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Development of Dual Frequency Gyrotron and Launcher for the JT-60SA ECH/ECCD System

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The development of a gyrotron and launcher operated at two frequencies, 110 GHz and 138 GHz, has made a significant progress toward electron cyclotron heating (ECH) and current drive (ECCD) in JT-60SA. High-power, long-pulse gyrotrons are required for the JT-60SA ECH/ECCD system which has the total injection power of 7 MW and the pulse duration of 100 s using 9 gyrotrons. The wave frequency in the original specification is 110 GHz, which is effective for off-axis ECH/ECCD to sustain a high-beta plasma at the toroidal field of 1.7 T. On the other hand, the higher frequency waves at 130 ˜ 140 GHz enables ECH/ECCD in the core plasma region at the maximum toroidal field of 2.3 T in JT-60SA. However, a dual frequency gyrotron that can generate the target output power and pulse length (1 MW for 100 s) was not developed since it requires high oscillation efficiency to obtain high power and low diffraction loss to achieve long pulse, simultaneously. In 2011, we stared to develop a new dual frequency gyrotron (110 GHz, 138 GHz) equipped with a triode type electron gun to obtain high oscillation efficiency. High-power, long-pulse operations of the dual frequency gyrotron have been carried out since the last IAEA FEC. Developments of an ECH launcher with high reliability based on a linear-motion antenna concept and a polarizer with optimized groove depth, width, and period for dual frequency operation are also in progress. Main results are as follows: (i) Oscillations of 1 MW for 10 s were successful at both frequencies for the first time in the world as a dual-frequency gyrotron by optimizing electron pitch factor using the triode electron gun; (ii) Low diffraction loss and cavity Ohmic loss enabling 1 MW for 100 s and 1.5 - 2 MW for several seconds were experimentally confirmed, and a 100 MJ oscillation was achieved (0.51 MW, 198 s, 110 GHz), so far; (iii) An oscillation at 82 GHz was also successful as an additional frequency showing the possibility of the use of fundamental harmonic waves; (iv) Launcher optics design toward dual-frequency operations showed little difference in the poloidal beam width for these frequencies; (v) Prototype tests of a wide-band twister polarizer at both low power (< 1 mW) and high power (˜0.25 MW, 3 s) showed promising results.

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Primary author: Dr KOBAYASHI, Takayuki (Japan Atomic Energy Agency)

Co-authors: Dr ISAYAMA, Akihiko (Japan Atomic Energy Agency); Mr HINATA, Jun (Japan Atomic Energy Agency); Dr HOSHINO, Katsumichi (Japan Atomic Energy Agency); Dr SAKAMOTO, Keishi (Japan Atomic Energy Agency); Dr KAJIWARA, Ken (Japan Atomic Energy Agency); Mr WADA, Kenji (Japan Atomic Energy Agency); Mr YOKOKURA, Kenji (Japan Atomic Energy Agency); Dr TAKAHASHI, Koji (Japan Atomic Energy

Agency); Mr SAWAHATA, Masayuki (Japan Atomic Energy Agency); Mr TERAKADO, Masayuki (Japan Atomic Energy Agency); Dr SAIGUSA, Mikio (Ibaraki University); Dr IKEDA, Ryosuke (Japan Atomic Energy Agency); Mr HIRANAI, Shinichi (Japan Atomic Energy Agency); Dr MORIYAMA, Shinichi (Japan Atomic Energy Agency); Dr ODA, Yasuhisa (Japan Atomic Energy Agency); Mr SATO, Yoshikatsu (Japan Atomic Energy Agency)

Presenter: Dr KOBAYASHI, Takayuki (Japan Atomic Energy Agency)

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