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JT-60SAにおけるECRHを用いたプラズマ着火に関する1次元モデル解析
One-Dimensional Analysis of Plasma Start-up using ECRH in JT-60SA

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Plasma start-up assisted by Electron Cyclotron Resonance Heating (ECRH) has been proposed to ensure reliable plasma breakdown in superconducting tokamaks where applicable voltage is low compared with conventional normal conducting tokamaks. ECRH assist has been experimentally investigated at normal conducting tokamaks such as JT-60U and DIII-D. Since the JT-60SA superconducting tokamak (R_0 = 2.96 m, a = 1.18 m, B_T = 2.25 T), which is now under construction in JAEA, has a limitation of the toroidal electric field up to 0.5 Vm^{-1}, we need to clarify conditions for robust plasma initiation. In JT-60SA, an ECRH system (110 GHz and 138 GHz) is planned to be used for plasma start-up. The main purposes of this paper are to clarify the dominant physical process in plasma start-up phase. We have previously studied the plasma start-up assisted by ECRH in JT-60SA using a zero dimensional (0-D) model. The 0-D model consists of electron and ion energy density equations, electron and neutral density equations, and the electric circuit equation. These are solved for spatially uniform plasma. The calculation using JT-60U parameters qualitatively reproduced the time evolution of the experimental results. However, the 0-D model is not enough to investigate the physical process, especially the radial transport.

In order to include radial transport, we are developing a one-dimensional (1-D) model. The 1-D model also consists of the same equation system as the 0-D model and includes the radial transport. In addition, we take the ECRH absorption efficiency into account. Figure 1 shows the radial profiles of electron temperature. The plasma is heated by on axis ECRH of 2 MW from t = 0.010 s. Peak of electron temperature is formed, then electron temperature reaches the steady state value from t = 0.033 s after ECRH injection. Figure 2 shows the threshold power for plasma start-up against the *injected* ECRH power. This calculation shows that the required ECRH power is dependent on the ECRH power absorption profile and that peaked power density profile located on axis is preferable for plasma start-up assisted by ECRH. The required ECRH power is estimated to be much higher than that in 100% absorption case. Inclusion of the effect of multi-path absorption is left for future.

In this paper, we will also discuss the effects of ECRH absorption efficiency, the error field, and the self-inductance.

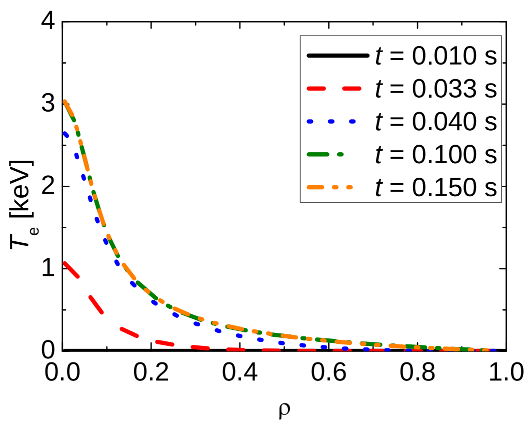

Fig.1 Radial profiles of electron temperature

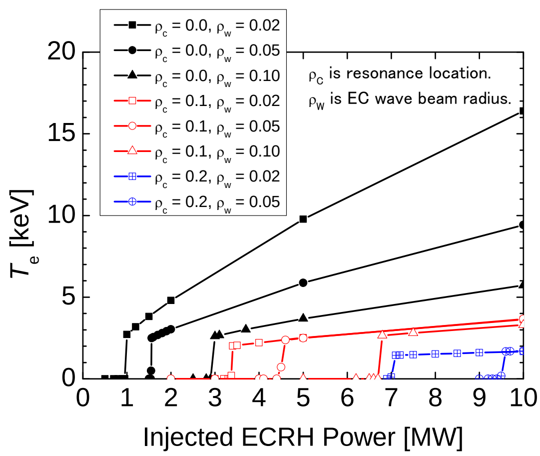

Fig.2 Threshold power for different ECRH power absorption profiles