Contribution ID: **510** Type: **ORAL**

Tensile testing of sub-sized T91 and 316L steel specimens in liquid lead

Wednesday, April 20, 2022 11:52 AM (12 minutes)

The influence of liquid lead on mechanical properties of ferritic-martensitic steel T91 and austenitic stainless steel 316L have been studied in the JRC's LIquid Lead LAboratory (LILLA). LILLA allows testing of mechanical and corrosion properties of materials in liquid lead with controlled dissolved oxygen concentrations and for temperatures up to 650℃. The load is generated by pneumatic bellow-based devices. For the present study, prior to tensile testing, polished sub-size flat and round tensile specimens were exposed in liquid lead at 450℃ for at least 100h and at 500℃ for at least 1000h. During this phase, the oxygen content dissolved in liquid lead was maintained below 10ˆ-9 wt.%. The tensile tests on T91 were performed at 400℃ in both argon and lead at an initial strain rate of 1x10ˆ-4 sˆ-1. For 316L, specimens from both the base metal and the 75mm thick submerged arc welded (SAW) joint were cut out and tested. Tensile tests on 316L were conducted both at 400℃ and 550℃ at initial strain rates of 5x10ˆ-5 sˆ-1 and 5x10ˆ-6 sˆ-1, respectively. During all tensile tests, the content of oxygen dissolved in lead was monitored continuously and kept below 10ˆ-8 wt.% with the cover gas control system implemented in LILLA (through flushing of Ar-H2 mixture). The test parameters were chosen based on outcomes of tests in lead-bismuth eutectic (LBE), where it had been demonstrated that mechanical properties of T91 are strongly influenced by strain rate, temperature, and oxygen content in LBE. The first LILLA post-test analysis have shown no evident impact of liquid Pb on the tensile properties of the investigated steels and welds exposed to the above-described conditions. The paper will address the observed results with respect to the literature data. This research supports resolution of key safety and licensing aspects related to structural materials and components for heavy liquid metal cooled fast reactor technology demonstrators considered in Europe, MYRRHA (with LBE coolant) and ALFRED (with lead coolant), and is embedded in the GEMMA Euratom Horizon 2020 collaborative project.

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Session Classification: 4.2 Structural, Novel, and Large Components Materials

Track Classification: Track 4. Fast Reactor Materials (Coolants, Structures) and Components