Development of High Mn-N Duplex Stainless Steel for Automobile Structural Components

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Recently, there is a general trend of using stainless steels for automobile structural materials rather than traditional carbon steels because of many advantages of stainless steels, i.e., high strength, toughness, corrosion resistance and formability. Fig. 1 shows the parts of automobile where stainless steel is applicapable. Moreover, it is environmentally friendly material that is easy to be recycled. However, the use of stainless steels is largely limited still now for its high price originated from its high Ni contents (8~12 wt. %). In this concept, it is a worldwide trend of stainless steel research to develop a new stainless steel with low Ni content.

For this reason, many stainless steel makers have paid attention to the high Mn-N austenite stainless steels of Fe-(16~19)Cr-(1~4.5)Ni-(8~11)Mn-(0.2~0.5)N in which expensive Ni, an austenite stabilizer, is largely replaced by inexpensive Mn which also acts as an austenite stabilizer. However, these high Mn-N austenitic stainless steels are not completely free from problems, which means that high Mn contents (~11 wt. %) of the alloy induces a decrease in the resistance to localized corrosion of the alloy.

To solve this problem, we are to reduce the Mn and Ni content further by changing the structure of stainless steel from austenite to duplex. In this concept, we developed a new stainless steel for automobile structural materials with duplex structure whose composition was designed by Schaeffler diagram and Thermo Calc. software. Table. 1 shows the compositions of candidate alloys and their positions in Schaeffler diagram was presented in Fig. 2. Finally, the mechanical properties and the resistance to localized corrosion of the designed alloys were judged by a tensile test (Fig. 3) and various corrosion tests, i.e., anodic polarization tests (Fig. 4), noise analysis and critical pitting temperature tests in Cl^- containing solutions.

Considering the mechanical properties and corrosion properties together, the optimized alloy composition developed through the procedures above was Fe-18Cr-6Mn-1Mo-0.2N. This alloy has significantly higher UTS and Y.S. values compared to those of commercial 304 stainless steel (Fig. 3) while its pitting potential is similar to that of 304 stainless steel (Fig. 4).

The authors expect that the new alloy is an attractive candidate material for front sub frame, low arm, torsion bar and fuel tank parts in automobile.

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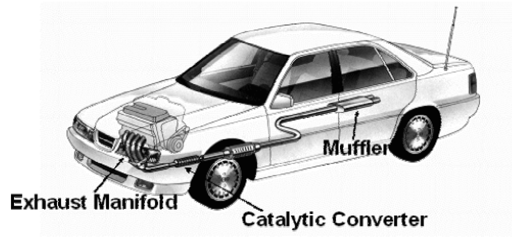

Fig. 1 Automobile parts for application of stainless steel.

Alloy	Fe	Cr	Mn	Ni	Mo	N
1	Bal.	18	6	0	1	0.2
2	Bal.	18	4	1	1	0.2
3	Bal.	18	11	2	1	0.2

Table. 1 Chemical compositions of candidate alloys (wt. %)

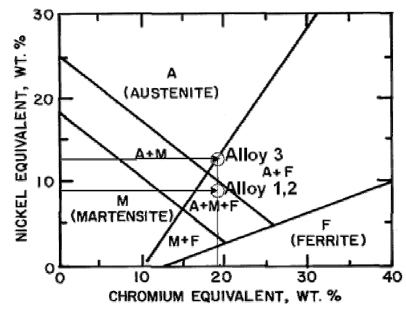

Fig. 2 Position of candidate alloys in Schaeffler diagram.

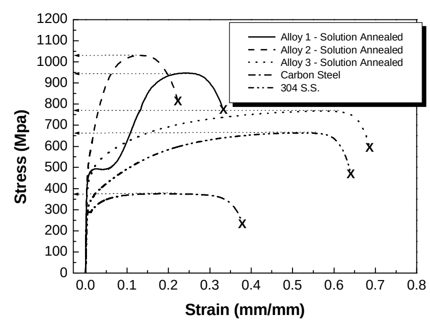

Fig. 3 Tensile test results of solution annealed alloys.

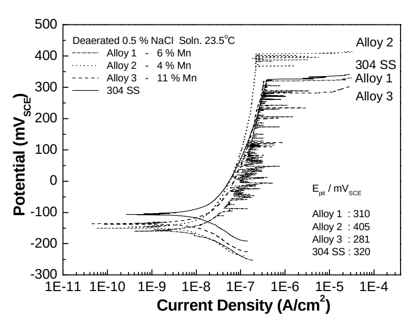

Fig. 4 Anodic polarization curves of alloys in deaerated 0.5 % NaCl solution at 23.5 °C.