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Long Time Oxidation Behavior of Machined 316 Austenitic Stainless Steel in Primary Water Reactor

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Abstract : Austenitic stainless steels are widely used in nuclear industry to manufacture critical components owing to their excellent corrosion resistance at high temperatures. Almost all the components used in nuclear power plants are produced by surface finishing (surface cold work) such as milling, grinding and so on. The change of surface states induced by machining has great influence on the corrosion behavior. In the present study, long time oxidation behavior of machined 316 austenitic stainless steel exposed to simulated pressure water reactor environment was investigated considering different surface states. Four surface finishes were produced by electro-polishing (P), grinding (G), and two milling (M and M1) processes respectively. Before oxidation, the surface Vickers micro-hardness, surface roughness of each type of sample was measured. Corrosion behavior of four types of sample was studied by using oxidation weight gain method for six oxidation periods. The oxidation time of each period was 120h, 216h, 336h, 504h, 672h and 1344h, respectively. SEM was used to observe the surface morphology of oxide film in several period. The results showed that oxide film on austenitic stainless steel has a duplex-layer structure. The inner oxide film is continuous and compact, while the outer layer is composed of oxide particles. The oxide particle consisted of large particles (nearly micron size) and small particles (dozens of nanometers to a few hundred nanometers). The formation of oxide particle could be significantly affected by the machined surface states. The large particle on cold worked samples (grinding and milling) appeared earlier than electro-polished one, and the milled sample has the largest particle size followed by ground one and electro-polished one. For machined samples, the large particles were almost distributed along the direction of machining marks. Severe exfoliation was observed on one milled surface (M) which had the most heavily cold worked layer, while rare local exfoliation occurred on the ground sample (G) and the other milled sample (M1). The electro-polished sample (P) entirely did not exfoliate.

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