(f) Calculation of total losses, Efficiency, Slip, Starting torque, Temp-rise, Total Weight and Kg/KW.

Note: By adding programs established for each part sequentially we get the Program for complete design.

Problem: Design a 30 KW, 440V, 50 Hz, delta connected, 3 ph Squirrel Cage Ind.Motor

7.1.3 Calculation of Stator Main Dimensions and Flux (Part-1)

Table 7.1 Approx. Values of Bav and q.

KW	1	2	5	10	20	50	100	500
Bav(T)	0.35	0.38	0.42	0.46	0.48	0.50	0.51	0.53
q(ac/m)	16000	19000	23000	25000	26000	29000	31000	33000

Table 7.2 Approx. Values of Power-Factor.

KW	5	10	20	50	100	200	500
1000rpm	0.82	0.83	0.85	0.87	0.89	0.90	0.92
1500rpm	0.85	0.86	0.88	0.90	0.91	0.92	0.93

Table 7.3 Approx. Values of Efficiency.

KW	5	10	20	50	100	200	500
1000rpm	0.83	0.85	0.87	0.89	0.91	0.92	0.93
1500rpm	0.85	0.87	0.88	0.90	0.91	0.93	0.94

From Table.7.1,Values of Bav= 0.4838 T and q = 26802 ac/m corresponding to 30 KW

Assuming No. of Poles (P) = 6,

Sync Speed (Ns) = 120 × f/P = 120 × 50/6 = 1000 RPM and n = 1000/60 = 16.667 rps

From Tables.7.2 and 7.3, Values of pf = 0.8621 and eff = 0.88 corresponding to 30 KW and 1000 RPM

KW input to motor = KW/eff = 30/0.88 = 34.0908

For Δ connection, Vph = V = 440 Volts

$$\text{Phase Current} = \frac{\text{KWinp} \times 1000}{3 \times \text{Vph} \times \text{pf}} = \frac{34.098 \times 1000}{3 \times 440 \times 0.8621} = 29.958\ \text{A}$$

Assuming Winding factor (Kw) = 0.955,

$$\text{Output Coefft(C0)} = 11 \times \text{Kw} \times \text{Bav} \times \text{q} \times \text{eff} \times \text{pf} \times 10^{-3}$$

$$= 11 \times 0.955 \times 0.4838 \times 26802 \times 0.88 \times 0.8621 \times 10^{-3} = 103.3417$$

$$D^2L = \frac{\text{KW}}{\text{C0} \times \text{ns}} = \frac{30}{103.3417 \times 16.667} = 0.0174$$

Total Core Length (L) = $\sqrt{\dfrac{D^2L}{(0.135\times P)^2}} = \sqrt{\dfrac{0.0174}{(0.135\times 6)^2}}$

$= 0.1629\text{ m} = 162.9\text{ mm} \approx 160\text{ mm}$ (Rounded off)

Assuming Ventilating ducts (nvd) = 2, each of length (bvd) = 10 mm,

Gross iron Length (Ls) = L – nvd × bvd = 160 – 2 × 10 = 140 mm

Assuming Iron factor (ki) = 0.92, Net Iron length (Li)

= Ls × ki = 140 × 0.92 = 128.8 mm

Core inner diameter (D) = $\sqrt{\dfrac{D^2L}{L}} = \sqrt{\dfrac{0.0174}{140/1000}} = 0.3299\text{ m}$

$= 329.9\text{ mm} \approx 330\text{ mm}$ (Rounded off)

Polepitch (PP) = $\dfrac{\pi\times D}{P} = \dfrac{\pi\times 330}{6} = 172.79\text{ mm}$

$\dfrac{\text{Length}}{\text{Polepitch}} = \dfrac{140}{172.79} = 0.926$ (≈ 1 and hence OK)

Periphoral Velocity(v) = $\dfrac{\pi\times D}{ns} = \dfrac{\pi\times 330}{16.67} = 17.28\text{ m/s}$ (≤ 30 and hence OK)

Flux (FI) = $\dfrac{\pi\times D\times L\times Bav}{P\times 10^6} = \dfrac{\pi\times 330\times 140\times 0.4838}{6\times 10^6} = 0.0134\text{ Wb}$

