Effect of Carbon and Nitrogen on Mechanical Stability of Metastable Austenitic Stainless Steel

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1. Introduction In metastable austenitic (γ) steels, e.g. type304, deformation-induced α'-martensitic transformation markedly influences the magnetic properties, strength-ductility balance, hydrogen embrittlement properties, and so on. Therefore, it is important to understand and control the mechanical stability of γ. In general, the mechanical stability of γ is evaluated by Md_{30} (temperature at which 50% α' is formed by 0.3 true tensile strain) which is sensitively affected by the chemical composition of the steel. In particular, C and N are strong γ stabilizing elements and they decrease Md_{30} remarkably. The effect of both elements are usually regarded to be equivalent as Nohara’s equation suggests; however it should be revalidated because the specimens used in Nohara’s investigation contained C and N simultaneously, and also, the composition range of N was very narrow (up to 0.04%N). In this study, the effects of C and N on Md_{30} were investigated by using 18%Cr-8%Ni steels with separately-added C or N.

2. Experimental procedure Low-CN metastable γ stainless steel (18%Cr-8%Ni-0.002%C-0.001%N steel) was used as a base material (Base steel). In addition, C and N of 0.1 or 0.2% were separately added to the Base steel (0.1C, 0.2C, 0.1N, 0.2N steel). These specimens were solution-treated at 1273K to 1373K for 1.8ks, followed by water cooling, and then tensile testing was conducted at 237 to 393K. The volume fraction of α' was estimated by means of saturation-magnetization measurement and the microstructural observation using FE-SEM/EBSD, OM and TEM were carried out.

3. Results and discussion Fig.1 shows the change in volume fraction of α' as a function of tensile true strain. The volume fraction of deformation-induced α' is significantly lowered by the addition of C and N. Comparing the change in volume fraction of α' between 0.1C and 0.1N steels reveals that C exhibits higher γ stabilization effect than N.

Fig.2 shows the temperature dependence of the volume fraction of α' induced by tensile deformation at true strain of 0.3. In all steels, volume fraction of α' becomes higher with lowering temperature. Moreover, the curves of C and N-added steels are shifted toward lower temperature region. In Fig.2, Md_{30} is given by the temperature at which the volume fraction of α' reaches 50%. This figure suggests that the effect of C and N on Md_{30} is almost the same in the case of 0.1 or 0.2% addition; however, the γ at ambient temperature (293K) is more stabilized by C compared with N. That means the effect of C and N on the mechanical stability depends on temperature greatly. In the presentation, we will discuss the reasons why such a difference are appeared from the view point of deformation microstructure related with stacking fault energy.

Reference