NEUTRON WALL LOADING OF TOKAMAK REACTORS*

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Neutron wall loading is a key parameter for the selection of fusion power core component materials. It influences the economic, performance, design, safety and environmental impact of the fusion power plant. This paper reports the determination of the range of neutron wall loading for economically competitive fusion power plants based on an analysis that couples the MHD stability physics results to a system design code. The cost of electricity (COE) was calculated for normal and superconducting toroidal field coil tokamaks as a function of aspect ratio (A), neutron wall loading and fusion power output. Results show that normal conducting coil reactor COE optimizes at lower A in the range of 1.4 to 1.6. Superconducting coil reactor COE will decrease with the increase of A. At selected net power output, normal and superconducting coil designs will optimize to similar COEs. Higher neutron wall loading or higher net power output will lead to lower COE. At constant power output, an increase in A will reduce the reactor dimension, resulting in a lower fusion power core cost. However this is offset by the reduction in plasma total $-\beta$ (a ratio of plasma and magnetic pressure), which means a less effective use of the magnetic field. At constant A, a higher magnetic central column current density or an increase in its radius can be used to generate a higher neutron wall loading. But this increase is limited by the maximum preferable total power output of ≤2 GWe. For the normal conducting coil design, there is the additional water/surface material erosion limit of the central column water coolant velocity of <10 m/s. Results show that under these design variations and limitations, the preferable range of neutron wall loading for both normal and superconducting coil designs is 4 to 8 MW/m^2. For a 2 GWe fusion power reactor design, at an average neutron wall loading of around 7 MW/m^2, both normal conducting and superconducting coil designs can have an attractive COE of less than 65 mill/kWh. The results of this work will help to determine the operational requirements of fusion power core components and therefore the selection of suitable materials. Details of the assumptions, calculations and results of this analysis will be presented in this paper.

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