The Wisconsin Tokamak Reactor Design - An Overview

G.A. Emmert, R.W. Conn, and G.L. Kulcinski

August 1973

UWFDM-69

FUSION TECHNOLOGY INSTITUTE

UNIVERSITY OF WISCONSIN

MADISON WISCONSIN

The Wisconsin Tokamak Reactor Design - An Overview

G.A. Emmert, R.W. Conn, and G.L. Kulcinski

Fusion Technology Institute
University of Wisconsin
1500 Engineering Drive
Madison, WI 53706

http://fti.neep.wisc.edu

August 1973

UWFDM-69

The Wisconsin Tokamak Reactor Design

- An Overview -*

by

G. A. Emmert
R. W. Conn
G. L. Kulcinski

August 1973

FDM 69

University of Wisconsin

These FDM's are preliminary and informal and as such may contain errors not yet eliminated. They are for private circulation only and are not to be further transmitted without consent of the authors and major professor.

*Research supported by the AEC and the Wisconsin Electric Utilities Research Foundation.

The Wisconsin Tokamak Reactor Design

- An Overview -*

The Wisconsin Fusion Design Team

reported by

G. A. Emmert, R. W. Conn, G. L. Kulcinski

Nuclear Engineering Dept.

University of Wisconsin

Madison, Wisconsin

SUMMARY

The University of Wisconsin Fusion Design Team has carried out a conceptual design of a 5000MW_{Th} Tokamak power reactor. This reactor is visualized as a near term power reactor using existing technology to the maximum extent possible. Where necessary, the best extrapolation beyond existing technology is used. Our design is perhaps more conservative than other designs and consequently has a number of different features. The system parameters, the design philosophy, and the tradeoffs between various engineering concerns will be reported. The major points are summarized below.

The aspect ratio has been determined by minimizing the cost of the toroidal magnets consistent with the required core space in the center of the torus. The basic dimensions and toroidal magnetic field are set by the power level, neutron wall loading, poloidal beta, ion temperature, and stability factor. Neutral beam heating has been studied using a 1-D transport code. It is found that, using a low density ($n \sim 3 \times 10^{13} cm^{-3}$) startup, 500 Kev beams injected tangent to the magnetic axis have good penetration and can achieve ignition in ~ 2 seconds with 75 MW of power. A poloidal divertor using superconducting coils outside the toroidal "D" magnets has been incorporated. This divertor is of the double null point type and produces a slightly vertically elongated plasma.

The blanket structural material is stainless steel and the coolant is lithium; compatibility problems limit the wall temperature to 500^{o}C. The pumping power of the lithium is less than 2% of the reactor output. Detailed neutronics calculations have been performed for the blanket and shield. The Mack program has been used to produce neutron and gamma kerma factors required to generate detailed heating rates. We have found that the net energy released per fusion event, including the alpha energy, is about 20 Mev. This is considerably less than has generally been supposed. A variational method has been developed and used to study changes in the amount of blanket structural material. It has been found that the breeding ratio drops from 1.44 to 1.17 as the structural material in the tritium breeding zones increases from 5% to 20% of the blanket. It has also been found that, in the superconducting magnets, the principal radiation damage is in the stabilizer. This can be alleviated by proper design. Consequently, the heat load to the magnets is the main criteria in the design of the shield.

Because of embrittlement and swelling problems induced in 316 S.S. by fusion neutrons, we have limited the first wall life to ~ 2 MW-yr/m^2. For our reactor, this means the first wall must be replaced every 2 years. A modest corrosion rate of .6 mil/year indicates that 2500 kg/yr of radioactive corrosion products will be released into the lithium cooling system. Studies of the induced activity in the blanket and shield indicate an inventory of ~ 300 curies/kW$_{Th}$ at shutdown after 10 years exposure. The afterheat is 32 MW at shutdown and 8 MW after 1 year.

* Research supported by A. E. C. and the Wisconsin Electric Utilities Research Foundation