Tungsten Coating on Low Activation Vanadium Alloy by Plasma Spray Process

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Tungsten metal and low activation vanadium alloys are promising candidates for the plasma facing material and the structural materials, respectively, in the first wall of fusion blanket system. Tungsten has a high melting point, such as 3650 K, and low sputtering rate in fusion plasma environment. Low activation vanadium alloys have demonstrated high mechanical strength up to 1000 K, high resistance to neutron irradiation and manufacturing feasibility, such as large scale melting, parts fabrication and welding. In the present study, tungsten coatings on the low activation vanadium alloy were fabricated by plasma spray process, which is practical for large area coating because of its high coating rate. The tungsten coating, interface and vanadium alloy substrate after coating are characterized. Engineering issues, bonding property and behavior of the constituent element and pick-up impurities were discussed.

The vanadium alloy substrate was a 2 mm-thick plate of NIFS-HEAT-2, which is the reference high purity V-4Cr-4Ti alloy. Tungsten powder of 99.9 % grade and in 325 mesh size was used as coating materials for plasma spray process. In the process, the vanadium alloy substrate surface was blustered and cleaned by argon arc sputtering. The tungsten powder was carried by argon gas to the plasma jet of argon and hydrogen mixture. The jet sprayed the substrate with the melted tungsten particle. The power of the plasma gun and scanning speed of the gun was 45-46 kW and 75 mm / sec, respectively. Initial and final surface temperature at coating was 620-720 K and 920-1070 K, respectively. The plasma spray chamber was filled with argon gas of about 10^4 Pa in pressure. The resulting thickness of the tungsten coatings was about 0.5 mm after 10 scans.

The tungsten coating side was convexly curved because of the difference in the thermal expansion coefficient of the tungsten and vanadium alloys, which is 4.6 and 9.8×10^{-6} K^{-1}, respectively, for the average in RT-773 K. The deformation did not induce peeling or cracking of the coating. Hardness of the tungsten coating was varied from 350-640 Hv with the load of 25 g, while that of the vanadium alloy substrate was 210-250 Hv. The large scattering of the hardness in the tungsten coating region was considered as a result of inhomogeneous solidification and rapid cooling rate of the tungsten coating. At the vanadium alloy substrate, oxygen contamination was detected around the interface to the tungsten coating, however an accompanied hardening and its depth from the interface were limited as about 10 Hv and 100 μm, respectively, which was expected not to induce significant change in mechanical property of vanadium alloy substrate. In the present study, the direct deposition and coating fabrication of tungsten on the vanadium alloy was successfully demonstrated.