§7. Charge Separation Characteristics of a Newly Constructed CUSPDEC Device Using Permanent Magnets

Takeno, H., Nakamoto, S., Ichimura, K. (Kobe Univ.),
Miyazawa, J., Goto, T.,
Nakashima, Y., Katanuma, I. (Univ. Tsukuba)

Cusp-type direct energy converter (CUSPDEC) was proposed as an efficient power generation device using in D-^{3}He fusion generation[1]. The authors were proposed an application of the device to reduction of thermal load of divertor plates[2]. Ions and electrons can be separated by the function of CUSPDEC, and their kinetic energy will be reduced by an appropriate biasing on the divertor plate. An introduction of permanent magnets (PMs) is required to compose CUSPDEC in a narrow divertor space, and a preliminary experiment of PM-CUSPDEC was performed[3]. Based on the result of this experiment, a new device of PM-CUSPDEC was constructed, and the present paper shows its separation characteristics.

The new device is composed of one magnetic coil and several PMs. Figure 1 shows results of orbit calculation in the r–z plane of the device, where variation to the number of PM is examined under appropriate field conditions. The starting positions (r_0, z_0) are: $z_0 = -25$ cm for all electrons, and $r_0 = 0.5$ cm for that with 30 eV while $r_0 = 0.5, 1, 1.5, 2$ cm for those with 10 eV. According to Fig. 1(a) of two PMs, 10 eV electrons of $r_0 = 1, 1.5, 2$ cm arrive at Plate1 (electron collector), but that of $r_0 = 0.5$ cm stagnates in the cusp region around $z \sim 15$ cm, and that of 30 eV passes through the cusp region in the radial direction. In Fig. 1(b) of three PMs, all electrons of 10 eV arrive at Plate1, and that of 30 eV stagnates in the cusp region. All electrons arrive at Plate1 in Fig. 1(c) of four PMs. These are the result of increase of magnetic field due to increase of PMs.

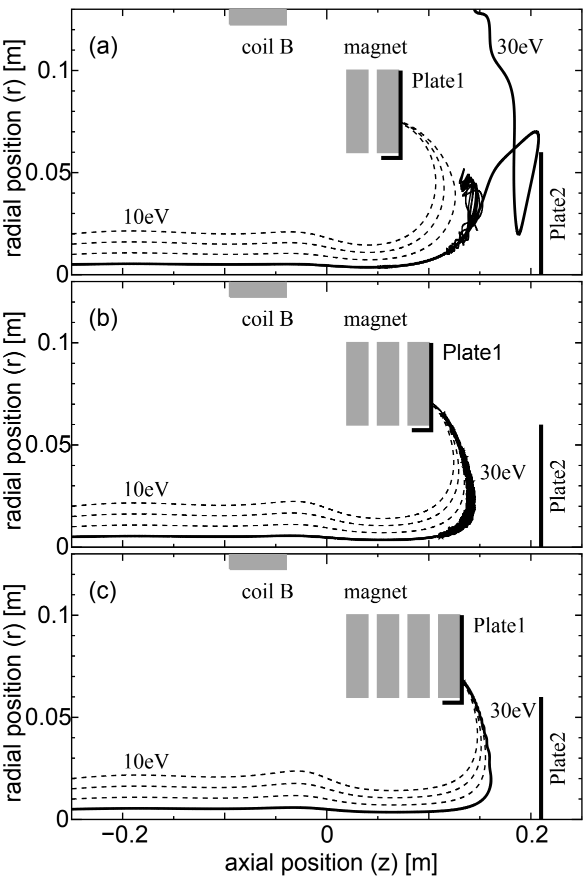

Fig. 1: Variation in electron orbit to the number of PM.

The corresponding experiment was performed. Figure 2 shows variation of electron currents of Plate1 and Plate2 (ion collector) which are denoted I_1 and I_2, respectively. They are normalized by the maximum value for each case of the number of PM. The variation was examined as a function of the coil current: on a small coil current, an upstream cusp field was remained for all cases, while both upstream and downstream cusp fields disappeared on a large coil current. Only on a certain middle coil current, desirable charge separation is achieved. As the coil current increases, I_1 rapidly increases and takes the maximum value and then decreases slightly although I_2 gradually increases and a constant value follows. This variation is consistent with the change of magnetic field. The coil current corresponding to the maximum I_1 increases as the number of PM increases. This means the magnetic field strength by PMs increases as the number of PM increases.

The separation efficiency defined by $I_1/(I_1+I_2)$ was evaluated by using the results of Fig. 2. The maximum efficiency increases as the number of PM increases, and 86% is obtained in the case of four PMs.

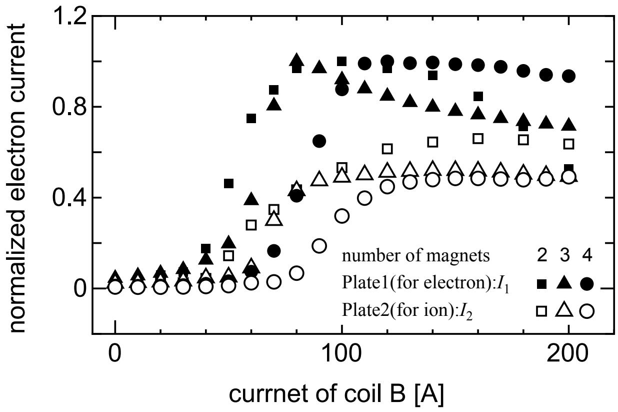

Fig. 2: Dependence of electron current on coil current.

1) H. Momota, et al., Proc. 7th ICENES (1994) 16.

2) H. Takeno, et al., Trans. Fusion Sci. Tech. **63**(1T) (2013) 131-134.

3) H. Takeno, et al., Ann. Rep. NIFS (2013-2014) 514.