Ripple loss of Alpha Particles in a Low-Aspect-Ratio Tokamak Reactor

TANI Keiji, NISHIO Satoshi, TOBITA Kenji,

TSUTSUI Hiroaki¹⁾, MIMATA Hedeyuki¹⁾, TSUJI-IIO Shunji¹⁾, AOKI Takayuki¹⁾ Japan Atomic Energy Research Institute, tanik@fusion.naka.jaeri.go.jp 1) Tokyo Institute of Technology

It has been shown in previous works that the toroidal field ripple shows a very strong decay in the plasma region in a low-aspect-ratio tokamak [1,2]. Moreover, the area of ripple-well region, the size of the ripple-enhanced banana drift and the area of stochastic orbit region are all become smaller, as the aspect ratio is reduced. By these synergetic effects, the ripple loss of alpha particles is strongly reduced as the aspect ratio becomes low (proportional to $A^{4.3}$ for A>3) and consequently, alpha particles are well confined in a low-aspect-ratio tokamak reactor "VECTOR (the Very Compact Tokamak Reactor)" [2,3]. It has also been shown by numerical studies using an orbit-following Monte-Carlo (OFMC) code [4] that thanks to the good confinement of alphas in a low-aspect-ratio system, the number of TF coils can be reduced by keeping the maximum heat load due to loss alpha particles on the first wall under an acceptable level (~ 1 MW/m²). These results, however, have been obtained by using a model field ripple [5]. In order to make an exact estimate of the field ripple, a new code to calculate 3D magnetic field in a realistic TF coil system (Fig.1) has been developed and combined with the OFMC code. Even in a low-aspect-ratio system, if the number of TF coils is reduced, it is necessary to allow some enlargement of the coil size to control the edge field ripple and consequently the ripple loss of alpha particles. Preliminary results are shown in Fig.2. The enlargement factor in Fig.2 is defined as the ratio of the inner bore radius of TF coil to that of original VECTOR. Figure 2 shows that about 30% of enlargement of coil size is necessary to reduce the number of TF coils by half (from 12 to 6) to meet the requirement for allowable heat load by loss particles. Dependences of ripple losses of alpha particles on other parameters important for the design of low-aspect-ratio tokamak reactors will also be presented at the meeting.



Fig.1 Top view of TF coil system of VECTOR



Fig.2 Enlargement factor of TF coil size to meet the requirement for allowable heat load.

References

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