



SOLIDIFICATION OF IRON CASTINGS: THE INFLUENCE OF INOCULATION

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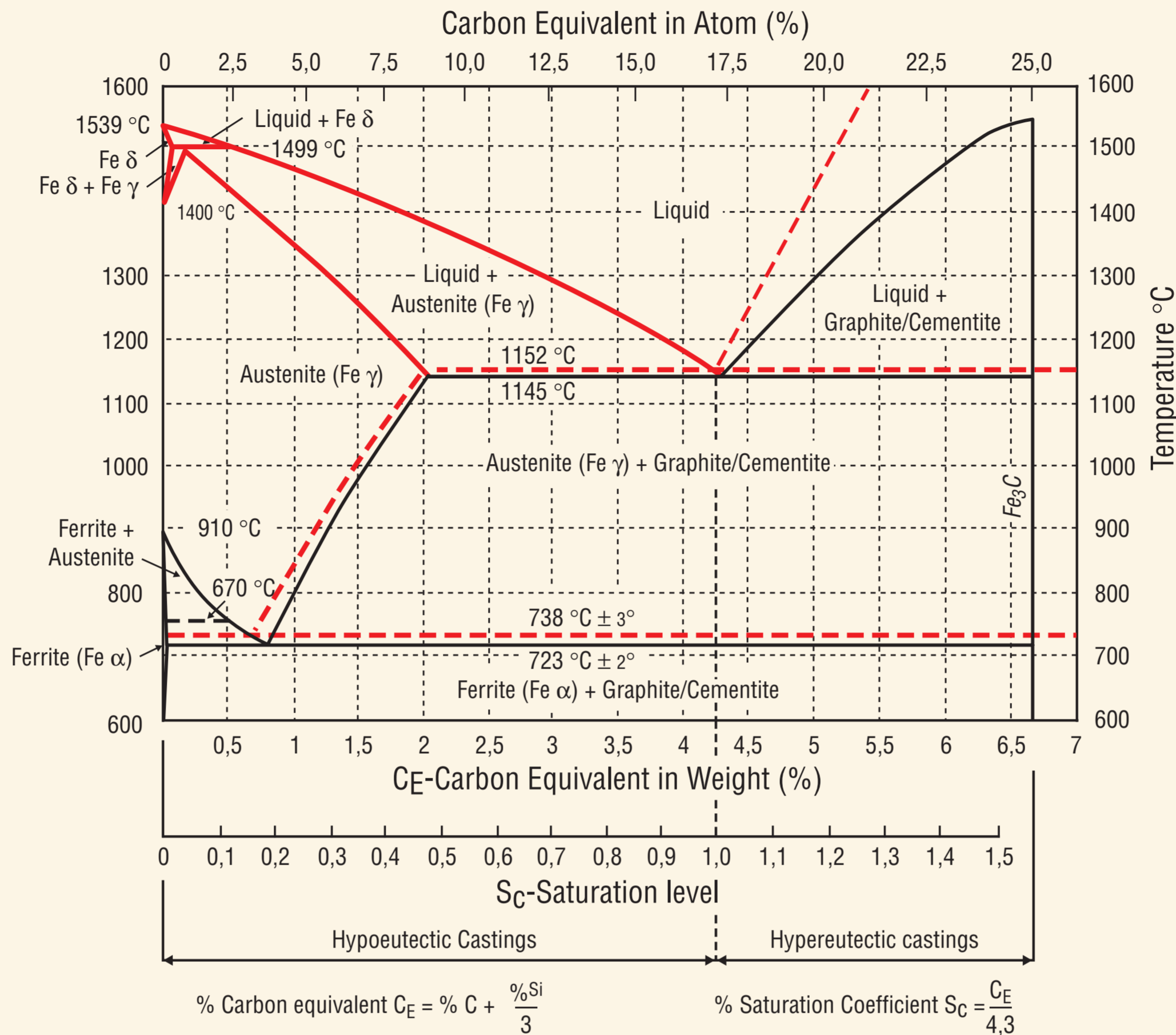
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CARBON - IRON DIAGRAM



INTERPRETATION OF SOLIDIFICATION USING COOLING CURVES

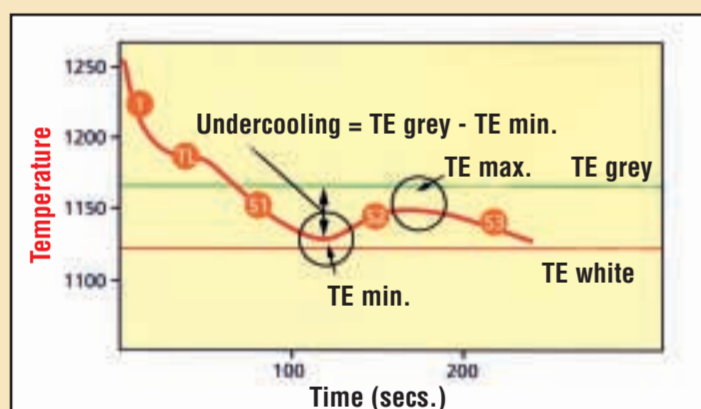


Figure 1.

Cooling curve for inoculated graphitic iron.

The metallurgical quality of iron castings depends on the solidification mode which can be modified by inoculation. The thermal analysis cooling curve can be interpreted as follows:

TL Liquidus temperature. The first solid phase starts to form. In hypoeutectic irons austenite is precipitated. In hypereutectic irons graphite is precipitated. Differs according to the silicon content.

TE grey Iron-graphite eutectic solidification temperature. Equilibrium temperature is 1154°C in pure iron-carbon alloy.

