Stainless Steels for Automotive Exhaust System

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1 Introduction

Adoption of stainless steels for automotive exhaust system has been increased to cope with tighter emission regulations, an improvement in the engine performance and extension of the durability of exhaust system. Since in the exhaust system the demand on its materials differs greatly from part to part, Kawasaki Steel produces many grades of stainless steels shown in Table 1 in order to meet each requirement.

An outline of these steel grades is given below.

2 Specifications and Properties of Products

2.1 Stainless Steels for Exhaust Manifolds

The exhaust manifold collects the high-temperature exhaust discharged from each combustion chamber of engine and sends it into the downpipe. Because the exhaust manifold is heated to high temperatures, its material is required to have high-temperature strength and oxidation resistance. R409L has been used when the operating temperature is not so high and R430LM and R430CuN, whose high-temperature strength has been increased by the addition of Nb, have been used when the operating temperature is high. Because the exhaust manifold is produced by assembling complex-shaped pipes and pressed parts, good formability is also required on its materials. Therefore, adoption of R429EX, which provides good formability as shown in Table 1, has been increased. Although the Cr content of R429EX is 15%, its oxidation resistance is equivalent to that of R430LM and R430CuN. Furthermore, R434LN2, whose high-temperature strength is increased by adding both 2% Mo and Nb, has recently begun to be adopted. Figure 1 shows the 0.2% proof stress of these steels. R434LN2 has the highest proof stress, followed closely by R429EX, R430LM and R430CuN. Figure 2 shows the results of an oxidation test. R429EX, R430LM and R430CuN maintained a protective oxide layer up to 900°C. At 1000°C, accelerated oxidation occurred in R429EX and the oxide layer spoiled in R430LM and R430CuN. On the other hand, R434LN2 maintained a protective oxide layer at even that temperature. This shows that R429EX has the same durability as R430LM and R430CuN, while R434LN2 lasts much longer.

These stainless steels are suitable for use not only in exhaust manifolds, but also in other hot sections such as downpipes and converter shells.

<table>
<thead>
<tr>
<th>Standard designation</th>
<th>JIS</th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>Cr</th>
<th>Mo</th>
<th>Ti</th>
<th>Nb</th>
<th>Others</th>
<th>YS (N/mm²)</th>
<th>TS (N/mm²)</th>
<th>E (%)</th>
<th>r-value</th>
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<tr>
<td>R409L</td>
<td>SUH409L</td>
<td>0.01</td>
<td>0.3</td>
<td>0.3</td>
<td>11.0</td>
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<td></td>
<td></td>
<td></td>
<td>225</td>
<td>414</td>
<td>38</td>
<td>1.5</td>
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<tr>
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<td>14.8</td>
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<td>0.3</td>
<td>0.3</td>
<td>17.5</td>
<td>0.54</td>
<td>0.43</td>
<td>Cu/0.54</td>
<td>321</td>
<td>478</td>
<td>35</td>
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<tr>
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<td>18.7</td>
<td></td>
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<td>328</td>
<td>477</td>
<td>33</td>
<td>1.2</td>
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<td>0.27</td>
<td></td>
<td>310</td>
<td>475</td>
<td>32</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Sheet thickness: 1.0 mm except for R20-5USR of 0.5 mm

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2.2 Stainless Steels for Metal Substrate

The metal substrate has a honeycomb structure of 30-50 μm thick Fe-20%Cr-5%Al stainless steel foil and supports a catalyst on its surface to clean exhaust. Since it is heated by exhaust to high temperature, the foil is required to have superior oxidation resistance.

In R20-5USR, oxidation resistance is improved by the addition of a small amount of La and Zr. As shown in Fig. 3, R20-5USR has a lower oxidation rate than the conventional steels and thus a longer life.

2.3 Stainless Steel for Mufflers

Mufflers are required to have wet-corrosion resistance because very corrosive exhaust gas condensates containing NH₄⁺ and Cl⁻ accumulate inside, and road deicing salts adhere to the exterior. R409L is used when the requirements for corrosion resistance are not severe. In parts requiring higher corrosion resistance, R439L, which has good corrosion resistance by increasing Cr content in 18%, and R432LTM and R436LT, which have been further improved in corrosion resistance by adding

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Mo, are used. Figure 4 shows the results of a corrosion test in synthetic exhaust gas condensate. The maximum corrosion depth decreased in proportion to Cr content (\text{%}) + 3.3 \times \text{Mo content (\%}), indicating that Cr and Mo are effective for improving the corrosion resistance in condensates.

3 Conclusion

Kawasaki Steel produces many kinds of stainless steels, which are suitable for each part of the exhaust system. These stainless steels are used widely for their good performance.

References


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