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Questions of Control of Asynchronous Generators Used at HPP and WPP Stations

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ABSTRACT: The article is based on the advantages of an asynchronous generator when using a phase rotor asynchronous generator instead of a synchronous generator for small HPPs and WPPs. Due to the simplicity of connecting the asynchronous generator to the network, the possibility of using WPP, mini- and micro-HPP, both autonomously and in the mode of transmission of electricity to the network is described. When used in stand-alone mode by connecting a capacitive compensator parallel to the stator winding, the power factor of the asynchronous generator must be close ($\cos\varphi \approx 1.0$) and based on minimizing power losses in the power line.

KEY WORDS: asynchronous generator, WPP, mini- and micro-HPP, mechanical characteristics, power factor, electromagnetic torque, energy saving, mode generator.

I.INTRODUCTION

In recent decades, large investments have been made in the widespread use of hydrocarbons. Currently, the total amount of fossil fuels used worldwide is 12 billion tons. tons of oil equivalent. That is, the amount of fossil fuel production over the last forty years is greater than the amount of hydrocarbon reserves mined in all of human history. However, conventional energy reserves are limited [1-3].

In addition, due to the chronic consumption of hydrocarbon resources, the environment and human health are deteriorating, climate change is taking place, and the ozone layer is being depleted. Experts estimate that 5 billion tons of carbon dioxide is released into the atmosphere each year. tons of carbon dioxide, about 300 mln. tons of carbon monoxide. This is 3.5 times more than in the first half of the twentieth century [1,4].

Under these conditions, the wider application of alternative energy sources is on the agenda. The reason is that their species, such as solar, hydro and wind energy, biomass, are almost unique and can be regenerated, which is very relevant to the current period of rapid innovative development, which is aimed at creating new jobs. In addition, the equipment and technology working on this basis is environmentally friendly, environmentally friendly, does not lead to man-made disasters.

Consequently, a number of countries are now increasingly implementing projects aimed at the development of the sector, for which they are investing, supporting promising developments and research. In this way, it is building bases and infrastructure for the production of electricity and heat [5-7].

Raising the level of research and introduction of renewable energy resources in the country, finding timely organizational, legal, scientific, technical, innovative solutions to existing problems is important for the country's development, improving the welfare of the population, public health, environmental transparency.

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In order to increase the reliability of electricity supply to consumers in the electricity sector of the country, in recent years, special attention has been paid to the introduction of renewable energy sources. The results of wind parameters measurements in Uzbekistan by a consortium of companies Inter Gopa and Geonet show that Uzbekistan's wind energy potential exceeds 512 GW. According to the German company Fichtner, the hydropower potential of the country's small mountain rivers is more than 4 million kW. According to the concept of energy development of the Republic of Uzbekistan until 2030, wind power plants (WPP) with a total capacity of 3,000 MW and small hydropower plants (HPP) with a total capacity of 600 MW will be built [1-2].

II. RESEARCH PROBLEM AND METHOD

The use of phase rotor asynchronous generators (AG) in such power plants significantly reduces the cost of the device, simplifies the process of their production and operation, simplifies the process of parallel operation with the network. In generator mode, due to the wide variation of the primary energy parameters, the rotational speed and slip of the rotor also change in a sufficiently wide range. Therefore, the mechanical characterization of AG constructed using analytical methods is quite different from that constructed using experimental data. Due to this situation, it is not possible to assume that the parameters of the asynchronous machine electrical switching circuit for the generator mode are constant [8].

The general view of the analytical expression of the electromagnetic moment of an asynchronous machine is as follows:

$$M = \frac{m_1 r' p U_1^2}{2\pi * f * s\left[(r_1 + r_2'/s)^2 + (x_1 + x_2')^2\right]} \tag{1}$$

where m_{1-} is the number of phases of the stator winding; p-stator winding number of pairs of poles; U-It is the stator winding voltage; f_1–requency of stator current; s- rotor slip; r_1 –stator shield active resistance; r_2'-rotor coil is provided active resistance; x_1-stator winding inductive resistance; x_2'-rotor winding inductive resistance.

