

Optimized Battery-Type Reactor Primary System Design Utilizing Lead

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Abstract – A number of small and medium size reactors are being developed worldwide as well as large electricity generation reactors for co-generation, district heating or desalination. The Seoul National University has started to develop 23 MW_{th} BORIS (Battery Optimized Reactor Integral System) as a multi-purpose reactor. BORIS is an integral-type optimized fast reactor with an ultra long life core. BORIS is being designed to meet the Generation IV nuclear energy system goals of sustainability, safety, reliability and economics. Major features of BORIS include at least 20 years of operation without refueling; elimination of an intermediate heat transport loop and main coolant pump; open core without individual subassemblies; inherent negative reactivity feedback; and inherent load following capability. Its one mission is to provide incremental electricity generation to match the needs of developing nations and especially remote communities without major electrical grid connections. BORIS consists of a reactor module, heat exchanger, coolant module, guard vessel, reactor vessel auxiliary cooling system (RVACS), secondary system, containment and the seismic isolation. BORIS is designed to generate 10 MW_e with the resulting thermal efficiency of 45%. BORIS uses lead as the primary system coolant because of the inherent safety of the material. BORIS is coupled with a supercritical carbon dioxide Brayton cycle as the secondary system to gain a high cycle efficiency in the range of 45%. The reference core consists of 757 fuel rods without assembly with an active core height of 0.8 m. The BORIS core consists of single enrichment zone composed of a Pu-MA(minor actinides)-U-N fuel and a ferritic-martensitic stainless steel cladding. This study is intended to set up appropriate reactor vessel geometry by performing thermal hydraulic analysis on RVACS using a computational fluid dynamics (CFD) code; to examine the liquid metal coolant behavior along the subchannels; to find out whether the given flux profiles and geometrical arrangement of fuel rods yield reasonable flow distribution during nominal operation using a subchannel analysis code; and to determine the natural circulation capability of the BORIS primary coolant system by calculating the total pressure drop in the system.