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POWER OPTIMIZATION IN THE STAR-LM MODULAR, NATURAL CONVECTION REACTOR SYSTEM

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ABSTRACT

The secure, transportable, autonomous reactor (STAR) project addresses the needs of developing countries and independent power producers for small, multi-purpose energy systems, which operate near autonomously for very long term. The STAR-LM variant described here is a liquid metal cooled, fast reactor system. The fast-spectrum converter reactor achieves long term energy sustainability and minimizes the radioactive waste stream. Traditional benefits of liquid metal coolants are preserved (compact system design, low system pressure, and separate coolant and working fluids). Selection of Pb-Bi eutectic coolant realistically enables ultra-long core refueling interval (15 years) for proliferation resistance and high capacity factor, and its compatability with the water/steam working fluid heightens passive safety and realistically enables radical system simplification for economic competitiveness (Spencer, 2000).

Previous development of STAR-LM resulted in a 300 MWt modular, pool-type reactor based on criteria for factory fabrication, full transportability (barge, overland, rail), and fast construction and startup. Steam generator modules are placed directly into the primary heat transport circuit, eliminating the intermediate heat transport loop. Natural convection heat transport at all power levels eliminates the need for main coolant pumps. Seismic isolation eliminates concern about seismic and sloshing-related loads in the pool configuration. Even end-of-spectrum postulated events such as loss-of-heat sink with failure to scram are terminated passively by inherent core power shutdown, and decay heat is passively rejected to the atmospheric air inexhaustable heat sink by guard vessel exterior cooling.

Recent concept development has focused on maximizing the power achievable in a small module size based on preserving key criteria for: i) full spectrum of modes of module transport from factory to site (including rail transport), ii) 100% natural circulation heat transport, iii) ultra-long core cartridge lifetime, and iv) coolant and cladding peak temperatures well within the existing (Russian) database for Pb/Bi coolant and ferritic steel core materials. For example, natural circulation is found to be capable of transporting 400 MWt in a fully transportable module size with 15 year core (at 100% capacity factor; 100,000 MWd/T average burnup, 1.5 peaking factor)

with core outlet temperature of 489 C, peak cladding temperature of 558 C, and steam outlet superheat of 82 C at 10 MPa pressure. Concept development is supported by transient accident analysis, analysis of guard vessel exterior cooling for decay heat rejection, and analysis of steam generator tube rupture.

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