06-052

Scope for Using Ceramic Coatings in the Nuclear Field

Ramanathan, L.V.(1);
(1) IPEN;

A wide range of coatings to protect or enhance specific properties of the substrate are presently available and processes to apply these coatings are well established. Surprisingly, use of coatings in the nuclear field has received very little attention. This presentation will highlight the scope for using ceramic coatings mainly on nuclear fuel claddings and reactor components. All components and structures inside commercial nuclear reactor pressure vessels are exposed to high levels of irradiation at high water/steam pressures and temperatures. Despite caution exercised during material selection, degradation in mechanical properties under irradiation has been the primary cause for accidents or unplanned shutdowns in the nuclear industry. Qualification of a coated material is further complicated as two different materials are involved, besides the interface, and is the main reason for scant use of coatings in the nuclear field. Nevertheless, the following instances exemplify the use of ceramic coatings: (a) Prevention of accelerated corrosion of zircaloy at high temperature (accident situation) is extremely important to avoid generation of H2 (cause of the explosions in the 3 reactors of the Fukushima Nuclear Plant in Japan). Had the zircaloy cladding been coated with alumina, the explosions could have been averted by delaying H diffusion through the alumina layer and gaining time to take other preventative measures. (b) At normal reactor operating temperatures, ZrH2 forms in the cladding causing blisters, cracking and embrittlement. This can be mitigated by using PVD-ZrO2 coatings with low hydrogen permeability. (c) Fuel rods swell during irradiation due to build-up of fission products, severely compromising reliability of the cladding. One option to prevent fuel-cladding interactions is to coat the inner walls of the cladding with a TiN-based coatings. Besides these instances, other applications for ceramic coatings will be presented and discussed.