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ARCHIVES
of
FOUNDRY ENGINEERING

ISSN (2299-2944)
Volume 19
Issue 2/2019

75 – 78

10.24425/afe.2019.127119

13/2

Published quarterly as the organ of the Foundry Commission of the Polish Academy of Sciences

Detectability of Defect and its Beginning on the Formed Cast-iron Cast

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Received 28.02.2019; accepted in revised form 06.05.2019

Abstract

The article describes the detection of a defect in a cast iron casting. It analyzes the cause of the crack in the Turbine Component casting. In this article, we are focusing on a particular turbine casting that is commonly used in automobiles as one of the components for turbochargers. The turbine is a casting made of ductile cast iron with a visible crack on the naked eye. The formation of cracks in castings is a common but undesirable phenomenon in the foundry practice. It is important to identify the errors, but also to know the cause of defects in castings. The solution is a detailed error analysis. In this paper I used metallographic analysis and magnetic powder method. The crack formation is due to tension in the casting, which results in tensile, shear, or shear forces. The crack formation kinetics is difficult because it is still very low during hardening and shortly after the casting is overloaded. The crack is most often due to core resistance or shrinkage molds that begin after the surface layer is tightened when the strength of the material is negligible to the end of the crystallisation.

Keywords: Ductile cast iron, Defect, Casting, The turbine component

1. Introduction

Casting defects are always the ultimate consequence of incorrectly casting technology, non-compliance with manufacturing practices, low level of organization and management of foundry. Casting production always carries the risk of defects [1]. In addition to loss of profits, cast mistakes and frequent misunderstandings occur between the customer and the supplier. The foundry has a need to find their own quality assurance concept to meet the demanding customer requirements. Casting is a wide-ranging department, and the production of quality castings is demanding and complicated, because even today, we are standing over the wrong cast without any clear guidance.

The casting quality is influenced by the mould pouring temperatures, the liquid metal streaming thrust force, moulding sand and the related occurrence of dirt spots, sand buckles, scabs, etc. [1-3]. One of the most important criteria of quality of castings, related to period of crystallization and solidification, is definition of an acceptable level of shrinkage defects, in specific regions of a casting, which is related to location of these defects and effectiveness of riser operation. Intensity and volume distribution of these discontinuities of shrinkage origin results of balancing between demand for the liquid metal in the solidifying zones. One of defects that have a major impact on the quality of a cast iron is formation of carbides which have deleterious effect on ductility and dynamic properties by segregation of the embrittling phases [5,9].

Properties of ductile cast iron

Ductile cast iron gives great possibilities for the variability of mechanical properties, so development in the foundry sector is directed to the use of this material. The mechanical properties of ductile cast iron include this material among high-grade casting materials. The cast iron cast iron differs significantly from grey cast iron by its structure and consequently its properties, especially mechanical. In terms of usability, grey cast iron is the most widely used casting material, but spheroidal graphite cast iron is a full-featured foundry material for more complex and more stressed parts, where it partially replaces steel castings. After the thermal treatment of ductile cast iron, an auspicious structure can be obtained, which has comparable mechanical properties to steel and its production is less demanding for raw materials and energy [6, 7].

The auspherical structure is more favorable and has less susceptibility to cracking than a sorbic structure, which means the possibility of applying ausferritic materials to the shape-like components without worrying about the possibility of early wear. They have a lot of advantages over other (otherwise processed) cast iron and could replace them in some cases, especially for dynamically stressed components, where heat-treated castings are not suitable for their high brittleness [8,9].

In this article, we are focusing on a turbine (fig. 1) casting that is commonly used in automobiles as one of the components for turbochargers. The turbine is a casting made of ductile cast iron with a visible crack on the naked eye.

Fig. 1. The turbine HBN

The turbine moves the blower into the car. The task of this blower is to compress the gas. The importance of this device has increased since the start of the turbocharger in the automotive industry, specifically in combustion engines. In these engines, a "turbo" is achieved by increasing the overall power and engine power by increasing the amount of intake air, which, along with the fuel, gets into the combustion chamber of the engine. The advantage of the turbo is that it provides even more power to the engine and the car, combined with a very small increase in weight. This is a very big positive aspect of this device [4, 5, 9].

2. Description of the approach

2.1. Magnetic particle Inspection

Magnetic Testing was first done as non-destructive material control methods. Indicates defects on the surface and just below the surface, since surface defects such as cracks and cracks are dangerous and always represent a high operational risk.

The magnetic method is a reliable method for determining cracks at the surface of a component, or just below the surface. It is advisable to verify the presence of cracks after visual inspection of castings. The magnetic powder method detects superficial and near subsurface disparity of materials and products that use the magnetic field to pass through the object under test. I used a fluorescent suspension in which the error could be seen under ultra violet light.

The crack passed through the entire cross-section of the sample. Figure 2 shows an inner surface and Figure 3 is a view from the outside. From the crack turbine a sample cut was performed to contain a large portion of the crack. A repeated magnetic test was then performed on the cut's element.

