as-cast in thin sections possible
- Increases artificially Mg fading time



Structures of poorly and well inoculated Ductile irons

summary

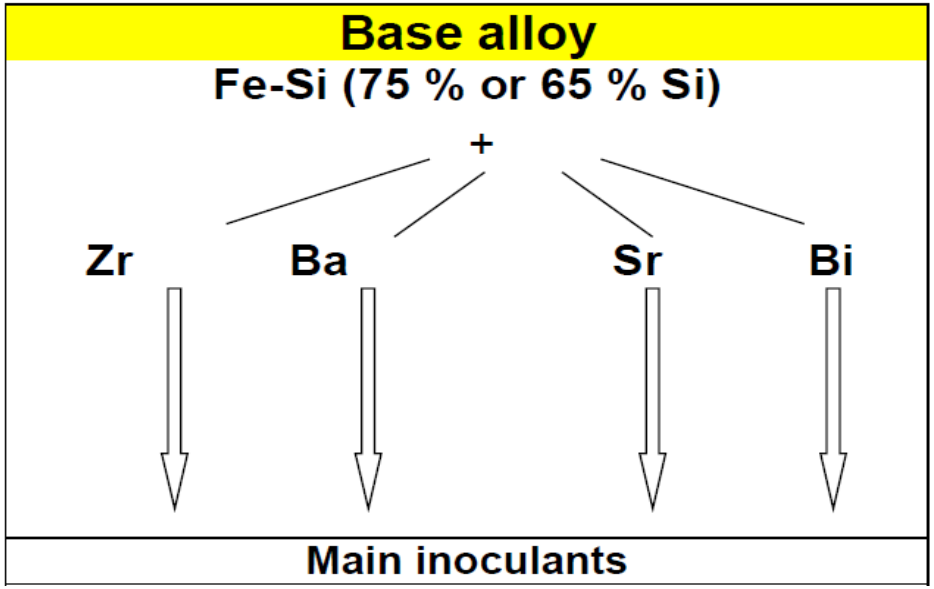
- **Inoculation materials**

- **What is the chemistry of an Inoculant ?**

Inoculants contain mainly :

- Silicon: main element
- Calcuim: promotes graphite
- Aluminium: promotes ferrite and graphite

Mainly Inoculants are :



Chemical elements and its effects :

- C : promotes graphite, reduces chill
- Ba : promotes ferrite, increases fading time
- Mn : reduces liquidus point , better dissolution
- Sr : powerfull for grey Iron
- Zr : reduces chill depth, ties up N
- Bi/RE : reduces chill, chunky
- La : reduces micro-shrinkage

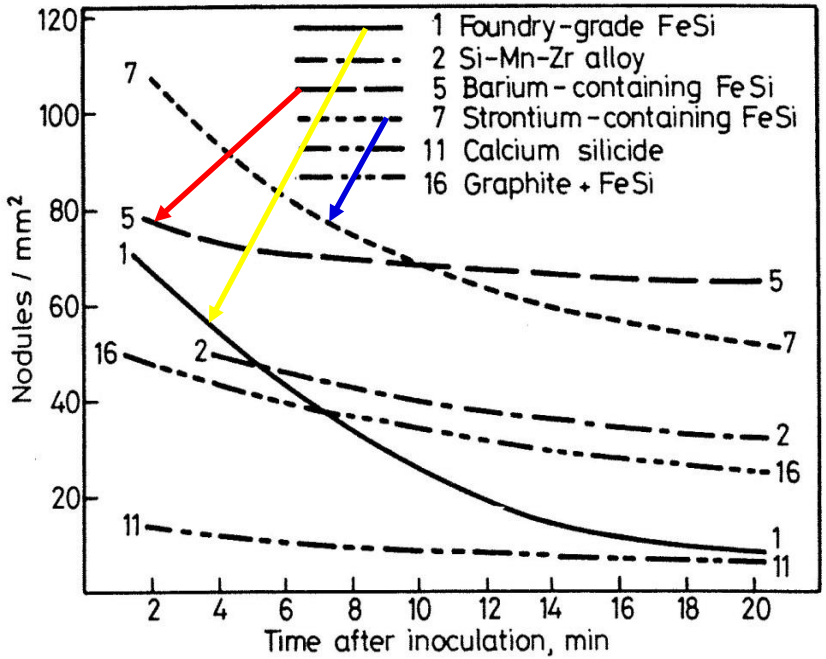
summary

- **Practical experience**

- **ZOOM ON INOBAR : Ba based inoculant**
  - ➢ Improvement of fading
  - ➢ Improved Nodularity & Reduced Carbides

An Inoculant can lose 50 % of its efficiency after only 5 minutes.