TE white Iron-iron carbide solidification temperature. Equilibrium temperature is 1145°C in pure iron-carbon alloy.

S1 Start of development of the solid stage, i.e. austenite or graphite.

TE min. Austenite and graphite are still growing; inoculation raises this temperature.

Undercooling (1154°C - TE min.). Too much undercooling tends to generate carbides. Inoculation raises TEmin, reducing undercooling.

S2 Recalescence. Increase in metal temperature.

TE max Maximum eutectic temperature. Determines recalescence (R = TE max. - TE min.), and relates to the graphitisation model.

S3 Second solidification stage. Secondary porosity relates directly to this part of the curve.

THE EFFECTS OF INOCULATION.

Inoculation modifies the profile of the thermal analysis curve, so that solidification follows the graphitic solidification model.

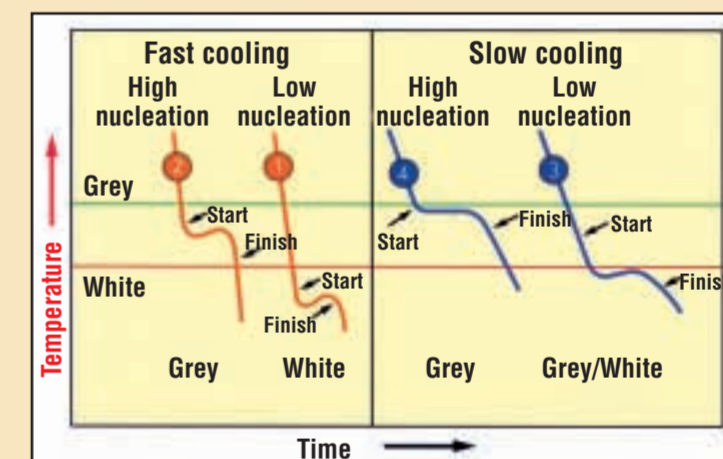


Figure 2. With both fast and slow cooling, inoculation raises the temperatures of the curve, promoting the graphitic model of solidification.

- (1) Fast and uninoculated cooling. TE min. < TE white, thus the iron is carbide or white.
- (2) Fast and inoculated cooling. TE min. > TE white. Grey iron forms.
- (3) In a thick casting, slow and uninoculated cooling, mottled or mixed graphitic-carbide structure forms.
- (4) Same as previous, but inoculated, is entirely graphitic.

SELECTION OF INOCULANTS FOR PRODUCTION OF GREY IRON CASTINGS

Priority	Aim
1	Prevention of carbides or white iron
2	Improve shape of type-A graphite (improved properties)
3	Delay fading of nucleation
4	Reduce microshrinkage
5	Reduction of graphite flotation
6	Minimise gas defects
7	Eliminate ferrite skin
8	Other

Effects of 'active' elements in grey iron inoculants.

Aluminium
Improves ferritisation. Neutralises nitrogen.
Foseco Products: INOCULIN* 75, 310, 320

Calcium
Improves graphite germination. Reduces tendency to chill.
Foseco Products: INOCULIN 75, 310, 320

Barium
Strong graphite promoter. Reduces inoculant fading.
Foseco Products: INOCULIN 325, 360

Strontium
Strontium eliminates carbide without increasing the number of eutectic cells (reducing the tendency to shrinkage due to excessive high cell count).
Foseco Products: INOCULIN 33, 33X, 48, SR50

Zirconium
Improves solubility of inoculant, neutralises nitrogen and improves inoculation. Combined with Mn, reduces melting point of inoculant.
Foseco Products: INOCULIN 80, 98, 25, 90, 95, 250, 900

Cerium and other Rare Earths
Cerium and other rare earths increase the number of eutectic cells and reduce fading. INOCULIN 920, which contains La, produces finer graphite, reducing flotation and associated gas defects.
Foseco Products: INOCULIN 920, 940 (94, RE75)

SELECTION OF INOCULANTS FOR PRODUCTION OF SPHEROIDAL GRAPHITE IRON CASTINGS

Priority	Aim
1	Eliminate carbides or white iron
2	Improve graphite form
3	Increase number of nodules
4	Reduce fading of nucleation
5	Eliminate microshrinkage
6	Minimise gas defects
7	Eliminate ferrite skin
8	Other

Effects of 'active' elements in spheroidal graphite iron inoculants.

Aluminium
Strong ferrite promoter, so for thin sections, inoculants with 4% aluminium content are used (INOCULIN 540).
Foseco Products: INOCULIN 75, 310, 320, 540

Calcium
Improves graphite germination. Reduces tendency to chill.
Foseco Products: INOCULIN 75, 310, 320.

Barium
Strong graphite promoter. Reduces inoculant fading. Also has a nodulising effect. Risk of slag when used in excess.
Foseco Products: INOCULIN 325, 360, 390.

Bismuth

0.1% Bi, combined with rare earths, increases the number of nodules, reduces their size and reduces tendency to whiten. Reduces graphite flotation. Can produce intercellular lamellar graphite unless offset by rare earths.

Foseco Products: INOCULIN 400, 440, 460.

Strontium

1% strontium in high purity FeSi eliminates carbide and increases the number of nodules, provided that nodulisation is carried out with Rare Earth-free FeSiMg.

Foseco Products: INOCULIN 400, 440, 460.

Zirconium

Increases inoculant solubility when combined with Mn. Neutralises nitrogen.

Foseco Products: INOCULIN 80, 98, 25, 90, 95, 250, 900

Cerium and other Rare Earths

Improve inoculation of spheroidal graphite iron, whether added in treatment with Mg or to the inoculant, and reduce inoculant fading.

Foseco Products: INOCULIN 920, 940 (94, RE75)

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