CONF-850310--5

NEW DIRECTIONS IN TOKAMAK REACTORS*

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The last major tokamak commercial power reactor design study in the U.S. was STARFIRE[1] which was done in 1979-1980. Since then a number of developments have occurred both in the national magnetic fusion energy program (e.g. new physics and technology developments and emphasis on developing substantially improved fusion concepts) and outside the program (e.g. utility concerns about large capital investments) which suggests that further studies of the tokamak as a power reactor are required. The U.S. DOE/Office of Fusion Energy is carrying out a variety of tokamak reactor scoping studies in FY-1985 to explore a possible basis for one or more in-depth conceptual designs to be undertaken after this fiscal year.

While STARFIRE incorporated a number of ideas from previous reactor studies and developed several new ideas, there remains a number of concerns that warrant attention and thus serve as a guide for new directions for tokamak reactor studies. Several of these new directions are summarized below.

- There is renewed interest in developing designs with reduced power plant output in the range of 500 MW(e). It will be necessary to assess the possible penalty in increased cost of energy and increased unit capital costs which would result from reduced plant output. It would also be useful to evaluate the potential benefits of locating two to four 500 MW(e) reactors at one plant site.

- The tokamak physics community has identified the possibility of achieving β's in the range of 20% and higher by the so-called second stability regime which would probably be obtained by producing bean-shaped plasmas with indentations on the inboard side. Important issues to be addressed include how best to use the higher β (i.e., achieving higher power density or lower magnetic fields) and the design impact of the bean-shaping requirements.

- It is important to identify improved current drivers for steady-state operation. It would be advantageous to develop plasma configurations which require lower plasma current while achieving higher β's. It is also desirable to identify current drive concepts which might operate at higher efficiencies and/or do not have accessibility constraints such as lower hybrid waves. It would be important to fully explore current drive methods that are compatible with configurations suitable for higher β operation. One promising candidate is the high speed magnetosonic wave.

* Work supported by the U.S. Department of Energy.

- Improved blanket designs are necessary which will emphasize design simplification, low activation materials, and good tritium control. A potential approach which has not been thoroughly explored for tokamaks is self-cooled liquid metal blankets using Li (or perhaps LiPb) and vanadium alloys. Key issues to be addressed include MHD pressure drops (the possibility of reduced magnetic fields due to higher β operation and/or the development of insulators for the coolant ducts offer considerable promise). Removal of chemical interaction concerns (via inert atmospheres in reactor buildings and the use of non-water coolants for in-vessel components) and the cost of vanadium are also important issues. The development of corrosion inhibitors is another area to be investigated.

- Improvements in impurity control are necessary and include more desirable divertor configurations which are coupled with very low plasma temperatures at the collector plates and improvements in the pump limiter concept such as the use of "self-pumping techniques"(2) and the use of advanced alloys which might produce self-sustaining low-Z surfaces in place of thick low-Z clads.

- It is also desirable to put increased emphasis on developing module designs that would minimize on-site construction.

References

1. "STARFIRE - A Commercial Fusion Tokamak Power Plant," Argonne National Laboratory, McDonnell Douglas Astronautics Company, General Atomic Company, and The Ralph M. Parsons Company, ANL/FPP-80-1 (September, 1980).

2. J. N. Brooks, et al., "Self-Pumping Impurity Control by In-Situ Metal Deposition," ANL/FPP/TM-174, June 1983.