Heat Treatment Effects on Fretting Wear Performance of Selective Laser Melted 316L Against 316L SS Thimble Tube Under High-Temperature Water Conditions

Hao Liu[1,2], Junjie Chen[1,2*], Zhanpeng Lu[1,2*], Zaiqing Que[3*]

[1]*Institute of Materials, School of Materials Science and Engineering, Shanghai University, 149 Yanchang Road, Shanghai, 200072, China*

[2] *State Key Laboratory of Advanced Special Steels, Shanghai University, 149 Yanchang Road, Shanghai, 200072, China*

[3] *Advanced Materials for Nuclear Energy, VTT Technical Research Centre of Finland, Espoo, FI-02044 Finland*

shouxin2035@163.com, *junjiechen@shu.edu.cn*, *zplu@t.shu.edu.cn*, *zaiqing.que@vtt.fi*

Abstract In pressurized water reactor (PWR) nuclear power plants, fretting wear failure between the in-core flux thimble tube and the core support plate could be a matter of concern in the neutron flux measurement system. Additively manufactured components are expected to be promising for the complex structural design of core support plates. In this study, the fretting wear behaviors of the Laser Powder Bed Fusion (L-PBF) 316L stainless steel (SS) plate with various heat treatments against 316L SS thimble tube were studied in a simulated PWR primary water environment. The results indicate that stress relieving and solution annealing heat treatments did not alter the fine columnar grain morphology of L-PBF 316L. Both local misorientation and microhardness of L-PBF 316L decreased with increasing heat treatment temperature. In terms of volume loss and wear track depth, as-built L-PBF 316L performed comparably to commercial wrought 316L, whereas the wear resistance of stress-relieved and solution-annealed L-PBF 316L was lower than that of as-built L-PBF 316L. As-built L-PBF 316L showed comparable performance to commercial wrought 316L in terms of volume loss and wear track depth. In contrast, the stress-relieved and solution-annealed L-PBF 316L exhibited significantly increased volume loss and wear track depth, indicating poorer wear resistance. The wear tracks on the thimble tube followed a similar pattern, with less volume loss observed when paired with as-built L-PBF 316L and commercial wrought 316L.

Keywords fretting wear, stainless steel, thimble tube,laser powder bed fusion