Nuclear Power from of Thorium – Different Approaches

Srikumar Banerjee and Hari Prakash Gupta

The importance of thorium for sustainability of nuclear power has been recognized way back in 1950s. High abundance in nature, a higher neutron yield per fission over a wide range of neutron energy (in the thermal and epithermal range), single valency of thorium which leads to higher stabilities of it's compounds and much reduced production of long lived radioactive waste in the Th-U^{233} fuel cycle have made thorium a very attractive source material for generation of nuclear energy. The thorium based fuel cycle is associated with the generation of U^{232}. Some of the daughter products of U^{232} have short half-lives and emit strong gamma rays. Therefore, U^{233} related activities such as fuel fabrication and subsequent fuel handling would need shielding and remote access. The first part of the paper will summarize the basic advantages and associated problems with the operation of thorium fuel cycle. Thorium being a fertile material, it's utilization in the power generation program requires judicious adoption of appropriate fuel cycles. Different approaches for thorium utilization in solid fuelled, molten salt and accelerator driven subcritical reactor and their merits and demerits will be discussed. The scientific issues connected with thorium in heavy water and light water reactors have been examined in terms of in-situ burning of U^{233}, saving in uranium, Pu generation, enhancement of burn up, and reprocessing challenges. Based on the analyses it has been argued that for a country such as India where the fissile inventory is not large and the policy of closed fuel cycle is adopted, an early introduction of thorium can only reduce uranium consumption to a limited extent. However, for gaining experience in thorium fuel cycle and for evaluating performance of thorium based fuel experimental irradiation of such fuels of different compositions are in progress. Molten salt reactors are quite promising for Th-U^{233} fuel cycles both from safety and fissile breeding point of view. For countries having an access to a large inventory of fissile materials, introduction of thorium for power generation can be effected at an early stage. The strategy, however, is also dictated by the policy of adoption of the once through or the closed fuel cycle.

Prof. Srikumar Banerjee

Prof. Srikuma Banerjee is Homi Bhabha Chair Professor at Bhabha Atomic Research Centre (BARC), Mumbai; Chancellor, Central University of Kashmir, Srinagar and Chairman, Board of Governors, IIT Kharagpur. He is also Chancellor of Homi Bhabha National Institute, Mumbai. He served as the Chairman, Atomic Energy Commission and Secretary to the Government of India, Department of Atomic Energy during 2009-2012 and as Director, BARC during 2004-2010. He is currently holding Distinguished Visiting Professor positions at Indian Institute of Science, Bangalore and University of Delhi.

His major research contributions are in the areas of phase transformations in zirconium and titanium alloys, effect of radiation on order – disorder transitions and tailoring microstructure and texture of nuclear structural materials through thermo-mechanical processing. He has over 350 research papers, co-authored a book titled Phase Transformation: Examples from titanium and zirconium alloys and co edited six books. As Director, BARC, he organized research in nuclear fuel cycle, design of innovative reactors, applications of radiation and isotope technology in agriculture, health care, and food preservation and industry. He is currently engaged in research in advanced nuclear fuel cycle, policy for sustainable energy and metallurgy of actinides.

His honour include Acta Metallurgica outstanding paper award (1984), Bhatnagar prize in Engineering Sciences (1989), Humboldt Research Award (2003), Indian Nuclear Society award (2003), Padmashri (2005), Distinguished Materials Scientist of the year (2008), National Metallurgist award (2008), Presidential Citation of American Nuclear Society (2012) and W.J. Kroll Medal from ASTM (2012). He is recipient of Doctor of Science (Honoris Causa) from ten universities and institutes. He is a fellow of Indian Academy of Sciences, Indian National Sciences Academy, Indian National Academy of Engineering, National Academy of Sciences, India and The World Academy of Sciences (TWAS).

Dr. H.P. Gupta

Dr H.P. Gupta is Raja Ramanna Fellow at Bhabha Atomic Research Centre (BARC), Mumbai. Dr. Gupta has joined the Theoretical Physics Division of Bhabha Atomic Research Centre after passing out from 13th batch of BARC Training School in 1970. His field of specialization is reactor physics. He has developed many computer codes including 3-dimensional space-time kinetics codes based on improved quasi static method, alternating direction explicit method with frequency transformation, modal method, optimization code based on particle swarm method for PWR in-core fuel management, neutronics coupled with hydrodynamics code for analyzing fast reactor accidents during disassembly phase etc. He has analytically solved the point reactor kinetics and one dimensional space time kinetics equations using perturbation method. Dr. Gupta has worked on design and safety aspects of different nuclear reactors like PHWRs, BWRs, PWRs and Fast reactors. He obtained his PhD degree in the subject of reactor kinetics from Bombay University. He has worked on the reactor physics aspects of 'Direct Use of spent PWR fuel In CANDU' (DUPIC) fuel during his stay in Korea Atomic Energy Research Institute, South Korea on postdoctoral fellowship. He is member of various safety committees of Atomic Energy Regulatory Board.