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TRANSPOSITION OF FUEL AND BLANKET ASSEMBLIES IN LMFBR'S

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The objective of this paper is to show how the transposition of selected fuel assemblies in a homogeneous core arrangement with blanket assemblies results in a core with superior plutonium breeding characteristics and potentially improved response to hypothetical accident transients which are not terminated by the plant protection systems. To accomplish this objective, a detailed comparison is made of the physics, breeding and inventory differences of a homogeneous and a heterogeneous core arrangement for reactor power levels of approximately 1000 and 2500 MW(t). This power range was chosen to determine if the heterogeneous core concept is applicable to commercial as well as demonstration size LMFBR plants.

The initial heterogeneous (bull's-eye) study was performed for the 1000 MWt size reactor. The fuel pin diameter was limited to 0.23 inches (FFTF technology). Considerable optimizations were performed which showed that the number of required fuel and control assemblies in the heterogeneous design could be reduced relative to the homogeneous concept. This study has demonstrated the feasibility of taking a homogeneous core arrangement and replacing it with a heterogeneous core without increasing the inside diameter of the reactor vessel. The resultant optimum heterogeneous core arrangement resulted in a breeding ratio which was higher by 0.1 relative to the homogeneous concept with a resultant reduction in compound system doubling time from 62 to 32 years.

Figure 1 shows the relative merit of the plutonium breeding of this heterogeneous design by showing a comparison of required net fissile plutonium required from a given stockpile versus the year of operation of the plant. For the homogeneous core, the initial plutonium investment starts out at approximately 1250 Kg, peaks at 1400 Kg in the 4th and 5th years and decreases to 875 Kg at the end of 30 years. Its net fissile gain over the 30 years of operation is 675 Kg (1550-875) after the reactor is decommissioned and its plutonium is returned to the stockpile. For the heterogeneous design, the initial peak fissile investment is slightly higher, 1600 Kg, but due to its better breeding performance, the investment at the end of 30 years is only 350 Kg. This results in a net fissile gain of 1465 Kg (1815-350), over twice that of the homogeneous concept.

