§56. Study of the Operation Scenarios in QUEST

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In a spherical tokamak (ST) device it is difficult to make a plasma current even with the central solenoid (CS). Reasons are the following. (1) As the toroidal field is smaller than that in a high aspect ratio tokamak, the field connection length is rather short for breakdown. (2) Stray field from the toroidal coils and feeder parts is relatively large due to the larger coil current than that in a high aspect ratio tokamak. (3) As CS has a small volt-second, no full plasma current cannot be obtained if breakdown is delayed. (4) As vacuum chamber is continuous, the large current is flown in the vacuum chamber and it is difficult to produce the plasma current anymore if breakdown is delays. (5) Large plasma volume in a ST leads to a smaller RF power density for a given power. Furthermore as a ST reactor cannot have CS due to the narrowness of the central part, it is quite crucial to start-up the plasma current. Although ECH helps the plasma breakdown, it does not mean the plasma current start-up. In the present ST device, such as QUEST equipped with CS, a variety of operation scenarios can be conceived to study ST plasma characteristics upon consideration above effects. For example, (1) Ohmic heating experiment, (2) Ohmic start-up and subsequent RF current sustainment, and (3) CS-less start-up experiments, and merging start-up experiments.

The cancel coil (CC) to make a null point in the EC resonant regime, has been proposed for QUEST (R=0.68m, a=0.4m, B_t=0.25 T) to ensure the breakdown and to perform above experiments. Although PF2 coil can cancel the field from the CS, it cannot cancel the field completely due to current ripple by the separate power source. As CS and CC coils are connected in series, no such ripple problems exist.

This cancel coil with 4 turns would be placed outside of the PF1 coils as shown in Fig. 1. The field null point for two CS coil layouts (short and long CS) and various turns of CC are shown in Fig. 2 for Ohmic discharge. By changing the turn number of CC the null point can be adjusted.

The typical Ohmic discharge waveforms calculated by plasma circuit equations is presented in Fig. 3 for I_p=50 kA. With CC, leakage field from CS is absent, the vertical coil current is almost flat during the plasma current flat top. Without CC, the vertical coil current (IPF1 and IPF2) must be increased to cancel the vertical field produced by CS. Thus, feedback control becomes relatively simpler. CCS feedback control system could be optimized using the high current OH discharge.

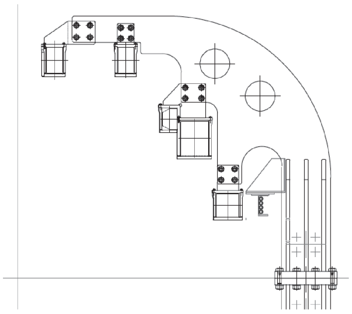

Fig. 1. The position of the CC in QUEST.

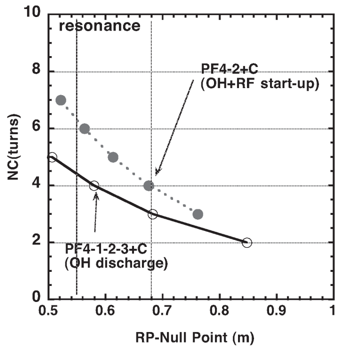

Fig. 2. Field null point for two CS layouts and various turn numbers of CC.

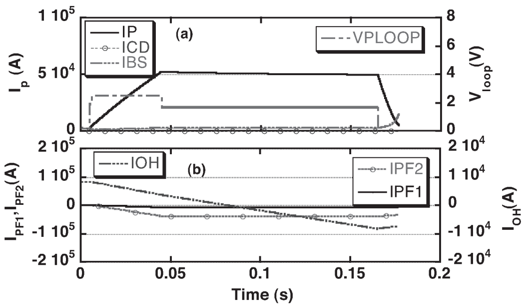

Fig. 3. Ohmich discharge waveform for I_p=50 kA with divertor function.

The CS-less start-up experiments are an important plan in QUEST. PF2 coils and divertor coil may be able to start-up the plasma current without CS. The two plasma currents can be produced in the two null points produced by upper CS and CC, and EC resonance, and they can be merged automatically or externally by divertor coils.

Above variety of experiments could be done in QUEST if the power supply could be used flexibly.

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