Three-Phase Induction Machine Design

GENERAL DATA

Given Output Power (kW):	1280
Rated Voltage (V):	1350
Winding Connection:	Wye
Number of Poles:	6
Given Speed (rpm):	1520
Frequency (Hz):	78
Stray Loss (W):	12800
Frictional Loss (W):	20
Windage Loss (W):	20
Operation Mode:	Motor
Type of Load:	Constant Power
Operating Temperature (C):	75

STATOR DATA

Number of Stator Slots:	54
Outer Diameter of Stator (mm):	748.65
Inner Diameter of Stator (mm):	639
Type of Stator Slot:	4
Stator Slot	
hs0 (mm):	0.1
hs1 (mm):	0.1
hs2 (mm):	23
bs0 (mm):	10
bs1 (mm):	19
bs2 (mm):	21.3
rs (mm):	0.1
Top Tooth Width (mm):	18.2054
Bottom Tooth Width (mm):	18.584
Length of Stator Core (mm):	482.3
Stacking Factor of Stator Core:	0.95
Type of Steel:	D21_50
Number of lamination sectors	3
Press board thickness (mm):	0
Magnetic press board	No
Number of Parallel Branches:	1
Type of Coils:	21
Coil Pitch:	8
Number of Conductors per Slot:	4
Number of Wires per Conductor:	10
Wire Diameter (mm):	2.588
Wire Wrap Thickness (mm):	0
Wedge Thickness (mm):	0
Slot Liner Thickness (mm):	0
Layer Insulation (mm):	0
Slot Area (mm^2):	468.471
Net Slot Area (mm^2):	466.296
Slot Fill Factor (%):	57.4548
Limited Slot Fill Factor (%):	75
Wire Resistivity (ohm.mm^2/m):	0.0217
Conductor Length Adjustment (mm):	0
End Length Correction Factor	1
End Leakage Reactance Correction Factor	1

ROTOR DATA

Number of Rotor Slots:	72
Air Gap (mm):	1
Inner Diameter of Rotor (mm):	523.15
Type of Rotor Slot:	4
Rotor Slot	
hs0 (mm):	0.1
hs01 (mm):	0.1
hs1 (mm):	0.1
hs2 (mm):	8.2
bs0 (mm):	7
bs1 (mm):	16
bs2 (mm):	13.5
rs (mm):	0.1
Cast Rotor:	Yes
Half Slot:	No
Length of Rotor (mm):	482.3
Stacking Factor of Rotor Core:	0.95
Type of Steel:	D21_50
Skew Width:	2
End Length of Bar (mm):	5
Height of End Ring (mm):	5
Width of End Ring (mm):	5
Resistivity of Rotor Bar	
at 75 Centigrade (ohm.mm^2/m):	0.0172414
Resistivity of Rotor Ring	

at 75 Centigrade (ohm.mm^2/m):	0.0172414
Magnetic Shaft:	No

MATERIAL CONSUMPTION

Armature Copper Density (kg/m^3):	8900
Rotor Bar Material Density (kg/m^3):	8933
Rotor Ring Material Density (kg/m^3):	8933
Armature Core Steel Density (kg/m^3):	7820
Rotor Core Steel Density (kg/m^3):	7820
Armature Copper Weight (kg):	85.5145
Rotor Bar Material Weight (kg):	39.2284
Rotor Ring Material Weight (kg):	0.886537
Armature Core Steel Weight (kg):	337.539
Rotor Core Steel Weight (kg):	339.732
Total Net Weight (kg):	802.9
Armature Core Steel Consumption (kg):	875.268
Rotor Core Steel Consumption (kg):	1149.05

RATED-LOAD OPERATION

Stator Resistance (ohm):	0.0251161
Stator Resistance at 20C (ohm):	0.02066
Stator Leakage Reactance (ohm):	0.0751691
Rotor Resistance (ohm):	0.123891
Rotor Leakage Reactance (ohm):	0.109391
Resistance Corresponding to	
Iron-Core Loss (ohm):	125.923
Magnetizing Reactance (ohm):	5.40788
Stator Phase Current (A):	675.34
Current Corresponding to	
Iron-Core Loss (A):	5.93276
Magnetizing Current (A):	138.144
Rotor Phase Current (A):	642.403
Copper Loss of Stator Winding (W):	34365.1
Copper Loss of Rotor Winding (W):	153383
Iron-Core Loss (W):	13296.5
Frictional and Windage Loss (W):	33.7261
Stray Loss (W):	12800
Total Loss (W):	213878
Input Power (kW):	1493.83
Output Power (kW):	1279.95
Mechanical Shaft Torque (N.m):	8773.93
Efficiency (%):	85.6826
Power Factor:	0.937881
Rated Slip:	0.107008
Rated Shaft Speed (rpm):	1393.07

