

5.5 Computer program: Design of Stator main dimensions

Problem:

Calculate diameter of core, length, size and number of conductors for a 15000kVA; 50Hz; 11kV ; 2 – Pole star connected salient pole cylindrical rotor alternator with armature winding having 60 phase spread. Assume :

avg. magnetic flux $B_{av} = .55\text{Wb/m}^2$

electrical loading $a_c = 36,000\text{ amp/m}$

current density $J = 5\text{ amp/mm}^2$

peripheral speed $V_a = 160\text{m/sec}$

windings should be arranged to eliminate 5th harmonic.

Synchronous speed $N_s = 50\text{ r.p.s}$

Solution:

Given $N_s = 50\text{ r.p.s}$ and $P = 2\text{ poles}$

Peripheral speed $V_a = 160\text{m/sec}$

$$V_a = \pi \cdot D \cdot N_s$$

$$\text{Therefore } D = V_a / (\pi \cdot N_s) = 160 / (3.14 \cdot 50) = 1\text{ m}$$

Now Distribution factor for 60 phase spread in order to eliminate 5th harmonic

$$K_d = .955$$

$$\cos(5\alpha/2) = 0$$

$$\text{giving } 5\alpha/2 = 90$$

$$\text{giving } \alpha = 36^\circ$$

$$\text{Pitch factor } K_p = \cos(\alpha/2) = .951$$

$$\text{Now } K_w = K_p \cdot K_d = .951 \cdot .955 = .8595$$

$$\text{Now } C_o = 1.11 \pi^2 \cdot f \cdot B_{av} \cdot a_c \cdot K_w = 1.11 \cdot 3.142 \cdot 50 \cdot .55 \cdot 36000 \cdot .8595 = 186.248$$

$$D^2L = P/(Co*Ns)$$

$$L = 15000/(186.248*50*12) = 1.6\text{m}$$

$$\text{Flux } \Phi = \pi * D * L * B_{av} = 3.14 * 1 * 1.6 * .55 = 2.76\text{Wb}$$

$$\Phi_{\text{pole}} = \Phi / \text{pole} = 1.38\text{Wb/pole}$$

$$T_{\text{ph}} = E_{\text{ph}} / (4.44 * f * K_w * \Phi_{\text{pole}}) = (11000 / \sqrt{3}) / (4.44 * 50 * .8595 * 1.38) = 24$$

$$\text{Total conductors } Z = 6 * T_{\text{ph}} = 144 = S_s$$

$$\text{Conductor per slot} = Z / (2 * \text{Poles}) = 144 / 4 = 36$$

Program:

function calculate_D_L_size_number_alternator_cylindrical_rotor

% given

Bav = .55;

ac = 36000;

J = 5;

Va = 160;

Ns = 50;

pole = 2;

Q = 15000;

f = 50;

Eline = 11000;

% therefore D

D = Va / (pi * Ns);

% _____

% Now distribution factor for 60 degree phase spread in

```

%order to eliminate 5th harmonic

%—————

Kd = .955;

alpha = (2*acosd(0))/5;

% Why as  $\cos(5*\alpha/2) = 0$  for 5th harmonic

fprintf('\nProgram to calculate D, L size and numer of conductors of Synch machine');

fprintf('\n—————');

fprintf('\nFor 5th harmonic elimination we have alpha = ');

disp(alpha);

fprintf('\nUsing alpha we also get.....');

% pitch factor Kp

Kp = cosd(alpha/2);

fprintf('\nPitch factor Kp = ');

disp(Kp);

% giving Kw

fprintf('\nStacking Factor Kw = ');

Kw = Kp*Kd;

disp(Kw);

% using Kw we get output coeffecient

Co = 1.11*pi*pi*f*Bav*ac*Kw*.001

fprintf('\nWe have Diameter D = ');

disp(D);

fprintf('\nLength L = ');

```

```

L = (Q)/(Co*Ns*D*D);

disp(L);

%Now flux phi

phi = pi*D*L*Bav;

fprintf('\nWe got Flux phi = ');

disp(phi);

phipole = phi/pole;

%Turn per phase

Eph = Eline/sqrt(3);

Tph = Eph/(4.44*f*Kw*phipole);

fprintf('\nTurns per phase Tph = ');

disp(Tph);

%total conductors Z

Z = 6*Tph;

fprintf('\nTotal conductors Z = ');

disp(Z);

%conductors per slot

Ss = Z/(2*pole);

fprintf('\nConductors per slot = ');

disp(Ss);

end

```

Output:

For 5th harmonic elimination we have $\alpha = 36$

Using α we also get.....

Pitch factor $K_p = 0.9511$

Stacking Factor $K_w = 0.9083$

$C_o =$

$9.8507e+003$

We have Diameter $D = 1.0186$

Length $L = 0.0294$

We got Flux $\phi = 0.0517$

Turns per phase $T_{ph} = 1.2194e+003$

Total conductors $Z = 7.3162e+003$

Conductors per slot = $1.8290e+003$

