ASPECTS REGARDING THE COOLING SYSTEM OF 330 MW SYNCHRONOUS GENERATORS

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Abstract: *The paper aims to highlight some aspects regarding the cooling system of the 330 MW synchronous generators, used in the schemes of the technological flow of electricity production in high-power power plants. The 330 MW synchronous generators are characterized by the fact that they use direct cooling systems with water for the stator windings and hydrogen in the rotor windings with the mention that the cooling of the rotor windings is carried out in a closed circuit.*

Keywords: energy group, synchronous generator, technological flow, conversion, electricity

1. INTRODUCTION

In order to have an overview of the role that synchronous generators have in the technological flow schemes of the energy groups with the power of 330 MW, in figure 1 we presented the single-wire electrical scheme for the discharge of electrical energy in the electrical energy system, respectively supply to consumers of own services.

As can be seen from figure 1, the 330 MW synchronous generator completes the cycle of energy transformations within the technological flow scheme and makes the junction between two power transformers [1]:

- TSB (block service transformer), which has the role of converting the electricity produced at the generator terminals from a voltage level of 24 kV, to the voltage level of the Overhead Power Line, of 400 kV;
- TSPB (block own services transformer), which has the role of converting the electricity produced at the generator terminals (24 kV), to the nominal supply voltage of the own services consumers included in the configuration of the technological flow scheme.

As can be seen from the single-wire electrical diagram presented in figure 1, in its configuration a general services transformer (TSG) is also interconnected, which has the role of supplying from the electrical network of the electricity distributor, the consumers of own services. The supply of consumers through the general services transformer takes place only during the start-up phase of the 330 MW energy groups. After the parallel entry of the electric power group with the National Energy System, through the switching apparatus, the supply of own services consumers is transferred from the general services transformer to the block own services transformer.

Considering the fact that in the configuration of a thermoelectric power plant there are several energy groups, in order to ensure the autonomy of each group's operation, it is necessary to use a own services transformer for each of them [2].

