# §15. New Structure of Cusp-type Direct Energy Converter Using Permanent Magnets


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Cusp-type direct energy converter (CuspDEC) has been developed to use as a direct energy conversion device for advanced fusion[1]. It has a function to separate charged particles according to their charge polarity and energy. This function is applicable to reduce the energy of divertor plasma: ions and electrons of the divertor plasma could be separated by a CuspDEC, and they could flow into individual divertor plates. If the plates are biased appropriately according to particle energy, those particles are decelerated, and thus thermal load of the plates could be reduced[2]. In order to realize this scenario, the CuspDEC should be settled at the narrow divertor space. In such a situation, composition of the CuspDEC by permanent magnets (PM-CuspDEC) may be suitable. This report presents new structure of CuspDEC using permanent magnets.

In the new structure of magnetic field, not only permanent magnets, but also current field by solenoid coils are used which simulates a guiding field of divertor plasma. In the present study, cylindrical hollow magnets magnetized axially are used. The magnets are aligned co-axially with solenoid coils at the downstream in the direction of the plasma flow.

Samples of the field line structure are illustrated in Fig. 1, which show radial-axial planes and plasma flows along with the axial direction. In Fig. 1(a), fields only by permanent magnets (pm) are shown. As shown in the figure, there exist two cusp fields near both ends of the magnets. When fields by coil currents are superposed, those cusp fields are cancelled. In a small current condition of Fig. 1(b), the cusp field in the upstream is cancelled and that in the downstream still exists. Electrons flowing into this field are deflected along the field lines and arrive at the downstream edge of the magnet, where an electron collector (P1) exists. On one hand, in a large current condition of Fig. 1(c), the cusp field in the downstream is also cancelled. In this field, electrons along the field lines are not deflected and go straight to the point cusp with ions, where an ion collector (P2) exists. In order to separate electrons and ions, an appropriate guiding field as Fig. 1(b) is required.

In a plasma source device, a prototype PM-CuspDEC was composed and tested. By using a similar structure to that in Fig. 1, motion of electrons was examined. Figure 2 shows samples of voltage-current characteristic of the electron collector (P1). Current of coil B ($I_B$) was varied for 0 A, 10 A, and 40 A while current of coil A ($I_A$) was kept constant to be 40 A. According to Fig. 2, electron current once increases as $I_B$ increases from 0 A to 10 A. However, it decreases as $I_B$ increases from 10 A to 40 A. This is consistent with the variation of field line structure. In the variation of $I_B$ from 0 A to 10 A, the null point in the upstream is moved radially while that in the downstream remains on the axis, thus field lines arriving at P1 increase and electron current of P1 increases. In the variation from 10 A to 40 A, the null point in the downstream is moved, thus field lines arriving at P1 decrease and electron current of P1 decreases. The fundamental characteristic of PM-CuspDEC was confirmed experimentally.

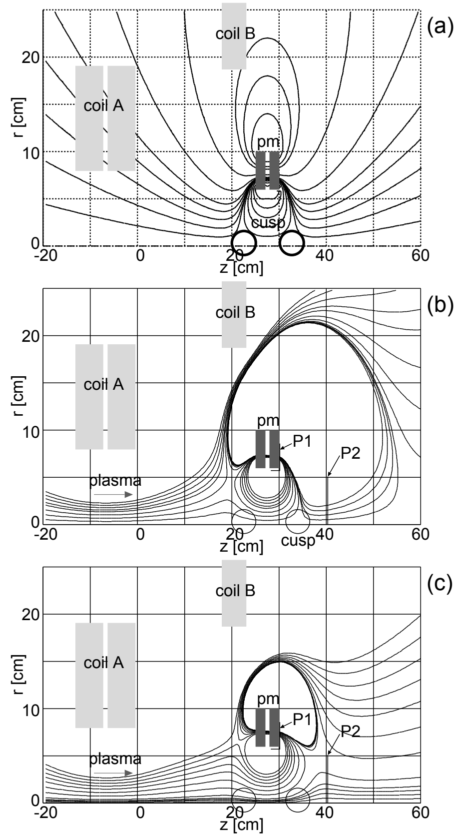


Fig. 1. Variation of field line structure by external magnetic field.

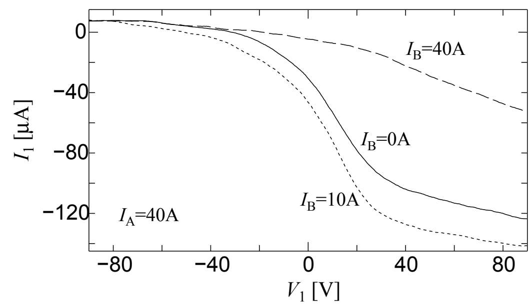


Fig. 2. Voltage-current characteristics of P1.


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

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