All quantities except slip s in expression (1) assumed to be constant, it is proportional to the mechanical load on the shaft changes. Expression (1) can be used to construct the mechanical characteristics in Figures 1 and 2. In this case, the parameters are replaced by values, and then the mechanical description sought for the asynchronous generator is constructed by assigning different values to the slip.

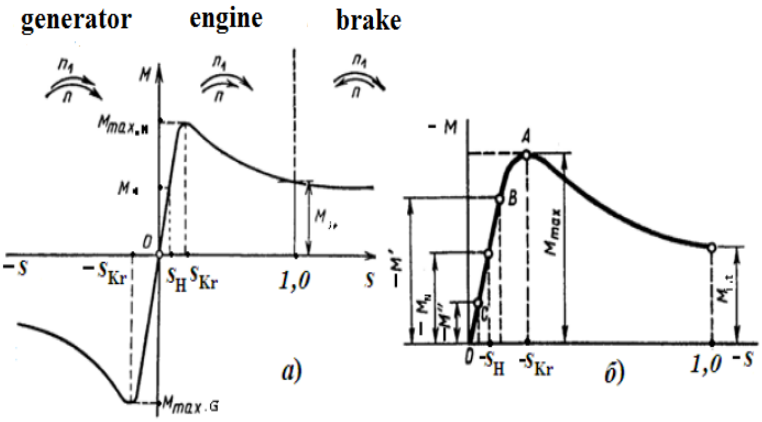

Fig. 1. Asynchronous machine generator (b) and all built-in mechanical characteristics for other modes (a)

The slip corresponding to the maximum torque is called the critical slip s_{kr}. To determine its value (assuming that the parameters are constant), we analyze the moment function, that is, take the first product of the slip from the moment and set it to zero (dM / ds = 0), for the general case we have the following result.

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$$S_{kr} = \pm c_1 r_2' / \sqrt{r_1^2 + (x_1 + c_1 x_2')^2} \quad (2)$$

Since the value is much smaller, $r_1 \approx 0$ is an expression for determining the critical slip s_{kr} will have the following appearance

$$S_{kr} = \pm r_2'/(x_1 + x_2') = r_2' 2/x_{qt} \quad (2.a)$$

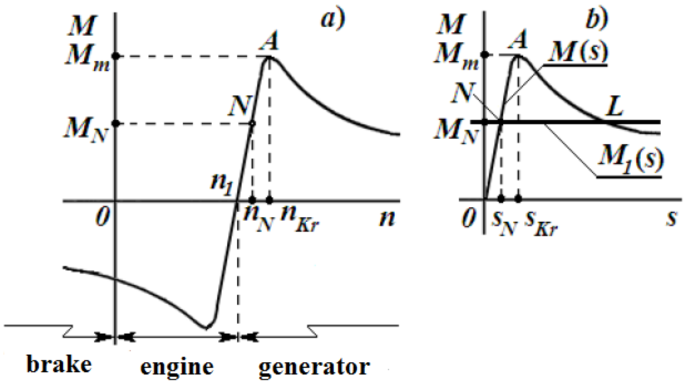

Fig. 2. Mechanical characteristics of asynchronous generator

Determining the value of the maximum (critical) moment M_{max} for (2) by setting the value of s_{kr} to (2. a) is

$$M_{max} \approx \pm \frac{1}{2} \frac{m_1 p U_1}{2\pi f_1 * c_1 \left[\pm r_1 + \sqrt{r_1'^2 + (x_1 + c_1 x_2')^2} \right]} \quad (3)$$

(2), (2.a) and (3) the positive (+) sign indicates the motor mode. miga, and the negative (-) sign refers to the generator mode (Figure 2.21, b). Active resistance of the stator winding for asynchronous machines of the sum of inductive resistances [$r_{1<<(x1+x2)}$ approx 10÷12 percent] because it is much smaller As $r_1 \approx 0$, we define a simplified expression of M_{max}

$$M_{max} \approx \pm \frac{1}{2} \frac{m_1 * p * U_1}{2\pi * f_1 * (x_1 + x'_2)} \quad (3.a)$$

The analysis of expression (3) shows that when an asynchronous machine is operating in generator mode, its maximum torque $M_{max.G}$ is greater than the maximum torque in motor mode $M_{max.}$ M.