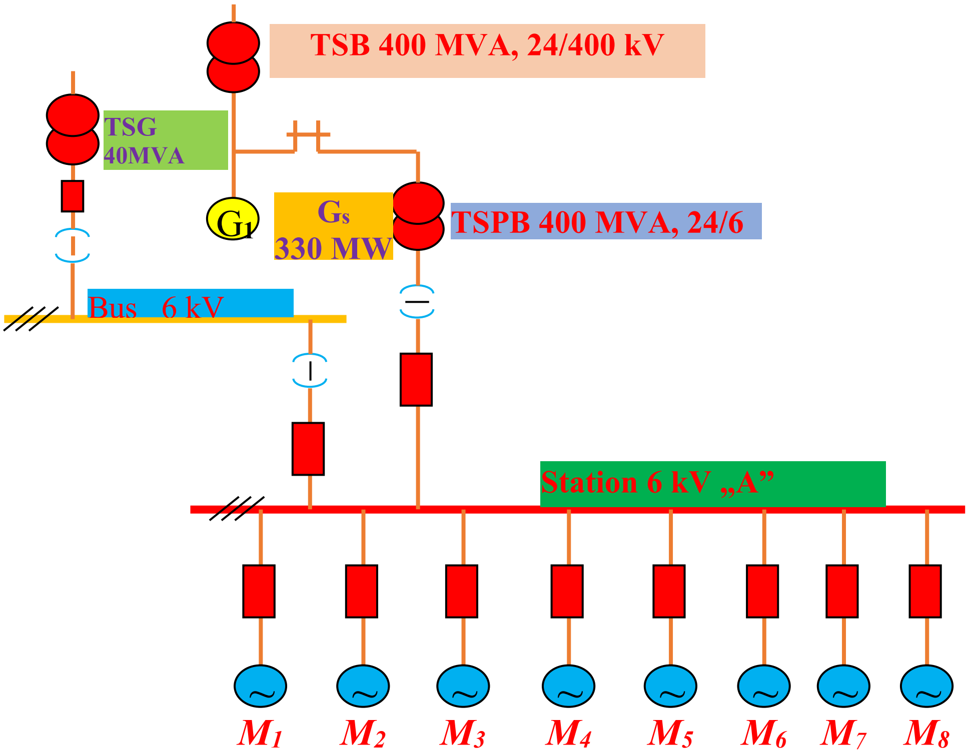

Figure 1. Single-wire electric power discharge diagram

2. ASPECTS REGARDING THE COOLING MODE OF 330 MW SYNCHRONOUS GENERATORS

The development of this work is supported by the complex cooling system of synchronous generators with a power of 330 MW, a system that incorporates water cooling of the stator windings, respectively, hydrogen cooling of the rotor windings. Starting from this consideration, it is necessary to specify that the water needed to cool the stator windings is taken from a river with a relatively high flow, located in the vicinity of the power plant. The cooling water is taken from the river through a dam and collecting channels, which feed the internal collection basins, from where the water is taken and directed to a chemical section, where it is subjected to demineralization and softening treatments. Table 1 shows the average values of the cooling water temperature taken from the rivers, for each season, associated with air temperature values [3].

Table 1

Temperature / *Season*	*The temperature of the water in the river [^0C]*	*Air temperature [^0C]*
Spring	*7*	*8.5*
Summer	*18*	*22*
The autumn	*9*	*10*
Winter	*4*	*0*

By referring to the parameters presented in table 1, in figure 2 we graphically highlighted the static dependence between the two temperatures, that of the cooling water coming from the river and that of the air.

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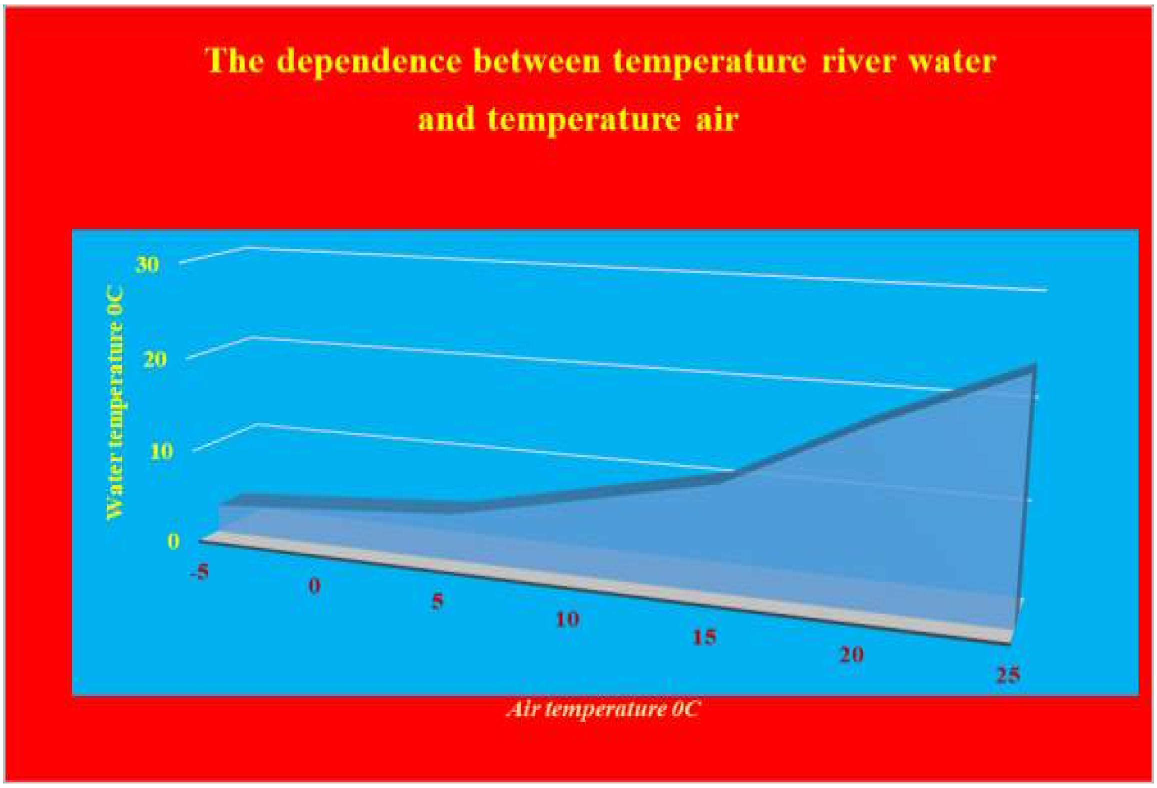

Figure 2. Variation characteristic between river water temperature and air temperature

It is well known that the synchronous generators with the power of 330 MW are synchronous machines that operate in generator mode and have the characteristic that the primary drive motor is a turbine with four bodies that mediates the achievement of the synchronism speed [1-5].

