THE EFFECT OF THIN SECTION CASTING ON THE HARDNESS AND TENSILE STRENGTH OF GGG40

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Abstract

Today, ferrous metals include large part of industry in the world although many non-ferrous metals and other materials discovered. Steel and cast iron are the important ferrous metals because of their mechanical, physical properties and behaviors. After the discovery of the nodular cast iron, it began to burst into prominence. Because, its similarity to steels from the point of mechanical properties and to cast irons in terms of chemical and physical properties. Besides, nodular cast iron has low cost, good castability and convenient machinability property. In this study, GGG40, which is widely used in modern industrial production, was chosen as test material. The test specimens with different diameters 20 mm, 25 mm and 30 mm were prepared by casting. Thin section casting is the fundamental point of this study. Then, tensile tests, brinell tests and spectrum analysis were performed and investigated.

Keywords: Casting, GGG40, section thickness, mechanical properties, spectrum analysis

1. INTRODUCTION

For centuries, casting is protecting its place in metal product industry and this is will keep on without a doubt. Discovered new materials, different conditions and such differences in casting methods can cause various mechanical properties in material. So engineers can investigate them from different point.

In this investigation we choose three different diameters (20, 25 and 30 mm) for casting and GGG40 as a material which is popular in recent years with good castability, convenient machinability, mechanical and physical properties. Its reputation come from similarity to steels from the point of mechanical properties and cast irons in term of chemical and physical properties and behaviors The application of nodular cast iron in the industry spans very wide ranges and various areas; for example automotive, agricultural, earth-moving applications, etc [1]. It has about 30% of the cast iron production in most industrial countries and it will undoubtedly keep rising [2]. And also its name is come from spherical graphite. The spherical graphite interrupts the continuity of the matrix much less than graphite flakes; due to this, nodular iron is better in strength and toughness than a similar structure of gray iron [3]. Experimental investigations of tensile strength versus elongation and also versus hardness on various ductile irons were carried out by Gilbert [4]. Basaj et al. focused on tensile properties continuum with Brinell hardness of as-cast ductile iron [5].

The manufacturing process and to be able to determine the changes which occur in tensile strength and hardness of GGG40 (EN-GJS-400-15/DIN 1693 or 60-40-18/ASTM A536) depending on section thickness during the casting process.

2. EXPERIMENTAL PROCEDURE

2.1 Preparing the test specimens

The test materials were produced by sand mould casting. All type test specimens were prepared using the mould model in **Fig. 1**. Test moulds were prepared utilizing a vertical molding process (Disamatic).

Fig. 1 Model (a), Sand mould in Disamatic (b), ultimate product (c)

Some of the elements, such as cerium, calcium, lithium and magnesium are known to develop nodular graphite structures in cast iron [6]. Mg was used in this study which is more preferred element for giving the spherical form to the graphite in industry because of low investment cost. The sandwich method (**Fig. 2**) was used for manufacture and the cast temperature was measured as a 1401 ˚C

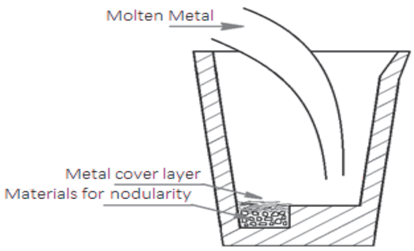

Fig. 2 Sandwich method [7].

When production is going on, a spectrum analysis was performed (**Fig. 3**) and results were obtained.

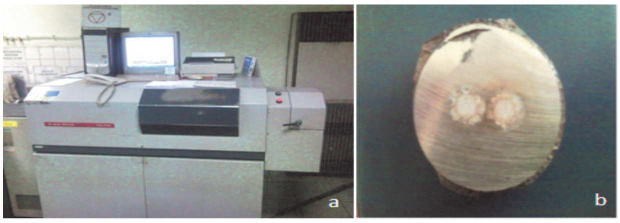

Fig. 3 Spectrum analysis test machine (a), the view of the specimen after a spectrum analysis

Specimens firstly were cast from GGG40 as diameters of 20/25/30mm and lengths of 225mm; then they were machined for tensile tests in accordance with standards. The Tensile tests were performed by Instron 8501 universal test machine (**Fig. 4**).

