Solution strengthened ferritic spheroidal graphite cast iron according DIN EN 1563: 2012-03- Production, properties and application

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Product quality
Process stability
Economic efficiency
Materials properties
Qualified employees
Environmental protection and health & safety

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**Initial situation**

The revised standard DIN EN 1563 includes three new cast iron grades:

- **EN-GJS-450-18**
- **EN-GJS-500-14**
- **EN-GJS-600-10**

<table>
<thead>
<tr>
<th>Material</th>
<th>EN-GJS-450-18</th>
<th>EN-GJS-500-14</th>
<th>EN-GJS-600-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rm [N/mm²] min.</td>
<td>450</td>
<td>500</td>
<td>600</td>
</tr>
<tr>
<td>Rp0.2 [N/mm²] min.</td>
<td>350 (310)</td>
<td>400 (320)</td>
<td>470 (370)</td>
</tr>
<tr>
<td>A [%] min.</td>
<td>18 (10)</td>
<td>14 (7)</td>
<td>10 (3)</td>
</tr>
</tbody>
</table>

Values in brackets: comparable grades of the conventional GJS
The pearlite generating elements

Mn, Cu, Sn

in the conventional alloys determine the pearlite / ferrite ratio and the mechanical properties.

Si contents between 3 and \( 4,3\% \) cause a solution strengthened 100 % ferrite microstructure with high mechanical properties.
**Contents of the project**

- Static Mechanical properties in dependence on the Silicon content
- Influence of carbide and pearlite generating elements (Mn, Cr, V) on the static mechanical properties
- Cast technological properties of high Silicon ductile iron
- Influence of inoculation on microstructure in dependence on the wall thickness
- Investigation of the machinability of high Silicon ductile iron
1) Static mechanical properties

Production of several cast samples for the materials investigation

- Radial sample
- Y2 sample
- Y4 sample
- Wedge samples
- Samples for shrinkage testing
$R_m$ and $R_{p0.2}$ pass through a maximum in dependence on the Si content
In the neighbourhood of 4,3 % Si the elongation is decreasing.
Continuous course of the hardness in dependence on Si content
2) Influence of carbide and pearlite generating elements on the static mechanical properties.

![Graph showing the relationship between Si in % and tensile strength (Rm [MPa]) with different added elements (Non, Mn 0.6%, Cr 0.3%, Mn 1%, Cr 0.6%, V 0.26%)].

No influence of the added elements on the tensile strength.
No influence of the added elements on the yield strength
The elongation is reduced with 0,6 % Cr
Y2-Probe: 4,03% Si; 3,01 %C; 1,0 % Mn

\[ R_m: 581 \text{ MPa}; \ R_{p0,2}: 486 \text{ MPa}; \ A: 19,8 \% \]

Y2-Probe: 3,99 % Si; 3,01 %C; 0,63 % Cr

\[ R_m: 649 \text{ MPa}; \ R_{p0,2}: 506 \text{ MPa}; \ A: 14,3 \% \]

ca. 25% pearlite
3) Cast technological properties of high Silicon ductile iron

- Dross generating behaviour

Filling of the bassin in dependence on the time
• Mold filling behaviour

Degree of filling in dependence on the Si content and pouring temperature

No strong influence of Si

Cast harp sample
4) Influence of inoculation on microstructure in dependence on the wall thickness

Different inoculants generate a wide range of microstructure.
Not only the inoculant determines the microstructure but also the Si content.
Schematic correlation between inoculation technique, wall thickness and microstructure

- Rising Si content
- Inoculation good
- Inoculation poor
- Different inoculants

Content of graphite shape V + VI [%]

Wall thickness [mm]
Graphite shape deviation comparable to Chunky graphite
5) Investigation of the machinability of high Silicon ductile iron

Longitudinal turning of cylindrical castings (diameter 120 mm)- tool life at cutting speed 240 m/min

![Bar Chart - Tool Life Comparison]

- Tool life 50 – 60 % longer
CastTech, Krefeld, 09.11.2012 – High Silicon Ductile Iron

Flank wear at the machining of planet carriers (300 kg), materials GJS-600-3 and GJS-600-10.
Comparison of hardness and microstructure of GJS-600-3 with GJS-600-10
Microstructure of GJS-600-3
Microstructure of GJS-600-10

etched
6) Summarization

- The new grades of GJS give an optimized combination of strength and toughness (static loading).

- The worse influence of carbide generating elements is suppressed by the high Si content.

- The castability of the Si alloyed GJS is not worse than the conventional alloys.

- The inoculation technology must be adapted to the new grades.

- The high Si contents enhance the probability of graphite deviations.

- The cyclic mechanical properties of the Si alloyed GJS grades are higher.
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Thank you!