Thermal Analysis of the Z-Pinch Power Plant Concept*

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The Z-Pinch Power Plant (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 1 to 20 gigajoules per shot at a rate of 0.1 Hz, a unique shock and energy absorbing system is being considered to contain and utilize the energy released. This integrated blanket shields the permanent structures from the high-energy neutron flux and the strong shock wave, breeds tritium, and is the working fluid that absorbs the released fusion energy. The absorbed fusion energy is then utilized to drive a power cycle to produce electrical energy. The total electrical power output of the Z-Pinch Power Plant considered is in the range of the power generated by a conventional, 1 GWe power plant..

In this paper, we report on the results of detailed thermal analyses of the ZP-3 power plant. In particular, we evaluate the transient heat up and steady-state temperature fluctuations of the fusion reactor as well as the thermal efficiency of various power generation schemes. For this preliminary study, the power generation schemes considered are variations of the standard Rankine and Brayton cycles. A focus of the study is to determine the impact of various working fluids on the time to reach steady state temperature, the peak operating temperature, the expected range of temperature fluctuations, the required working fluid mass flow rate, as well as the thermal efficiency and temperature differential of the electrical power generation scheme. All working fluids considered contain enough lithium to breed the required tritium fuel and include pure lithium and molten lithium fluoride salts with various amounts of beryllium and sodium.

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