Effect of Niobium Addition in Grey Cast Iron on Mechanical Properties

Abstract

There are many studies focussed on changing graphite morphology in grey cast iron process in order to improve mechanical properties. Rare earth element addition is one of the most important approach to achieve this goal. The role of rare earth elements is to enhance perlite formation and increase tensile strength. In the present study, the effect of niobium (Nb) addition to the composition of grey cast iron was investigated. Results showed that Nb addition between 0.1% and 0.4% as a charging element to furnace improved microstructural features and mechanical properties.

1. Introduction

Grey cast iron’s (GCI) worldwide production is far higher than other casting alloys that’s why it is no doubt GCI is most important casting materials [1]. GCI has broad usage area on automotive industry such as cylinder sleeve, brake disc, flywheel etc. As a result of high compression strength, high thermal conductivity, better machinability comparing to other cast irons and relatively low cost [2].

Graphite morphology and volume fraction are determined the properties of grey cast iron densely. Thermal conductivity is one of the most important properties for grey cast iron which has flake-like graphite and it is correlated with carbon equivalent. Based on brake discs, carbon equivalent generally ranges from 3.8 to 4.6%. Excess graphite which provides high thermal conductivity also causes a decrease of the mechanical properties. For effective solution, alloying with some trace elements such as molybdenum, vanadium, nickel, chromium etc. could be used. Niobium has a long past as an alloying element on steel. There are some works about the effect of niobium on the phase transformation temperature, micro-hardness, NbC particles sedimentation etc. [3-4].

2. Experimental Procedure

Low silicon pig iron and steel scrap were used as charge materials. For fully dissolve, FeNb (65% Niobium content) was added to the furnace charge. Composition was analyzed by spectral and chemical methods. The composition of samples was: C 3.20, Si 2.1, Mn 0.80 and Cu 0.25 (wt.%). The niobium content was 0.00, 0.23, 0.45 (wt.%) properly. The alloy materials were melted at 1480 °C in a 100 kg capacity medium-frequency induction furnace and then poured into green sand mould. Inoculation materials were added during melted samples transferring to the ladle. The samples removed from sand mould at room temperature.

Macro-hardness of the samples was measured using Stiefelmayer OBPC 3000D Brinell hardness tester. The static load was 3000 kgf and the dwell time of load was 15 seconds. The tensile strength of the samples was determined by Shimadzu AG 250 kN.

3. Results and Discussion

- Chemical analyses of samples are shown in Table 1.

Table 1. Chemical analyses of the samples.

<table>
<thead>
<tr>
<th>C</th>
<th>Si</th>
<th>Nb</th>
<th>Cu</th>
<th>Mn</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.21</td>
<td>2.12</td>
<td>-</td>
<td>0.26</td>
</tr>
<tr>
<td>2</td>
<td>3.23</td>
<td>2.14</td>
<td>0.23</td>
<td>0.25</td>
</tr>
<tr>
<td>3</td>
<td>3.22</td>
<td>2.13</td>
<td>0.45</td>
<td>0.24</td>
</tr>
</tbody>
</table>

Hardness values of the 0, 0.23, 0.45 wt.% Nb containing samples are shown in Figure 1. Based on the obtained results, when the niobium content increased, the hardness values also improved and the samples which contains % 0.45 niobium has reached the highest hardness. Niobium forms primary MC-type carbides [3].

\[
[Nb] + [C] = NbC_{(s)}
\]

As a result of this reaction, hardness values had improved by niobium addition. In addition the aggregation of niobium rich phase may cause higher hardness values.
Effect of niobium addition on tensile strength is shown in Figure 2. After the tensile test, the results show that addition of niobium improved tensile strength of specimens. Niobium addition reduced cell size and properly blunt graphite flake size. Additionally, mechanical properties improved by increasing niobium content. Moreover, niobium carbide phase possibly play role in improved tensile strength.

4. Conclusion

Mechanical effect of niobium addition on grey cast iron materials was investigated. Experimental results established that increasing niobium addition (0.23% and 0.45%), both hardness and tensile strength improved on grey cast iron. Niobium carbide phase may improve mechanical properties. As in more niobium addition improve mechanical properties by reducing cell size and leads to shorter and finer graphite flakes. Interlamellar spacing of the pearlite became more refined.

References