In this paper, we review the design approach developed in the ORNL Fusion Power Demonstration Study. In carrying out this study, we have emphasized the application of current and near-term technologies as the most logical path to demonstrate commercial feasibility in this century. In addition, we are pursuing simplified, practical concepts to present fusion as a more acceptable energy source for the utility industry.

The following design concepts are a summary of those having greatest impact on reactor feasibility by the application of current or near term technology.

1. Blanket Structural Material

It is our judgement that an alloy similar to type 316 stainless steel will be capable of achieving integral wall loading of 10-20 MW-yr/m². This is accomplished primarily by limiting the first wall temperature to 400°C to minimize radiation effects. Moreover, the unique helium production reactions associated with nickel-bearing alloys in thermal neutron fluxes allow an excellent simulation of fusion reactor neutron radiation effects in existing fission reactors.

2. Blanket Coolant

We are pursuing three alternatives for the primary blanket coolant with the major emphasis on design reliability. Sodium-potassium salts seem to offer the most promise due to their capability to transfer heat at low pressure. Helium and liquid lithium are also being pursued as attractive alternatives.

The ultimate choice will necessarily be based on development and demonstration.

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test programs.

3. Power Conversion System

The recommended power conversion system would consist of a primary and intermediate heat transfer loop coupled to a conventional steam cycle. Assuming a primary loop exit temperature of about 450°C, a steam cycle thermodynamic efficiency of ~35% can be achieved.

4. Pulsed Electrical System

Our studies indicate that the primary energy storage requirements can be satisfied with conventional motor-generator flywheel sets. Advanced energy storage concepts such as homopolar generators and superconducting energy storage devices may offer some cost savings, but do not appear to be necessary for commercial feasibility.

The following design concepts are representative of the approach taken to simplify the overall reactor design and improve its reliability for commercial application.

1. Vacuum Topology

We are proposing that the Tokamak Reactor System be enclosed in a vacuum building. By eliminating the atmospheric pressure on the toroidal plasma vessel, the requirement for leak tightness becomes insignificant since the pressures on both sides are nearly equal. It is our opinion that this approach has significant assembly, disassembly, and repair advantages over the more conventional vacuum first wall approach.

2. Blanket Modular Approach

In order to minimize downtime and facilitate maintenance, the blanket design philosophy has been to seek a modular approach which eases the problems of remote maintenance. Thus, remote maintenance has been identified as a major objective and design consideration in the development of the engineering
design for the blanket configuration. In this context, we are stressing small, easily replaced individual blanket modules.

3. **Size Reduction**

Our plasma engineering studies indicate that the reactor size for ignition is essentially in the range of a moderate sized commercial power plant (500 to 1000 MWe). Assuming that beta values of 5-10% can be obtained, the overall size of the reactor can be quite small in comparison to other recent reactor concepts. This overall size reduction has major implications in enhancing the practicality of tokamak power reactors.

4. **Blanket First Wall Design**

The design approach with respect to the blanket first wall has been to minimize thermal and hydraulic stresses and to operate at a temperature that ductility loss due to radiation damage will not be a serious limitation. It has been shown that the ASME Structural Design Code yields acceptable design stresses.

The tokamak device, by the nature of its configuration and pulsed operation, is an exceptionally complex engineering design problem. We have concluded that innovative design concepts are essential to cope with this basic complexity. We feel that the commercial feasibility of fusion power has been significantly improved by the design approaches described.
References