The fading effect can be reduced with Ba .

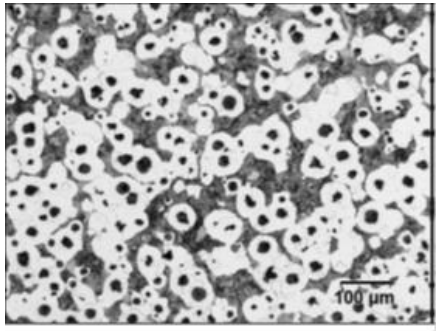


Effect of various inoculants on nodule number [Morgan]

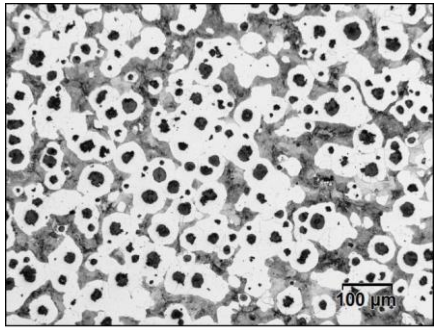
- **ZOOM ON INOBAR : Ba based inoculant**

Ba is able to reduce the Chill depth

From 9% Ba, chill depth stable at 0.3 mm



0,4% FeSi after Mg treatment and inoculation
Center of the casting, Nital Attack



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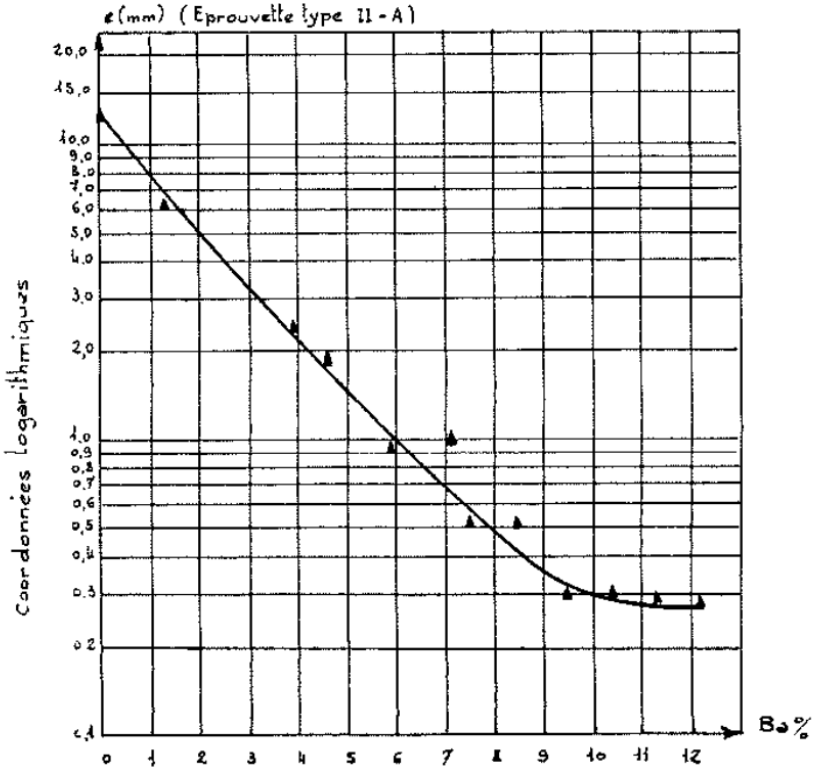
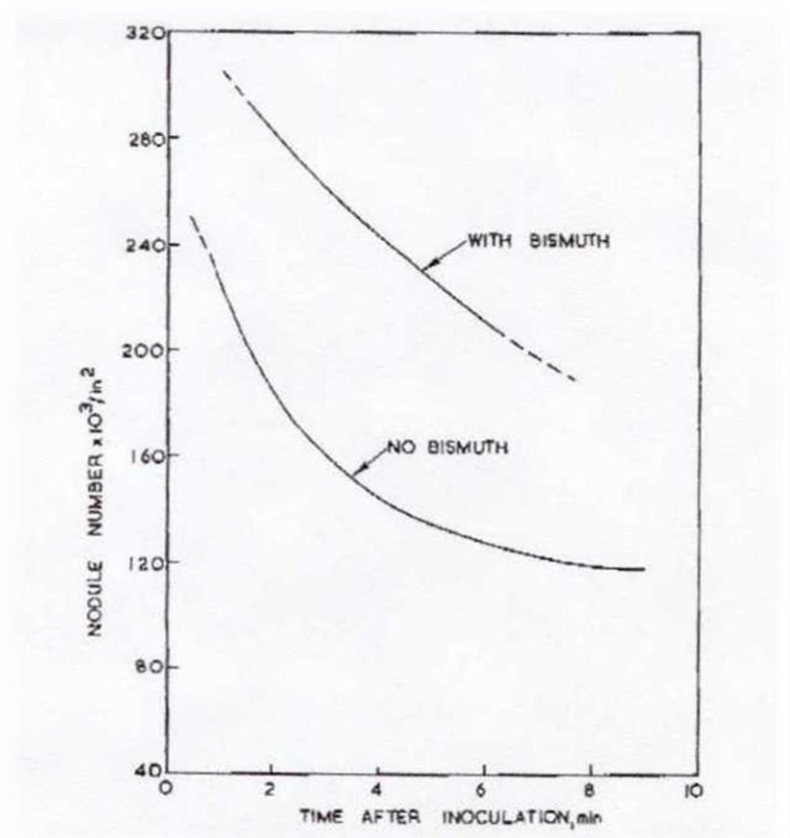


