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Influence of Pouring Temperature on The Formation of Spheroidal and Lamellar Graphite In Cast Iron

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Abstract

The objective of this research is to investigate the effect of pouring temperature on the microstructure of the cast iron. The pattern was designed with 300 mm of width and the thickness variations are 25 mm and poured at five different temperatures; 1300, 1325, 1350, 1375 and 1400°C. Several cast irons, prepared with different chemical compositions and microstructures (three lamellar and three spheroidal structures) have been examined by extensive mechanical testing and optical microscopy. The fluidity of spheroidal and lamellar graphite in cast iron increases with the pouring temperature. The numbers of nodules were decreased by increasing pouring temperature for spheroidal structures. Whereas, the numbers of flakes of lamellar structures changed by both pouring temperature and chemical composition. In general, with increasing pouring temperature, the amount of pearlite in the internal structure of both lamellar and spheroidal graphite cast iron materials were increased.

Key words

Spheroidal and lamellar graphite cast iron, pouring temperature, tensile test, impact test

1. INTRODUCTION

Cast iron has been widely used in dies for automobile panel, high strength steel pipes, etc., due to its excellent mechanical properties, wear resistance, heat resistance and simple production, low production cost[1-2]. With the development of sheet metal technology, the forming pressure and speed increased significantly. Wear is one of the important failure patterns for the moving mechanics parts[3]. The quality of the lost foam casting is influenced by many parameters. These parameters such as the pouring temperature, the size of the quarz sand, the density of polystyrene foam, the vibration duration, the casting size and the material composition. The higher of superheat will decrease the surface tension of liquid metal [4]. The pouring temperature has the dominant factor in determining the value of tensile strength and elongation of the casting [5]. The gas formed increases 230 % at the temperature of 750- 1300 °C [6]. The flow rate of metal alloys at high temperature will decrease with temperature because of increasing the gas volume [7]. The metal flow rate increases with temperature up to 1150 °C [8]. The thickness increasing of the pattern will be able to increase the length of metal flow [9].

2. EXPERIMENTAL STUDIES

In this study, a medium frequency induction furnace was used to produce spheroidal and lamellar graphite cast iron. The spheroidal cast iron experimental alloys were made with a constant mix of 45% cast iron scrap and

55% steel scrap of chemical compositions. The lamellar graphite cast iron experimental alloys were made with a constant mix of 40% H_2 pig iron and 60% steel scrap of chemical compositions. The charge materials, including the chemical compositions and percentages used for the production, are listed in Table 1. After spheroidisation and inoculation the molten iron was poured into Y type permanent mold given in Table 2. The pattern was designed with 300 mm of width and the thickness variations are 25 mm and poured at five different temperatures; 1300, 1325, 1350, 1375 and 1400ºC.

Table 1. Details of the charge materials

Item	%C	%Si	%Mn	%S	%P	% Percentage
H_2 Pig iron	3.95	1.55	0.65	0.06	0.02	40
Ductile cast iron	4.15	0.85	0.06	0.01	0.04	45
Steel scrap	0.10	0.19	0.66	0.02	0.02	55-60

Table 2. The chemical composition of ınoculation and spheroidizing

Item	%Si	%Al	%Mg	%Ba	%Ca	Particle Size, mm
Inoculant (FeSi75)	65–75	0.5–1.5	-	2–3	1–2	0.6-3
Spheroidizer	42–48	1	6–7	-	0.8–1.2	1–10

Three cast lamellar graphite cast irons with different pouring temperature were selected as the specimens. In this study, GLJ-A, GLJ-B and GLJ-C were selected as the specimens. Three cast spheroidal graphite cast irons with different pouring temperature were selected as the specimens. In this study, GJS-A, GJS-B and GJS-C were selected as the specimens. Spheroidal and lamellar graphite cast iron with chemical compositions listed in Table 3 was prepared. The carbon equivalent (CE) value was defined by:

CE = mass %C + 1/4 mass % Si + mass 1/2 % P

Table 3. Chemical compositions of the samples (mass %)

Sample	C	Si	Mn	P	S	Cr	Ni	Cu	Ceş
GJL - A	3.20	2.15	0.69	0.04	0.09	0.08	0.05	0.10	3.76
GJL - B	3.30	2.05	0.69	0.03	0.10	0.29	0.51	0.24	3.83
GJL - C	3.06	2.12	0.70	0.05	0.10	0.19	0.06	0.55	3.62
GJS - A	3.68	2.26	0.14	0.02	0.01	0.02	0.02	0.04	4.26
GJS - B	3.56	2.38	0.32	0.02	0.01	0.05	0.03	0.10	4.17
GJS - C	3.46	2.15	0.38	0.02	0.01	0.17	0.09	0.44	4.01

