

# Development And Application Of New Generation Of Multi-Functional Brushless Exciting Devices With Non-Conventional Combination Methods

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**Abstract**— The application of combined multi-functional brushless exciting devices in brushless independent exciting systems permits both as to reduce expenses for the exciting systems manufacturing as to elaborate the transportable high reliable flexible energy power devices and also hydro-sets for the small power engineering with the wide functional scope, high level of automation and diagnostic of the state of rotating power producing semi-conducting converter. The permanent qualified maintenance is not needed that is important for the users working at the extra-ordinary situations for the oil and gas mining, for the farmer households, for the distant municipal corporations and the other industrial and domestic users.

**Keywords**— *combined multi-functional brushless exciting device*

The article gives the design description, operation results and application field of the combined multi-functional brushless exciting device (CMBED) with the application of non-conventional methods of magnetic, electric and constructive superposition, permitting mutual inductivity connection between the windings of the combined machines. CMBED were elaborated in the Joint-Stock Company “Uralelectrotyazhmash” co-operating with the Electrical machines department of the Federal State Autonomous Educational Institution of Higher Professional Education «Ural Federal University named after the first President of Russia B.N. Yeltsin».

The basic electric circuit of the windings connection for the exciter CMBED type, photograph (Fig. 1) and cross sectional drawing of the exciter ББ-59/7-10 set on the experimental stand for the exciting of the generators СГД-85/36-4М, СБТ-85/64-4, СГД-99/64-4 types are given. The sensor operation of the current of exciting winding of the synchronous generator is described.

As an example (Fig. 2.) one of the oscillograms of the strait start of the asynchronous motor БАН-118/23-8, 400 kW from the synchronous generator СГД-99/64-4, 1000 kW illustrating the transient process dynamic in the exciting

device under the sudden voltage alteration on the excited synchronous machine.

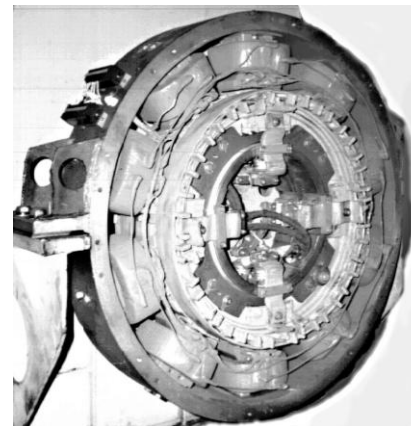


Fig. 1. ББ-59/7-10

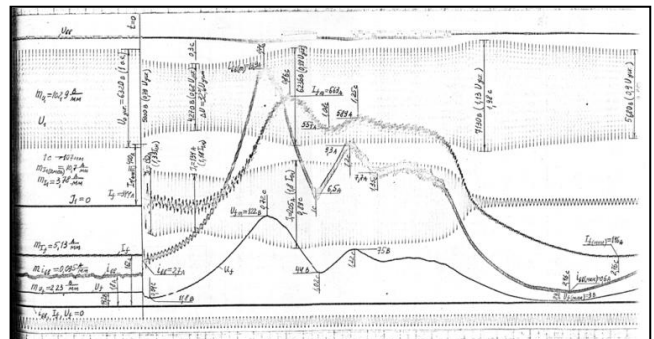


Fig. 2. The oscillogram of the strait start of asynchronous motor БАН-118/23-8, 400 kW from the synchronous generator СГД-99/64, 1000 kW

The depth of the first failure of voltage on the generator lead terminals is 21% from the nominal voltage. The maximum voltage failure on the generator lead terminals is 32% from the nominal voltage. The attainment time of the maximum voltage is 0,72 second. The voltage build-up rate of voltage rise on the generator exciting winding calculated using under the methodic State Standard 183-74 is 7,9 p.u./s, that meets the State Standard requirements.

The voltage build-up rate rise on the generator exciting winding should more or equal to 2 p.u./s.

The oscillogram of sudden 3-phase short circuit from the idle motion of the generator ББМ-99/64-4 is given in the report. The theoretical and experimental researches confirmed

that there are no emergency or operational regimes that obstruct the forcing regime of synchronous generator excitation.

The types, parameters of the brushless combined type exciters for the range of the developed generators and countries of application are given in the report.

Russian Federation: Bistrinskaya HPP, Tolmachevskaya HPP-1, Pravdinskaya HPP-3, Tolmachevskaya HPP-3, Jumaguzinskaya HPP, Ust-Gjegutinskaya HPP;

Italy: Vidzhevano HPP;

Colombia: Erradura HPP, Vuelta HPP.

