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PIN DIAMETER OPTIMIZATION IN 1200 MWe HETEROGENEOUS VS. HOMOGENEOUS LMFBRs

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LMFBRs with internal blankets (heterogeneous reactors) are known for reducing the sodium void reactivity and increasing the breeding ratio. As for homogeneous reactors, the optimization of the fuel pin diameter for heterogeneous reactors is of great interest. It was found that for strongly coupled heterogeneous cores, the performance of the heterogeneous reactor is nearly the same as that for the homogenized heterogeneous reactor[1]. The optimum pin diameter is thus obtained by changing the fuel pin diameter until the homogenized fuel volume fraction is the same as the optimum fuel volume fraction of the homogeneous core. This paper addresses the optimization of the fuel pin diameter with respect to doubling time for a loosely coupled 1200 MWe oxide heterogeneous reactor. The results will be compared with those of a homogeneous reactor.

In this study the heterogeneous core was chosen to give a low sodium void reactivity. The resultant loosely coupled radial-parfait heterogeneous reactor layout contained 432 core, 217 internal blanket, 198 radial blanket assemblies and 30 control positions. It was characterized by three internal blanket regions, one of which is at the core center. The related homogeneous reactors contained 402 core assemblies (two enrichment zones), 252 radial blanket assemblies, and 19 control positions.

The breeding ratios for the heterogeneous core are substantially better than those of the homogeneous core. These varied from 1.313 for a 0.260 in. pin to 1.420 for a 0.320 in. pin for the heterogeneous reactors, while for the heterogeneous reactors, while for the homogeneous reactors the breeding ratio varied respectively from 1.216 to 1.353. In Fig. 1 the compound system doubling times are given as a function of pin diameter for the two reactor core concepts. For pin diameters above 0.280 in. the doubling time of the heterogeneous core is higher than that of the homogeneous reactors by 2 to 4 years. This effect may be attributed to the relatively higher fissile inventories of the heterogeneous reactor due to the internal blankets. These ranged from 6228.2 kg for the 0.260 in. pin to 8154.4 kg for the 0.320 in. pin while for the homogeneous reactors they were respectively 4029.8 kg to 5281.9 kg. We note, however, that the rate of increase in the doubling time with respect to decreasing pin diameter is less for the heterogeneous reactors than that for the homogeneous reactors. This appears to be characteristic of a weakly coupled system. As the pin diameter of the heterogeneous core is decreased, more reactors are utilized in the blankets due to the increased leakage into the blankets. This in effect increases the coupling between the core regions. The concept of a homogenized fuel volume fraction becomes more applicable and and implies lower doubling times for the heterogeneous reactor. We also note that the optimum pin diameter of 0.300 in. of the heterogeneous reactors is smaller than the 0.330 in. of the homogeneous reactors(2). This is a consequence of the additional heavy metal contribution of the internal blankets. Internal blankets in the core tend to decouple the system into small reactors, thus increasing the leakage component and reducing the spectral component. Thus, the heterogeneous reactor configuration exhibits an improved safety characteristic through the reduction of the sodium void reactivity. The sodium void reactivity (core voided) in Δk ranged in the homogeneous reactor from 0.0282 for the 0.260 in. pin to 0.0235 for the 0.320 in. pin, and from 0.0084 to 0.0080 respectively for the heterogeneous reactors.

We can thus conclude that in choosing between the loosely coupled heterogeneous and homogeneous concepts the choice of pin diameter is important with respect to breeding performance while with respect to sodium void reactivity the heterogeneous concept is superior for all pin diameters in this study.

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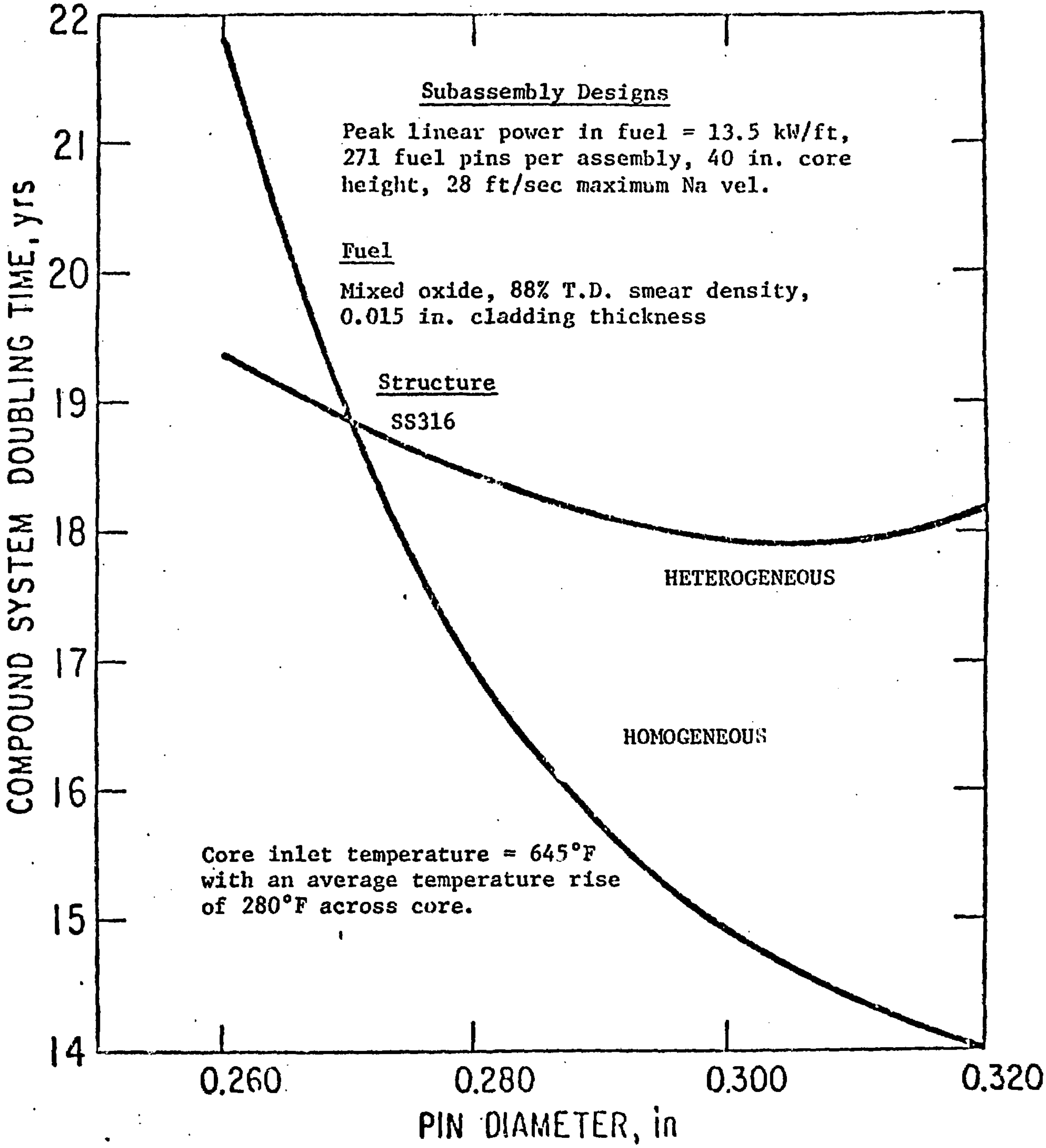

Fig. 1. Compound System Doubling Time vs. Pin Diameter for Heterogeneous and Homogeneous Reactor Concepts. One Year External Cycle Time, 1% Loss.