New Products & Technologies

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 R430LNM 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 R430LNM 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, R430LNM and R430CuN. **Figure 2** shows the results of an oxidation test. R429EX, R430LNM and R430CuN maintained a protective oxide layer up to 900°C. At 1 000°C, accelerated oxidation occurred in R429EX and the oxide layer spalled in R430LNM 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 R430LNM 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 1 Examples of chemical composition (mass%) and mechanical properties

Standard designation Kawasaki Steel standard	JIS	C	Si	Mn	Cr	Mo	Ti	Nb	Others	YS (N/mm²)	TS (N/mm²)	El (%)	r-value
R409L	SUH409L	0.01	0.3	0.3	11.0	—	0.25	—		225	414	38	1.5
R429EX		0.01	0.9	0.4	14.8	—	—	0.45		301	462	36	1.4
R430LNM	SUS436J1L	0.01	0.3	0.3	17.5	0.54	—	0.43		321	478	35	1.3
R430CuN	SUS430J1L	0.01	0.5	0.2	18.7	—	—	0.45	Cu/0.54	328	477	33	1.2
R434LN2	SUS444	0.01	0.3	0.2	19.0	1.9	—	0.35		338	492	34	1.4
R20-5USR		0.01	0.2	0.1	20.1	—	—	—	Al/5.8	440	570	24	
R439L	SUS430LX	0.01	0.1	0.2	18.0	—	0.24	—		275	450	35	1.2
R432LTM		0.01	0.1	0.2	17.5	0.51	0.28	—		295	470	33	1.2
R436LT	SUS436L	0.01	0.1	0.2	17.7	1.23	0.27	—		310	475	32	1.2

Sheet thickness: 1.0 mm except for R20-5USR of 50 μm

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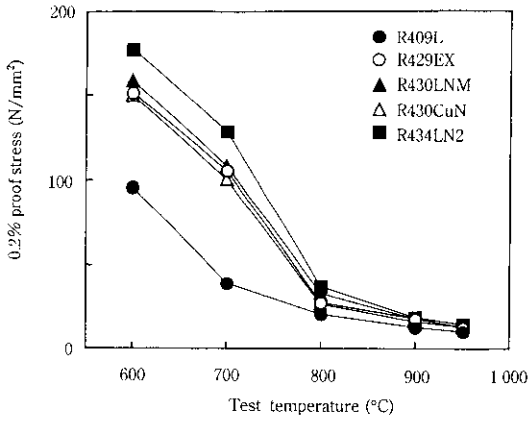


Fig. 1 0.2% proof stress of stainless steels for exhaust manifold at high temperatures

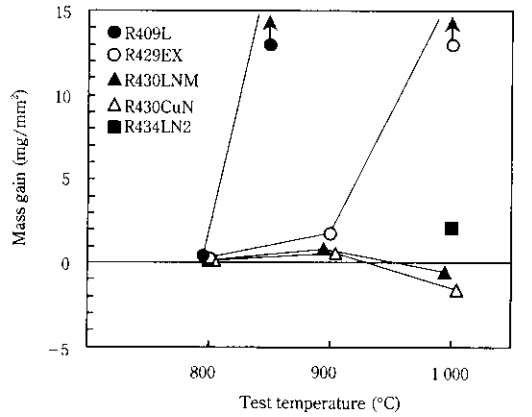


Fig. 2 Mass change of stainless steels for exhaust manifold after oxidation at various temperatures for 200 h in air

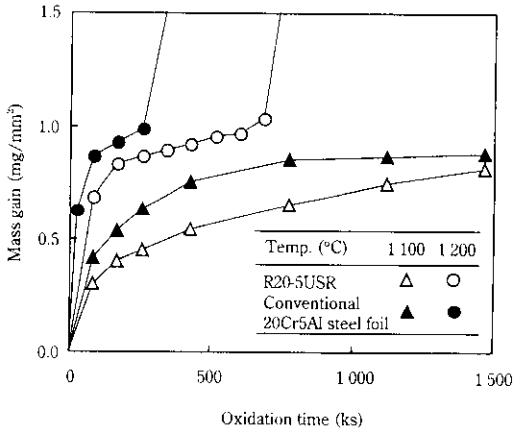
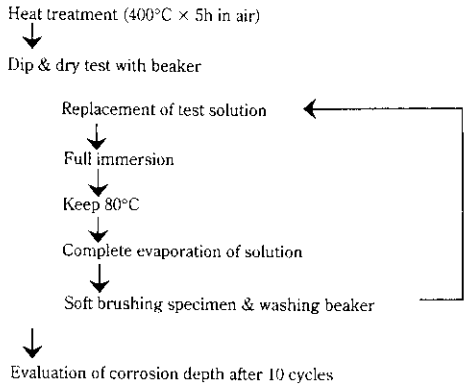


Fig. 3 Oxidation behavior of 50 μm thick R20-5USR foil in air



Chemical composition of the synthetic exhaust gas condensate

(ppm)

Cl^-	SO_3^{2-}	SO_4^{2-}	CO_3^{2-}	NO_2^-	NO_3^-	CH_3COO^-	HCHO	COOH	NH^+	Activated carbon
250	1250	1250	2000	100	20	400	250	100	2500	50 g/l

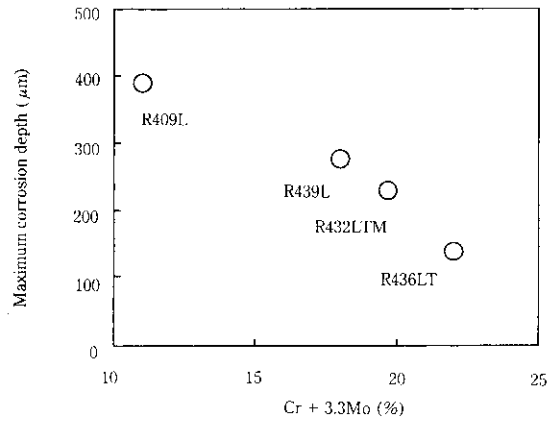


Fig. 4 Effect of Cr and Mo content on maximum corrosion depth in synthetic condensate corrosion test

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 NH_4^+ 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

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 (%) + 3.3 × 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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