L.1 : Laser cutting of fuel subassembly of FBTR at IGCAR

The Fast Breeder Test Reactor (FBTR) at IGCAR uses mixed plutonium-uranium carbide (70% PuC, 30% UC) as its driver fuel. This fuel has so far achieved 154 GWd/t burn-up without any failure. In order to generate design data for future BHAVINI (Bharatiya Nabhikiya Vidyut Nigam) reactors, Post–Irradiation Examination (PIE) of burnt fuel subassemblies with different composition is carried out after a desired burn-up. For PIE, a fuel subassembly is discharged from the FBTR and its dismantling is carried out in a hot cell. Conventional mechanical methods of FBTR fuel subassembly dismantling have been found to be complicated, with a large time consumption, contamination and secondary waste generation. Further, mechanical methods create stress on surface, with shape deformation, and it becomes extremely difficult to measure swelling, crack, and stress of a burnt subassembly at different locations.

Looking at the advantages and successful experience of laser based cutting technique over mechanical methods in PHWR's in last few years, Solid State Laser Division of RRCAT re-engineered its home-built fiber coupled industrial Nd:YAG laser (250 W average power and 5 kW peak power) for dismantling of highly radioactive fuel subassemblies of FBTR in hot cell at IGCAR, Kalpakkam.

The laser beam was delivered through a 400 μm optical fiber with a focused spot size of 400 μm on the job to minimize waste generation. The laser system has a dual port time shared fiber optic beam delivery, with one fiber port for optimization of cutting process outside hot cell, and another for cutting in hot cell. A compact, shielded cutting nozzle assembly having 20 mm outer diameter, which can be easily inserted through the S-bend in hot cells, and has a provision to pass the cutting gas along with the tube containing fiber to maintain compactness, was specially developed for this purpose. As the fuel subassemblies were hexagonal in shape and sodium (the liquid coolant in the FBTR) was stuck on the inner wall of the fuel with some expected swelling after a huge burn-up, a loaded roller was attached to the nozzle to maintain the focus position. Due to the presence of highly radioactive sodium, cutting parameters were optimized with nitrogen as an assist gas at a pressure of 8 kg/cm^2. Optimized parameters for cutting were : 2 ms pulse duration, 8 J pulse energy, repetition rate of 25 Hz, with speed of cutting ~120 mm/minute.

The laser cutting was successfully exploited for dismantling of an FBTR fuel subassembly in March 2007. It had undergone a burn-up of 154 GWd/t and was containing Pu-U carbide fuel having a radiation level of 10^7 rad/hour. The total cutting time of the subassembly was 2 minutes, with a cut width of 400 μm. This fuel assembly was precisely cut at a gap of 5 mm from the position of the fuel pins.

Although, RRCAT had earlier performed some major operations in PHWR, this is for the first time that laser cutting operation of FBTR fuel assembly, at such a high level of radioactivity, with highly active sodium on the surface, has been carried out. With this work, the laser cutting is now established as a convenient tool for PIE activities of FBTR fuel subassemblies.

Fig.L.1.1: Laser cutting of FBTR fuel subassembly in hot cell

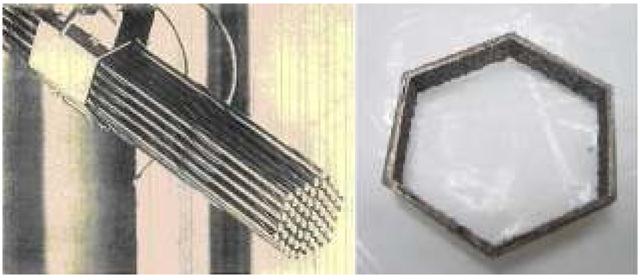

Fig.L.1.2 : a) A fuel pin bundle being extracted from a fuel subassembly; b) A cut sample of the hexagonal fuel subassembly.

Figure L.1.1 shows laser cutting of FBTR fuel subassembly in a hot cell. Fig.L.1.2.a shows a fuel pin bundle being extracted from the fuel subassembly for PIE data. Fig.L.1.2.b shows a cut sample of hexagonal fuel subassembly.

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