Philosophy of future ready thorium reactor designs

R.K. Sinha

Thorium fuel cycle has attracted attention from the beginning of the nuclear era and is important for the sustainability of nuclear energy in the world. Many IAEA studies have pointed out limitations of available uranium alone to meet the future demands of energy for the mankind. It is inevitable that Thorium has to play a significant role for sustainability of nuclear energy in future. Besides the abundance of Thorium in nature being 3-4 times that of uranium, the thorium fuel cycle has many attractive features due to better thermal, physical and neutronic properties as well as irradiation behaviour of thorium and ^{233}U. With the expected growth in the nuclear power programme, future nuclear energy systems are required to meet progressively increasing needs for further enhanced safety features and sustainability from environmental considerations, while remaining economically competitive. The wide-spread growth of nuclear energy has to address concerns relevant to proliferation risks also. Future ready reactor designs including those using thorium have to address following major issues and find their technological solutions in order to achieve long term sustainability:

a) Sustainability of nuclear fuel resources
b) Minimisation of the volume of long-lived nuclear waste
c) No unacceptable radiological impact outside the plant boundary with failure of all active systems, and failure of external infrastructure to provide coolant, power and other services, and malevolent acts by an insider, one of the consequences of which is the failure of instrumentation signal initiated shutdown actions, and Inability of plant operators to manage the events and their consequences, for a significantly long time.
d) Capacity to address non-electrical energy needs and allied applications

The fuel cycles based on thorium can address these issues owing to a number of favorable neutronic and material characteristics which makes it a better option.

Due to modest uranium reserves and abundant Thorium resources, Thorium fuel cycle and Thorium based reactors are very important to India. Over a period of time India has developed expertise in all aspects of thorium utilisation starting from mining, metal extraction, fuel fabrication, irradiation in reactors, reprocessing, and recycling the recovered ^{233}U. In-line with the maturing of these technologies, development of innovative and advanced reactors is being pursued. India is developing technologies for thorium based reactors in many configurations, from light water cooled designs to high temperature liquid metal and molten salt cooled options. A research reactor, KAMINI, based on ^{233}U was commissioned at Indira Gandhi Centre for Atomic Research (IGCAR) in Kalpakkam in 1996. This is the only reactor in the world currently operating with ^{233}U based fuel. Advanced Heavy Water Reactor (AHWR) aims at technology development for industrial scale thorium utilisation. Thorium is also planned to be used in the High Temperature Reactors, which hold promise of producing hydrogen as an alternate energy carrier for transport applications, thus ensuring long term energy security. For long-term sustainability, it is envisaged to take full advantage of the unique characteristics of ^{233}U -Thorium fuel cycle, through development and deployment of advanced nuclear energy systems, such as molten salt breeder reactors and accelerator-driven sub-critical systems.

Dr. Ratan Kumar Sinha

Dr. Ratan Kumar Sinha is currently serving as Secretary, Department of Atomic Energy and Chairman, Atomic Energy Commission. He assumed the position in May 2012.

Previously, during his more than four decade of illustrious career in Bhabha Atomic Research Centre, Department of Atomic Energy, Dr. Sinha has held the positions of Head, Reactor Engineering Division, Director, Reactor Design & Development Group and Director, Bhabha Atomic Research Centre.

Dr. Sinha is widely regarded as an expert of international stature in the field of nuclear reactor technology. He is responsible for the design, experimental development and implementation of several innovative and passive features in the next generation Indian reactors, using thorium as a major component of their fuel. His initiatives in these areas are driven by a vision of achieving energy independence through the deployment of advanced nuclear energy systems, which may be located close to population centres in our densely populated country.

Since the inception of IAEA's prestigious International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) activity, Dr. Sinha has been a designated participant in many of its technical as well as policy making committees, including the INPRO Steering Committee. Dr. Sinha was the Chairman of seven INPRO Steering Committee Meetings, held during the period 2005-2009.

Dr. Sinha's contributions have consistently been of a very high calibre. He has enabled development of self-reliance, and achievement of internationally recognised excellence, in several key technology areas, of great importance to the Indian nuclear programme.

He has received several awards and honours. These include the first Homi Bhabha Science and Technology Award (1992), VASVIK Award (2000), Indian Nuclear Society Award (2001), the DAE Special Contributions Award (2006), Indian National Academy of Engineering Prof. S.N. Mitra Memorial Award (2011) and Goyal Prize from Kurukshetra University (2015). He also received the Prime Minister's cash award (1998) for contributions to the 1998 Pokhran Tests. He was elected a Fellow of the Indian National Academy of Engineering (1998), a Member of the International Nuclear Energy Academy (2010) and a Fellow of the Maharashtra Academy of Sciences (2011). Dr. Sinha was conferred the honorary Doctorate of Science (D.Sc.) degree by the University of Mysore (2009) and the Ph.D. (h.c.) of Defence Institute of Advanced Technology, Pune (2013), honorary Doctorate of Sciences (D.Sc.) by Amity University (2014) and was recipient of Distinguished Academician Award from IIT, Patna (2013).