World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:18, No:06, 2024

The Effect of Bath Composition for Hot-Dip Aluminizing of AISI 4140 Steel

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Abstract : Hot-dip aluminizing (HDA) is one of the several aluminizing methods to form a wear-, corrosion- and oxidation-resistant aluminide layers on the surface. In this method, the substrate is dipped into a molten aluminum bath, hold in the bath for several minutes, and cooled down to the room temperature in air. A subsequent annealing after the HDA process is generally performed. The main advantage of HDA is its very low investment cost in comparison with other aluminizing methods such as chemical vapor deposition (CVD), pack aluminizing and metalizing. In the HDA process, Al or Al-Si molten baths are mostly used. However, in this study, three different Al alloys such as Al4043 (Al-Mg), Al5356 (Al-Si) and Al7020 (Al-Zn) were used as the molten bath in order to see their effects on morphological and mechanical properties of the resulting aluminide layers. AISI 4140 low alloyed steel was used as the substrate. Parameters of the HDA process were bath composition, bath temperature, and dipping time. These parameters were considered within a Taguchi L9 orthogonal array. After the HDA process and subsequent diffusion annealing, coating thickness measurement, microstructural analysis and hardness measurement of the aluminide layers were conducted. The optimum process parameters were evaluated according to coating morphology, such as cracks, Kirkendall porosity and hardness of the coatings. According to the results, smooth and clean aluminide layer with less Kirkendall porosity and cracks were observed on the sample, which was aluminized in the molten Al7020 bath at 700 □C for 10 minutes and subsequently diffusion annealed at 750 □C. Hardness of the aluminide layer was in between 1100-1300 HV and the coating thickness was approximately 400 µm. The results were promising such that a hard and thick aluminide layer with less Kirkendall porosity and cracks could be formed. It is, therefore, concluded that Al7020 bath may be used in the HDA process of AISI 4140 steel substrate.

Keywords : hot-dip aluminizing, microstructure, hardness measurement, diffusion annealing
Conference Title : ICHTC 2024 : International Conference on High Temperature Coatings
Conference Location : Riga, Latvia
Conference Dates : June 20-21, 2024