The rotor of synchronous generators with a unit power of 330 MW produces a rotating magnetic field that generates a time-varying magnetic flux, which chains the turns of each phase circuit of the stator winding and induces an electromotive voltage in each phase of the stator. The intensity of the electric current circulated through the windings of the synchronous generator, generates a heating of them depending on the load, which is why it is necessary to cool them. The evacuation of the heat produced inside the 330 MW synchronous generators as a result of the losses, is done using hydrogen and water as a cooling medium. Water is used in the cooling circuit of the stator of the synchronous generator after having previously undergone certain chemical treatments aiming at certain standardized parameters [1-11].

Hydrogen is necessary for filling the generator, replacing losses through leaks and additions in order to maintain the purity and pressure of the hydrogen in the generator. The hydrogen needed to cool the rotor of the synchronous generator is obtained through an electrolysis process, carried out in a hydrogen station, located inside the perimeter that delimits the thermoelectric plant [1-11].

In the synchronous generator rotor cooling installation, the hydrogen is cooled in turn or in heat exchangers mounted in the generator housing, the cooling water being demineralized water, provided by the thermal water treatment installations or condensate taken from the regenerative circuit of the group. Depending on how the heat is transferred from the active parts of the synchronous generator to the cooling medium, we distinguish two cooling possibilities [1-11]:

- direct cooling;
- indirect cooling

Direct cooling is characterized by the fact that the cooling channels traversed by the cooling medium are located in notches or even inside the elementary terminals of the windings, thus the heat developed in the conductors of the windings passes directly to the cooling medium. Indirect cooling is characterized by the fact that heat released in the windings reaches the cooling medium passing through the insulation of the conductors, the notches and through the iron of the magnetic core [1-11].

In figure 3 we presented the variation characteristic between the load load of a 330 MW synchronous generator and the hydrogen pressure.

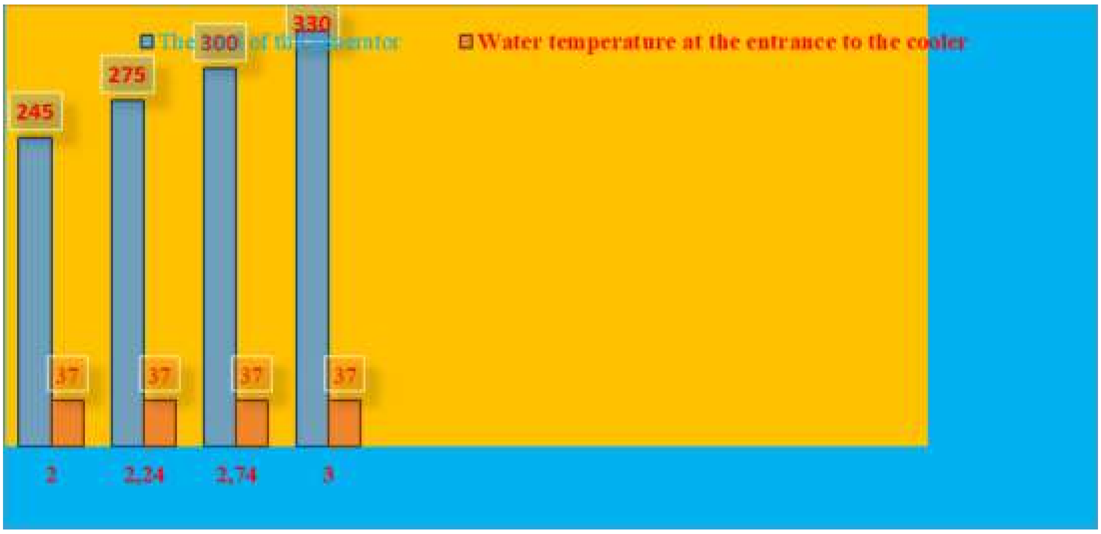

Figure 3. Dependence of hydrogen pressure in the generator and load load

3. CONCLUSIONS

By referring to the technical prescriptions recorded in the Book of the Synchronous Generator with the power of 330 MW and taking into account the statistical data from their exploitation activity, the following aspects can be concluded [11-12]:

1. The use of hydrogen as a cooling agent for 330 MW synchronous generators has the effect of reducing ventilation losses by approximately 14.3 times compared to air, under similar pressure and temperature conditions.
2. The reduction in ventilation power losses in hydrogen-cooled turbogenerators can be estimated at about 0.3-0.5 of the total losses, which equates to an increase in generator efficiency of about 1%.

