PREFACE

ON HIGH CONVERSION RATIO LIGHT WATER REACTORS

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Received March 24, 1987
Accepted for Publication August 5, 1987

When I first published a paper on high conversion ratio plutonium recycle in pressurized water reactors (PWRs) in 1975 (Ref. 1), the idea was simply to squeeze out as much as possible of the water in a standard lattice without destroying the cooling. My tools at that time were very limited, but they did indicate that we could get conversion ratios of about 0.9 and still maintain sufficient water for cooling. This was followed by a paper given at the annual meeting of the American Nuclear Society and the European Nuclear Society in Washington, D.C., during November 1976, at which Dr. H. Märkl of Kraftwerk Union (KWU) was present.[2] We discussed the paper and he indicated that the idea may be looked at by engineers from his firm. As you will note, almost all of the papers on tight lattices following this Preface have been done in the Federal Republic of Germany, other European countries, and Japan. In the United States, the Electric Power Research Institute (EPRI) provided about $180 000 during 1978 to 1980 to study the tight-lattice concept.[3] Since then there has been no support for further studies in the United States.

The reason for improving fuel utilization is obvious. Even in the United States we have only 2 000 000 to 2 500 000 t of natural uranium ores. The matches, ^{235}U, are rather limited and they should not be wasted regardless of the current price of uranium

Our current designs for light water reactors (LWRs) without reprocessing (as is the case in the United States today) give us a fuel utilization of ~ 0.6%. With the use of plutonium recycle it is improved to ~1%. By the redesign of new cores for PWRs, I believe that conversion ratios of 0.90 can be achieved and the corresponding fuel utilization with plutonium recycle can be increased to 4%. Thus, we can improve our fuel utilization by a factor of ~7.

The latest design concept I have seen is that of Cornelis H. M. Broeders and Mario Dalle Donne from the Karlsruhe Nuclear Research Center.[4] Their homogeneous concept appears to be a beautiful design that can be fitted into the 1300-MW(electric) reactor designed by KWU. The water fraction is somewhat larger than in their previous studies to make the water loss reactivity coefficients sufficiently negative to avoid problems with an anticipated transient without scram. The water-to-fuel volume ratio is 0.701. The spiral rib design using stainless steel tubes has many advantages over Zircaloy tubes. One of them is that the critical heat flux is considerably enhanced by the use of integral spiral ribs.

Most of the work in Ref. 3 was done to analyze the loss-of-coolant accident (LOCA) for PWRs using the Babcock & Wilcox Company codes that had been approved by the U.S. Nuclear Regulatory Commission. The core was a replacement core for the Oconee reactors [2568 MW(thermal)] operated by Duke Power Company. Calculations of the blowdown phase for a double-ended break of the cold leg of the pump discharge piping indicated that the end of blowdown would occur slightly later due to the higher pressure drop in the tight-lattice core. Furthermore, our analysis indicated slightly higher core reflooding rates due primarily to the lower average linear heat rate. In fact, the tight-lattice core was completely covered again after 120 s. The calculated cladding temperatures were also somewhat less than for the original operating core. Thus, it appears that there should be no problem with respect to LOCA.

The loss of water reactivity or void coefficients that were calculated in Ref. 3 were done only for 10% total plutonium in the oxide. At 12%, the void coefficient is now calculated to be positive. The Japan Atomic Energy Research Institute has initiated a benchmark calculation that was to be completed by April 1, 1987. This may lead to better results on the void coefficient as well as eigenvalues.

What should we do in the future? I feel that we should do the following:

1. Reflooding experiments: the data used in Ref. 3 are based on the FLECHT experimental data of F. F. Cadek et al., obtained in 1971 (Ref. 5). These should be redone for tight-lattice cores in which the pitch-to-diameter ratio for a hexagonal lattice is varied from 1.10 to 1.30 using a rod diameter as small as 0.75 to 1.00 cm With these results the calculations done in Ref. 3 should give quite accurate results for LOCA.
2. critical heat flux experiments for tight-lattice fuel assemblies
3. neutron physics critical experiments using various mixtures of plutonium and depleted uranium for pitch-to-diameter ratios of 1.10 to 1.30.

The 25 papers (13 in this special issue and 12 in February *Nuclear Technology*) following this brief Preface will go into detail about many advances in water reactor technology. In particular, we should eliminate as much as possible the need for human intervention in the case of an accident, i.e., new plants should depend on "passive safety systems." There are many ways to obtain passive safety systems and I will not attempt to list them. One of the ways is given in the July/August 1986 issue of the *EPRI Journal*.[6]

In any event, I believe that any new designs for LWRs should be able to take advantage of the improved fuel utilization that can be obtained simply by a reduction in the water volume fraction.

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