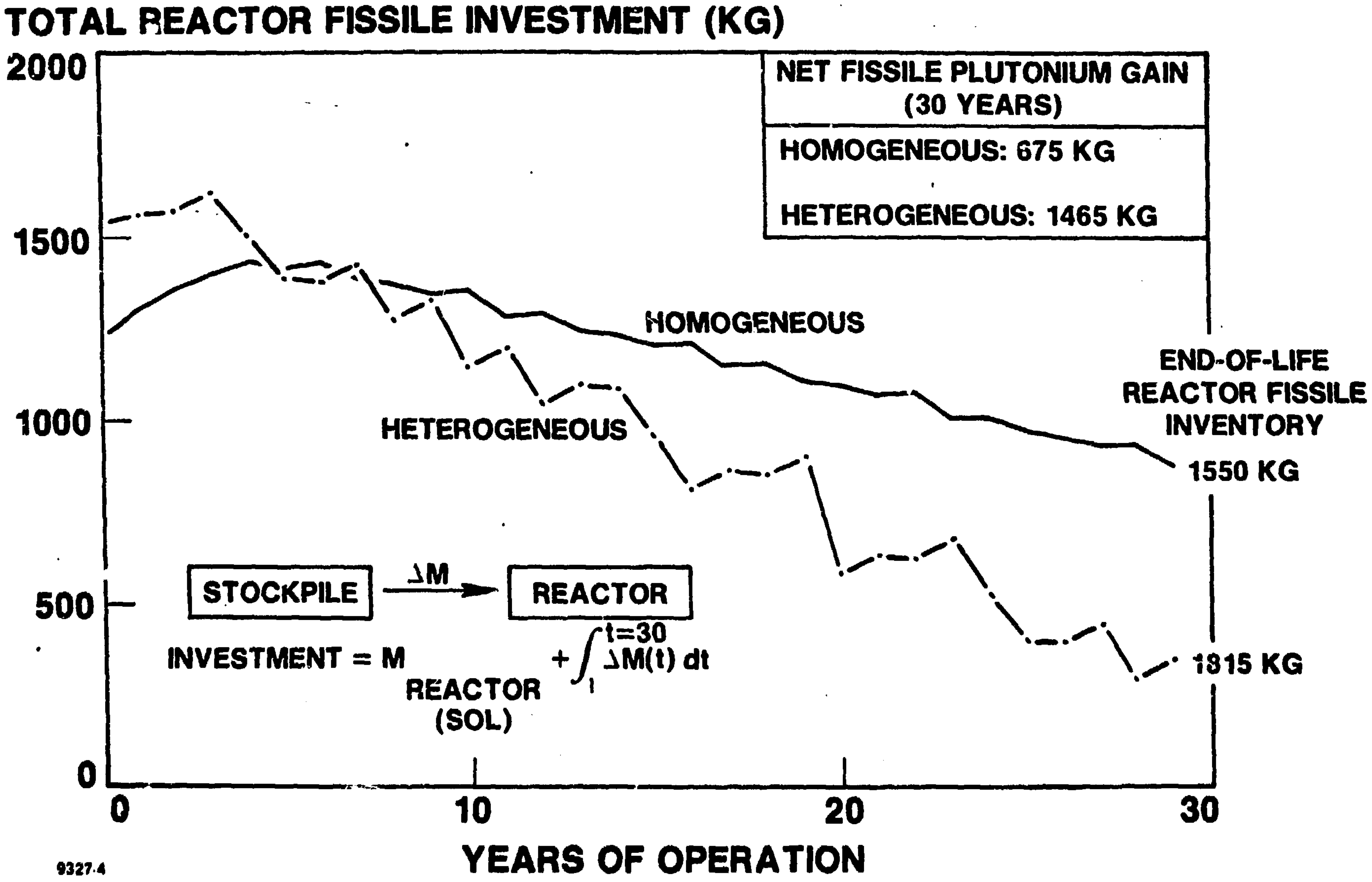
In addition to its superior breeding performance, the heterogeneous concept has a reduced fuel sodium void reactivity worth and the added feature of incoherence between the fuel and blankets. The maximum positive fuel assembly voiding reactivity is only $2.66 in the heterogeneous design relative to $3.90 for the homogeneous design. This results in a considerable reduction in the initiating reactivity available for an HCDA. Because the blankets have a relatively long time constant for sodium voiding during an HCDA, the hypothetical accident is terminated prior to significant addition of the sodium void worth of the blankets, while the Doppler feedback available from the blankets tends to reduce the peak reactivity insertion.

In the 2500 MW(t) power range, detailed physics calculations have shown that the reduction in doubling time due to the heterogeneous design is at most only 3 years. These studies were performed with a fuel pin diameter of 0.31 inches. The major merit of the heterogeneous system in the larger reactor is in the reduction in the fuel maximum sodium void worth from the homogeneous value of approximately $7 to $3. As in the smaller demonstration plant, the fuel/blanket sodium voiding incoherence is maintained. Thus, the HCDA energy of a heterogeneous design should be minimal as compared to the homogeneous concept. A second advantage of the heterogeneous system is that, although doubling time is not improved significantly, the breeding ratio is much higher. For certain assumptions of an LMFBR/LWR buildup scenario, breeding ratio is more significant than doubling time (for first generation plants, for example, if inventory is available, the doubling time is fictitiously long if the Pu is to be used in a low inventory second generation plant).

In summary, an optimum radially heterogeneous concept reduces the sodium void worth and increases incoherency which reduces the already low probability of an energetic HCDA in both the demonstration and commercial size reactors. In demonstration size plants, there is a significant reduction in compound system doubling time (approximately 30 years), whereas in the large size plants the benefit is smaller (approximately 3 years).

FIGURE 1

NET FISSILE PLUTONIUM INVESTMENT FROM STOCKPILE (FFTF—TYPE FUEL ASSEMBLY)



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