Maximum torque multiplicity of asynchronous machines $k_M = M_{max} / M_M$. Strictly defined by the State Standard, i.e. $k_M \geq 1,8$. Some special asynchronous machines are k M 's value reaches 3.0. This coefficient is an asynchronous machine characterizes the ability to overload.

III. RESULTS

The following important conclusions can be drawn from the analysis of the expressions of electromagnetic torque and power losses of the rotor coil:

1) The active resistance of the critical slip s_{kr} rotor chain changes in proportion to r'$_2$;
2) The value of the maximum torque M_{max} does not depend on the active resistance of the rotor chain r'$_2$;

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3) The maximum torque of the induction motor M_{max} and the overload capacity k_M are mainly the inductive resistances between the stator and rotor windings (x_1 and x_2, respectively). inversely proportional to the sum;
4) The maximum torque M_{max} is proportional to U_1^2 as in any slip moment, i.e. the overload capacity of the motor decreases sharply when the applied voltage decreases.

M = f (s) - the nature of the change in the motor mode of the mechanical characteristic is explained as follows. If the load torque is exceeded from the no-load mode, the slip s increases. In this case, the following expressions are sufficient to calculate the current I'_2 passing through the resistance of the rotor chain of the active-inductive character and its angle ψ_2 lagging behind EMF E'_2 in this chain, mainly the rotor current I'_2 and the phase shift angle ψ_2 increase, cos ψ_2 decreases.

$$I'_2 = \frac{s*E'_2}{(r'_2+js*x'_2)} = \frac{E'_2}{\frac{r_2}{s}+jx_2} \quad (4)$$

$$\psi_2 = \text{arctg}\frac{x_{2s}}{r_2} = \text{arctg}\frac{s*x_2}{r_2} = \text{arctg}\,\frac{x_2}{r_2/s} \quad (5)$$

As the slip increases, the inductive nature of the rotor current increases, while its active component increases first (at a small time ps2) and then decreases (regardless of the increase in total current) (3, Fig. B), because EMF E'_2 and current I'_2 The displacement angle I'_2 between ψ_2 increases.

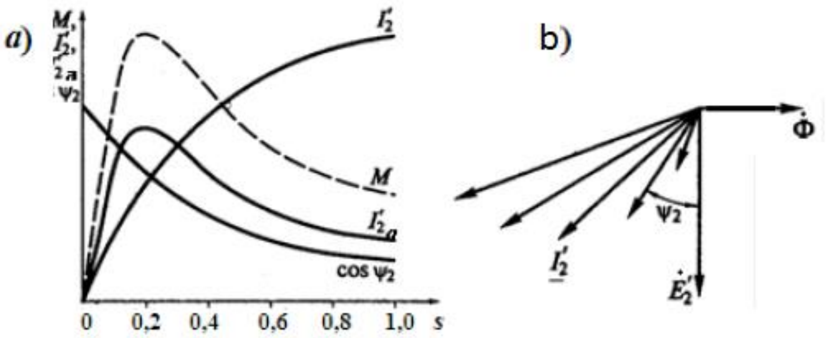

Fig. 3. Mechanical description of an asynchronous machine

The mechanical characteristics of a phase rotor asynchronous motor at different rotor resistances (Fig. 4.) are shown in Fig. 5. According to him, the torque of the turbine is M Turb. = Cons. The value of the rotor electric circuit r'21 corresponds to 1 point of the mechanical characteristic, the value of the rotor speed and the amount of rotor slip $S_1=(n^I-n_I)/n_I$.

