EN 1563 – NEW GENERATION DUCTILE IRONS (Solid Solution Strengthened Ductile Irons).

INTRODUCTION

In the new edition of the European Standard EN 1563:2012, three “new” grades of ductile cast iron were introduced as standardized material. These silicon alloyed cast irons were developed in the early nineties and standardised in a Swedish standard as a material with an increased strength and an improved and more constant machinability. As there was no international standard and sufficient material data available, their market introduction was difficult. These problems are mostly solved with the new EN 1563.

SOLUTION STRENGTHENED FERRITIC DUCTILE IRONS (SSF)

SSF cast iron is a high strength ductile cast iron quality alloyed with silicon between 3.2 and 4.3 % Si, depending upon required quality instead of manganese and copper or tin. This alloying level of silicon is constant per SSF-grade, unlike normal ferritic-pearlitic grades, where alloying level of manganese and copper depends on casting size and geometry. This constant Si-level, independent of casting size and geometry, results in a fully ferritic matrix and homogeneous properties in all sections of the casting as there is hardly no influence of wall thickness and cooling rate.

The improved mechanical properties are caused by solid solution strengthening of the ferrite matrix by silicon. Up to about 4,3% silicon a linear relation can be found between silicon percentage and tensile and yield strength, where elongation is surprisingly high compared to ferritic/pearlitic grades. Above 4,3% silicon a sudden drop in elongation will be found and the material shows brittle behaviour.
Typical for these SSF cast irons is the faster increase in yield strength as in tensile strength with increasing silicon percentage. As the yield strength is the limiting parameter for a construction, higher loads are possible for SSF designs compared to normal ferritic/pearlitic cast iron of equal strength, before plastic deformation will occur. Fatigue limits are equal or slightly better compared to ferritic/pearlitic cast irons. For an engineer this higher yield strength gives the possibility to reduce wall thickness and realize weight savings. Due to the lower specific density a weight saving of 1.5% will be automatically realized.

Often higher silicon levels in cast iron are associated with reduced impact properties; however two remarks are to be made. Impact properties of SFF iron are not worse compared to equal strength ferritic/pearlitic cast irons and more important
the Charpy impact test, however often used, is not the most suitable method to give an indication of the behaviour of a cast iron product under impact conditions, as stress/strain condition in an impact test are completely different from those is a product and impact rate in reality is orders of magnitude less compared to the impact test.

MACHINABILITY

In general improved machinability properties will be found for these castings due to an lower average and a more homogeneous hardness. Tool wear will be less or higher cutting speeds can be used, either to improve tool life or increase productivity of the machining. It can be necessary to adapt the quality of the tooling as chips from these SSF cast irons will not so easily break, compared to ferritic/pearlitic ductile irons. In general machined surfaces will be smoother and variation in machined tolerances will be less, not only within a casting, but also within a batch and from batch to batch, as properties will be more constant.

EXPERIENCES

As in all ductile irons, also in SSF cast iron imperfections will occur. These imperfections can be caused by slag and dross inclusions, porosities and imperfect graphite shapes.

In our experience slag and dross defects are despite the higher silicon percentage not worse compared to ferritic/pearlitic ductile irons, of course well designed (filtered) gating systems and good ladle de-slagging operations are necessary as is also the need for other ductile irons.

The SSF material shows a slightly higher tendency for porosities, in critical designs a higher porosity level (CC2→CC3 or CC3→CC4 or CC5) can be found compared to ferritic/pearlitic ductile iron, also it seems in areas with centre line porosity, the thickness of the centre line is increased. When solid feeding solutions are used porosities are not supposed to cause any problem as our experiences have proven.

Due to the increased silicon percentage the tendency for chunky graphite increases. This phenomenon is especially sensitive for wall thickness, for a nodularity inspection it is absolutely necessary to section the thickest areas and not the easier thinner walls. Also it can be necessary to change dimensions of the samples used for nodularity inspection poured at the moulding line from the last metal of the ladle. Nevertheless for higher (50-75 mm) wall thicknesses a reduced nodularity can be expected, fortunately the SSF-material shows lesser dependence to nodularity compared to ferritic/pearlitic ductile iron.
As could be seen in figure 1, a strong cut off in mechanical properties occurs after about 4,3% silicon. Foundry men should realize that most spectrometer samples of the melt and treated ladles are made before inoculation, were another 0,05 to 0,15% silicon can be added. For the EN-GJS-600-10 grade care should be taken not to exceed the limit.

Most spectrometers are not calibrated for these higher silicon percentages, in general the tendency is to measure less silicon as is available in the sample, when starting production of SSF cast irons, spectrometers need to be adapted for this material and special high silicon calibration samples should be acquired.

Literature


2. Björkegren and Hamberg, Ductile iron with better machinability compared to conventional grades, Foudryman, December 1998, page 386-391.