3. RESULTS AND DISCUSSION

In this study were investigated characteristic and mechanical properties of lamellar and spheroidal graphite cast iron materials which produced in different compositions and at different casting temperatures. The variation in the number of flaks and phase amounts of the materials in the flaky cast iron with flake graphite is shown in

Figure 1-2 and in graphite nodule number and size and phase in the spheroidal graphite cast iron materials is shown in Figure 3-4.

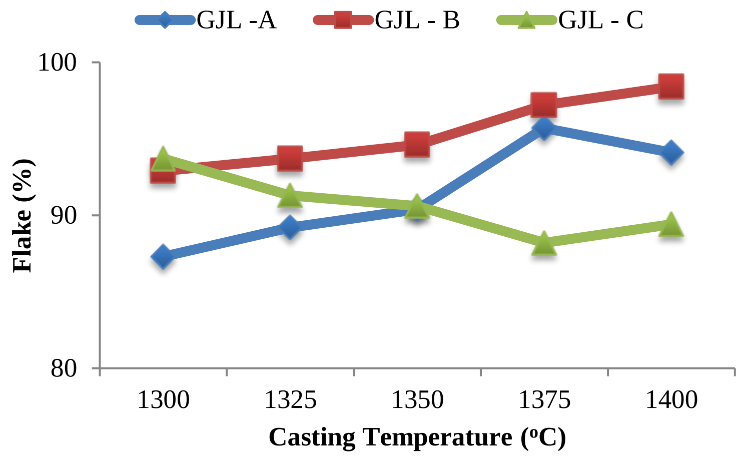

Figure 1. Change in flux amount of flake graphite cast iron materials depending on casting temperature

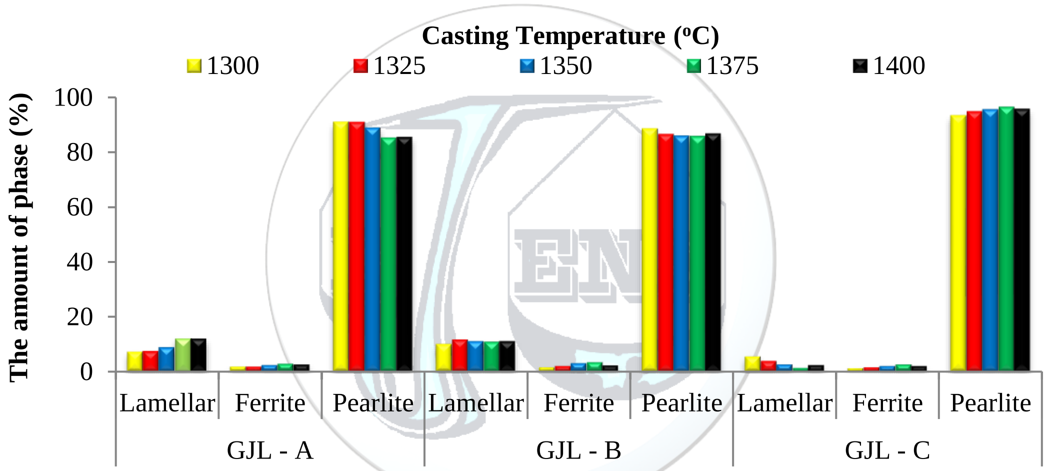

Figure 2. Change in phase amounts of casting temperature in cast iron depending on with lamel graphite

As shown in Figures 1 and 2 above, the number of flakes of casting temperature residue materials in GJL-A and GJL-B specimens in lamellar graphite cast iron has increased. However, the number of flaks appears to decrease in the GJL-C sample. In addition, the amount of lamellar phase of the samples showed an increase in the GJL-A and GLJ-B samples with increasing casting temperature, but the amount of perlite phase decreased. On the GJL-C sample, the amount of lamellar phase decreased with increasing casting temperature, but the amount of perlite phase increased.