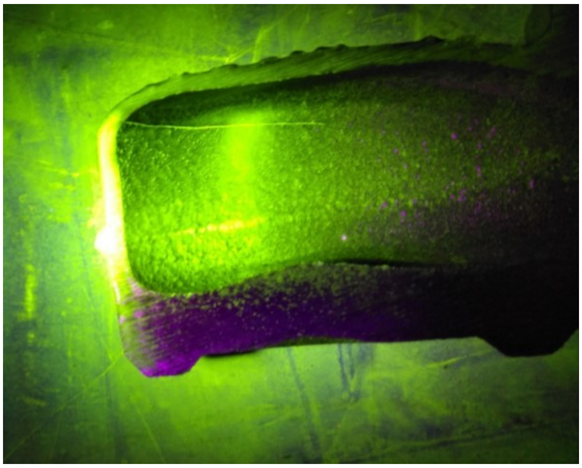

Fig. 2. The inner surface of element

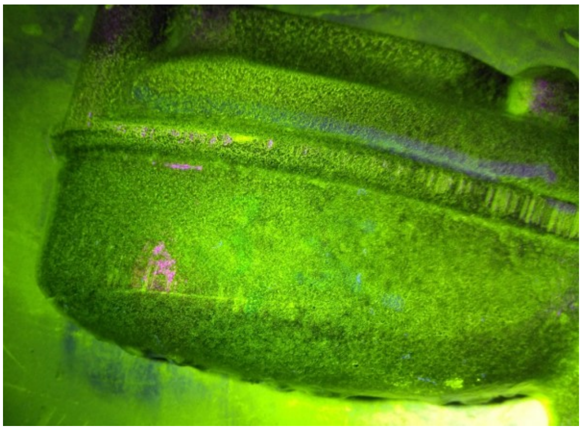

Fig. 3. The crack on outside surface

2.2. Spectral analysis

Spectral analysis was performed on a machine from Oxford Instruments. Energy Dispersive Spectroscopy (EDS) Analysis provides elemental and chemical analysis of a sample inside the sample (fig. 4).

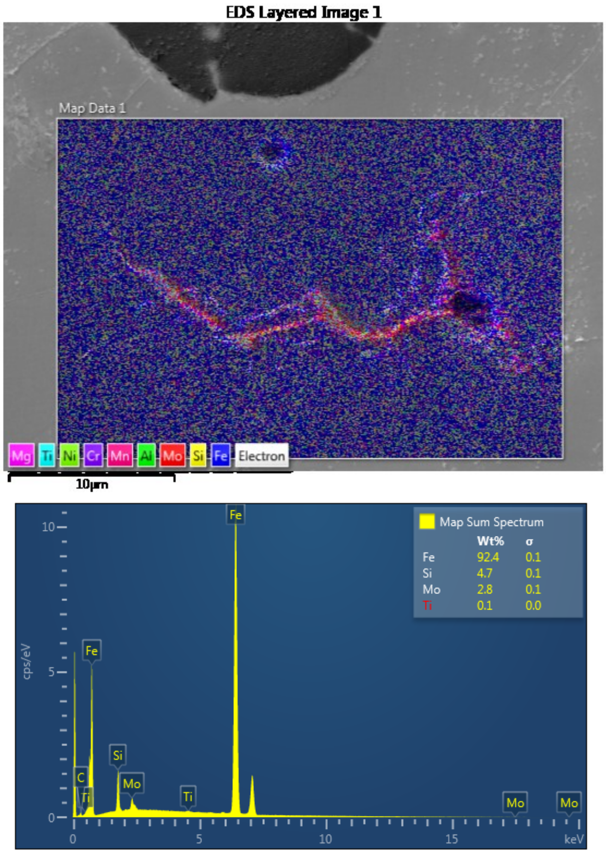

Fig. 4. Spectral analysis

Table 1.
Chemical composition of experimental material (weight %)

C	3,20	**Co**	<0,14
Si	3,4	**Cu**	0,13
Mn	0,21	**Nb**	<0,010
S	0,082	**Ti**	<0,033
Cr	0,32	**V**	0,12
Mo	0,32	**W**	<0,055
Ni	0,45	**Fe**	95,3

2.3. Metallographic analysis

Metallographic analysis was performed in line with STN 42 0461 setting out procedures to describe in the qualitative manner the elements which can most frequently be found in cast iron, such as graphite, ferrite, pearlite. Base material and heat-treated material were analysed. NEOPHOT 2 light microscope was employed to assess the structure visually.
On the Figure 5 is a graphite graphite ferrite cast iron:
VI6 - Fe, graphite size is over 30 to 60 µm

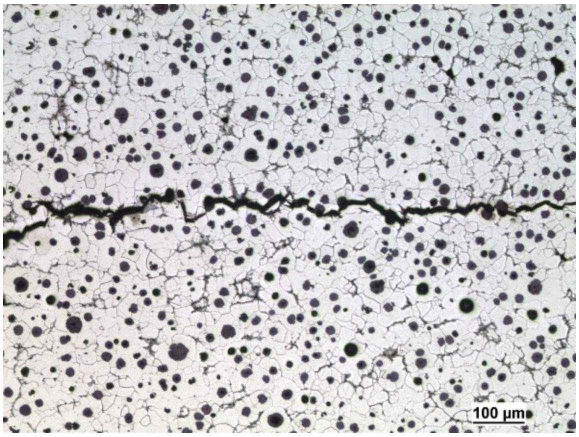

Fig. 5. The character of the crack in the etched pattern

Detail of the crack, the crack propagates preferably transcrystallically, and in the selected locations it also follows the grain boundaries (fig. 6).

