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THE ANALYSIS OF ADVANCED FAST SPECTRUM HEAT SOURCES FOR SPACE APPLICATION

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ON THE ANALYSIS OF ADVANCED FAST SPECTRUM HEAT SOURCES FOR SPACE APPLICATION*

by

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Two alkali metal cooled reactor families of types previously described by LRL^(1,2,3) have been investigated to determine their minimum practical size in the near MW_{th} range. Both types employ uranium-mononitride fuel, tungsten alloy cladding and structure, and a tungsten clad tantalum alloy vessel. A convectively-cooled type employs lithium as primary coolant, and the other is cooled by sodium heatpipes. Both operate at $1500^{\circ}K$, employ dual and redundant reactivity controls⁽⁴⁾ (molybdenum side reflector-liquid 6Li control elements) and are required to be water immersion and intrusion safe at all points in life, through launch and re-entry. Figure 1 shows the outer radii of these families including blow-off side reflectors of sufficient thickness to achieve this safety condition. This parameter is much more significant than reactor mass (150-300 Kg) for space applications due to its influence on the shield mass required for significant attenuation. In the carpet plots of Figure 1, the independent variables are core aspect ratio (L/D) and power (MW_{th}) for the heatpipe cooled reactors, and L/D and the fuel spacing parameter (β) for the convectively-cooled reactors. (Optimized heatpipe performance defines fuel element size and spacing as a function of power.)

In order to provide a comparison of maximum interest, the convectively-cooled family is uniformly fueled with ^{233}U . Since the axially-oriented

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heatpipes act as independent circuits, uniform radial power is an additional constraint for the second family. This is achieved (usually $\pm 5\%$) by a three zone loading employing ^{233}U in the two outer zones with appropriate or alloy additions in the inner zone.

Hawley⁽⁵⁾ and DeHerman⁽⁶⁾ have shown that Gd_2O_3 dispersions are sufficient for water safety for thermal reactors and Hampel et al⁽⁷⁾ have shown Eu_2O_3 can accomplish this for reactors where the median neutron energy causing fission is < 0.3 Mev. However, configuration changes such as blow-off side reflectors appear necessary for those reactors with energies > 0.3 Mev.

The detailed nature of the designs should be emphasized. Temperature dependent properties are used throughout. The incremental nature of fuel element configurations, the polygonal deviations from circular geometry, differential thermal expansion, fuel swelling, burnup, and fissile daughter production through life are accounted for, together with the effect of individual heatpipe failures for that family. The method of optimized design analysis used here has been documented⁽⁸⁾ and functions in a single computer pass to produce (in ~ 10 minutes) a detailed design as well as a complete functional analysis over the reactor lifetime.

Figure 1 verifies earlier predictions^(9,10) that heatpipe cooled reactors are competitive with the convectively-cooled reactors in this size and temperature range. In addition, this study has shown that the codes used can be efficiently applied even in parametric systems studies while involving more realistic detail and constraints than have been previously available.

a) Heatpipe cooled, U-233/U-235 fuelled, radially power flattened

b) Convectively cooled, U-233 fuelled, not radially power flattened

FIGURE 1. Reactor Outside Radii

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