Chapter 12
Counter-Rotating Type Power Technologies to Exploit Offshore Energies

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ABSTRACT

For the next leap in power-generating technologies, the world is obligated to not only cope with the warming global environment but also to conserve the natural ecosystem. This chapter discusses the advances in technology designed to successfully exploit offshore marine and wind resources. (1) The Counter-Rotating Type Hydro/Tide Power Unit, which is composed of the tandem runners and the peculiar generator with double rotational armatures, is applicable to both rising and falling tides at the power station with the embankment, in place of the traditional bulb type turbines. (2) The Floating Type Ocean Wave Power Station, where a pair of floats lines up at the wavelength spacing, can get the superabundant velocity energy. (3) The Intelligent Wind/Tide Power Unit, which is composed of the tandem wind/tide rotors and the double rotational armatures, is suitable for offshore wind and the tidal stream.

INTRODUCTION

For the next leap in power-generating technologies, we are under obligation not only to cope with the warming global environment but also to conserve the natural ecosystems for getting the sustainable societies. As for the renewable fluid resources in the world, we can further exploit onshore hydro resources of about 2 TW, the wind resources of about 72 TW, and the marine resources more than $2x10^3$ TW, where we are consuming now the electric power of about 1.4 TW. That is, the marine resources should occupy the great attention of the electric power generation in the

DOI: 10.4018/978-1-4666-1625-7.ch012

future, in cooperation with the hydro and the wind resources. It is, however, very difficult to convert successfully and predictably marine resources into electric power, because the marine circumstances may change suddenly in dependence on not only tidal fashions but also weather systems. Besides, we must make the power unit size as small as possible and must avoid civil engineering work on a large scale to ensure the safety navigations of the marine vehicles and to conserve the marine lives.

To exploit successfully the marine resources, it is required to prepare several kinds of power units suitable for the individual resource. The author has invented the unique counter-rotating type power units, to exploit fruitfully/effectively the promising ocean and wind resources. This chapter introduces and discusses the advanced technologies in such units.

COUNTER-ROTATIONS

Double Rotational Armature Type Generator

The author has prepared the peculiar generator composed of the inner and the outer rotational armatures, without the traditional stator. Figure 1 shows the performances of the model synchronous generator (3-phase, 4-pole, permanent magnet, AC generator with double rotational armatures), where the rated output P = 1kW at the induced frequency f = 50Hz and the induced voltage E = 100V while the relative rotational speed N_T = 1500min^{-1}. Figure 1a shows the relation between the outer armature rotational torque T_F* and the inner armature rotational torque T_R*, in keeping the rotational speed of the outer armature constant at N_F = 750 min^{-1}, while changing the rotational speed of the inner armature N_R at the various external loads. These rotational torques do not include the mechanical torques such as the bearings in the generator, and T_R* is given by the absolute value though the direction of T_R* is against T_F*. It is obvious that T_R* coincides with T_F* irrespective of the relative rotational speed ($N_T = N_F - N_R$) and the output/load, because the rotational torque should be always dynamically counter-balanced between both the armatures. That is, the rotational torque counter-balances dynamically between the inner and the outer armatures. The relative rotational speed affects the output P and the induced voltage E against I_G, as shown in Figure 1b. The output increases with the increase of the induced voltage E at the same I_G, while E is in proportion to the relative rotational speed N_T.

Advantages

The above armatures should be counter-driven, respectively, by the tandem runners/rotors, while the rotational torque between both armatures/runners/rotors counter-balances in the unit. Besides, the relative rotational speed in the magnetic field is nearly two times faster than the speed of the traditional generator with the stationary armature. Such operating conditions bring forth the superior advantages as follows.

a. The diameter of the generator can be reduces at the same induced voltage as the traditional generator, while the individual rotational speed are the same as the traditional speed.
b. The induced voltage is sufficiently high without supplementary equipments such as a gearbox, while the individual rotational speed and the generator dimensions are the same as those of the traditional generator.
c. The cavitation can be suppressed well because it is possible to make the relative rotational speed reduce as described above.
d. The rotational moment hardly acts on the mounting bed because not only the reaction force does not act on the outside but also the counter-rotation negates the gyro-effect. That is, it is not necessary to set rigidly the generator on the solid mounting bed anchored to the ground or the seabed. Then,