

ABSTRACT

Spent fuel subassemblies from the Fast Breeder Test Reactor (FBTR) are to be stored in leak tight containers until they are required to be sent for reprocessing. Use of advanced fuels like uranium carbides and plutonium carbides, which are known to be highly chemically active with oxygen and moisture demands adequate leak tightness during long term storage to avoid undesirable chemical reactions. Use of low melting alloys which act as liquid/solid sealants in the storage containers in which fuel subassemblies are to be kept are being considered for this purpose. Lead-lithium (0.7 wt % lithium) eutectic alloy was chosen as one of the candidate alloys for the purpose on the basis of theoretical assessments. The candidate sealing alloy should have good compatibility with the structural materials of fuel subassemblies as well as the fuel and fission products. AISI type 316 stainless steel in solution annealed, ten and twenty percent cold worked condition is the clad and wrapper material used for the fabrication of fuel pins and subassemblies. Compatibility studies between eutectic Pb-Li alloy and AISI type 316 stainless steel material in the above conditions were undertaken at different temperatures and time durations.

The Pb-Li eutectic alloy was prepared using pure lead and lithium as raw materials. Since lithium is chemically active, the preparation of the alloy was carried out in a stainless steel glove box under argon atmosphere. The prepared alloy was used for the experiment after chemical analysis and microstructural characterisation with respect to composition and segregation

respectively. Tensile specimens of AISI type 316 stainless steel were obtained in three conditions namely solution annealed, 10 % cold worked and 20% cold worked. The tensile specimens were encapsulated in stainless steel capsules filled with Pb-Li eutectic alloy. The capsules were further sealed in a quartz tube under vacuum (10^{-4} torr) for the subsequent thermal ageing treatment. The thermal ageing treatments were carried out at 623, 773 and 873 K for 500, 1000, 3000, 5000 and 7000 hours. After the ageing treatments, the specimens were cleaned and then tensile tested using a 10 tonne capacity Instron machine.

The results of the tensile testing show that the variations in strength over the temperature range of 623 K to 873 K are well under 6 ~ 8 % for annealed and 10 % cold worked material while the variation with regard to total elongation is about 16 ~ 18 % for the same conditions. A slightly larger fall with regard to yield strength is seen for 20 % cold worked material where the drop is of the order of about 16 ~ 18 %. The variation in % total elongation and ultimate tensile strength is of the same order as in the earlier two cases.

Optical metallography studies revealed that there is a tendency for a reaction layer to form in the regions where the stainless steel comes in contact with the Pb-Li molten alloy. This is however thin at 623 K (~ 8 μm), somewhat thicker at 773 K (~ 16 μm to ~ 30 μm) and reaches a value of about 50 μm at 873 K for 7000 hours holding time. The grains abutting the reaction layer have coarsened very appreciably at 873 K, especially for

5000 and 7000 hours ageing time and the width of the grain growth zone is confined to a region of about 200 μm only.

Electron Probe Microanalysis has shown that chromium and nickel tend to get depleted from the border areas of the stainless steel while lead diffuses into the stainless steel matrix along the grain boundaries. However, such depletion of nickel and chromium from the matrix and the diffusion of lead into the latter do not seriously deteriorate the tensile properties of the stainless steels.

The tensile properties of AISI type 316 stainless steel are not subject to any serious jeopardisation through contact with this molten Pb-Li eutectic alloy for periods extending even upto 7000 hours at 873 K. Thus use of Pb-Li eutectic alloy would be suitable for the storage of irradiated fuel.