NO-LOAD OPERATION

No-Load Stator Resistance (ohm):	0.0251161
No-Load Stator Leakage Reactance (ohm):	0.07895
No-Load Rotor Resistance (ohm):	0.123877
No-Load Rotor Leakage Reactance (ohm):	0.152211
No-Load Stator Phase Current (A):	142.157
No-Load Iron-Core Loss (W):	14053.9
No-Load Input Power (W):	28469.9
No-Load Power Factor:	0.0471415
No-Load Slip:	6.53127e-006
No-Load Shaft Speed (rpm):	1559.99

BREAK-DOWN OPERATION

Break-Down Slip:	1
Break-Down Torque (N.m):	42796.6
Break-Down Torque Ratio:	4.8777
Break-Down Phase Current (A):	4355.71

LOCKED-ROTOR OPERATION

Locked-Rotor Torque (N.m):	42796.6
Locked-Rotor Phase Current (A):	4355.71
Locked-Rotor Torque Ratio:	4.8777
Locked-Rotor Current Ratio:	6.44965
Locked-Rotor Stator Resistance (ohm):	0.0251161
Locked-Rotor Stator	
Leakage Reactance (ohm):	0.0556333
Locked-Rotor Rotor Resistance (ohm):	0.12508
Locked-Rotor Rotor	
Leakage Reactance (ohm):	0.0424116

DETAILED DATA AT RATED OPERATION

Stator Slot Leakage Reactance (ohm):	0.0321689
Stator End-Winding Leakage	
Reactance (ohm):	0.018042

Stator Differential Leakage
  Reactance (ohm):   0.0249529
Rotor Slot Leakage Reactance (ohm):   0.0114501
Rotor End-Winding Leakage
  Reactance (ohm):   0.0125192
Rotor Differential Leakage
  Reactance (ohm):   0.0308922
Skewing Leakage Reactance (ohm):   0.0545106

Stator Winding Factor: 0.945214

Stator-Teeth Flux Density (Tesla):   1.29871
Rotor-Teeth Flux Density (Tesla):   1.41611
Stator-Yoke Flux Density (Tesla):   2.21185
Rotor-Yoke Flux Density (Tesla):   1.43773
Air-Gap Flux Density (Tesla):   0.610459

Stator-Teeth Ampere Turns (A.T):   27.6198
Rotor-Teeth Ampere Turns (A.T):   15.428
Stator-Yoke Ampere Turns (A.T):   1329.4
Rotor-Yoke Ampere Turns (A.T):   113.624
Air-Gap Ampere Turns (A.T):   631.002

Correction Factor for Magnetic
  Circuit Length of Stator Yoke: 0.140457
Correction Factor for Magnetic
  Circuit Length of Rotor Yoke: 0.369139
Saturation Factor for Teeth: 1.06822
Saturation Factor for Teeth & Yoke: 3.3551
Induced-Voltage Factor: 0.958491

Stator Current Density (A/mm^2):   12.8382
Specific Electric Loading (A/mm):   72.6651
Stator Thermal Load (A^2/mm^3):   932.889

Rotor Bar Current Density (A/mm^2):   14.7034
Rotor Ring Current Density (A/mm^2):   279.121

Half-Turn Length of
  Stator Winding (mm):   845.625

    WINDING ARRANGEMENT

The 3-phase, 2-layer winding can be arranged in 9 slots as below:

AAAZZZBBB

Angle per slot (elec. degrees):   20
Phase-A axis (elec. degrees):   100
First slot center (elec. degrees):   0

    TRANSIENT FEA INPUT DATA

For one phase of the Stator Winding:
  Number of Turns: 36
  Parallel Branches: 1
  Terminal Resistance (ohm):   0.0251161
  End Leakage Inductance (H):   3.68139e-005
For Rotor End Ring Between Two Bars of One Side:
  Equivalent Ring Resistance (ohm):   1.90601e-005
  Equivalent Ring Inductance (H):   2.6462e-008
2D Equivalent Value:
  Equivalent Model Depth (mm):   482.3
  Equivalent Stator Stacking Factor: 0.95
  Equivalent Rotor Stacking Factor: 0.95
Estimated Rotor Inertial Moment (kg m^2):   60.8092