DEVELOPMENT OF HOT ROLLED PICKLED OILED
490 MPA CLASS USE PLAIN CARBON STEEL
FOR AUTOMOTIVE PIPE APPLICATION

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SYNOPSIS

At this year, demand for automotive steels with high strength increases including pipe application for automotive. This is in-line with current trend of automotive steel demand which requires higher strength and thinner gage. Furthermore, automotive application requires an excellent surface quality and consistency of mechanical properties along the strips.

This paper describes the development of 490 MPa plain carbon steel strips by optimizing rolling temperature in hot rolling instead of using HSLA steel as raw material. Customer requires Hot Rolled Pickled Oiled KS 49 requires with tensile strength 490 MPA minimum and elongation 18% minimum.

Keywords:
Automotive steel pipe, finishing and coiling temperature, plain carbon steel, hot rolled pickled oiled
1. INTRODUCTION

Steel is commonly material used as raw material for several applications such as automotive, bridge structure, oil and gas, pipeline, etc. At this year, demand for automotive steels with high strength increases including pipe application for automotive. This is in-line with current trend of automotive steel demand which requires higher strength and thinner gage, resulting in significant weight saving.

High strength steels can be achieved by optimizing temperature of rolling process especially finishing temperature and coiling temperature, it could get the desired properties without use any alloying elements. Furthermore, usage of plain carbon steel as raw material will reduce the raw material cost.

PT Krakatau Steel (Persero) Tbk product development activity closely related with current market product situation, The development of Hot Rolled Pickled Oiled (HRPO) 490 MPa class was driven by request from our pipe maker automotive customer. Customer requires tensile strength 490 MPa minimum and elongation 18% minimum.

This paper briefly describes development of 490 MPa class HRPO product for pipe automotive application.

2. PRODUCT REQUIREMENTS AND DESIGN

The requirements of the developed steel are in accordance with Table 1 and Table 2. Its tells us chemical composition and mechanical properties, compare to typical of chemical composition and mechanical properties as summarised in table 1 and table 2. The steel material design considered the uniformity of the targeted mechanical properties.

<table>
<thead>
<tr>
<th>Element (%)</th>
<th>Requirements</th>
<th>Typical</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0,30 max</td>
<td>0,17</td>
</tr>
<tr>
<td>Mn</td>
<td>0,30 – 1,00</td>
<td>0,90</td>
</tr>
<tr>
<td>Si</td>
<td>0,35 max.</td>
<td>0,013</td>
</tr>
<tr>
<td>P</td>
<td>0,040 max.</td>
<td>0,01</td>
</tr>
<tr>
<td>S</td>
<td>0,040 max.</td>
<td>0,004</td>
</tr>
</tbody>
</table>

Table 1. Chemical composition requirements and typical of product.

<table>
<thead>
<tr>
<th>Properties</th>
<th>Requirements</th>
<th>Typical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength</td>
<td>490 min.</td>
<td>501 – 546</td>
</tr>
<tr>
<td>Elongation</td>
<td>18 min.(^\dfrac{1}{1})</td>
<td>28 – 40</td>
</tr>
</tbody>
</table>

Note : \(^\dfrac{1}{1}\) = for 1,60 ≤ T < 3,00

In general, steel raw material for pipe automotive application should have excellent surface quality (free from surface defect such as lamination, open scratch, & rolled in scale) along the strips.
3. PRODUCTION PROCESS

The production of steel for this application is carried out in the existing hot strip mill and cold rolling mill with processing route as generally shown in figure 2.

Figure 1. Production process line in hot rolling and cold rolling

In the hot rolling process, plain carbon steel slab as raw material are subsequently hot rolled to obtain specified thickness. The Thermo-Mechanical Control Process with adjustment of mechanical properties by control of microstructure with optimizing finishing and coiling temperature to achieve required mechanical properties. The HRC is then processed at hot skin pass mill (HSPM) to improve its flatness before descaling process in continuous pickling line (CPL) in Cold Rolling Mill (CRM).

The slab is reheated up to about 1200°C and soaked at that temperature in the reheating furnace, then it's get the first stage of reduction at roughing mill. This steel is then rolled at a temperature between non-recrystallization and Ar₃ transformation temperature in finishing mill in to achieve the final thickness. Temperature after last stand rolling in finishing mill is
called Finishing Temperature and its around 850°C. The steel strip pass through laminar cooling in order to get its exact mechanical properties, then its coiled at about 560°C. It consequently results the formation of upper bainite microstructure transformation.

The HRC as improved its flatness in Hot Skin Pass Mill then processed in continuous pickling line (CPL) to remove the scale which is formed naturally in hot rolling. The pickling process design parameter are use higher concentration of hydrochloric acid in the final tank and its temperature around 80°C to optimize its descaling process.

4. RESULT AND DISCUSSION

4.1 Mechanical Test Results of Hot Rolled Coil

The results of tensile test which were taken from production data of HRC in transversal direction are presented at table 3. Tensile strength and elongation of the steel with thickness range $\leq 3.0$ mm are 490 MPa min. and 18% min. respectively. All these values are within specified values and comply with customer requirements.

<table>
<thead>
<tr>
<th>Thickness (mm)</th>
<th>Properties</th>
<th>Requirements</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1.60 \leq T &lt; 3.00$</td>
<td>Tensile Strength</td>
<td>490 min.</td>
<td>500 – 580</td>
</tr>
<tr>
<td></td>
<td>Elongation</td>
<td>18 min.&quot;(*)&quot;</td>
<td>28 – 40</td>
</tr>
</tbody>
</table>

Figure 2. Tensile test result of HRC
4.2 Metallography Observation

Microstructure of the hot rolled steel plate is shown in figure 4. Upper bainite were observed by means of optical microscope. It is well known that upper bainite consists of needles of ferrites separated by long cementite particles\(^3\). Plates of bainite form without any diffusion, but shortly after transformation, the carbon partitions into the residual austenite and precipitates as cementite between the ferrite\(^4\).

![Figure 4](image-url)

**Figure 4.** Microstructure of the hot rolled steel plate in: (a) surface position, (b) half thickness, (c) and (d) quarter thickness.
Hardness value of the material in through thickness direction were also measured uniformity of about 144 – 180 HV as can be seen in figure 5.

![Microhardness Test Result of HRC](image)

**Figure 5. Microhardness test result of HRC**

5. SUMMARY

Product design by using plain carbon steel and controlling finishing and coiling temperature has fulfilled mechanical properties of customer requirements. Pickling process after Hot Skin Pass Mill could achieve good surface quality of HRPO product.

6. REFERENCES