Figure 3. Microstructure drawings of specimens of lamellar graphite cast iron produced at a casting temperature of 1350°C (x200) a) GJL-A b) GJL-B c) GJL-C

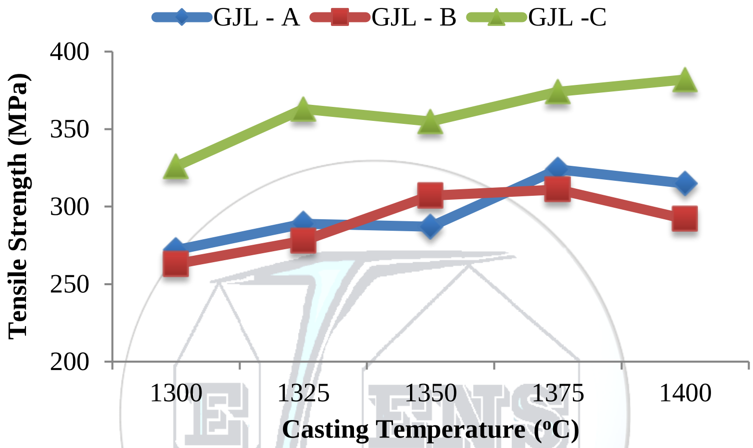

Figure 4. Tensile strength results of lamellar graphite cast iron materials produced at different casting temperatures

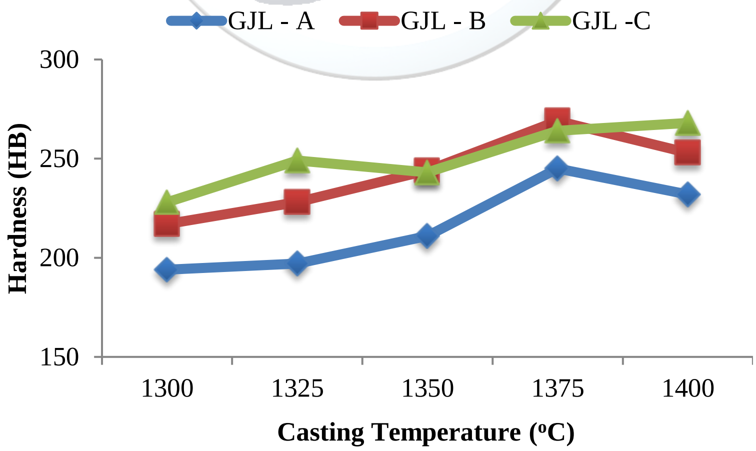

Figure 5. Hardness results of lamellar graphite cast iron materials produced at different casting temperatures

When the tensile strength and hardness results of lamellar graphite cast iron materials are examined, it has been observed that with increasing casting temperature, the tensile strength and hardness values of the samples generally increase. However, the strength properties of samples with a casting temperature of 1400 °C showed a slight decrease.

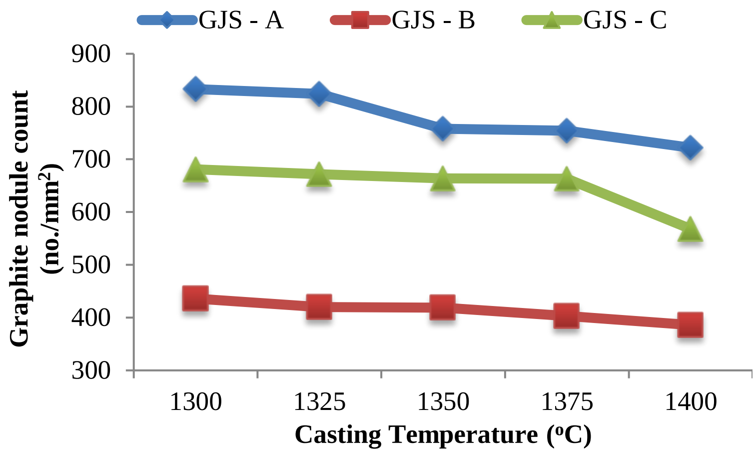

Figure 6. Change in nodule quantity of spheroidal graphite cast iron samples depending on casting temperature