Fig. 4 Instron test machine

Then, hardness tests specimens were prepared by cutting lengthwise from GGG40 cast bars which were resulted in 20mm,25mm, and 30mm diameters and 225mm lengths before. So the hardness test samples lengths have become 20mm and their diameters (20/25/30mm) remained same. Sandpapering and polishing were applied respectively (**Fig. 5**).

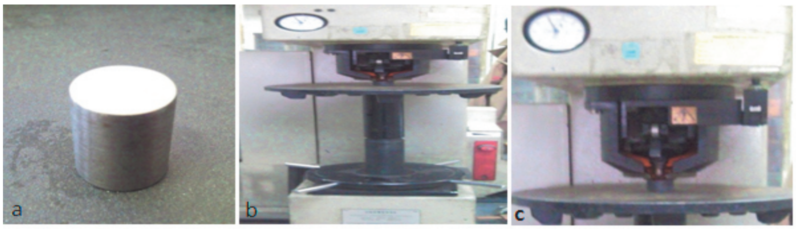

Fig. 5 View of after polishing one of hardness test specimen (a), when a hardness test was applying (a,b)

After all these processes , Brinell Hardness tests were performed with a 5mm diameter tungsten carbide ball and 750 kgf, from different points of the test specimens surfaces (**Fig. 5**).These different points were on the assumed lines which were placed on the surface from the centre to outward like **Fig. 6** [8].

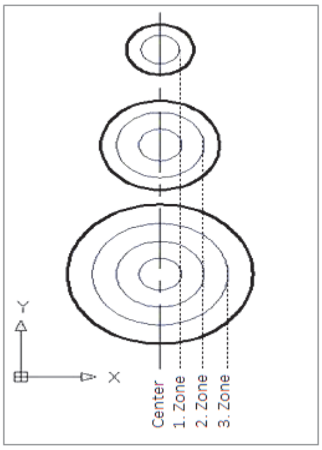

Fig. 6 Schematic drawing of application zones for various diameters (20/25/30mm)

3. RESULTS

3.1 Spectrum Analysis

Spectrum analysis was chosen and applied which is a method for analyzing to chemical composition of a material. The chemical composition of materials are imported for experimental works because of their effects on mechanical properties and other investigations about comparison or matching on before or after papers. And the spectrum analysis results for chemical composition of the material that was used in this study were given in **Table 1**.

Table1 The spectrum analysis results

Elements	Spec. test	Elements	Spec. test	Elements	Spec. test	Elements	Spec. test
%C	3.18	**%Cr**	0.023	**%Ni**	0.015	**%Bi**	0.00053
%Si	2.59	**%Cu**	0.023	**%V**	0.0036	**%La**	0.004
%Mn	0.19	**%Sn**	0.031	**%Ti**	0.014	**%Ce**	0.003
%P	0.031	**%Mg**	0.029	**%Al**	0.014	**%Fe**	93.8
%S	0.004	**%Mo**	0.0005	**%B**	0.00019		

3.2 Tensile test results

The results of tensile tests which were carried out are shown in **Fig. 7**. Maximum (ultimate) tensile stress values were given on the vertical axis and the diameters before machined (cast diameters) were given on the horizontal axis. According to the tensile test results, when the casting diameters decreased, the maximum tensile results increased. These results are in compliance with the results of Goodrich and Lobenhoger [9]. The highest maximum tensile values were observed in specimens that have minimum cast diameter (Ø20).

The values of Ø25 were lower in comparison to values of Ø20, and also the values of Ø30 were lower in comparison to values of Ø25. This situation correlated with the rate of cooling. Fast cooling rates in the thin casting section produced stronger castings with greater pearlite content [10]. The amount of ferrite in the cast matrix depends on not only composition but also the rate of cooling [3].

