ABSTRACT

As a candidate of structural material for the SSC magnet cryogenic use, high manganese nonmagnetic steel (KHMN30L) has been developed to give several favorable results in terms of its production, metallurgy and usability. It is proved available to make a mass production of both 1.5mm and 2.5mm thick sheet coil. The suitable balance of nonmagnetism, strength and cryogenic toughness is achieved along with their sufficient stability and uniformity. The material usability has been investigated to involve the experiment of semi-perforation / fine blanking of a collar with 2.5mm thick specimen currently manufactured at a factory.

1. INTRODUCTION

The cold mass of a SSC superconducting magnet comprises principally several components such as beam tube, super conductor, insulator, collar, yoke, helium shell, end yoke, etc. High manganese nonmagnetic steel (KHMN30L) developed for collar, beam tube, (and end yoke) has been studied in terms of the production, metallurgy and utilization including semi-perforation test with 2.5mm thick steel manufactured, which follows to the previous papers.1,2) The summarized list of nonmagnetic material and magnet components is presented in Table 1 to list up a matter of magnet construction including the design, fabrication and performance in addition to the material production, metallurgy and utilization. As for the material it is noted that the matching of nonmagnetism and the strength is of great significance.

2. PRODUCTION OF HIGH MANGANESE NONMAGNETIC STEEL

In order to satisfy the targets mainly for the collar and beam tube mentioned in Table 1, there is a possibility of selecting a nonmagnetic metallic material like austenitic steel, super alloy or aluminum alloy when the cost performance is also considered. The authors have put
Table 1. Summary of material and magnet for the SSC.

<table>
<thead>
<tr>
<th>Item</th>
<th>Target</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alloy designing</td>
<td>RT: 4K</td>
<td>Fabricability</td>
</tr>
<tr>
<td>Production process</td>
<td></td>
<td>Yield</td>
</tr>
<tr>
<td>(Steel making)</td>
<td></td>
<td>Cost performance</td>
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<tr>
<td>(Descaling)</td>
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<tr>
<td>Temper rolling/annealing</td>
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<tr>
<td>Strength</td>
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<td></td>
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<tr>
<td>Ductility/Toughness</td>
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<tr>
<td>Fatigue/Corrosivity</td>
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<td></td>
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<tr>
<td>Magnetic permeability</td>
<td></td>
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<tr>
<td>Thermal coefficient</td>
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<td></td>
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<tr>
<td>Utilization</td>
<td></td>
<td></td>
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<tr>
<td>Stamping/Spot welding</td>
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<tr>
<td>Fine blanking</td>
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<tr>
<td>Burring/Dimpling</td>
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<td>TIG welding</td>
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<tr>
<td>Sensitizing</td>
<td></td>
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<tr>
<td>Design</td>
<td></td>
<td>Tooling</td>
</tr>
<tr>
<td>Fabrication</td>
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</tr>
<tr>
<td>Performance</td>
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</tbody>
</table>

Table 2. Chemical compositions of high manganese steel.

<table>
<thead>
<tr>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>Cr</th>
<th>Ni</th>
<th>N</th>
<th>V</th>
<th>P</th>
<th>S</th>
<th>Al</th>
<th>O₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal</td>
<td>≤0.4</td>
<td>≤1.0</td>
<td>≤10.0</td>
<td>≤2.0</td>
<td>≤0.15</td>
<td>---</td>
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</tr>
<tr>
<td>Example</td>
<td>0.11</td>
<td>0.6</td>
<td>28.4</td>
<td>7.1</td>
<td>1.0</td>
<td>0.06</td>
<td>0.033</td>
<td>0.002</td>
<td>0.02</td>
<td>0.026</td>
</tr>
</tbody>
</table>

*Temper cold-rolling as final process

Figure 1. Equilibrium phase diagram of Fe-Mn-C at 1100°C and composition range of KHMN30L.