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# PHYSICS AND FEASIBILITY STUDY OF THE FAST-MIXED SPECTRUM REACTOR CONCEPT*

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Reactor physics and fuel cycle studies, coordinated with heat transfer and material science and structural analysis work has indicated the feasibility potential of the coupled Fast-Mixed Spectrum Reactor (FMSR) concept. This concept employs what are considered reasonable extrapolations of present fast breeder reactor technology to achieve a once-through-and-store reactor fuel cycle. Since the fuel cycle for this reactor is intended to use only natural or depleted uranium for its equilibrium feed, the resultant reactor would have excellent anti-proliferation characteristics. It would also extend utilization of natural uranium resources by a factor of about 15 relative to LWR reactors when on its equilibrium fuel cycle; startup requirements would of course reduce this factor.

The design objectives are achieved by design for a high breeding ratio through such features as reduced neutron leakage and use of metal fuel. A moderator region is employed to flatten the radial power distribution. It also significantly increases the local Doppler coefficient and provides a safety advantage in the area of severe hypothetical disassembly accidents to the extent that this region performs the same safety function as the thermal region in the coupled fast-thermal reactor concept of R. Avery.[1]

One fuel management procedure for the helium- or sodium-cooled FMSR reactor employs two fuel zones radially outside of a fast core enclosed by a moderator such as beryllium or graphite. A subassembly unit would contain either fuel (to be shuffled) or moderator. Typical fuel management schemes use five to six different shuffle positions throughout the fuel residence in the reactor. Early residences are in the outer regions of the reactor, during which time the fuel subassemblies slowly accumulate fissile material. In this fuel management strategy, the fuel is discharged from the fast core region. Table I represents

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[1] R. Avery, Coupled Fast-Thermal Power Breeder, Nuc. Sci. & Eng., 3, pp. 129-44 (1958).

the results of one such study for the helium-cooled FMSR. Even though the fuel burnup requirements are not too far beyond those achieved in EBR-II irradiations with metallic fuel of the Mark-II design, the calculated fluence damage is very large. However, steels presently under irradiation in the United States, coupled to a suitable vented metal fuel design, may be able to survive such irradiations with only limited dilation. Further extensive irradiations are necessary to verify this. The corresponding duct dilation problem may be greatly mitigated or resolved by one of several designs under consideration.

Results of studies of FMSR design options, including sodium-cooled FMSRs will be provided, along with supporting heat transfer and material evaluation results. Some safety implications and advantages inherent in the FMSR design will also be presented.

TABLE I

Summary of the Fuel Cycle Studies
Helium-Cooled FMSR

| | | |
|---|---|---|
| Number of Fuel Subassemblies | | 408 |
| Number of Fuel Subassemblies Shuffled per Cycle | | 12 |
| Cycle Duration (Full Power Day) | | 185 |
| Reactivity Swing Over the Cycle, ΔK (Positive) | | 0.021 |
| Breeding Ratio | | 1.65 |
| Inventory (Tonnes) | Pu | Heavy Metal |
| Core BOC | 5.38 | 126.05 |
| Discharge/Yr* (80% Load Factor) | 0.62 | 8.3 |
| Average Enrichment (%) | 7.4 | |
| Burnup (MWD/T) | | |
| Average | 133,000 | |
| Peak | 162,000 | |
| Peak Fluence (E > 0.1 MeV) | $8.5 \times 10^{23}$ | |

Zonal Conversion Ratios:

| | |
|---|---|
| Zone 1 | 5.68 |
| Zone 2 | 3.15 |
| Zone 3 | 2.27 |
| Zone 4 | 1.50 |
| Zone 5 | 1.19 |
| Zone 6 | 1.08 |