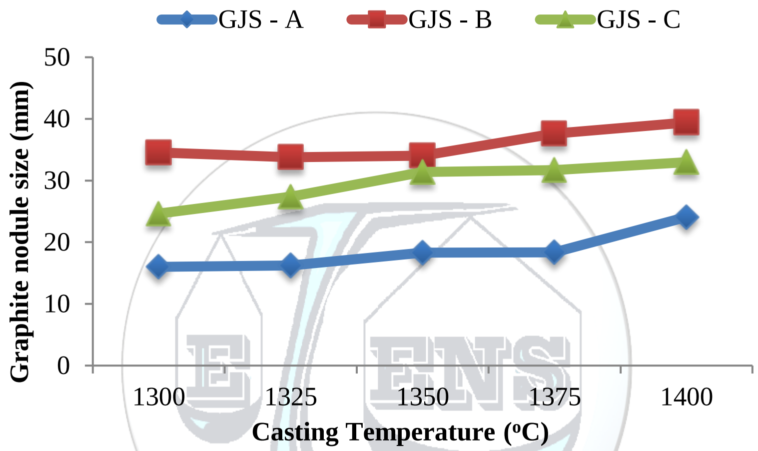

Figure 7. Change in nodule size of spheroidal graphite cast iron samples depending on casting temperature

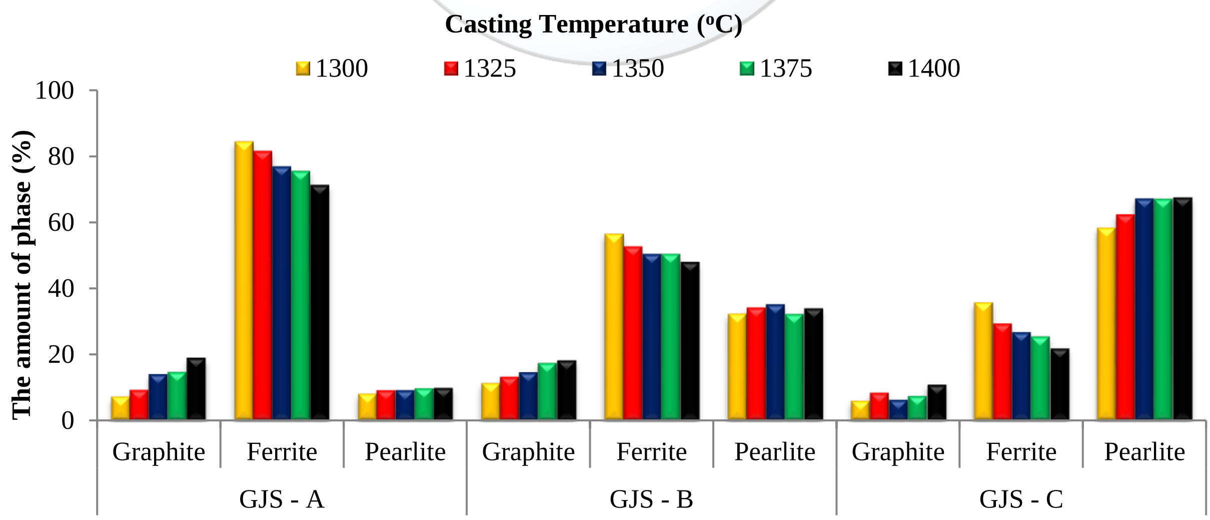

Figure 8. Change in phase amounts of casting temperature in cast iron depending on with spheroidal graphite

In spheroidal graphite cast irons, as shown in Figures 5 and 6, the amount of graphite nodule decreases with increasing casting temperature. However, graphite nodule size has been observed to increase with increasing casting temperature. With the increase in the casting temperature in the spheroidal graphite cast irons, an increase in the amount of graphite phase was observed, but the amount of ferrite phase decreased. The amounts of perlite phases in the samples generally did not change.

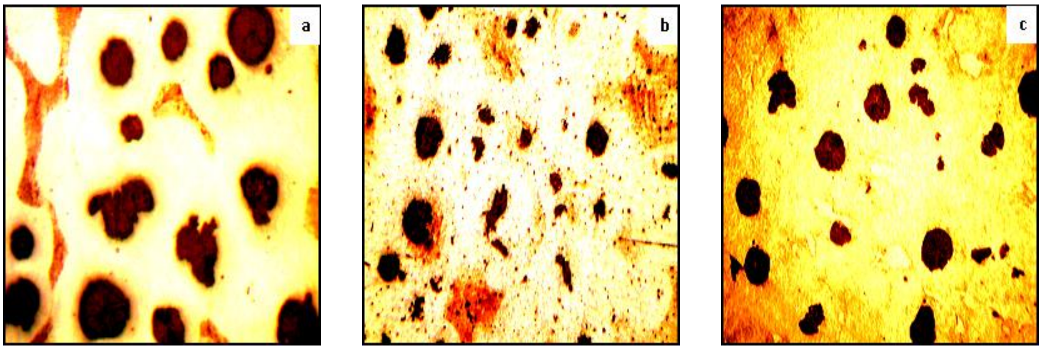

Figure 9. Microstructure drawings of spheroidal graphite cast iron specimens produced at casting temperature 1325ºC a) GJS-A (x200), b) GJS-B (x100), c) GJS-C(x200)

