NAVAL APPLICATION OF BATTERY OPTIMIZED REACTOR INTEGRAL SYSTEM

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ABSTRACT

Past civilian N.S. Savanna (80 MW_{th}), Otto-Hahn (38 MW_{th}) and Mutsu (36 MW_{th}) experienced stable operations under various sea conditions to prove that the reactors were stable and suitable for ship power source. Russian nuclear icebreakers such as Lenin (90 $MW_{th} \times 2$), Arukuchika (150 $MW_{th} \times 2$) showed stable operations under severe conditions during navigation on the Arctic Sea. These reactor systems, however, should be made even more efficient, compact, safe and long-life, because adding support from the land may not be available on the sea. In order to meet these requirements, a compact, simple, safe and innovative integral system named Naval Application Vessel Integral System (NAVIS) is being designed with such novel concepts as a primary liquid metal coolant, a secondary supercritical carbon dioxide (SCO_2) coolant, emergency reactor cooling system, safety containment and so on. NAVIS is powered by Battery Optimized Reactor Integral System (BORIS). An ultra-small, ultra-long-life, versatile-purpose, fast-spectrum reactor named BORIS is being developed for a multi-purpose application such as naval power source, electric power generation in remote areas, seawater desalination, and district heating. NAVIS aims to satisfy special environment on the sea with BORIS using the lead (Pb) coolant in the primary system. NAVIS improves the economical efficiency resorting to the SCO_2 Brayton cycle for the secondary system. BORIS is operated by natural circulation of Pb without needing pumps. The reactor power is autonomously controlled by load-following operation without an active reactivity control system, whereas B_4C based shutdown control rod is equipped for an emergency condition. SCO_2 promises a high power conversion efficiency of the recompression Brayton cycle due to its excellent compressibility reducing the compression work at the bottom of the cycle and to a higher density than helium or steam decreasing the component size. Therefore, the SCO_2 Brayton cycle efficiency as high as 45 % furnishes small sized nuclear reactors with economical benefits on the plant construction and maintenance. BORIS is being designed to generate 23 MW_{th} for at least twenty consecutive years without refueling and to meet the naval nuclear system goals of compactness, safety, reliability and economics. BORIS utilizes proliferation-resistant nitride fuel with a high thermal conductivity and open cartridge type core without individual subassemblies. BORIS consists of a reactor module, heat exchangers, coolant module, guard vessel, ERCS, secondary system, and safety containment.