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NEW DESIGN INDUCTION GENERATOR FOR WIND TURBINES

Introduction. Generally, wind power plant engines are slow-speed; therefore, the use of traditional synchronous generators for production of electric voltage with frequency of 50Hz requires mechanical speed-up units resulting in plant design complication, weight increase and operational reliability degradation. Alternatively, it is possible to use low-speed synchronous generators, but in order to produce voltage with frequency of 50Hz, they must have a large number of poles, which would also result in size and weight increase.

Low-speed induction generators for the wind power plants. Conventional synchronous generators with the electromagnetic excitation have a brush assembly with the sliding contacts for direct current supply to excitation winding, which complicates their design and reduce operational reliability. Multipolarity is relatively simply implemented in the designs of induction generators [1] being a kind of classic synchronous machines. Such generators are non-contacting (excitation winding is stationary), simple in design and more reliable as compared with other types. Estimated power of induction generator is determined according to following formula [2]:

$$P_i = 0{,}164\alpha_i K_f K_r K_\sigma B_\delta A D^2 l_\delta n\,, \tag{1}$$

where α_i is estimated pole overlap coefficient; K_f, K_r are magnetic excitation flux shape coefficient and winding coefficient, respectively; K_σ is magnetic excitation flux leakage coefficient; B_δ is maximum value of magnetic induction within the air gap; A is linear load of stator winding; n is rotor rotation frequency;

Active materials (windings copper and magnetic core electrotechnical steel) utilization efficiency is characterized by the specific coefficient, of which expression results from (1):

$$K_A = \frac{P'}{D^2 l_\delta} = 0{,}164\alpha_i K_f K_r K_\sigma B_\delta A \tag{2}$$

In the conventional induction generator designs, value B_δ is limited by the magnetic saturation of stator teeth and does not exceed 0.9T, and value A is limited by the cooling conditions and stator winding insulation thermal endurance. In case of air-cooled machines $A \le 5 \cdot 10^4$ A/m. The value K_σ for the conventional induction generators makes $0{,}4 \div 0{,}45$. It is apparent that the value K_A and therefore generator power within the set dimensions could be increased by the proper affecting values K_σ, B_δ *i* A. Let us consider induction generator design [3], which provides the increase of values B_δ and A. The longitudinal generator section is shown in Fig.1.

Cylindrical rotor bushing 3 is fixed on shaft 1 by means of disks 2; toothed radial packages 4 and 5 assembled of the insulated electrotechnical steel laminations are mounted on the bushing external surface with mutual axial displacement. Packages teeth are mutually circumferentially displaced by the geometrical angle π/z_2, where z_2 is number of teeth per package.

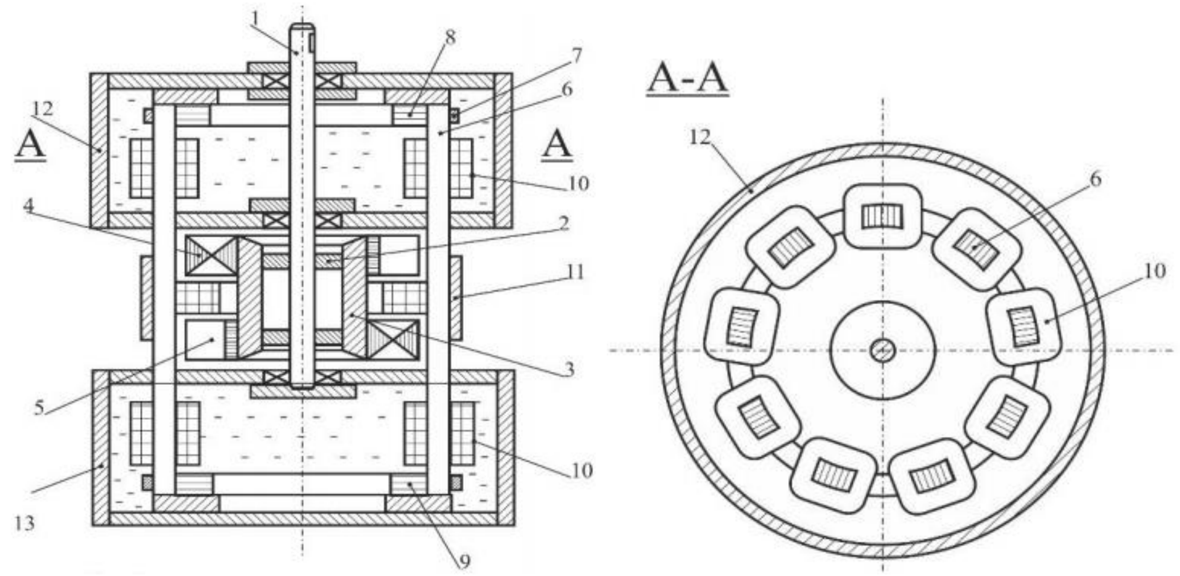

Figure 1 – Longitudinal and cross-sectional view of the generator

Stator is made with magnetic core in form of separate longitudinal packages 6 located circumferentially outside the rotor teeth. Packages are assembled of the radially directed electrotechnical steel laminations. Ends of packages 6 are pressed by clamps 7 against the external surfaces of cylindrical laminated packages (yokes) 8 and 9. Coils 10 of upper and lower stator winding portions are located on the packages 6 portions projecting outside the rotor. In the heightwise midportion of generator, longitudinal packages are bonded to each other by non-magnetic alloy filled in the gaps between them. In case of three-phase generator, number of longitudinal packages is set according to formula: $z_1 = 2z_2 \pm K$, where $K = 1, 2, 3...$ and z_1 must be multiple of three. In gaps between the rotor toothed packages, toroidal excitation winding 11 is located with its external surface attached to the longitudinal packages 6. Both stator winding portions along with the respective yokes and portion of longitudinal packages are placed in the closed casings 12 and 13 filled with the dielectric liquid. External surfaces of casings can be provided with the cooling devices, as necessary.

When direct current is supplied to excitation winding and wind engine rotates the rotor, teeth of packages 4 and 5 continuously change their positions in relation to the internal surfaces of longitudinal stator packages causing change of magnetic flux size and direction in the latter ones. These fluxes link the coils of both stator winding portions causing development of electromotive force (EMF) with frequency $f = z_2 n / 60$.

Summary.

1. The formula is derived for the estimated power of new design induction generator. Possibilities to increase this power amount are shown.
2. The analysis is conducted of induction generator parameters with the doubled number of longitudinal stator packages rows, which allows increase in estimated power as compared to the baseline design.

References:

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