A Study of Corrosion-Resistant Materials in Molten A356 Alloy

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ABSTRACT

In some industrial implementations, the mechanical elements have prolonged contacts with molten Al or Al alloys, such as the feed screw and barrel of an injection molding machine, which can process molten Al alloy into solid parts, and the rollers in the hot-dip aluminizing bath. These mechanical elements always fail due to the attack of molten Al. This study intends to investigate the corrosion behaviors of the refractory metals, superalloys and metal nitrides to develop the materials suitable for manufacturing the feed screw and barrel of an injection molding machine. Experimental results indicate that heat-resistant steel and IN718 Ni-base superalloy are seriously corroded in molten A356 alloy; thereby forming relatively thick alloy layers on the base materials. Conversely, the metals, such as Nb, W, Ti and Mo, form peritectic alloys with Al and exhibit better corrosion resistance in molten A356 alloy. Furthermore, continuous alloy layer was not observed on Mo-Re and Nb-Ti-W alloys, while these alloys are locally attacked after dipping in molten A356 alloy for 1 to 6 h. In contrast to refractory metals and superalloys, CrN thin film and CrN/TiN multilayer are less corroded in molten A356 alloy. In contrast, TiAlN film is corroded in the early stage of dipping in molten A356 alloy. After certain incubation period, the coated steel was locally attacked, forming hemispherical pits on both CrN and CrN/TiN coated steels. The incubation time for the pit nucleation on the CrN coated steel was shorter than that for the CrN/TiN coated steel. Once the obvious pits formed, the pitted areas increased with dipping time, regardless of the type of coating. After 21 h of dipping, the coating that remained adhering to the steel substrate showed no reaction with the molten Al. The different incubation time of the distinct coatings can be explained by their different coating microstructures. That is, the CrN/TiN coating displayed a finer columnar structure than the CrN coating. The structural refinement resulted from the multilayer coating structure reduced the density of the coating defects. Consequently, the CrN/TiN coating retarded the pit nucleation more effectively than the CrN coating. Additionally, compared to CrN/TiN coating, the surface of CrN coating had more droplets that are potential sites for pit nucleation. Finally, the higher the surface roughness of the steel substrate, the more the corroded area is.

Keywords : metal nitride ; IN718 Ni-base superalloy ; ion nitriding ; CrN ; TiAlN ; CrN/TiN ; droplets ; molten A356 alloy

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