§50. Experiments of Current Start-up by RF on QUEST

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1. Introduction

Spherical tokamak (ST) is a candidate for cost-effective fusion reactor and the improvement of the plasma performance of ST has been tried in many institutes. It is important to obtain the academic basics to support high beta and steady state operation approaches. The QUEST (Q-shu University Experiment with Steady State Spherical Tokamak) project focuses on the steady state operation of the spherical tokamak (ST) which has the capability to attain high β rather than conventional tokamaks. A final target of the project is the steady state operation of ST with relatively high β under controlled plasma wall interaction (PWI).

The QUEST project will be developed in increment step such as, I. low β steady state operation in limiter configuration, II. low β steady state operation in divertor configuration, III relatively high β steady state operation in closed divertor configuration, where β means the ratio of plasma pressure to magnetic pressure. The specific purpose in phase I is:

To examine the steady state current drive and the generation of closed flux configuration by electron Bernstein wave (EBW) current drive (CD).

The purposes in Phase II are:

To comprehensively establish recycling control based on control of wall temperature, and advanced wall control under high plasma performance.

To improve diverter concepts and to establish the way of controlling particles and heat loads during long duration operation.

To obtain relatively high β (10%) under high elongated plasma shape and additional heating power in short pulse discharge up to 1 s.

2. Plasma start-up experiments by use of RF

The first experiments on QUEST started on Oct., 2008. The purpose of this experimental campaign is to make sure the soundness of the machine and to obtain tokamak plasma. In this experimental campaign, it is impossible to operate the machine in steady state and the pulse duration is limited up to a few seconds because of the limitation of power supply for TF coil. The power supply will be improved in next year and steady state operation will be done.

Plasma start-up experiments with the assistance of ohmic heating (OH) were carried out. RF system of 8.2 GHz in frequency and 200KW in power was used as a heating source in the experiments. Figure 1 shows the time trace of 2D image of visible light in first formation of tokamak configuration measured with high speed camera. The center solenoid with the cancel coil and a pair of PF coil were used to achieve this discharge. Peak of plasma current is about 10kA and plasma shifts outwards at 0.50595s because of poor equilibrium due to weak vertical field. At first plasma was produced by power of RF and a cylindrical plasma around electron cyclotron resonance (ECR) layer can be observed at 0.4545 s. And then the current of center solenoid increases gradually and plasma deformation appears due to the upwelling of return magnetic field from the seam of coils of the center solenoid, which is composed of three independent coils. At 0.486675 s, the plasma was divided into three parts. The center part of plasma forms tokamak configuration afterwards. At 0.4923 s, a bright point appears on the surface of the inner limiter and this bright point expanded as shown the picture at 0.49365 s. Just before the appearance of the bright point, glimmers at the top side of the inner limiter can be observed. At 0.49875s, tokamak configuration was formed tentatively and the plasma shifts outwards because of weak vertical field. These pictures will be useful to understand the formation of closed flux surface.

Plasma start-up experiments without OH assistance have been carried out by use of 8.2GHz and 2.45GHz RF systems. Plasma current up to 1kA could be observed, however the clear formation of closed flux surface was not achieved.

3. Preparation of new antenna for EBWCD

In ST, EBWCD is a promising way to start-up and maintain plasma current. In the case of EBWCD, the polarization and the injection angle to the magnetic field are important to control the conversion efficiency to EBW in the plasma. To realize the purpose, new phased array antenna is designed and is going to be developed.

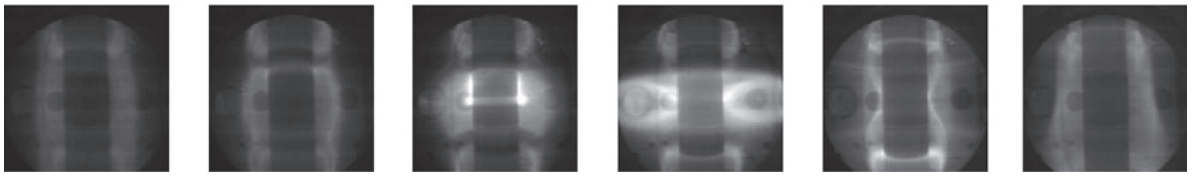

Fig.1 Time traces of 2D image of visible light on the first formation of tokamak plasma measured with high speed camera. The center stack can be seen at the center part of each picture.