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Performance analysis of commercial scale Ar–Cs disk MHD generator connected to electric power system with synchronous generator

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Abstract

Performance analyses of a commercial scale closed-cycle MHD disk generator are performed. A large scale MHD generator, superconducting magnet, inversion system and synchronous generator are designed. The MHD generator is operated with Ar–Cs plasma and connected to the ac power infinite bus through line-commutated inverters, while the synchronous generator is operated in parallel. The thermal input is 1000 MW, and the power output is 400 and 200 MW, from the MHD and synchronous generators. Fault analyses have found that rather large fluctuations within the MHD generator are induced by faults of the inverter and power transmission line, but control of the inverters can recover the MHD generation system to normal operation within 0.15 s. The feature of behavior of the MHD generator is the same with or without the parallel operation of the synchronous generator. The interaction between the MHD and the synchronous generators is small, and this feature is much different from the open-cycle MHD generation system, since the variation of output current of the closed-cycle disk MHD generator is much smaller compared with open-cycle MHD generators.

Keywords: Commercial scale disk MHD generator; Ar–Cs non-equilibrium working plasma; Line-commutated inverter; Interaction with synchronous generator; Fault analyses

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1. Introduction

The behaviors of closed-cycle MHD generators are much different from those of open-cycle MHD generators, and therefore, the interaction between a closed-cycle MHD generator and an ac power system through the inversion system must be studied independently of open-cycle MHD generators. MHD power generation is a combined system, where the MHD and synchronous generators are operated in parallel, and therefore, the interaction between these generators must also be studied. The closed-cycle MHD generator is operated with He or Ar, and the basic characteristics of these kinds of plasma are similar, but the behaviors of MHD generators are different from each other from the viewpoint of the time constant and ionization instabilities. Both MHD generators operated with He or Ar must also be studied independently. There are two types of inverters, i.e. line-commutated inverters and forced-commutated inverters, and they have different characteristics. How the behaviors of a commercial scale closed-cycle MHD disk generator operated with Ar–Cs and connected with the ac power system through line-commutated inverters are different from the pilot plant scale disk generator is one of the important items for commercialization of closed-cycle MHD generators.

Several studies of the behaviors of MHD generators connected with the ac power system through inverters have already been reported for the open-cycle MHD generators [1–3] and closed-cycle disk MHD generators [4–6], showing very important features of the interconnection of the MHD generator and the ac power system.

This paper treats the behaviors of a closed-cycle MHD disk generator of commercial scale, operated with an Ar–Cs nonequilibrium plasma and connected with the ac power system through line-commutated inverters in parallel operation with a synchronous generator. The thermal input is assumed to be 1000 MW, which is 10 times larger than the pilot plant scale MHD generator [5,6], and the power output is 400 MW and 200 MW from the MHD generator and synchronous generator, respectively. Basic designs and nominal operation is described first, then fault analyses are performed, and finally, the effects of parallel operation of the synchronous generator is examined.

2. Design of commercial scale MHD generator, SCM, inversion system and synchronous generator

Fig. 1 depicts the schematic diagram of the whole system used in the present study. The commercial scale disk type MHD generator is operated with an Ar–Cs nonequilibrium plasma. The MHD generator is connected to the ac power system through line-commutated inverters, and a synchronous generator is operated in parallel.

2.1. MHD generator and superconducting magnet

The commercial scale closed-cycle disk MHD generator designed, is operated with supersonic outflow of the cesium-seeded non-equilibrium argon plasma. The thermal input is large with 1000 MW, and the MHD generator is of high performance with electric output of