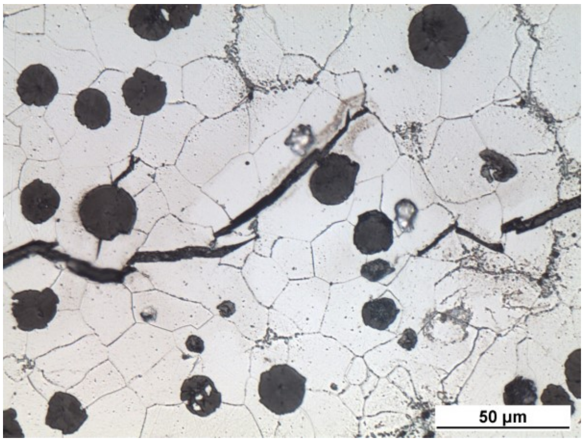

Fig. 6. The character of the crack in the etched pattern etch. 3 % nital

The globular perlite is located in the area of the grain contact and creates a web in the microstructure. From the character of the structure it could be assumed that it was obtained by ferritizing annealing LGG with a certain percentage of the perlite in the matrix.
Carbides predominantly based on Mo are very fine. Thickness below 1 µm, length several µm. They exited along the boundaries of ferritic grains (fig. 7).

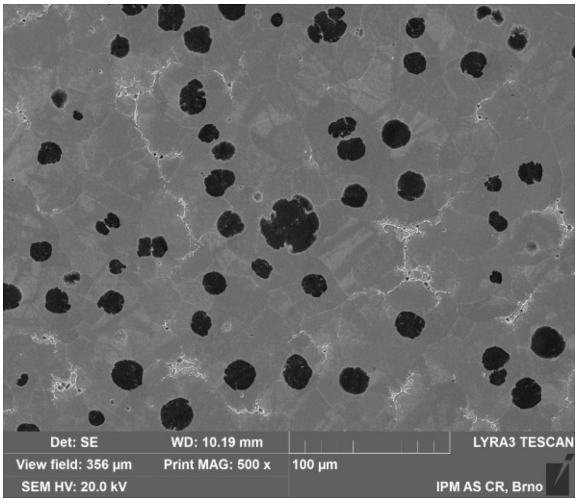

Fig. 7. Electron Image

Heat treatment did not destroy the pearlite, but only to spheroidize the lamellar perlite (cementite or carbide). Brinell hardness is 214 HBW. The strength determined by the hardness is approximately 705 MPa. Locations that were analysed on a light microscope as a fine globular perlite were subsequently analysed for REM. It has been confirmed that they form a net which is probably formed by carbides of alloying elements such as Mo, Si content is very high in this cast iron (around 5.2%). The analysis contained in our analysis included a higher Al content (around 1.5%), but the other analyses did not confirm this. Al has feritizing effects as well as Si. Higher Si content in ferrite increases strength, but also the fertility of the ferrite. Some carbides are partially excluded even beyond the ferritic grain boundaries, which are weakened in this case, and as a result, the tear spreads locally across the grain boundaries. The chemical composition of individual carbides could not be detected because they are very small.

3. Conclusions

It is supposing that the higher content of silicon caused the crack. Silicon increases the brittleness of the material. The solution to this problem is to adjust the chemical composition of the material been mentioned.

The crack formation is also due to tension in the casting, which produces tensile or shear forces. The crack formation kinetics is difficult because it is still very low during hardening and shortly after the casting is overloaded. The crack is most often due to core resistance or shrinkage moulds that begin after the surface layer is tightened when the strength of the material is negligible to the end of the crystallisation. Even after the crystallization is complete, there is a large temperature difference and strength heterogeneity in the casting, therefore, the warming conditions are more favourable for cracks. In the case of cracks, it is always a place that is forcibly weakened.

Causes of defects in the casting structure, casting, metallurgy, chemical composition, bad melting, liquid metal treatment and non-compliance with prescribed temperatures. The ultimate technical solution lies in deepening the knowledge of casting, as well as from several leading disciplines that influence the casting. We cannot make industrial casts without defects anymore, so any discarded casting should serve to analyse and be a source of instruction.

Acknowledgements

This study has been supported by the Scientific Grant Agency of the Ministry of Education of the Slovak Republic KEGA 028ŽU-4/2019.The authors acknowledge the grant agency for support.

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