In the experimental campaign of 2006FY, EC and ICRF heating have made steady progress for high power and long pulse operations. The most noteworthy result was the extension of the long pulse operation in the high power region exceeding 1 MW using both ICRF and ECH. In 2005FY we achieved the record of 1.6 GJ for input energy, the highest value in the world magnetic fusion devices, with the average input power of 490 kW (ICRF: 380kW, ECH: 110kW). The main target in the steady state operation in 2006FY was to achieve as long pulse sustainment as possible with the input power of more than 1 MW. It is again clarified that the input energy was not limited by heating system performance but by sudden impurity influx inside the plasma chamber.

At the long pulse operation, impurity influx of metal dusts or flakes from the wall or divertor tiles has been a major factor of plasma. Especially in the higher power operation of more than one mega watt, the impurity influx frequently caused bright sparks. After the bright sparks, a plasma was usually terminated by radiation collapse. In the last year campaign, the long pulse discharge by mega watt power injection was an important task in LHD. Because the high power can sustain high density plasmas and it improves the plasma parameters such as temperature and confinement time. For this purpose, a new technique, booster ECH, was developed. A plasma sustainment with the injection power of 1.0 MW and 8 minutes was successfully achieved. The additional ECH injection was effective to recover the plasma from the radiation collapse due to sudden impurity influx.

Besides the long pulse operation, the high power RF heating was also the main topic of this year. In accordance with the higher magnetic field operation enabled by sub-cooling of the helical coil system, higher power density heating, especially near the magnetic axis became possible. The ECH antenna alignment has been checked with high power inside the vacuum vessel before the experimental campaign. The confirmation of the alignment of the injection beam made the optimization process for attaining the high electron temperature in the higher magnetic field operation.

ECH In 2006FY, one more of existing six 88.9 mm waveguide lines was evacuated to improve the stand-off voltage at the high power transmission. Total number of evacuated lines became four including two 31.75 mm lines. After the reconstruction of the transmission line, the conditioning process was shortened and the allowable injection power was much improved. This newly evacuated line will be used for the transmission of collaboration with University of Tsukuba.

The technology of transmitting the microwave power with high efficiency through the long-distance transmission line is one of the key technologies of future fusion devices. The alignment method of a wave beam based on the moment and the phase information retrieved from infra-red images are developed under US-Japan collaboration with MIT group, and it was demonstrated the beam could be aligned within the tolerance of the required precision. The investigation of the method of mode analysis in the waveguide using this technique is continued.

The method of high power beam measurement in the vacuum vessel is established also using the infra-red images. The beam pattern measurements have been performed with thermal paper or liquid crystal plates outside of the vacuum vessel, since they easily give direct information on the required position. A new method adopts far infrared camera measuring the temperature rise of a Kapton sheet target set inside the vacuum vessel. Kapton sheet has following preferable characteristics for the in vessel beam measurement: adequate absorption for microwave, good emissivity for infra-red region, adequate thermal diffusivity, unflamable and dust free etc. Beam quality, alignment and its controllability are checked inside the vacuum vessel for almost all ECH antenna.

ICRF Long pulse operation was an important item for ICRF team. To achieve the further better results, many improvements were enforced. As for the impedance matching system, the feedback control system to realize the real time matched condition during the long pulse operation was improved using advanced technology. The signals of directional coupler which include reflected power ratio and phase information were used to calculate the impedance matched conditions to control the liquid levels of stub tuners. This system was used for the real long pulse experiment.

The antenna monitor and local divertor plate monitor were improved by installing new infra-red cameras to measure the antenna temperature profile and carbon plates temperatures. The temperature of divertor plates and antenna side protectors were important factor to success the long pulse operation beyond several minutes. In addition, the cooling capacity of transmission line and ceramic feedthrough using circulating nitrogen gas was improved for long pulse operation.

In 2006, the installed antenna number was recovered from 2 pairs of former experimental campaign to 3 pairs to keep the backup set. The antenna protectors were built up against the enhanced NBI heating power.

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