CALCULATION OF ELECTROMAGNETIC PARAMETERS OF AXIAL GENERATOR OF LOW POWER

ЭЛЕКТРОМАГНИТНЫЙ РАСЧЁТ ЭКСПЕРИМЕНТАЛЬНОГО 3-Х-ФАЗНОГО СИНХРОННОГО ВЕТРОГЕНЕРАТОРА

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Abstract: *In this article, there is considered calculation of electromagnetic parameters of axial wind generator on 3 phases of AC, which partly may cover some of demand in electric energy.*

Key words: *B – magnetic induction [Tl]; D − average value of the diameter of the rotor [m]; E – electromotive force (EMF) [V]; l – length of active part of wire [m]; v (ω)– velocity [m/sec (turn/sec)].*

For calculating EMF of generator, we used classic Faraday's formulation:

$E = B \cdot l \cdot v$. Value of magnetic induction, created by neodymium magnets, we took according to technical literature equals 0,7÷1,0 Tl. Active part of wire, the part witch covered by magnets $l = 0{,}05$ m. Length of circle, on witch located magnets $L = \pi \cdot D$, where $D = 0{,}25$ m, so after one rotation the magnet passes length $L = 3{,}14*0{,}25 = 0{,}785$ m, that means, EMF in wire of 0,05 m, crossed lines of uniform electromagnetic field with magnetic induction B = 0,8 Tl with velocity 0,785 m/sec equals E = 0,8 · 0,05 · 0,785 ≈ 0,03 V.

In calculating were accepted next concessions:

- the electromagnetic field in zone of magnet's location we considered as uniform;
- the reactive resistance of wires was accepted as insignificant (cosφ = 1);
- the temperature in every part of generator is constant.

Every phase A, B and C of stator is composed by 3 connected in coils series of cooper wires located on circle at an angle 120 degree. Coils series of stator may be connected between each other either in «star» (Y) or «triangle» (Δ). In case of «star» (Y) connection the voltage and resistance increases in $\sqrt{3}$ times, compared to «triangle» (Δ) connection.

Below given starting values for calculating of electric parameters of 12V generator:

I_r = 8 A – rated load current;

w_1 = 36 turns – number of turns of wire in one coil of the stator

n = 4 coils – the number of coils in one phase of the stator;

k = 0,75 – the coverage ratio of the turns of the coil magnetic field;

l_{AV} = 0,22 m – the average length of one turn of stator coil.

Consider calculating for «star» (Y) connection in next order:

1. Rated load current I_r, = 8 A, therefore accepted permissible density of current for cooper wire j = 2 A/mm^2, we took for coils the wire with diameter equels $Ø_{Cu}$ = 2×1,63 mm (double wire). The total cross-sectional area of the wire is $S = 2 \cdot \pi \cdot Ø^2_{Cu} / 4 = 2 \cdot 3{,}14 \cdot 1{,}63 / 4 = 4{,}17$ mm^2.

2. EMF of idle running on each phase we found as

$E_{1Y} = 2 \cdot \sqrt{3} \cdot k \cdot E \cdot n \cdot w_1 = 2 \cdot 1{,}73 \cdot 0{,}75 \cdot 0{,}03 \cdot 4 \cdot 36 = 11{,}21$ V. The coefficient 2 in the formulation indicates that the EMF is induced in both sides of coil turn. The vectors of the EMF will be directed according to the contour of the coil, which means it will be formed.

3. Electrical resistivity according to technical literature for 1 meter of cooper wire in 20°C with S = 4,17 mm^2 equals R_r = 0,0042 Om×m.

4. Voltage on each phase of generator with $I_н$ = 8 A found from the formulation: $\Delta U_{1Y} = I_r \cdot R_r \cdot l_{AV} \cdot n \cdot w_1 = 8 \cdot 0{,}0042 \cdot 0{,}22 \cdot 4 \cdot 36 = 1{,}06$ V.

6. Power that produces on each phase equals:

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$\Delta P_{1Y} = I_r \cdot \Delta U_{1Y} = 8 \cdot 1{,}06 = 8{,}48$ W.

7. Linear voltage at the terminals of the generator at I = 8 A can be determined as:
$U_Y = E_{1Y} - \Delta U_{1Y} = 11{,}21 - 1{,}06 = 10{,}15$ V.

8. Calculate the useful power of one phase at nominal load current $I_r = 8$ A. $P_{1Y} = I_r \cdot U_Y = 8 \cdot 10{,}15 = 81{,}2$ W.

9. Calculate the output power of the generator at the rated load current
$P_{3Y} = 3 \cdot P_{1Y} = 3 \cdot 81{,}2 = 243{,}6$ W.

10. Define the average value of the EMF after the semiconductor bridge diode rectifier: $E_{AV} = 2{,}34 \cdot E_{1Y} = 2{,}34 \cdot 11{,}21 = 26{,}23$ V.

Results and discussion

The results of electromagnetic calculation of the 12-volt three-phase generator are summarized in Table 1.

Table 1

ω, turn/sec	ω, turn/min	E_{1Y}, V	U_Y, V	P_{1Y}, W	P_{3Y}, W	E_{AV}, V
1	60	11,21	10,15	81,2	243,6	26,23
2	120	11,21	10,15	81,2	243,6	26,23
3	180	22,42	20,3	162,4	487,2	52,46
4	240	33,63	30,45	243,6	730,8	78,69
5	300	44,84	40,6	324,8	974,4	104,92
6	360	56,05	50,75	406	1218	131,15
7	420	67,26	60,9	487,2	1461,6	157,38
8	480	78,47	71,05	568,4	1705,2	183,61
9	540	89,68	81,2	649,6	1948,8	209,84
10	600	100,89	91,35	730,8	2192,4	236,07

The actual parameters of the generator will differ from the calculated values in the lower side due to the presence of assumptions mentioned above. In addition, the additional power losses are not taken into account in the calculation will occur in the electric cable, the diode rectier and so on.

Conclusion

In the article considered and solved the following tasks:

1. The principle of operation of electric generator.
2. The proposed method of electromagnetic calculation of the experimental 3-phase generator.
3. The calculation of operational characteristics.

Bibliography

1. Bezrukikh P. P. Wind Energy. (A reference and textbook). – Moscow : publishing house Energy, 2010. – 320p.
2. Kharitonov V. P. Autonomous wind power installation. – Moscow : GNU, 2006. – 280 p.