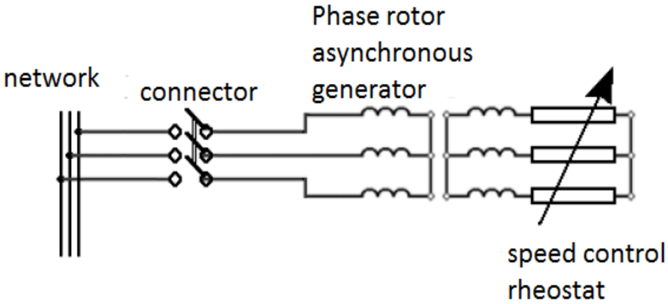

Fig. 4. Phase rotor asynchronous generator circuit diagram

At r'$_{2II}$ of the rotor resistance, 2 points, $S_{(II)}$ slip and n^{II} rotor rotation speed, respectively, correspond. This means that as the values of r'$_2$ change, the slip changes to $S=S_{(I)\div)}0$ and the rotor speed varies from $n=n_1$ дан $n=n_{max}$

This method can be used in the range where the rotor speed is nmax>n>n1 between the speed of the ideal no-load mode and the maximum speed. The maximum speed of the rotor is the maximum rotational speed that can ensure the static and dynamic reliability and stability of the mechanism of the rotating part of the WPP and HPP.

There is no need for any, complex or simple device used in synchronous generators to connect asynchronous generators in parallel with the network. It is possible that the stator winding of an asynchronous generator, which rotates the rotor at a speed close to n1 with the help of a hydraulic turbine or two wind wheels, is connected directly to the network by means of a "connector" (Fig. 4). In this case, the stator current is not several times greater than the rated current in synchronous generators, and the situation is not as serious as when the rated current at the start of two asynchronous motors is 4 ÷ 7 times higher than the rated current. Perhaps the current in the stator winding of an asynchronous generator is close to the rated current.

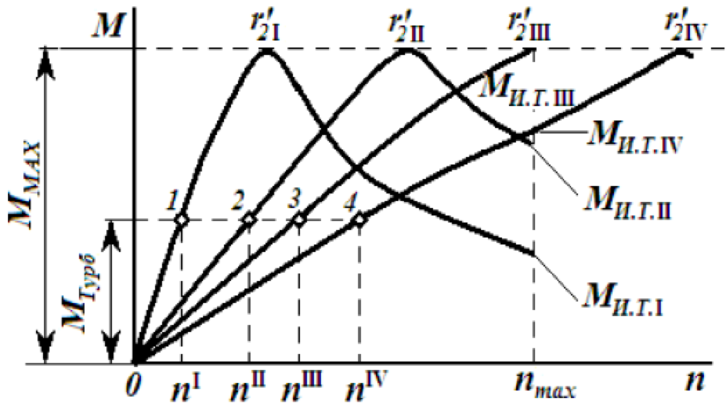

Fig. 5. Rotor winding active resistance effect of mechanical characteristics of the generator

IV. CONCLUSION

Thus, when small HPPs and WPP s use a phase rotor asynchronous generator instead of a synchronous generator, the following undoubted advantages of an asynchronous generator are obvious:

1. Asynchronous generators have a simple structure, small weight and dimensions, so their cost is 1.5 ÷ 2.0 times cheaper.

2. Due to the simplicity of connecting the asynchronous generator to the grid, it is possible to use WPP, mini- and micro-HPPs at the same time, both in autonomous and grid power transmission modes, and only in autonomous and only grid power sales modes. When used in stand-alone mode, it is necessary to connect a capacitor compensator (CC) in parallel with the stator winding.

When connecting such a power plant to the grid, KK ensures that the power factor of the generator is close together ($\cos\varphi \approx 1.0$) and that power losses in the transmission line are minimal. These features of the asynchronous generator fully meet the needs of private entrepreneurs, allowing the existing power system - a state-owned company to produce cheap electricity at no cost to capital construction.

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