

4.5 Computer program: Design of slip-ring rotor

Problem:

Design a 30HP, 3 phase, 440V, 960 r.p.m, 50Hz, delta connected squirrel cage induction motor. Assume specific electric loading 25000, specific magnetic loading .46 Wb /m²full load efficiency 86% power factor = 0.87 calculate the following

- i) Stator core dimension D and L
- ii) Number of stator slots and winding turns

Solution:

$$P_o = 30\text{HP} = 30 \cdot 746\text{kW}$$

$$\text{eff} = 86\% = 0.86$$

$$\text{p.f.} = .87$$

$$\text{therefore input k.V.A} = 30 \cdot 746 / (.86 \cdot .87) = 29.92\text{k.V.A}$$

$$\text{We also have } a_c = 25000$$

$$B_{av} = .46\text{Wb}$$

$$K_w = .9 \text{ as always}$$

$$C_o = 1.11 \cdot \pi^2 \cdot B_{av} \cdot a_c \cdot K_w \cdot 10^{-3} = 1.11 \cdot 3.14 \cdot 3.14 \cdot .46 \cdot 25000 \cdot .9 \cdot 10^{-3} = 120.3$$

$$\text{Now as } N = 960\text{r.p.m so } N_s = N/60 = 16.67 \text{ r.p.s}$$

$$\text{So number of poles} = 2f/N_s = 6$$

$$\text{kVA} = C_o \cdot N_s \cdot D^2 \cdot L$$

$$\text{so } D^2L = 29.91 / (120.3 \cdot 16.67) = .015\text{m}^3$$

$$L/\tau = 1 \text{ considering a good overall design}$$

$$\text{where } \tau = \pi \cdot D / \text{Pole}$$

$$L \cdot \text{Pole} / (\pi \cdot D) = 1$$

$$\text{Substituting } L = .015/D^2 \text{ and rearranging}$$

we have $D^3 = .015 \cdot 6 / 3.14 = .028 \text{m}^3$

So $D = .3 \text{m}$

hence $L = .015 / D^2 = .16 \text{m}$

So we get peripheral speed $V_a = \pi \cdot D \cdot N_s = 3.14 \cdot .3 \cdot 16.67 = 15.6 \text{m/sec}$

so as V_a is less than 30m/sec hence these dimensions are permissible.

Now $B_{av} = \text{Pole} \cdot \Phi_m / (\pi \cdot D \cdot L)$ giving us

$\Phi_m = B_{av} \cdot \pi \cdot D \cdot L / \text{Pole} = .46 \cdot 3.14 \cdot .16 \cdot .3 / 6$

$\Phi_m = .0115 \text{Wb}$

Number of stator turns $T_s = E_s / (4.44 \cdot f \cdot \Phi_m \cdot K_{ws}) = 440 / (4.44 \cdot 50 \cdot .0115 \cdot .955)$ so $T_s = 180$

Total number of stator pole per phase per pole $S_s = 3 \cdot \text{pole} \cdot \text{phase} = 3 \cdot 6 \cdot 3 = 54$

Slot pitch = $Y_{ss} = \pi \cdot D / S_s = 3.14 \cdot .3 / 54 = .017$

So $Z_{ss} = 6 \cdot T_{ph} = 1080$

Number of slot = $1080 / 54 = 20$

Program:

function design_squirrel_cage_induction_motor

$P_o = 30 \cdot .746$; %kw

$V_{in} = 440$;

$N = 960$;

$N_s = N / 60$;

$f = 50$;

$B_{av} = .46$;

$pf = .87$;

```

eff = .86;

ac = 25000;

Kws = .955;

phase = 3;

%rating in kVA

Q = Po/(eff*pf);

Kw = .9;

fprintf('\nProgram to design squirrel cage induction motor');

fprintf('\n_____');

Co = 1.11*pi*pi*Bav*ac*Kw*(10^-3);

%number of poles

pole = (2*f)/Ns;

%Q = Co*Ns*D2L

fprintf('\nInput power or rating power = ');

disp(Q);

D2L = Q/(Co*Ns);

%for good overall design

%L/tow = 1

%L*pole/pi*D

D3 = (Q*pole)/(Co*Ns*pi);

D = D3^(1/3);

fprintf('\nHence Diameter D = ');

disp(D);

```

```

fprintf('\nHence Length L = ');
L = pi*D/(pole);
disp(L);
%peripheral speed Va
Va = pi*D*Ns;
fprintf('\nPeripheral speed = ');
disp(Va);
if(Va<30)
fprintf('\nAs Peripheral speed is less than 30m/secs so dimensions are permissable');
else
fprintf('\nAs Peripheral speed is not less than 30m/sec the dimensions are not
mpermissabel. But still the dimensions will be');
end
phim = Bav*pi*D*L/pole;
fprintf('\nFlux density phim = ');
disp(phim);
%number of stator turns Ts
Ts = Vin/(4.44*f*phim*Kws);
fprintf('\nNumber of stator turns Ts = ');
disp(round(Ts));
%total number of stator slot per phase per pole Ss
Ss = 3*pole*phase;
fprintf('\nTotal number of stator slot per phase per pole Ss');

```

```

disp(Ss);

fprintf('\nSlot pitch Yss = ');

Yss = pi*D/Ss;

disp(Yss);

Zss = 6*round(Ts);

fprintf('\nTotal Coconductors Zss = ');

disp(Zss);

fprintf('\nNumber of Slots = ');

noofslots = Zss/Ss;

disp(noofslots);

end

```

Output:

Input power or rating power = 29.9118

Hence Diameter D = 0.3201

Hence Length L = 0.1609

Peripheral speed = 16.0904

As Peripheral speed is less than 30m/secs so dimensions are permissible

Flux density $\phi_{im} = 0.0119$

Number of stator turns $T_s = 174$

Total number of stator slot per phase per pole $S_s = 56.2500$

Slot pitch $Y_{ss} = 0.0179$

Total Coconductors $Z_{ss} = 1044$

Number of Slots = 18.5600