7.1.3 *(a) Computer Program in "C" in MATLAB for Part-1*

```
% 3ph, KW = 30;V = 440; P = 6; f = 50Sq.Cage IM
%------------Standard Curves/Tables for%Data-------------->
SKW=[1 2 5 10 20 50 100 500];
SBav=[0.35 0.38 0.42 0.46 0.48 0.50 0.51 0.53];
Sq=[16e3 19e3 23e3 25e3 26e3 29e3 31e3 33e3];
SKWa=[5 10 20 50 100 200 500];
SPF6P=[0.82 0.83 0.85 0.87 0.89 0.9 0.92]; %for 1000RPM
SEFF6P=[0.83 0.85 0.87 0.89 0.91 0.92 0.93];% for 1000RPM
SPF4P=[0.85 0.86 0.88 0.9 0.91 .92 .93];% for 1500RPM
SEFF4P=[.85 .87 .88 .9 .91 .93 .94];% for 1500RPM
%(1)<-----------Main Dimensions----------------------->
KW=30;V=440;f=50; P=6;  %Input Data------>
insW=3.4;Hw=4;HL=1;insH=6;nvd=2;bvd=0.01;ki=0.92;Bc=1.35;Vph=V;
%Assumptions
```

```
Zr=1;kwr=1;cdb=6;Tb=6;cde=6;dd=0.05;Brc=1.35;    %Assumptions
spp=3;Tstrip=1.9;Zsw=3; % Assumption
Kw=0.955;nvd=2;bvd=10;ki=0.92;Tstrip=1.9;insS=0.5;%Assumptions
insW=3.4;Hw=4;HL=1;insH=6;nvd=2;ki=0.92;Bc=1.35;%Assumptions
Bav=interp1(SKW,SBav,KW,'spline');
q=interp1(SKW,Sq,KW,'spline');
pf=interp1(SKWa,SPF6P,KW,'spline');
eff=interp1(SKWa,SEFF6P,KW,'spline');
if P=4 pf=interp1(SKWa,SPF4P,KW,'spline');end;
if P=4 eff=interp1(SKWa,SEFF4P,KW,'spline');end;
KWinp=KW/eff; Iph=KWinp*1e3/(3*Vph*pf); Ns=120*f/P;
ns=Ns/60; C0=11*Kw*Bav*q*eff*pf*1e-3; DsqL=1/C0*(KW/ns);
L1=sqrt(DsqL/(0.135*P)^2); L=floor(L1*100)*10;  Ls=(L-nvd*bvd);
Li=ki*Ls;       D1=sqrt(DsqL/(L/1000));       D=ceil(D1*100)*10;
PP=pi*D/P;  LbyPP=L/PP;  if LbyPP <0.8||LbyPP >2 continue; end;
v=pi*D*ns/1000;    if v >30 continue;end;
FI=pi*D/P*L*Bav/1e6;
%----------------------------------------------------------
```

7.1.4 Design of Stator Winding (Part-2)

Assuming Slots/pole/ph(spp) = 3, No of slots(S) = spp × 3 × P = 3 × 3 × 6 = 54

Slot pitch (sp) = $\frac{\pi \times D}{S} = \frac{\pi \times 330}{54} = 19.1986$mm

(OK since it is between 18 and 25mm)

Turns/ph (Tph) = $\frac{Vph}{4.44 \times f \times FI \times Kw} = \frac{440}{4.44 \times 50 \times 0.0134 \times 0.955} = 154.8$

Conductors/ph (Zph) = Tph × 2 = 154.8 × 2 = 309.7

Slots/ph (sph) = 54/3 = 18

Conductors/slot (Zs) = Zph/sph = 309.7/18 = 17.2 ≈ 18(Rounded off to even integer)

Corrected Turns/ph (Tph) = Zs × sph/2 = 18 × 18/2 = 162

Corrected flux (FI) = $\frac{Vph}{4.44 \times f \times Tph \times Kw} = \frac{440}{4.44 \times 50 \times 162 \times 0.955} = 0.01281$ Wb