Three-Phase Induction Machine Design

File: Setup1.res

GENERAL DATA

Given Output Power (kW): 3

Rated Voltage (V): 380

Winding Connection: Wye

Number of Poles: 4

Given Speed (rpm): 1400

Frequency (Hz): 50

Stray Loss (W): 30

Frictional Loss (W): 10.6207

Windage Loss (W): 9.90086

Operation Mode: Motor

Type of Load: Constant Power

Operating Temperature (C): 75

STATOR DATA

Number of Stator Slots: 36

Outer Diameter of Stator (mm): 170

Inner Diameter of Stator (mm): 115

Type of Stator Slot: 1

Stator Slot

hs0 (mm): 0.62

hs2 (mm): 16.2

bs0 (mm): 2.5

bs1 (mm): 2.6

bs2 (mm): 7.26

Top Tooth Width (mm): 7.60075

Bottom Tooth Width (mm): 5.78233

Length of Stator Core (mm): 200

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: 9

Number of Conductors per Slot: 30

Number of Wires per Conductor: 1

Wire Diameter (mm): 0.965

Wire Wrap Thickness (mm): 0

Wedge Thickness (mm): 1

Slot Liner Thickness (mm): 1

Layer Insulation (mm): 1

Slot Area (mm^2): 103.031

Net Slot Area (mm^2): 40.2016

Slot Fill Factor (%): 69.4917

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: 33

Air Gap (mm): 0.5

Inner Diameter of Rotor (mm): 25

Type of Rotor Slot: 1

Rotor Slot

- hs0 (mm): 0.7
- hs01 (mm): 0.1
- hs2 (mm): 15
- bs0 (mm): 1.1
- bs1 (mm): 4.31
- bs2 (mm): 2

Cast Rotor: Yes

Half Slot: No

Length of Rotor (mm): 200

Stacking Factor of Rotor Core: 0.95

Type of Steel: D21_50

Skew Width: 1

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: Yes

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):	2.46984
Rotor Bar Material Weight (kg):	3.51613
Rotor Ring Material Weight (kg):	0.150983
Armature Core Steel Weight (kg):	12.7809
Rotor Core Steel Weight (kg):	11.6514
Total Net Weight (kg):	30.5692

Armature Core Steel Consumption (kg):	29.0357
Rotor Core Steel Consumption (kg):	15.4328

RATED-LOAD OPERATION

Stator Resistance (ohm):	3.75257
Stator Resistance at 20C (ohm):	3.08679
Stator Leakage Reactance (ohm):	3.57321
Rotor Resistance (ohm):	1.79512
Rotor Leakage Reactance (ohm):	3.21109
Resistance Corresponding to Iron-Core Loss (ohm):	1024.85
Magnetizing Reactance (ohm):	66.1766

Stator Phase Current (A):	6.84787

Current Corresponding to

Iron-Core Loss (A): 0.18032

Magnetizing Current (A): 2.79253

Rotor Phase Current (A): 5.80588

Copper Loss of Stator Winding (W): 527.912

Copper Loss of Rotor Winding (W): 181.531

Iron-Core Loss (W): 99.9698

Frictional and Windage Loss (W): 20.9561

Stray Loss (W): 30

Total Loss (W): 860.368

Input Power (kW): 3.86025

Output Power (kW): 2.99988

Mechanical Shaft Torque (N.m): 20.2455

Efficiency (%): 77.7121

Power Factor: 0.84982

Rated Slip: 0.0566864

Rated Shaft Speed (rpm): 1414.97

NO-LOAD OPERATION

No-Load Stator Resistance (ohm): 3.75257

No-Load Stator Leakage Reactance (ohm): 3.5754

No-Load Rotor Resistance (ohm): 1.79413

No-Load Rotor Leakage Reactance (ohm): 6.57006

No-Load Stator Phase Current (A): 3.13777

No-Load Iron-Core Loss (W): 125.477

No-Load Input Power (W): 289.626

No-Load Power Factor: 0.125714

No-Load Slip: 0.000325227

No-Load Shaft Speed (rpm): 1499.51

BREAK-DOWN OPERATION

Break-Down Slip: 0.26

Break-Down Torque (N.m): 38.5696

Break-Down Torque Ratio: 1.9051

Break-Down Phase Current (A): 17.9706

LOCKED-ROTOR OPERATION

Locked-Rotor Torque (N.m): 24.9485

Locked-Rotor Phase Current (A): 26.2596

Locked-Rotor Torque Ratio: 1.2323

Locked-Rotor Current Ratio: 3.8347

Locked-Rotor Stator Resistance (ohm): 3.75257

Locked-Rotor Stator
Leakage Reactance (ohm): 3.54278

Locked-Rotor Rotor Resistance (ohm): 2.06493

Locked-Rotor Rotor
Leakage Reactance (ohm): 2.65521

DETAILED DATA AT RATED OPERATION

Stator Slot Leakage Reactance (ohm): 2.51625

Stator End-Winding Leakage
Reactance (ohm): 0.547379

Stator Differential Leakage
Reactance (ohm): 0.509584
Rotor Slot Leakage Reactance (ohm): 1.80809
Rotor End-Winding Leakage
Reactance (ohm): 0.119678
Rotor Differential Leakage
Reactance (ohm): 0.881913
Skewing Leakage Reactance (ohm): 0.401327

Stator Winding Factor: 0.959795

Stator-Teeth Flux Density (Tesla): 0.662616
Rotor-Teeth Flux Density (Tesla): 0.838101
Stator-Yoke Flux Density (Tesla): 1.61914
Rotor-Yoke Flux Density (Tesla): 0.331934
Air-Gap Flux Density (Tesla): 0.417131

Stator-Teeth Ampere Turns (A.T): 4.34275
Rotor-Teeth Ampere Turns (A.T): 6.4489
Stator-Yoke Ampere Turns (A.T): 119.206
Rotor-Yoke Ampere Turns (A.T): 1.23112
Air-Gap Ampere Turns (A.T): 196.953

Correction Factor for Magnetic
Circuit Length of Stator Yoke: 0.316957
Correction Factor for Magnetic
Circuit Length of Rotor Yoke: 0.7
Saturation Factor for Teeth: 1.05479
Saturation Factor for Teeth & Yoke: 1.6663
Induced-Voltage Factor: 0.842326

Stator Current Density (A/mm^2): 9.36292

Specific Electric Loading (A/mm): 20.4707

Stator Thermal Load (A^2/mm^3): 191.665

Rotor Bar Current Density (A/mm^2): 3.24907

Rotor Ring Current Density (A/mm^2): 19.2729

Half-Turn Length of
Stator Winding (mm): 351.326

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): 110

First slot center (elec. degrees): 0

TRANSIENT FEA INPUT DATA

For one phase of the Stator Winding:

Number of Turns: 180

Parallel Branches: 1

Terminal Resistance (ohm): 3.75257

End Leakage Inductance (H): 0.00174236

For Rotor End Ring Between Two Bars of One Side:

Equivalent Ring Resistance (ohm): 7.28516e-006

Equivalent Ring Inductance (H): 1.08434e-008

2D Equivalent Value:

Equivalent Model Depth (mm): 200

Equivalent Stator Stacking Factor: 0.95

Equivalent Rotor Stacking Factor: 0.95

Estimated Rotor Inertial Moment (kg m^2): 0.0258669