FUSION-PRODUCT TRANSPORT IN AXISYMMETRIC TOKAMAKS: LOSSES AND THERMALIZATION

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High-energy fusion-product losses from an axisymmetric tokamak plasma are studied. Prompt-escape loss fluxes (i.e. prior to slowing down) are calculated including the non-separable dependence of flux as a function of poloidal angle and local angle-of-incidence at the first wall. The flux is strongly peaked at near grazing incidence, suggesting that blistering-injected impurities can reduce reactor burn times by 50-70%. Non-prompt losses (during slowing down, without anomalous effects) are also calculated to be $\lesssim$ 0.1 x (prompt loss) x $\sqrt{Z_{eff}}$ and consequently make a small contribution to impurity production. Sensitivity studies show the plasma-wall separation to be the strongest factor controlling prompt losses. Modest increases ($\leq$ 20%) in wall radius (plasma radius fixed) of a device, such as the ORNL-EPR, are found to reduce blistering-injected impurities to a level which should no longer limit the burn time.

Fusion-product (fp) thermalization and heating are calculated assuming classical slowing down. The present analytical model describes fast ion orbits and their distribution function in realistic, high-β, non-circular tokamak equilibria. First-orbit losses, trapping effects, and slowing-down drifts are also treated. By solving a 3-D (+ time) PDE, it is possible to obtain an invariant of

the slowing down process: μ/E = (magnetic moment)/energy = constant, and explicit expressions for the slowing-down drifts. Large banana-width effects give rise to a net co-going alpha particle current. The large banana-width orbits smear the energy deposition over large regions of the plasma. This causes the flux-surface-averaged ion heating rates to be 10-20% below in-situ rates on axis, but enhances the edge heating $\gtrsim$ 10-fold over in-situ deposition. While this result implies reduced alpha "ash" accumulation on axis, the reduced heating rate makes start-up and maintenance of ignition more difficult.

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