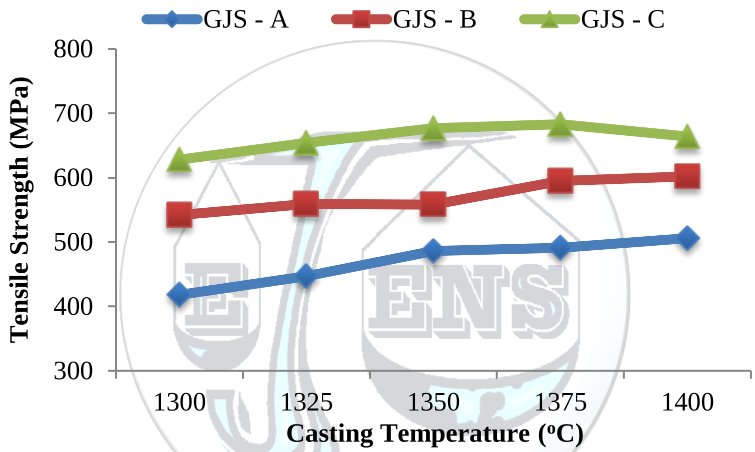

Figure 10. Tensile strength results of spherical graphite cast iron materials produced at different casting temperatures

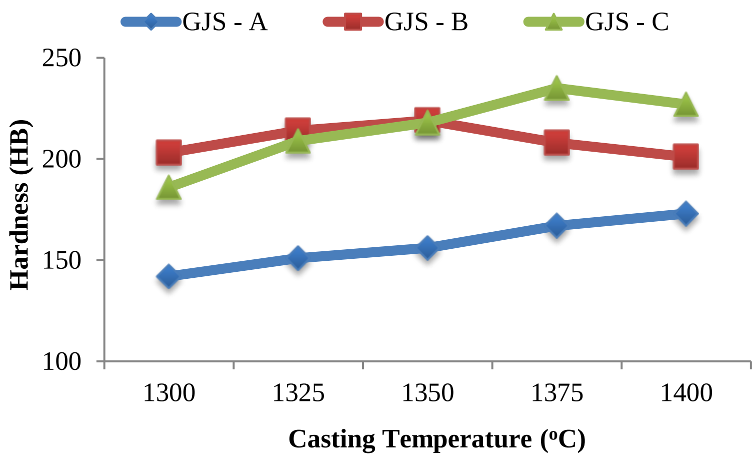

Figure 11. Hardness results of spherical graphite cast iron materials produced at different casting temperatures

When the tensile strength and hardness results of spherical graphite cast iron materials are examined, it has been observed that increase in tensile strength and hardness values of the samples are generally observed when the increase in the casting temperature. However, the casting temperature of the GJS-B coded sample showed a decrease in hardness value after 1350°C.

4. CONCLUSION

The results obtained from the materials produced by adjusting the casting temperature between 1300 ºC and 1400 ºC in lamellas and spheroidal graphite cast irons with different chemical compositions are summarized below.

1. When the microstructure and mechanical properties of the materials produced at different casting temperatures are examined, it has been understood that setting the casting temperature of the lamellar graphite cast iron materials at 1325 ºC to 1350 ºC is suitable for the materials to be produced in the specified composition. However, it has been found that for the graphite cast iron material with the chemical composition code GJS-A, the casting temperature is higher than 1400 °C and for GJS-B and GJS-C coded samples it is set to 1350 °C to 1375 °C.
2. For lamellar graphite cast iron, the general microstructure was found to be of type A 1 according to ASTM A247, but with increasing casting temperature and an increase in the size of GJL-B coded observed.
3. In the case of the increase of the casting temperature spheroidal graphite cast irons, the decrease of the number of nodules have occurred. As a result, the amount of ferrite phase in the microstructure decreased and the amount of perlite and graphite phase increase observed.

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