How to Produce Ductile Iron
Some Basic Counsels

Pierre-Marie CABANNE -- RIO TINTO Iron & Titanium

A casting + A Grade Composition

Thickness

C, Si, Mg, Ni, Cu, S, P, Mn
Resin Molding process:
- Strong Mold: vibrations
- Weight charge ~ casting weight

Green Sand Molding process:
- Increase Nb of Risers
- Use pressure control riser

C_{(iron)} + SiO_2_{(sand)} \rightarrow CO_2 + Si \rightarrow >>>> Bad skin
Melting Process

Casting Composition

C, Si, Mg, Ni, Cu, S, P, Mn

Charge Composition

Returns: 0 > 33 > 40
Good Steel: 30 > 33 > 40
HPI-Sorelmetal: 70 > 33 > 20

Graphite & FeSi & CSI

Depending on the grade, the quality request and the casting design

Melting Process

Returns: need to be well known (letter, painting, good storage, ...)

Steel Scrap: no dust, low Zn coating, very well know, low bad elements (segregate, carbide, pearlite, poison, ... as V, Nb, Ti, W, Bo, Cr, Mn, P, ...)

Graphite: pay attention to S (Mg recovery), N & H (pinholes), ash & grain size (C recovery), water (price), origin & crystallography

HPI as Sorelmetal: pay attention “low price don’t say good quality, long collaboration, technical service & assistance, good delivery, ... & low level of bad elements”
Melting Process

Sequence for charging raw materials:

- start by laying out a small steel charge,
- introduce a part (¼) of the HPI, to increase the melting’s beginning
- Then, add good steel scraps and returns
- And finish by the HPI (¾) to achieve maximum nucleation efficiency

Charging the Induction Furnace:

Sequence for charging alloying materials:

- Graphite and SiC should be added at 40 to 70% of the charge:
  - To have enough time for melting or dilution
  - To avoid the reduction of the liner or crown formation
  - To have better yield
Melting Process

Recarburisers:

Charged in first

Big hole created on the bottom

Charged on first liquid bath

Sticking on the bottom liner as a crown
Melting Process

Recarburisers:

If charged the last

Bad yield and sticking on the top liner as a crown

Graphite and SiC should be added at 40 to 70% of the charge:

- To have enough time for melting or dilution
- To avoid the reduction of the liner or crown formation
- To have better yield

FeSi will have better effect if it is added practically at the end of the melting.

Other alloys (Ni, Mo, Cr, Cu, …) if requested, will be added, if possible in the ladle to avoid pollution.
**Melting Process**

- Melt as quick as possible and stop at 1400 – 1420°C to avoid the oxides reversion
- De–slag & take a “spectro” sample
- Prepare the additions or/and corrections
- Wait the “iron” request from the molding line
- Introduce the corrections and “push” the power until +/- 1500°C
- De–slag & take a “spectro” sample & a Thermal analysis or chill test bar
- Practice pre-conditioning (1Kg/T of good graphite of FeSi or inoculant)
- and wait 5 minutes for oxides removing

**Mg Treatment Process**

- FeSiMg grain size: depending of the weigh ladle: big ladle = biggest grain size
- Good steel or DI chips: < 1%
- FeSi or Inoculant: 0 to 1% - 0,4 is enough
- FeSiMg 5-7 : 1 to 1,6%
Mg Treatment Process

\[ \text{Mg}_{\text{spectro}} = \text{MgS} + \text{MgO} + \text{MgZnO}_3 + \text{Mgxxxx} + \text{Mg}_{\text{free}} \]

Base iron: S < 0.02%
Treated iron: 0.008 < S < 0.015%

Rusty, sterile, Sand, …

GOOD & FONDAMENTAL for NODULES

Depending Bad or Good Steel Scrap

Base iron: 0 \text{ active} < 200ppm
Treated iron: 2 < \text{ active} < 20ppm

Mg% \text{ add on the ladle} = \left[ 0.76 \left( S_{\text{initial}} - S_{\text{final}} \right) + S_{\text{final}} \right] \cdot \text{Mg yield}

>>> FeSiMg adding in the ladle
Inoculation: 500 Kg to 2 Tons

Block of Inoculant: 0.1 to 0.15%

Grain Inoculant: 0.2%

Grain Inoculant: 0.1 – 0.15%
Why Inoculation?
To avoid Carbides:
To increase Nodule count:

What is Inoculant?
It’s a Fe-Si alloy with “magic” elements:
Fe-Si + / - Ca, Al, Ce, La, Ba, Zr, Sr, Bi, … Mn (?)

And Cooling Time?
Avoid to practice “check-out” at “red color”, only ...
for specific and “sensible” grade
And to finish: Quality control!

- Raw Material: dirty, rusty, contamination, composition certificate, origin, safety delivery, …
- Melting: minimum 2 spectro analysis, chill test or thermal analysis with or without Te
- Mg Treatment: just after treatment: spectro analysis
  - after the last mold: nodularity sample
  - time before the last mold pouring
- Mechanical test: sample outside the mold, sample attached to the casting or the mold, sample from the casting
- On/In the casting: US, Eddy current, Radio, die penetrant, dimension, …

But before to finish, before to start and during the process:

- Discuss with and call to the Sorelmetal Technical Service
- Use good material, at least as Sorelmetal
- Read the Sorelmetal suggestions and the SoBoDi