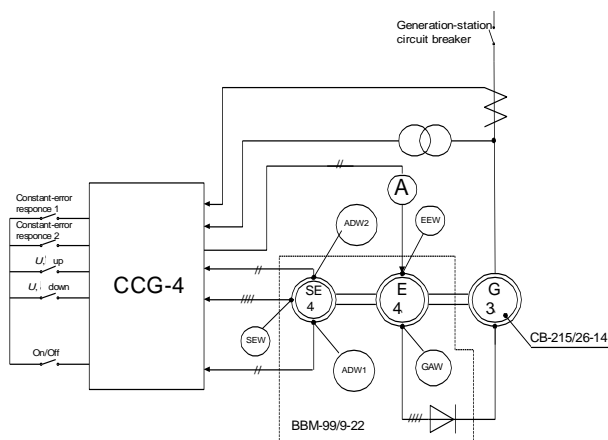


Fig. 3. Scheme of brushless excitation system

The block diagram of the brushless excitation system is given on Fig. 3 and explained by the example of the exciter for the vertical-shaft synchronous hydrogenerator CB-215/26-14, 1375 kVA, 1100 kW, 6,3 kV, 50 Hz, 428,6 rpm. The brushless exciter BBM-99/9-22 is used for this generator. The hydrogenerators CB-215/26-14 with the exciter BBM-99/9-22, control cabinet CCG-4 is used (2 sets) for Tolmachevskaya HPP-1.

The exciter BBM-99/9-22 is shown on the block diagram on Fig. 3 as two generators: E,4~ and SE,4~. The synchronous generator E,4~ - is a brushless exciter, which armature is installed on the hydrogenerator shaft. The generator armature winding E,4~ (GAW) through rotating diode rectifier energizes the excitation winding of the hydrogenerator CB-215/26-14 without use of brushes and slip rings. The excitation winding of the exciter E,4~ (EEW) is installed on core poles of its stationary magnetic system. The four phase generator, indicated on the block diagram as SE,4~ is a subexciter of field magnet type.

The exciter E,4~ and subexciter SE,4~ are united in one magnetic system of the exciter BBM-99/9-22. The subexciter SE,4~ has no its separate stator. Its stator is a stationary inductor of the exciter E,4~. The stator windings of the subexciter SE,4~ are arranged in pole's shoes. The initial excitation is provided without external source by the magnetic

inserts in two diametrically arranged pole's core of the exciter B,4~.

The subexciter SE,4~ has three electrically separate stator windings, indicated on the block diagram EEW, ADW1, ADW2. The four phase winding of the subexciter (SEW) through controlled thyristor rectifier installed in the control cabinet CCG-4 energizes the excitation winding (EEW) E,4~. The exciter armature winding (GAW) and the stator power winding of the subexciter (SEW) are four phase.

The additional windings of the subexciter ADW1 and ADW2 are one phase. The winding ADW1 is used for supply of the automatic excitation regulator, the winding ADW2 is an output winding of the rotor current detector.

The estimation of various excitation systems of synchronous electrical machines in the technical literature is carried out as a rule by means of comparison of mass, prices and energy losses only of the excitation system equipment that is proved in case of structurally uniformed excitation systems. For excitation systems with a different structure the estimation shall be made for all technical complex including a synchronous electrical machine to be excited, a power equipment of excitation system and a control cabinet including cables, bus ducts, ect. The above mentioned approach was applied by the OJSC «UETM» by comparison of various excitation systems for hydrogenerators of small capacity applicable for Ust-Djegutinskaya HPP.

The results of comparison are given in the Table in the report. The comparison of mass, expenditure of active materials and required areas was carried out under condition of a flood discharge equality by production of 1 kW of active power (output of a hydroturbine on the shaft of generator is the same for all types), by loss equality in hydrogenerators and excitation systems in comparable types and also by active and reactive power of hydrogenerators giving up to consumers (total power and its components are identical for all types of excitation systems considered). According to Table the minimum expenditure of materials has a brushless excitation system of type CMBED. The brushless excitation system uses the active power from the hydroturbine shaft. For its functioning, the rated capacity of hydrogenerator, an auxiliary power source for initial excitation are not required. It does not generate high voltage harmonics in the network destroying insulation of the excitation system elements and hydrogenerator. As the above mentioned Table shows, the application of the combined multifunctional brushless exciter instead of static excitation system has allowed to reduce a mass of technical complex for 8% in comparison with the excitation system, where the matching transformer is applicable, and for 12% in comparison with the static excitation system, where the additional winding arranged in slots of the electrical machine to be excited, instead of the matching transformer.

Concerning dynamic properties for the rated operation duties, the brushless excitation system with application of exciters type CMBED doesn't yield to the static excitation system, and what is more, it has advantages by deep fits of voltage on the buses of the generator to be excited.