§3. Development of Compact Toroid Injector for LHD

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A compact toroid (CT) injector named SPICA mk. I (SPheromak Injector using Conical Accelerator) has been developed.[1-2] The main task of its design was to achieve high efficiency ε. Here, ε is defined as the ratio of CT kinetic energy to the energy stored in the power source (fast capacitor banks are used in general). More than 15 kJ of CT kinetic energy is necessary to inject a spherical CT of 0.1 m radius into the LHD plasma confined in 3T magnetic field. For example, if one can achieve 15 % of ε, a small capacitor bank of 100 kJ can be used.

SPICA mk. I was assembled on March 1999. SPICA is equipped with two electrically isolated inner-electrodes for two-stage CT acceleration.[2] A power source for CT generation was installed on March 2000. This power source consists of 10 capacitor banks of which the total stored energy is 40 kJ (20 kV, 200 μF). Five ignitrons are used to trigger the capacitor banks. In a test discharge using dummy coil of 10 mΩ / 330 nH, the maximum current of 300 kA was observed at 15 kV of charging voltage. Another power source for CT acceleration (100 kJ, 40 kV) will be installed on March 2001.

Throughout the design work of SPICA, it is found that the efficiency ε is high when the ratio of the electrode inductance to the circuit inductance is large.[2] This means that the electrode length should be as long as possible. The longer electrode length can be obtained when two inner-electrodes are connected electrically and one power supply is used for both CT generation and acceleration (one-stage operation). In ref. 2, the optimization is carried out mainly assuming the CT mass m_{CT} of 0.1 mg. In the experiment, m_{CT} is one of the most controllable variables as it is determined by the gas injection rate. After the discharge simulation using the fourth order Runge-Kutta method, Fig. 1 is obtained for the one-stage operation using only CT generation power source. In this case, high ε of 17 % is obtained. Figure 2 shows the m_{CT} dependence of ε, and one can see that there is an optimum CT mass around m_{CT} = 0.2 mg. Before the installation of acceleration bank in the next year, this one-stage operation is the main theme of the experiments. Another important issue to inject a CT into LHD is that the CT should fly more than 5 m without decomposition. This will be also examined in this year.

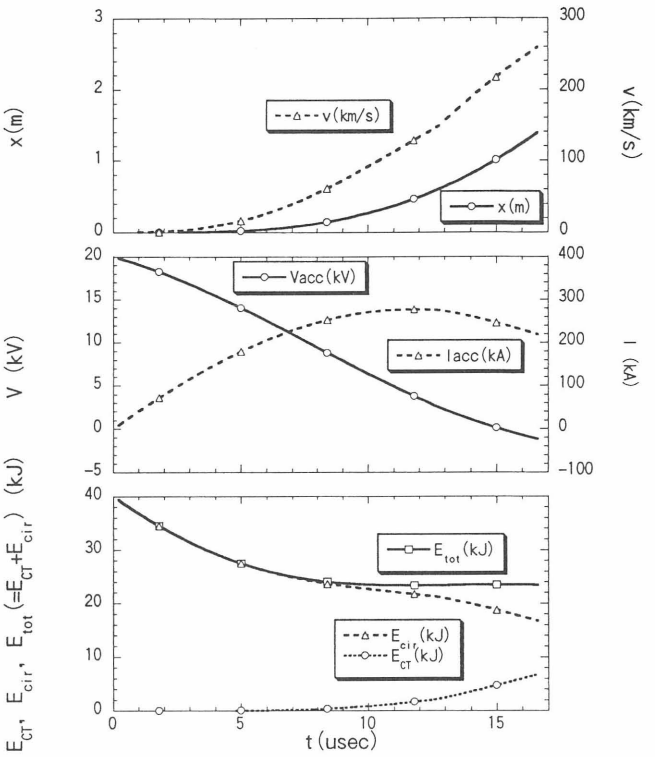

Fig. 1. Simulated waveforms of SPICA mk. I with 20 kV – 40 kJ power supply. CT mass of 0.2 mg, circuit resistivity of 20 mΩ, and external inductance of 0.48 μH are assumed.

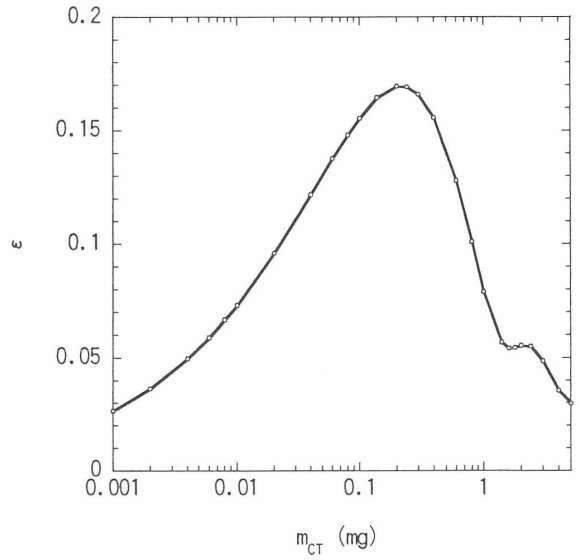

Fig. 2. CT mass m_{CT} dependence of efficiency ε. Parameters used are identical to that of Fig. 1.

References

1) Miyazawa, J. Yamada, H. and Motojima, O., Jpn. J. Appl. Phys. **37** (1998) 6620.

2) Miyazawa, J. *et al.*, NIFS-614 (1999); Miyazawa, J. *et al.*, Fusion Eng. Design (to be published).