§12. Feasibility Study on Pulse Operation in Tokamak DEMO Reactor by Using System Code

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Discussion beyond ITER is activated in the world, and design of DEMO reactor has been initiated in Japan and Europe. Based on the physical engineering knowledge and the reasonable extension from ITER, the DEMO might be designed and constructed. One of the critical issues is a steady-state operation in the ITER, and high performance plasma should be explored in many existing tokamak devices such as JT-60SA and so on.

Here in order to lighten the burden for the steady-state operation in the DEMO, we have studied the feasibility of the pulsed operation for the DEMO reactor by using our system code.

In this study, we have referred DEMO-CREST design[1], which has several operation points for various plasma performances. Here we have employed the case of the normalized beta value of β_N = 1.9 ,which is roughly same with that of ITER, and following parameters are employed.

Table I. Main Parameters of DEMO-CREST reactor

Plasma major radius	R = 7.25 m
Plasma minor radius	a = 2.13 m
Plasma current	Ip = 15.9 MA
Plasma elongation	κ = 1.85
Safety factor	q = 5
Confinement factor	HH = 0.96
Normalized beta value	β_N = 1.9
Fusion Power	P_{fusion} = 1260 GW
Net electric power	P_{net} = 30 MW

At first we have carried out the thermal analysis of the blanket, and found that the blanket temperature saturates after a few tens minutes. Therefore, the operation period more than one hour might be sufficient for the temperature saturation of the blanket. While, the long pulse is preferable from the viewpoint of the blanket test for the high neutron fluence condition. Here we expected a quite long operation period; i.e., 20 hours or more, and the feasibility for the DEMO reactor size has been studied.

The inductively-driven operation period has been calculated as a function of the normalized beta value for different plasma temperature. In Fig. 1, we can see that the major radius of R ~ 10 m is required so as to achieve a 20-hours inductive operation for the plasma with β_N ~ 2. If the plasma temperature is raised up to 20 keV, the DEMO reactor with a smaller major radius (i.e., less than 10 m) might be acceptable, although the divertor problem might become more severe.

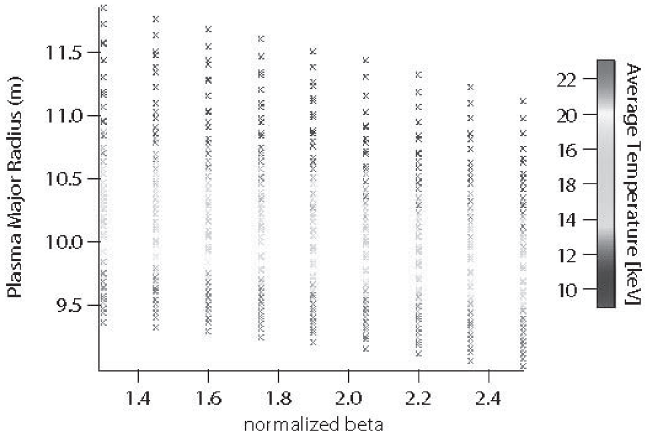

Fig. 1 Plasma major radius as a function of a normalized beta for different plasma temperature, so as to achieve an inductive operation period of 20 hours.

Next we have introduced a non-inductively current drive, so as to prolong the pulse duration. Here we have employed the NBI current drive. Figure 2 shows the major radius to achieve a 20-hours operation as a function of the non-inductive current drive power.

Figure 2 shows that a remarkable decrease of the major radius can be seen as the moderate power is anticipated, and a device with a major radius of R = 8 ~ 8.5 m might become feasible. In addition, Figure 2 also shows that the operation temperature strongly affect on the plasma major radius. For example, in case of 11.35 m reactor, without non-inductive current drive, plasma temperature must be 18 keV or more. Meanwhile, with 120 MW of current drive power, the operation at 14 keV is possible. While we should remark that the introduction of non-inductive current drive requires the development of high energy NBI.

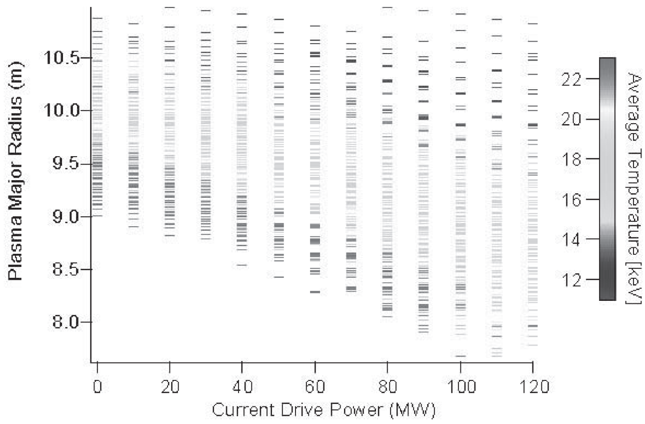

Fig. 2 Plasma major radius as a function of a non-inductive current drive power for different plasma temperature, so as to achieve an inductive operation period of 20 hours.

[1] R. Hiwatari, et al., Nuclear Fusion, **45** (2005) 96.