

## Is it all Chunky Graphite that you see or could it be something else?

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Chunky graphite has been a phenomena encountered and studied since the invention of ductile iron in 1948. Still chunky is confused or mixed with other graphite forms such as compacted graphite and degenerated graphite. The paper will show why chunky can be confused with compacted graphite and why degenerated graphite can easily be called chunky graphite and why it can be difficult to find a good cure.

**Keywords:** *Chunky graphite, Compacted Graphite, Degenerated graphite, Cooling rate, Silicon level.*

### 1. Introduction

Graphite is one of the essential components in cast iron. Controlling the formation and growth of graphite is important to acquire the desired properties in the final casting. What makes it complicated is that the graphite can come in many different shapes, and trying to fix one can create unwanted graphite forms. Some of the shapes are very difficult to keep apart and they can appear in the same sample and even side by side.

### 2. Compacted to Chunky

#### 2.1 Compacted Graphite

Compacted graphite has similar appearance to flake graphite only with thicker and more curved randomly oriented flakes. Closer examination reveals the branch ending in a half sphere. Compacted graphite can be a wanted graphite shape, as it gives strength and thermal properties intermediate to flake and spheroidal graphite [1]. Most common causes for unwanted compacted graphite are insufficient residual Mg level in relation to base iron S-level; too high S level in relation to residual Mg or contamination with Ti, Zr or Al. [2, 3]

#### 2.2 Chunky Graphite

Chunky graphite is often found in the areas last to freeze and looks like small chips or fragmented compacted graphite finely and randomly distributed, either over large areas or confined to cells. [4, 5]

Reviewing literature, the most common causes listed for chunky are too high level of Cerium, high Si-level or slow cooling. [4, 6]

#### 2.3 Is it possible to mix them up?

Yes, as compacted and chunky share similarities in growth [4, 6], the type you get depends on cooling rate, composition and difference in nucleation potential.

In figure 1, transition from spheroidal to compacted to chunky graphite is observed in samples from varying section size. This illustrate the effect cooling rate has on graphite formation and growth. With decreasing cooling rate, the risk for chunky graphite increases [5, 6]. The example shows how the structure can transform from spheroidal to compacted to chunky in the same casting with decreasing cooling rate. As a result, it can make it difficult both to classify the graphite correctly and to select best strategy to overcome the problem since the problem is different in different casting sections.

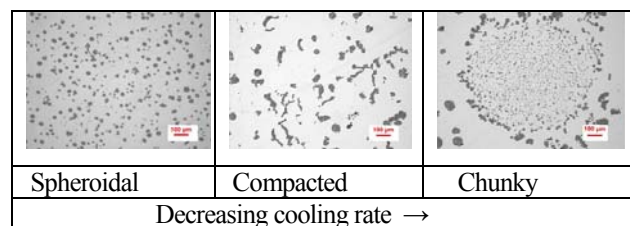


Fig. 1 Transition in structure caused by decreasing cooling rate.

By changing the composition and especially the Si-level it is possible to transform graphite in the same iron from compacted to chunky. In figure 2 it can be seen how a structure with compacted graphite can be improved to more spheroidal by increasing the Si-level.

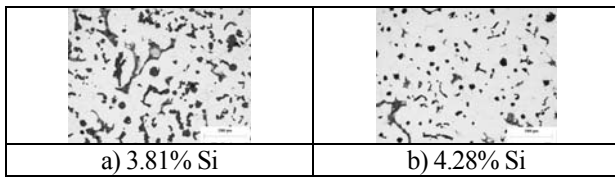


Fig. 2 Transition in structure caused by increase in Si-level.

Inoculation is listed as something that can both help prevent chunky [4] and can cause chunky [7].

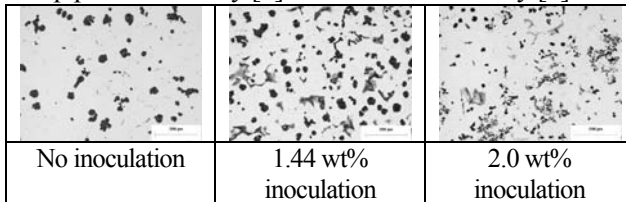


Fig. 3 Transition in structure caused inoculation and increase in Si-level.

Figure 3 illustrate how inoculation can help improve a structure by increasing the nodule count, but also how inoculation can cause chunky graphite if not controlled. Inoculation introduces Si, and increasing the Si-level increases the risk for chunky graphite, but at the same time it is recommended to increase nodule count to avoid chunky graphite.

### 3. Degenerated Graphite

Unwanted graphite forms are often referred to as degenerated graphite forms [8], but behind this term, there can be many graphite forms with very different causes and cures. Hoover [9] actually use the term chunky or coupled vermicular, while Murthy et al. [10] use compacted graphite in connection with both chunky and exploded graphite. The imprecise term degenerated graphite along with mixing of chunky, compacted and exploded graphite can generate confusion.

With the recent boom in wind energy it has become more common to make large ductile iron castings. In these large and thick castings, chunky or degenerated graphite is more encountered and unwanted.

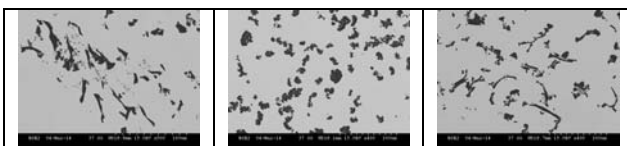


Fig. 4 Variation in graphite shape observed within a small area in one sample.

Figure 4 shows how the graphite morphology varies within the same sample, from a heavy casting,

over an area of 4\*4 mm. This is an example of the difficulty in classifying the different graphite morphologies that can arise and how conditions for graphite growth and nucleation can vary within a very small area.

### 4. Conclusion

Is it all chunky graphite that you see or could it be something else was the question.

The answer is yes and no.

It is difficult to correctly identify the various graphite shapes as they in many cases share both structural similarities, growth similarities and co-exists within the same casting. This problem is more pronounced in larger castings with variation in section size as effect of cooling rate, segregation and fading of Mg and inoculation overlaps.

Combined with the imprecise term degenerated graphite and the mixing of graphite morphologies chunky can easily be confused with compacted graphite and graphite nucleated on small inclusions can be classified as chunky graphite.

It is therefore important to analyze the conditions to take the correct actions and avoid introducing another defect.

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