3. The use of hydrogen as a cooling agent in 330 MW synchronous generators increases the operational security of electro-insulating materials and their life span, due to the fact that they are no longer affected by oxygen in the air and water vapor, and in the case of the apathy of a internal short-circuit mode, combustion is not maintained by hydrogen.

3 REFERENCES

[1]. Cartea tehnica a turbogeneratorului THA – 330 – 2

[2]. **Cristinel Popescu, Cornel Hațiegan, Cristinel Racoceanu, Andreea Cristina Bejinariu**-*Aspects on the influence of starting the own services consumers of an energy group with unit of 330 MW on the power supply*, Conference proceedings 21 th International conference KNOWLEDGE-BASED ORGANIZATION, pag.84-89, published Online,DOI: https://doi.org/10.15/kbo-2017- 0161.

[3]. **C. Moțoiu** – *Centrale hidro și termoelectrice*, E.D.P, București, 1975

[4]. **Popescu Cristinel** - *Aspects regarding the variation between load parameters and power delivered by 330 MW synchronous generators*, Annals of the „Constantin Brancusi" University of Targu Jiu, Engineering Series , No. 2/2022

[5]. **Cozma V., Panov V.,Popescu C.** – *Maşini electrice,Maşini de curent continuu şi transformatoare*, vol.1 . Ed. Sitech, Craiova, ISBN 978-606-11-2636-1, 2012

[6]. **Popescu Cristinel** - *Aspects regarding the inspecting and monitoring of insulation at medium voltage electrical cables used in power disdtribution systems*, Annals of the "Constantin Brâncuși" University of Târgu Jiu, Engineering Series, No. 1/2018, pp.62- 66.

[7]. **Cornel Haţiegan, Ioan Padureanu, Marcel Romulus Jurcu, Marius Biriescu, Mihaela Răduca, Flaviu Dilertea**, *The evaluation of the insulation performances of the stator coil for the high power vertical synchronous hydrogenerators by monitoring the level of partial discharges*, Electr Eng, Vol. 99, Nr. 3 2017

[8]. **Popescu Cristinel, Racoceanu Cristinel** - *Aspects regarding the efficiency achievedby replacing the auxiliary generator with electrical transformer of 20/0.6 kV at the synchronous generators of 330 MW*. International Multidisciplinary Scientific GeoConference-SGEM Pages: 79- 84 Published: 2016, DOI:10.5593/SGEM 2016/B12/S03.011,

[9]. **C Haţiegan, CP Chioncel, E Răduca, C Popescu, I Pădureanu, MR Jurcu, D Bordeaşu, S Trocaru, F Dilertea, O Bădescu, IM Terfăloagă, A Băra, L (Barboni) Haţiegan**, *Determining the operating performance through electrical measurements of a hydro generator*, IOP Conference Series: Materials Science and Engineering, Hunedoara 2016, Volumul 163, Nr.1, 2017

[10]. **Cornel Haţiegan, Ioan Hălălae, Cristinel Popescu, Nicoleta Gillich, Luminiţa (Barboni)Haţiegan, Eugen Răduca, Lidia (Filip)Nedeloni**, *Evaluation Insulation of the Stator Coil a Hydro-Generators Through Monitoring the Level of Partial Discharges*, Annals of „Constantin Brâncuşi" University of Târgu Jiu, Nr. 3., 2016.

[11]. **Guzun Basarab Dan, Gal Stelian Al., Darie George, Olovinaru Dan**- *Centrale, stații și rețele electrice. Elemente de bază*, Editura Academiei Române, București, 2005

[12]. Instrucțiuni de exploatare grup energetic 330 MW