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Improved Strength-Ductility Combination by Layer-Integrated Steels

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Abstract – Multilayered (layer-integrated) steel composites which consist of martensitic steel and austenitic steels have been developed to achieve better strength-ductility combination than conventional steels. In this study, multilayered steel composites were fabricated by controlling such parameters as fracture toughness and layer thickness of martensite, work hardening exponent of austenite and strength ratio between martensite and austenite. It was shown that, by controlling the geometric and material parameters of the layers, variety of extraordinary high strength-ductility combinations could be achieved.

A multilayered (layer-integrated) steel composite which consists of martensitic and austenitic steels has been developed to achieve better strength-ductility combination than conventional steels show in our group. Since strength of multilayered steel composite is determined by a rule of mixture of that of constituent materials, the application of ultra high strength martensitic steel is indispensable. However, the martensitic steel has very low ductility and fracture toughness. In the previous study, we demonstrated that enhancement of the elongation of multilayered steel composite could be achieved by controlling the layer thickness of martensite and selecting the work hardening exponent of austenite. It is also considered that fracture toughness of martensite, interfacial bonding strength, and strength ratio between constituent materials are important factor to enhance ductility [1, 2]. In this study, according to the previous results, we tried to fabricate multilayered steel composites to achieve extraordinary high strength-ductility combination.

Type 420J2 stainless steel (SS420J2), which shows ultra high strength about 2 GPa was prepared for martensite, and Type 304, 304N2 and 301 austenitic stainless steel (SS304, SS304N2 and SS301), which have different work hardening exponent and yield stress, were prepared for austenite. Martensitic and austenitic steel sheets were stacked into laminates alternately, then bonded by hot-rolling and cold-rolling. The final thicknesses were 0.75-2.0 mm. Prior to tensile test, the heat treatment was conducted at temperature of 1273 and 1373 K for 2 min followed by water-quenching or air-cooling. Figure 1 shows the obtained SS420J2/SS304 multilayered steel with 25 layers under the heat treatment condition at 1373 K for 2 min followed by air-cooling.

The stress-strain curves of multilayered composites of SS420J2/SS301 combinations, which have several volume fractions between martensite and austenite, under the heat treatment condition at 1273 K for 2 min followed by air-cooling are shown in Fig. 2. It was shown that, by controlling the geometric and material parameters of the layers, variety of extraordinary high strength-ductility combinations could be achieved.

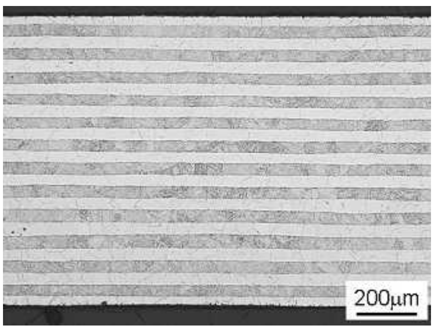

Fig. 1 SEM micrograph of the obtained multilayered steel.

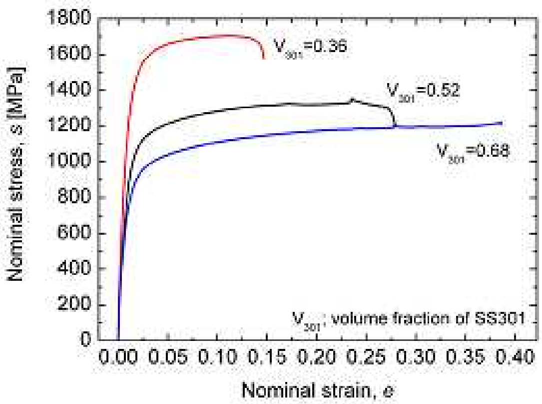

Fig. 2 Stress-strain curves of multilayered steels, SS420J2/SS301, with several volume fractions under the heat treatment condition at 1273 K for 2min followed by air-cooling.

References

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