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Small Enclosed Diesel Generator with a Multifunctional Brushless Exciter and Nanostructured Insulating Materials Used

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Abstract

The design and ventilation system features of a small enclosed diesel generator with a multi-functional brushless exciter suitable for application under extreme environmental service conditions as well as the results of the generator ventilation system calculation and the thermal stability analysis are presented in the paper.

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1. Introduction

The development of small-scale power industry in Russia has led to the development of low-power diesel generators which are able to work under various emergency and extreme climatic conditions, including fire hazard conditions during repairs of gas and oil pipelines, requiring a highly reliable power supply. It is appropriate to have a generator of a closed design with a combined brushless exciter to work under conditions mentioned above.

Low and medium power generators ranging from 60 to 200 kW for diesel power stations are being designed at the Electrical Machines Department of the Ural Federal University. The construction was designed on the basis of the Barahchinskiy Electro Mechanical Plant generators of the protected type. A number of changes were made on the prototype construction. The patent covered combined multifunctional brushless (SMBV) exciter designed at the Electrical Machines Department of the Ural Federal University is proposed as the exciter [1]. The characteristic

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feature of the SMBV is an unconventional magnetic and electric combination of several electromechanical transducers [2]: a four-phase synchronous exciter with combined magneto electric and electromagnetic excitation; an inductor pilot exciter; an induction pilot exciter; a power-supply source for the control system and exciter's initial excitation; an exciter's rotor current sensor; a rotating four-phase uncontrolled semiconductor converter; a controlled four-phase converter of induction and inductor pilot exciters; a semiconductor converter of initial excitation. Non-conventional combination methods being applied make it possible to impart new characteristics to the device, to reduce active materials consumption for the excitation device, to lower the cost price for its manufacturing.

Operating experience of the SMBV by high power synchronous generators has revealed the SMBV-based excitation system being a highly reliable and completely independent brushless excitation system both in terms of the power supply and control channels.

2. Design features

New insulating materials are recommended to be used in the generator and the excitation system.

The proposed selection of the excitation system and insulation materials will enable:

- Improving the reliability of the diesel power plant
- Ensuring the complete independence of the generator, including that of the control channel supply
- Automating the system completely and ensuring a high level of self-diagnostics
- Reducing operating costs
- Increasing the life of the generator
- Changing from protected to totally enclosed type without changing the height of the rotation axis of the device
- Being able to get implemented for the explosion and fire safety performance

While designing a new generator, retaining, first, the rotation axis height and the prototype's dimensions was set as the main aim. In changing from protected to totally enclosed design, changes in the generator construction are to be minimal in order to maintain the production technology and ensuring the possibility of using the magnetic system of the protected design diesel generators being produced.

The prototype has the exciter in cantilever located, i.e. outside the casing, which is denied to the enclosed generator. That is why the exciter was introduced into the body of the generator. Various designs of MBV generators have been examined. To intensify cooling, a 2-circuit system with the inner contour of the axial type is applied. The internal fan is located on the drive side and the SMBV - at the opposite end shield.

In connection with the changes in the design of the generator it is necessary to develop methods of heat and ventilation calculation. To determine the thermal state of the generator with the exciter, a complete equivalent thermal circuit (ETC) was developed taking into account different cooling conditions at the end shields [3]. In developing the ETC, the encapsulation of the coil ends of the generator and exciter windings, heating the air in ducts and cooling pipes are also taken into consideration. The power of heat sources was calculated using the program for calculating the electromagnetic synchronous generator, developed in the MathCAD package. Power loss in the SMBV was determined by the method developed at the Department of Electrical Machines of the former Ural State Technical University. Calculation of the thermal resistance and heat conductivity is made on the basis of approaches presented in technical literature. The thermal design of the installation is implemented using the capabilities of the MathCAD package.

Calculations performed in [4] showed that the use of the profile extrusion frames made of aluminum alloy with a higher degree of cooling fin to intensify the outer loop, while maintaining ventilation ducts between the frame and the stator core for the inner contour of the ventilation does not provide the necessary level of cooling intensification for the enclosed generator. Therefore, a number of measures to reduce windings overheating are proposed.

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