Automated Fabrication of Thoria Based Fuel: Challenges and Initiatives

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The processes and techniques for fabrication of uranium-based fuel and plutonium-based fuel are well established. However, fabrication of thorium-based fuel has an additional challenge, due to high gamma radiation. 233U produced from thorium in reactor is contaminated with 232U, whose daughter products are hard gamma emitters. Therefore, 233U fuel can be fabricated only in shielded cells. We have limited experience of remote fuel fabrication in shielded facility. Therefore, a mock up facility is being set-up at BARC to demonstrate fully remotised and fully automated fuel fabrication.

An automation system in a hot cell should have many additional features, compared to one operating outside. It has to be designed for remote maintenance, in addition to design for remote operation. The sub-assemblies have to be designed for remote assembly and remote dis-assembly using available remote handling tools, such as Master Slave Manipulators and in-cell crane. The system has to be compact to accommodate it in the limited space of hot cell. Components in the hot cell, especially electrical and electronic components, should have good radiation tolerance. In addition, the system should be designed to prevent accumulation and spread of contamination.

The reactor core of AHWR consists of 452 fuel clusters of 4300 mm length and 118 mm diameter. The cluster has 54 Mixed Oxide (MOX) fuel pins of (Th-Pu) ad (Th-233U), arranged in three rings around a central rod. Pellets used in these pins will be fabricated by ceramic processes, starting from PuO_2, ThO_2 and $233UO_2$.

Usually, the plants for fabrication and reprocessing of fuel are not located at reactors sites. However, in the case of AHWR, all of the will be co-located. An additional plant will be set-up at the same site for assembly of $(Th\text{-}Pu)O_2$ pins and $(Th\text{-}233U)O_2$ pins, fabricated in two separate plants. It will also be used for dis-assembly of irradiated fuel cluster for separating the two types of pins, which will be reprocessed in separate streams.

The mock-up facility is being developed by Radio Metallurgy Division (RMD); Engineering Design and Development Division (ED&DD); and Division of Remote Handling and Robotics (DRHR) of BARC. In the facility, the automated handling of mixed oxide powder, fuel pellets, fuel pins and fuel cluster will be demonstrated. In addition to various processing, these components are subjected to a many inspections, such as dimension inspection, weight measurement, visual inspection and various NDTs. Mock-up systems for automated fabrication of pellets and pins are already made. Many novel tools and techniques were developed for automated material transfer. Another outcome of the development is the layout of hot cell and equipments, optimising the hot cell space, the number of material transfers and the number of equipments. The layout also provides access for remote maintenance.

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Mr K. Jayarajan, after graduation in Mechanical Engineering, joined 28th batch of BARC Training School and undergone one year training in Nuclear Science and Engineering. In 1985, he joined Division of Remote Handling and Robotics (DRHR) of BARC. Now, he is an Outstanding Scientist and is heading Tele-manipulator Section of the Division.

Shri Jayarajan has done many pioneering works in remote handling technology for Indian nuclear programme. The first sets of servo manipulators installed in Indian hotcells were designed by him. He has also developed of a few Master Slave Manipulators, Mobile Robots, Automation Systems and Special Purpose Remote Handling Tools for nuclear industry. In addition, he has developed a few systems for the defence sector, for handling hazardous materials. Cancer care has been another priority area of Shri Jayarajan. He was involved in development of Bhabhatron, the first indigenous teletherapy machine for cancer treatment. Every day, thousands of cancer patients are being treated from Bhabhatrons installed in various hospitals in the country. He was awarded Homi Bhabha Science and Technology Award for this achievement. His publications have more than 200 citations. Shri Jayarajan is a Fellow of Indian National Academy of Engineering (FNAE).