§79. Control Experiments on Plasma Merging Fueling Method using the Coaxial Helicity Injection (CHI) in QUEST

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i) Introduction

As the plasma current start-up problems are solved by the iron core and vertical field without central solenoid (CS) in STOR-M [1], the next big problem such fueling is emerged for realizing a D-^{3}He ST reactor. Because fueling such as gas puffing, pellet injection and compact toroid (CT) injection are recognized as the extremely difficult task due to a high-temperature plasma.

Thus, we have proposed the new fueling method using the plasma current merging technique [2].

ii) Merging fueling by the second plasma current

In this proposed scenario as shown in Fig.1, the second smaller plasma current containing the newly fueled particles is repetitively produced above the main plasma current by additional OH transformer. As the plasma current directions of those two plasmas are the same, the second plasma current is pulled down by the main plasma current or the external horizontal coils. Two plasma currents are merged and then fuel particles are transferred to the main plasma. These experiments could be conducted in the UTST [3] or VEST [4].

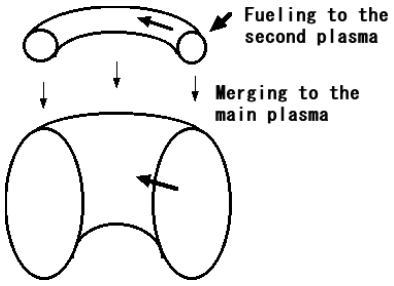

Fig. 1 Concept of the merging fueling method

iii) Merging fueling by coaxial helicity injection (CHI)

On the other hand, the plasma current start-up using the CHI has been planned and being progressing in collaboration with R. Raman in Princeton Plasma Physics Laboratory [5]. High voltage would be applied between two tungsten plates at the bottom and inclined side plates. After demonstration of CHI start-up experiments in QUEST, the same system could be used to study the fueling using the CHI. In this report, we study whether such experiment could be conducted or not in QUEST.

As the magnetic flux surface, calculated by QUEST equilibrium code with the pressure and current profile effects, is quite similar to the one by single loop current approximation, we use this method for this CHI studies.

As CHI injection experiment needs the divertor coil activation, the CHI produced plasma current should be the same direction of the divertor coil current to supply the CHI current. This can be understood by the calculated magnetic surface as shown in Fig.2.

After the main plasma current is produced by CS coil with divertor coil activation, the high voltage is applied at the bottom plates to produce the CHI plasma current. The magnetic field line is connecting two electrode plates. Thus, newly created CHI plasma would merge into the main plasma current, and provide the fuel particles. This procedure could be repeated for repetitive fueling.

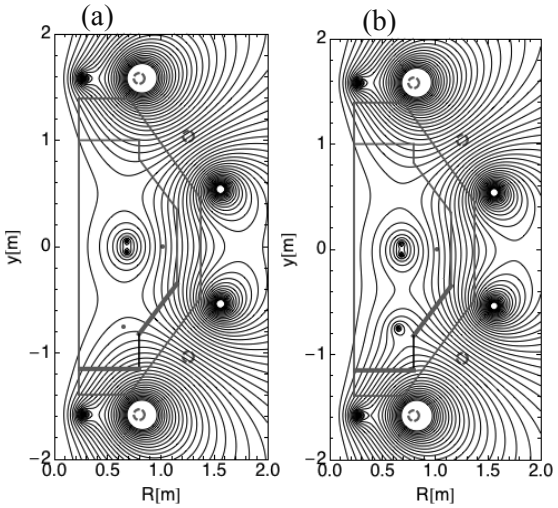

Fig. 2. (a) Magnetic surface of QUEST with I_p=20 kA before applying the CHI voltage (based on #22123), (b) CHI produced current (10 kA) is assumed for CHI merging fueling experiments. Two electrodes are shown by the bold parts at the bottom. Coil currents are I_{PF32}=I_{PF31}=1.5 kA, I_{PF26}=-0 kA, I_{PF17}=-1.7kA.

The best configuration for CHI fueling experiments is to use the bottom two divertor plates, which is different from the present configuration. Although the divertor operation used so far in QUSET [1] could be used for CHI fueling experiments, further detailed evaluations on the various electrode layouts and poloidal coil current pattern are required.

[1] O. Mitarai, et al., Nucl. Fusion 55 (2015) 063034
[2] O. Mitarai, K. Nakamura, et al., Fusion Eng. Des. (2015), available online 21 December 2015
[3] Y. Ono et al., Nucl. Fusion **43** (2003)1-6
[4] K. J. CHUNG et al, Plasma Science and Technology, Vol.15, No.3, Mar. 2013
[5] R. Raman and V. F. Shevchenko, Plasma Physics and Controlled Fusion, 56 (2015) 820149 103001