Tensile Properties and Microstructure of Girth Welds for High Strength Linepipe

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ABSTRACT
This study was conducted to confirm that the tensile and Charpy impact properties of weld metal produced using commercial welding consumables could achieve high yield strength of 830 MPa or more with Charpy impact energy of 50J or more. Mechanized pulsed gas metal arc welding (P-GMAW) using a single wire with narrow groove weld geometry is basically applied to girth welding. And the multi-wire processes, such as tandem wire and dual-touch processes have been developed to increase welding productivity. In this study, the single wire-single torch (single torch) and the single wire- dual touch (dual torch) processes were applied to produce X100 joints. A series of four experimental girth welds were produced using three kinds of commercial welding wires classified ER90S-G, ER100S-G and ER110S-G in this study. Tensile properties, hardness distributions and microstructures of weld metal were evaluated. It was confirmed that the girth weld metal produced by using the dual torch process using commercial welding wire could achieve high yield strength of 851 MPa with Charpy impact energy of 50J or more at -50 deg. C.

KEY WORDS:
X100, Girth welds, Acicular ferrite, Carbon content

INTRODUCTION
To maximize economic advantages, the use of high strength steels (X80 and over) in pipeline systems has been investigated. X80 and X100 grade steels have been developed and utilized for gas pipelines (Zhou et al., 2008). Welding of these high strength pipes posed challenges because of their sensitivity to variations of welding conditions. Thus several kinds of investigations have been conducted to characterize the properties of X80 and X100 welds under specific conditions (Hammond et al., 2002, Gianetto et al., 2006, Gianetto et al., 2008 and Fiore et al., 2008). From these investigations it has been confirmed that weld metal can match the X80 and X100 grade pipes using commercially available welding consumables under the developed welding procedures. On the other hand necessity of strain based design in pipeline systems is discussed more seriously with spreading applications of a high strength pipes more than X80 and there is great focus on overmatching criteria for pipeline girth welds. One of proposed criterion of weld overmatching is that the yield strength of weld metal must be greater than that of the actual pipe rather than the specified minimum yield strength. This criterion led the minimum yield strength requirement for the girth weld metal to around 830 MPa (120 ksi) for X100 pipes.

This study was conducted to confirm that the tensile and Charpy impact properties of weld metal produced using commercial welding consumables could achieve high yield strength of 830 MPa or more with adequate impact energy of 50J or more.

EXPERIMENTAL PROCEDURES
An X100 DSAW pipe with a diameter of 914mm and a wall thickness of 19mm was used as a mother pipe. The chemical composition of base metal of DSAW pipe is shown in Table 1.

<table>
<thead>
<tr>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>Others</th>
<th>Pcm</th>
<th>Ceq(IW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.064</td>
<td>0.1</td>
<td>1.78</td>
<td>Cu, Ni, Mo, Nb, Ti</td>
<td>0.198</td>
<td>0.473</td>
</tr>
</tbody>
</table>

The pipe ends were prepared by machining with a bevel angle of 5 deg., a hot pass bevel angle of 45 deg. and an offset distance of 2.8mm. A root pass bevel angle was 37.5 deg.. The root pass bevel depth and a root face were both 1.3 mm. A schematic diagram of the bevel preparation is shown in Fig. 1.

Fig. 1 Schematic diagram of the pipe joint preparation

Table 1 Chemical composition of base metal of DSAW pipe (mass%)