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# STUDY OF THE INFLUENCE OF DIFFERENT DESIGNS OF MASSIVE ROTOR OF ASYNCHRONOUS GENERATOR ON THEIR MAXIMUM POWER

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**Abstract.** The article deals with the experimental results of the short-circuit experience, active and inductive resistances of a massive rotor with short-circuited copper cells. And also experimental mechanical characteristics of model asynchronous generators with different massive rotors at the same overall power have been studied.

It is known that in order to increase the efficiency of modern electric power systems operation, it is necessary to create reliable and economical sources of active power. Researches show that asynchronous georators (AG) without traditional windings on the rotor with stator excitation largely meet these requirements [1-4].

The reactive power consumption of AG is compensated by static reactive power sources or synchronous compensators.

When calculating the transient processes of AG, a static mechanical characteristic is used, which is usually presented in the form of a refined Kloss formula obtained under the condition that the parameters of the substitution scheme are constant, i.e., it does not take into account the saturation of the magnetic circuit scattering paths and the current displacement in the short-circuited rod at large slips (S ' Skr) [5-8].

In AG with power over 10 kW there is a relatively high saturation of the scattering and current displacement paths. Consequently, the torques calculated according to the above formula differ significantly from the actual values obtained experimentally, although modern methods of calculating AG make it possible to calculate with sufficient accuracy for practice all mechanical characteristics of individual points. However, it is necessary for each speed to determine the parameters of the substitution scheme, taking into account saturation and displacement [9-12].

To provide the necessary convergence of calculation of mechanical characteristics of AG with gear and short-circuited massive rotors with experience in the presence of saturation of the magnetic circuit and current displacement, the following formula is fair (in relative units):

$$M = 2\text{Км}(1 + q + \alpha S)/(S/S\text{кр} + S\text{кр}/S + 2q + 2\alpha S); \quad (1)$$

$q = r1/r2'$. where: Км – multiplicity of the maximum moment.

г1 – active stator resistance;

г2' – given active rotor resistance.

The coefficient α can be determined by substitution in (1) the values of any characteristic point of the torque curve. Such a point can be taken as the starting torque point. In this case, it can be taken as a starting point:

$$\alpha = 1/2\text{Кп}(\text{Км} - \text{Кп})(1/S\text{кр} + S\text{кр}) - \text{Км}/(\text{Км} - \text{Кп}) - q; \quad (2)$$

where: Кп – multiplicity of starting torque.

If at calculation on (2) factor $\alpha = 0$, This means that AM has no saturation or displacement, and the formula itself is converted to the usual Clause formula [13-16].

The calculated mechanical characteristic of an AG with a smooth massive rotor is determined from the expression:

$$M = 2\text{Км}(1 + q + \alpha S)/(\sqrt{S/S\text{кр}} + \sqrt{S\text{кр}/S} + 2q + \alpha S); \quad (3)$$

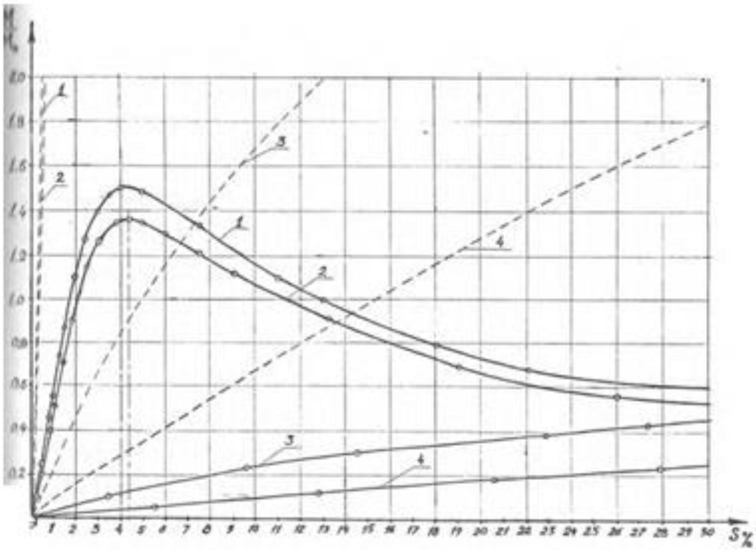
where α – also determined by (2).

Experimental studies to determine the maximum capacity of AGs with various massive rotors were carried out on the electrodynamic model of the Department of "Electrical Networks and Systems" of TashGTU, which contains model AGs with massive rotors of the following configurations: smooth, toothed and two squirrel-cage rotors with copper rods in the number $Z_2 = 48$ and $Z_2 = 80$ pieces [17-21].

The experiment scheme consists of a primary motor - model DC motor (DPT) of independent excitation and model AG, the power of which is transmitted to the system through an inductive regulator (IR), with a power of Sn = 160kVA, to maintain a constant voltage (U = Const) on the terminals of the test AG when the slip S changes [22-24].

