

Long pulse operation of NBI systems for JT-60U

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In JT-60U, the experiment for plasma discharge duration up to 65 sec has been conducted since last year so as to investigate the behavior of steady state plasma. To study high performance plasma for continuous discharge, it is necessary to extend pulse duration of neutral beam injector (NBI) from 10 sec (the current pulse duration limit); because the NBI system is main heating and current drive system. The four units, which tangentially inject neutral beam to plasma, were modified for long pulse operation. Modification on various electric power supplies, control system and beam limiter equipped with injection port was carried out.

In NBI system, one of the pulse duration limits is the temperature rise of the beam limiter. The limiter prevents damage of the injection port. The limiter is made of molybdenum and is not cooled actively. The temperature rise was observed to be 190 degrees for 7.6sec with 2 MW of NBI power per a unit. A three-dimensional solid model was constructed for a thermal Finite Element Model analysis to evaluate the temperature rise of the limiter. It was found that the maximum temperature of the limiter exceeded 750 degree for 30 sec beam injection. Therefore, a new limiter was designed to suppress the temperature rise. It has a shallow angle against beam and large volume.

On the other hand, another operation limit of NBI is re-ionization in the injection port. There is significant re-ionization of the neutral beam due to collisions with gas molecules, and then the re-ionized power may damage components in the injection port. Therefore the beam pulse duration was gradually expanded under checking the temperature of the limiter and the pressure in the port. Up to now, it was attained successfully that the injection pulse length was extended up to 30 sec with 2MW power at 80keV by one unit. 330MJ of the total integrated injection beam power into JT-60U plasma was achieved, including the negative-ion based NBI operation for 17 sec.