Influence of Ba on chill depth [JC.Percheron]

- **ZOOM ON SPHERIX : Bi/RE based inoculant :**

  - Good performance in various sections castings
  - Excellent performance for thin sections ferritic as-cast
  - Improved nodularity and increased nodule count
  - Helps to avoid Chunky



Effect of Bismuth in ductile irons inoculated with ferrosilicon

- **Case study with Spherix :** Extremely powerful in thin sections to meet the required structure as-cast

- **Industrial trial :** Clutch Plate GJS 500

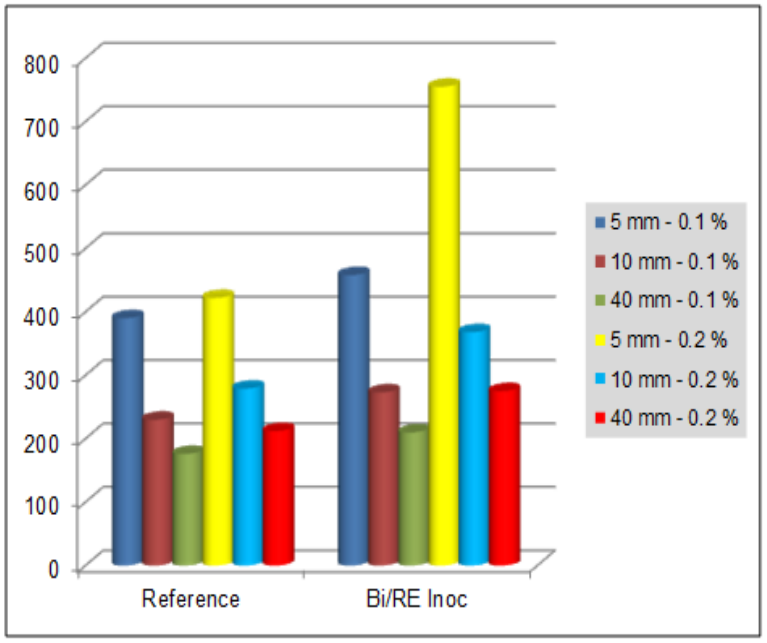
Standard process :