Taking into account insufficient power of DPT at removal of full mechanical characteristics of all AGs, the test was carried out at low voltage U=87 V. In the process of their gradual increase in the generated active power (increased slip) led to voltage planting, despite the powerful IR, which is associated with an intensive consumption of reactive power. As a result, there was an additional increase in slippage, which was suppressed by voltage recovery by regulating the DI. The phenomenon of relative voltage planting with increased slippage was strongly manifested in AG with squirrel-cage massive rotors (SMCR), weakly in AG with smooth massive rotor (SMR).

Experimental mechanical characteristics of the model asynchronous rotors generators. (Pn = 5 kW, U = 230V).



1-rotor is massive with copper short-circuited cells, Z2=80.
2-rotor solid with copper squirrels, $Z_2$= 48.
3-rotor solid toothed, $Z_2$= 48.
4-rotor solid smooth.
____ at:$U_L$ = 87 V (experiment).
------- at: $U_L$ = 230 V (calculation)

As it is visible from the experimental mechanical characteristics resulted in figure, AG with K.Z rotors (curves-1,2) have the high power indicators from the mode point of view it is quite acceptable: steep in ascending part and gentle in descending part. It is also characterized by a sharp decline in critical slip and an increase in maximum power. AG with GMR has a less steep characteristic (curve-4), as the equivalent active rotor resistance is high, and, consequently, the critical slip is the largest.

AG with GMR has a less steep characteristic (curve-4), as the equivalent active rotor resistance is high, and, as a result, the critical slip is greatest. Sharp reduction of critical sliding and increase of maximum power (curve-3) is the result of special copper short-circuit rings and longitudinal slots on the rotor surface - toothed massive rotor (GMR) - which contribute to the reduction of this resistance. On the other hand, the launch of AG in the motor mode with the least active rotor resistance is not possible due to the low starting torque, which corresponds to the motor mode of AG with KZMR [25-27].

As a result of recalculation of the maximum active power received experimentally-tally (solid curves) by the nominal voltage, on the basis of the known quadratic voltage dependence at the same critical slips and at the overall active power of 5 kW, we obtain the following overload capacity (Km) of each AG**.**

**Table 1.**

| Model AG type | Kм | Sкр,% |
|---|---|---|
| GMR | 2,1 | >100 |
| with ZMR, Z2=48 | 3,6 | 39 |
| from the CMMR, Z2=48 | 9,5 | 4,3 |
| with CPMR, Z2=80 | 10,45 | 4 |

**Table 2.**

| Model AG type | $I_o$ | $\cos\varphi_н$ | $I_н$ |
|---|---|---|---|
| GMR | 8,9 | 0,54 | 12,627 |
| with ZMR, Z2=48 | 14,35 | 0,584 | 19,683 |
| from the CMMR, Z2=48 | 13,83 | 0,84 | 27,84 |
| with CPMR, Z2=80 | 15,75 | 0,87 | 34,855 |

Comparison of AG with GMR and normal (blended) AG from the point of vision developed by their of moment Mvr with the sum of electromagnetic Maem and dampening Md, which converts excess kinetic energy into heat energy losses in the rotor circuits depending on the value of the active resistance of the rotors. Losses in KZMR from induced currents even in the critical sliding area do not cause dangerous heating of the array due to its small value.

Knowing the Km, it is possible to set the values of nominal currents of the investigated model AG for various massive rotors on the basis of the results of no-load, short-circuit experience and by the known nominal values cosφн from the expression:

$$I_н=I_o/K_o=I_o/(\sin\varphi_н–K_м\cos\varphi_н(1-\sqrt{}1-1/K^2_м)) \qquad (4)$$

here: $I_o$, $K_o$ - current and idle speed.

## Conclusions

1. As a comparison of the results of the short-circuit experience shows, the active and inductive resistances of a solid rotor with short-circuited copper cells are much smaller than the corresponding resistances of a smooth solid rotor for the same rotor sizes.
2. The introduction of empirical corrections into the refined formula of the Class of Empirical Corrections taking into account the influence of the magnetic saturation of a circuit and current displacement in a massive rotor, gives more accurate convergence of the calculated mechanical characteristics of AG with different massive rotors in comparison with experimental ones. Therefore, it allows to take into account mechanical characteristics quite accurately in the calculations of electromechanical transients.
3. The above experimental mechanical characteristics model AGs with different massive rotors at the same overall capacity show that AGs with massive short-circuited rotors have a great advantage over AGs with other configurations of massive as well as normal rotors in terms of basic energy performance.
4. Increasing the overall power of AGs with massive rotors leads to a reduction of Vkr and increased Mkr, i.e. at load AGs have sufficient small slides, provide minimal losses in the rotors and high efficiency, etc.

Experimental studies show that the reviewed model AGs with various massive rotors in the range of slip variation S from 0 to 100% work deviceically.

maximum rotating moments shows that the maximum moments of

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