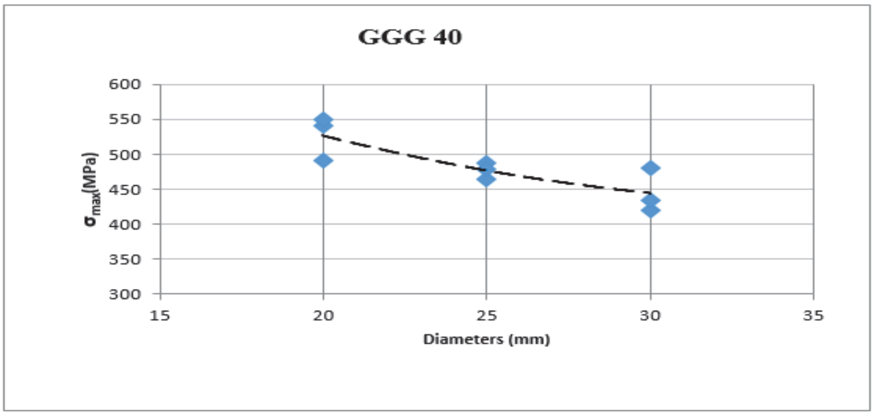

Fig. 7 Variation of ultimate tensile strength according to cooling rate due to cast section thickness

3.4 Hardness test results

The hardness tests results were shown in **Fig. 8**. The Figures show that, generally, maximum hardness values are in the centers of specimens for each diameter. In other words, according to both the test results, generally, a decrease in hardness values from the centre outward was observed. Besides all these, the maximum change in hardness per unit distance was observed in the smallest diameter (Ø20).

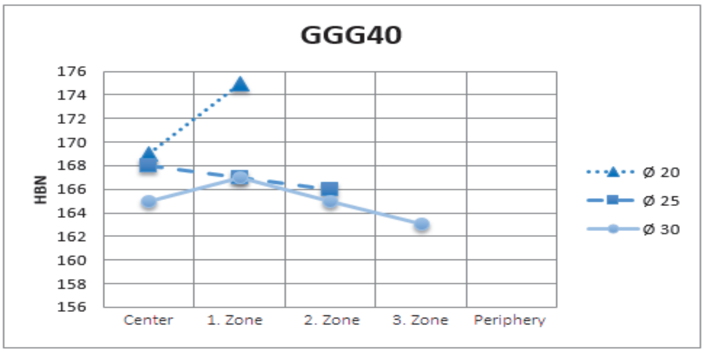

Fig. 8 Variation of hardness for different zones according to cooling rate due to cast section thickness

CONCLUSION

GGG 40 was chosen as a cast material in this study, which is a realization and brief explanation about the casting process of nodular cast iron. All phases of this casting process were realized and explained. Section thickness, spectrum analysis, and also interdependence of these to affect the mechanical properties from the point of tensile strength and hardness of GGG 40 were studied.

The cooling rate which is related with section thickness affects the mechanical properties [10, 11]. It's observed that, the tensile strength increased in specimens having diameters of 20mm, 25mm, and 30mm (≤ Ø30), with the same conditions and same material but the increase was very high according to the standards (about >Ø30) for this material [2]. So that is not going on exactly linear. The rate of tensile strength increase is higher in diameters which are smaller than 30mm. The results show that it's increasingly going on.

According to hardness test results, generally, a decrease in hardness values from the centre outward was observed. This is caused by carbon segregation and inclusions [12, 13]. The maximum change in hardness per unit distance was observed in the smallest diameter and also it caused by difference of cooling rate which is depend on section thickness.

These observations showed that once again, nodular cast iron is a very functional material in engineering and can be handled meticulously and in a controlled manner to obtain the expected mechanical properties. Based on these, the trace amount changes in the chemical composition or the heat treatment's qualifications and variations generate a variety of rich mechanical results that may be controlled through adjustments indicate that nodular cast iron is a perfect engineering material [14].

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