- Nodularisation process with pure Mg (Converter)
- Ladle inoculation with 0.4% Standard FeSi
- Late inoculation 0.1% Ba based inoculant

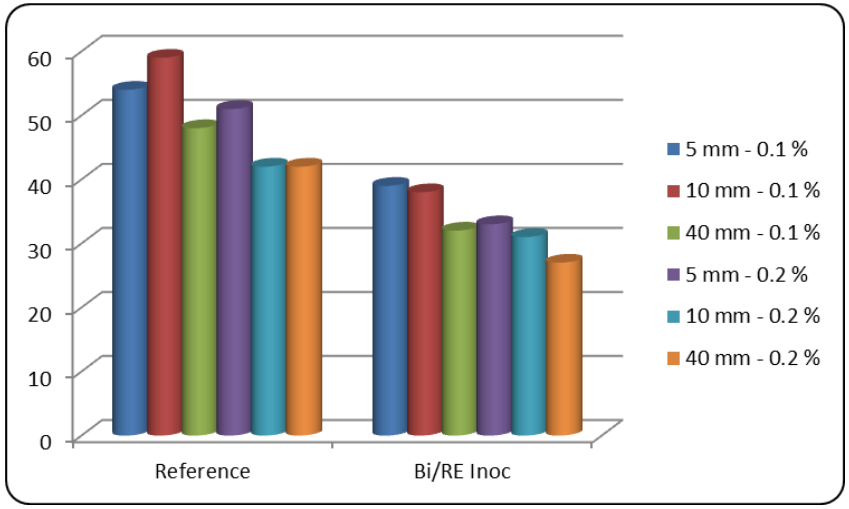
trial process :

- Nodularisation process with pure Mg (Converter)
- Ladle inoculation with 0.4% Standard FeSi
- Late inoculation 0.1% Bi based inoculant

- **Results on "step wedge":**

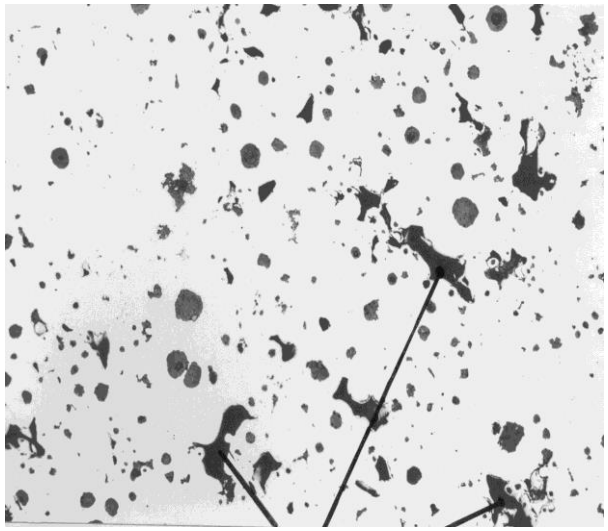


Influence of Bi/RE inoculant on Nodule Count

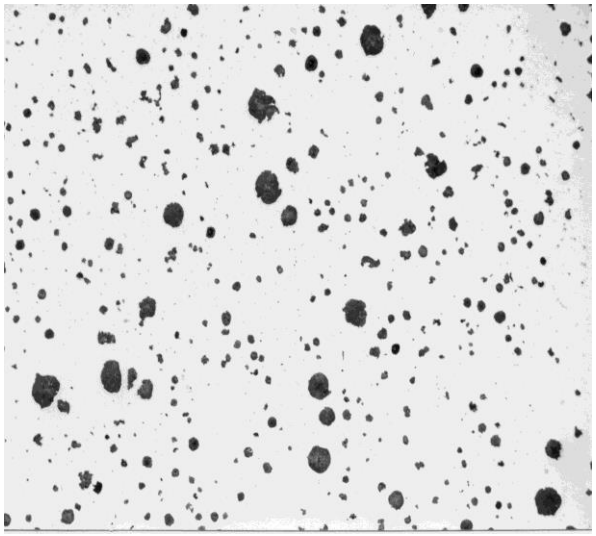


Influence of Bi/RE inoculant on pearlite

- **ZOOM ON FeSiLa : La based inoculant**
  - Powerful against micro-shrinkage
  - Improves self-feeding capacity



