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THERMOHYDRAULIC ANALYSIS OF THE Z-PINCH POWER PLANT PRIMARY CYCLE

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Recent projections of the U.S. Department of Energy (DOE) indicate that the United States will need at least 50 GW of additional electricity-generating capacity in 2020. Many alternatives have been proposed to meet the growing energy demand. Among other factors that play an important role in the selection of the best alternatives for future power generation are: economical competitiveness, safety, waste minimization, nonproliferation, societal impact, and environmental problems related to plant operation and decommissioning. The Z-Pinch power plant (ZP-3) delivers electric energy in the range of commercial nuclear plants but without generating the type and quantities of waste produced by other technologies. The ZP-3 concept is a member of the Inertially-confined Fusion Energy (IFE) research programs. IFE concepts use the energy form discrete capsules containing fusion material ignited by lasers or X-rays and contain the energy release within physical walls, either liquid or solid. The ZP-3 is the first concept to use the results at Sandia National Laboratories' Z accelerator in a power plant application. Assuming high yield fusion pulses of 3 to 20 gigajoules per shot at a rate of 0.1 to 0.3 Hz, a unique shock and energy absorbing system is being considered to contain and utilize the released energy. The absorbed fusion energy is then utilized to drive a power cycle to produce electrical energy. The total electrical power output of the ZP-3 plant considered is 1 GWe. The high temperatures developed in the primary cycle make it suitable to provide a heat source for high efficiency hydrogen generation plants.

In this paper, we investigate the thermohydraulic characteristics of the ZP-3 primary cycle. The generation of electric energy using power cycle is possible only if a minimum operating temperature is achieved and maintained in the primary cycle. Many energy losses are associated with the operation of the primary cycle. These thermal and pressure losses have a direct impact on the development of the Concentrated Thermal Energy Source (CTES) temperature profile. It also affects the component performance and the net electric energy generation. The effect of some important thermal and pressure losses will be evaluated and their impact on the CTES temperature profile will be estimated. The major components of the primary cycle are: the CTES, the main heat exchanger (MHEX), and the piping system. The performance of the primary cycle, as well as, the efficiency of each individual component will be evaluated using the first law approach and exergetic analysis. Lithium is a required component of the liquid wall for breeding the tritium fuel required to sustain the process. In this study, three fluids were selected to serve as heat transport media: Pb-17Li, an eutectic alloy with molecular formula $Pb_{83}Li_{17}$; Flibe, a 2:1 mixture of the salts lithium fluoride (LiF) and beryllium fluoride (BeF_2); and pure lithium metal. All thermohydraulic analyses will be performed for each fluid and the results will be compared. These preliminary results will serve as the basis for future research toward the development of a general thermohydraulic model of the ZP-3.

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