European Association for the Development of Renewable Energies, Environment and Power Quality (EA4EPQ)

International Conference on Renewable Energies and Power Quality (ICREPQ'11)
Las Palmas de Gran Canaria (Spain), 13th to 15th April, 2010

Design and Experimental Study of a Novel Two-stage Brushless Hybrid Excitation Synchronous Machine

Zhu Shushu, Liu Chuang, Yihao Xu, Ma Yundong

Aero-Power Sci-Tech Center
Nanjing University of Aeronautics and Astronautics
No.69,Yudao Street, 210016 Nanjing (P.R.C)
Phone/Fax number: (+086)13813911892,
e-mail: A.shuiying5417750@ yaohoo.com.cn, B.lc@nuaa.edu.cn, C.yhxu1985@163.com

Abstract. A novel two-stage brushless generation system which is based on Tangential / Radial Hybrid Excitation Synchronous Machine (T/R-HESM) is proposed in this paper. The configuration and operation principle are introduced. Meanwhile, a novel two-stage brushless scheme is designed. Comparing with traditional brushless scheme, the problems such as complex system and long axial length can be overcome by novel scheme. In this paper, this novel scheme which can realize complete self-excitation, is introduced in detail and compared with current scheme. In the aspect of excitation system, the exciter is designed. Finally, a prototype is made to verify the correctness and reliability of this novel two-stage brushless scheme by experiment. From above-mentioned study, the application of hybrid excitation synchronous machine is expanded in the areas of aerospace, wind generation and so on.

Key words

generation system, hybrid excitation, two-stage, brushless, self-excitation

1. Introduction

Hybrid excitation synchronous machine (HESM) was firstly proposed by USSR scholar in 1980th. Primary excitations by permanent magnets as well as a secondary field coil excitation source are utilized in HESM. By combining the advantages of permanent magnet (PM) machines with the possibility of controlling magnetic flux by excitation coils, this kind of electrical machine has a widely used prospect. So, HESM has become the new research hotspot [1-3].

Meanwhile, avoiding slip rings and brushes is the key technical problem to improve reliability and ensure long-term operation without maintenance. Many schemes are proposed. For example, in the area of aviation, three-stage brushless exciter synchronous machines are adopted as main generation system of aircrafts. As Fig.1 shows, this scheme consists of auxiliary exciter, exciter and main-generator [4-6]. Permanent magnetic generator is chosen to be auxiliary exciter, which provides electrical power to a rectifier/chopper set. The chopper is connected to the stationary excitation windings of exciter, whose three-phase output exciter is rectified and applied to exciting windings of main generator. Sometimes, the permanent magnetic generator is replaced by power supply. In the area of civil grid generation, the rectifier can be connected to grid. So, the auxiliary exciter or power supply is abandoned. In the area of off-grid generation, the excitation current of generation system is provided by the output voltage of main generator. However, residual voltage is too low to start the generation system. So, auxiliary power supply cannot be avoided.

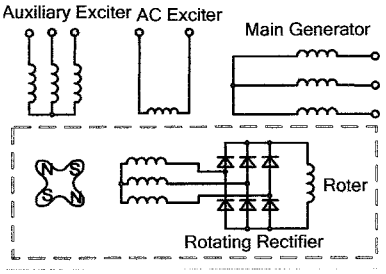

Fig. 1. The traditional scheme three-stage brushless synchronous generator

In order to expand the application field of HESM, T/R-HESM is proposed in this paper. The new configuration and operational principles are described. Its 2D model is built by finite element method (FEM) to get the static