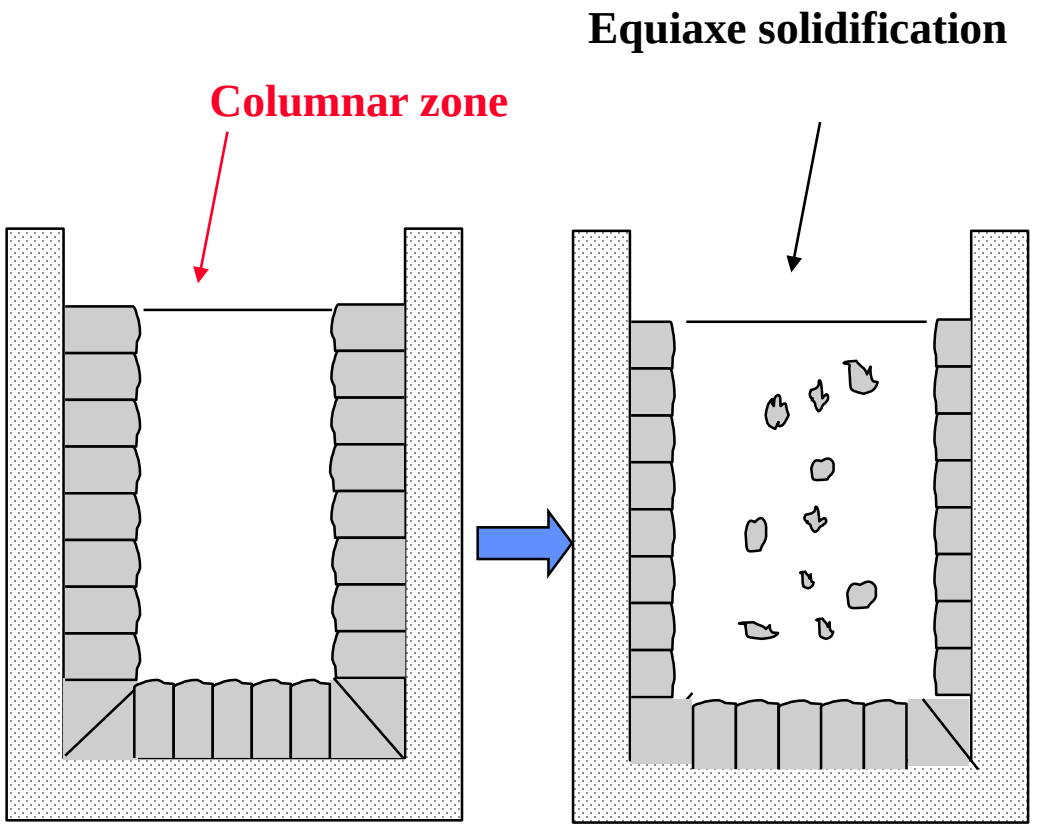
Without La
Microshrinkage



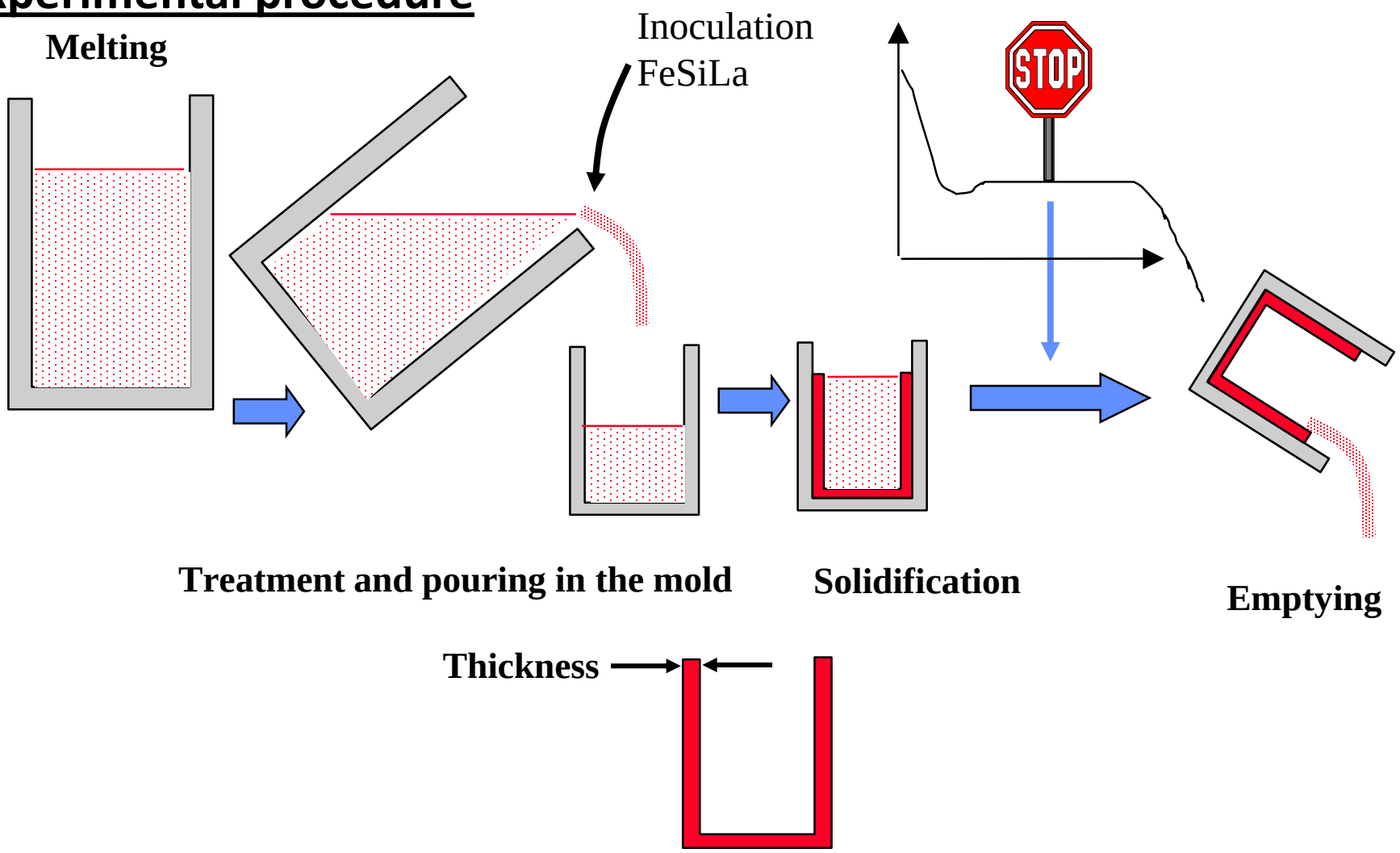
With FeSiLa
No Microshrinkage

- **ZOOM ON FeSiLa : La based inoculant**

  - Lanthanum promotes the Equiaxe solidification instead of the classical columnar solidification mode



Experimental procedure



Without La 0%

Diameter 60 mm

Thickness **6 mm**

With La 0.8%

Diameter 60 mm

Thickness **2 mm**

At a given solidification stage, when “La” is added, the **equiaxe solidification** is favoured :

- **Thickness of the columnar zone is reduced**: larger free flowing of liquid is favoured to move within channels for the feeding of casting sections.

- Semi-solid iron contains more solid particles after filling of a given volume chamber : **less liquid is needed** to compensate the solidification contraction.

- Promotion of Late eutectic graphite precipitation.

CONCLUSION

- Inoculation is an important step in the production of Grey and Ductile Iron Castings.
- Inoculants are complex Ferrosilicon based products with various elements like Bi, RE, Sr, Zr etc.
- The correct inoculation practice is absolutely necessary to obtain the required structure in the casting

The choice should be based on cost and technical considerations


Thank you for your attention
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