Confinement of Alpha Particles in a Low-Aspect-Ratio Tokamak Reactor

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Studies were made on ripple-induced losses of fusion produced alpha particles in a low-aspect-ratio tokamak reactor ‘VECTOR (Very Compact Tokamak Reactor)’ [1] by using an orbit-following Monte-Carlo code [2]. The distribution of toroidal field (TF) ripple strongly depends on the aspect ratio. In a low-aspect- ratio tokamak, TF ripple shows a sharp decay in the plasma region [3]. Moreover, the area of plasma region where trajectories of energetic alpha particles become stochastic as well as the area of plasma region where alpha particles can be trapped by a local field ripple is reduced as the aspect ratio becomes smaller. Consequently, alpha particles are well confined in VECTOR.

The number of TF coils is one of the key parameters for the design of tokamak-type fusion reactors. The smaller the number of coils is, the easier the design of reactor system becomes. In a tokamak system with a conventional aspect ratio, the reduction of the number of TF coils results in a considerable increase of alpha particle losses. However, the dependence of the ripple loss on the number of TF coils N becomes very weak in a low-aspect-ratio tokamak, if the field ripple at the plasma edge is kept constant. This implies that a marked reduction of the number of TF coils can be made in a low-aspect-ratio tokamak. The allowable number of TF coils is mainly given by the peak heat load on the first wall due to loss particles. Assuming a toroidal peaking factor of 2 for the heat load, about 1.5% and 1.0% of TF ripple at the outer edge of plasma might be allowable for the first wall with and without cooling system, respectively. In both cases, the number of TF-coils can be reduced to about 4.

References

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