

### §3. Fast Power Control Capability of Large-Scale Travelling Wave Direct Energy Conversion

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#### 1) Objectives of Study

The major energy produced in D-<sup>3</sup>He fusion plasma is released as a kinetic energy of charged particles, especially that of the high energy protons. Objectives of the present study is to reveal behavior of self-excitation of a commercial scale travelling wave type direct energy converter (TWDEC) and to explore a capability of fast power control of TWDEC by numerical simulation.

#### 2) Basic Equations and Numerical Schemes

The basic equations used in the one (z-direction) dimensional analysis are the momentum conservation equation for fusion protons, Poisson's equation for the electric field, and external electric circuit equations. In the present analysis, the cylindrical coordinates are used because the basic configuration of the TWDEC is a cylinder.

#### 3) Self-excitation of Commercial Scale TWDEC

It has been found that the self-excitation is difficult with the designed load resistance but becomes possible with switching the load resistance from a smaller value to the designed value, resulting in the electrode voltage of about 1 MV with about 7 milliseconds and about 65 % of energy conversion efficiency.

#### 4) Fast Control of Electric Output Power

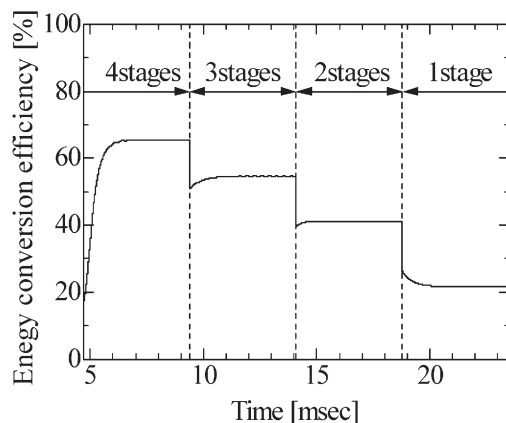


Fig.1 Time variation of the energy conversion efficiency when the number of stages is changed.

Figure 1 shows the time variation of conversion efficiency by changing the operation stages of TWDEC. Figures 2 and 3 depict the electric potential distributions along TWDEC with 3 and 2 stages operation, respectively.

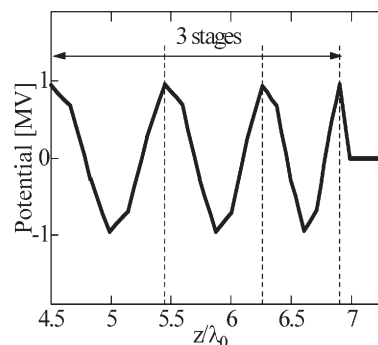


Fig.2 Electric potential distribution along TWDEC with 3 stages operation.

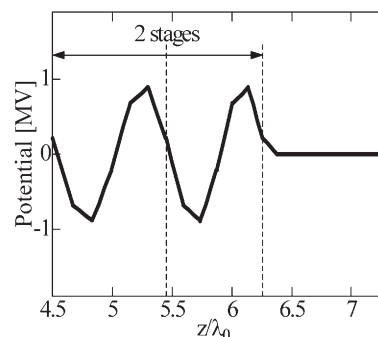


Fig.3 Electric potential distribution along TWDEC with 2 stages operation.

#### 2) Conclusions

The commercial scale travelling wave type direct energy converter (TWDEC) has been studied, and the following results have been obtained:

- (1) The TWDEC can be self-excited with the electrode voltage of about 1 MV with about 7 milliseconds by switching the load resistances. About 65 % of energy conversion efficiency is obtained.
- (2) The electric power becomes 100 %, 84 %, 63 %, and 33 % by decreasing the number of operation electrodes, and the time required for changing the load is about 5 milliseconds, suggesting that TWDEC can rapidly control the electric power.

#### References

- 1) Kawana, R. and Ishikawa, M.; 15th Int. Conf. on MHD Energy Conversion, Moscow (2005) Vol.1, p.302.
- 2) Ishikawa, M., Horita, K., Yasaka, Y., Takeno, T., and Tomita, Y.; Fusion Engineering and Design 181 (2006) 1689.