

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 (mm²): 103.031

Net Slot Area (mm²): 40.2016

Slot Fill Factor (%): 69.4917

Limited Slot Fill Factor (%): 75

Wire Resistivity (ohm.mm²/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): 0.7

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.mm²/m): 0.0172414

Resistivity of Rotor Ring

at 75 Centigrade (ohm.mm²/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): | 3.47852 |
| Rotor Ring Material Weight (kg): | 0.150983 |
| Armature Core Steel Weight (kg): | 12.7809 |
| Rotor Core Steel Weight (kg): | 11.6812 |
| Total Net Weight (kg): | 30.5614 |

| | |
|---------------------------------------|---------|
| 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): | 3.60224 |
| Rotor Resistance (ohm): | 1.79497 |
| Rotor Leakage Reactance (ohm): | 7.0389 |
| Resistance Corresponding to | |
| Iron-Core Loss (ohm): | 1025.05 |
| Magnetizing Reactance (ohm): | 69.9797 |

| | |
|---------------------------|---------|
| Stator Phase Current (A): | 7.28461 |
|---------------------------|---------|

Current Corresponding to

Iron-Core Loss (A): 0.17756

Magnetizing Current (A): 2.60086

Rotor Phase Current (A): 6.06445

Copper Loss of Stator Winding (W): 597.397

Copper Loss of Rotor Winding (W): 198.043

Iron-Core Loss (W): 96.9516

Frictional and Windage Loss (W): 20.7446

Stray Loss (W): 30

Total Loss (W): 943.136

Input Power (kW): 3.94331

Output Power (kW): 3.00017

Mechanical Shaft Torque (N.m): 20.3518

Efficiency (%): 76.0826

Power Factor: 0.816193

Rated Slip: 0.0615241

Rated Shaft Speed (rpm): 1407.71

NO-LOAD OPERATION

No-Load Stator Resistance (ohm): 3.75257

No-Load Stator Leakage Reactance (ohm): 3.60484

No-Load Rotor Resistance (ohm): 1.79382

No-Load Rotor Leakage Reactance (ohm): 35.6322

No-Load Stator Phase Current (A): 2.97592

No-Load Iron-Core Loss (W): 126.085

No-Load Input Power (W): 279.052

No-Load Power Factor: 0.127152

No-Load Slip: 0.000322941

No-Load Shaft Speed (rpm): 1499.52

BREAK-DOWN OPERATION

Break-Down Slip: 0.23

Break-Down Torque (N.m): 33.4

Break-Down Torque Ratio: 1.64113

Break-Down Phase Current (A): 16.1126

LOCKED-ROTOR OPERATION

Locked-Rotor Torque (N.m): 20.4146

Locked-Rotor Phase Current (A): 24.0855

Locked-Rotor Torque Ratio: 1.00308

Locked-Rotor Current Ratio: 3.30635

Locked-Rotor Stator Resistance (ohm): 3.75257

Locked-Rotor Stator

Leakage Reactance (ohm): 3.57683

Locked-Rotor Rotor Resistance (ohm): 2.0614

Locked-Rotor Rotor

Leakage Reactance (ohm): 3.74494

DETAILED DATA AT RATED OPERATION

Stator Slot Leakage Reactance (ohm): 2.51611

Stator End-Winding Leakage

Reactance (ohm): 0.547379

Stator Differential Leakage

Reactance (ohm): 0.538747

Rotor Slot Leakage Reactance (ohm): 5.51726

Rotor End-Winding Leakage

Reactance (ohm): 0.163654

Rotor Differential Leakage

Reactance (ohm): 0.932383

Skewing Leakage Reactance (ohm): 0.424294

Stator Winding Factor: 0.959795

Stator-Teeth Flux Density (Tesla): 0.647229

Rotor-Teeth Flux Density (Tesla): 0.818638

Stator-Yoke Flux Density (Tesla): 1.58069

Rotor-Yoke Flux Density (Tesla): 0.324051

Air-Gap Flux Density (Tesla): 0.407444

Stator-Teeth Ampere Turns (A.T): 4.18414

Rotor-Teeth Ampere Turns (A.T): 6.17787

Stator-Yoke Ampere Turns (A.T): 99.197

Rotor-Yoke Ampere Turns (A.T): 1.20188

Air-Gap Ampere Turns (A.T): 192.379

Correction Factor for Magnetic

Circuit Length of Stator Yoke: 0.329424

Correction Factor for Magnetic

Circuit Length of Rotor Yoke: 0.7

Saturation Factor for Teeth: 1.05386

Saturation Factor for Teeth & Yoke: 1.57574

Induced-Voltage Factor: 0.829595

Stator Current Density (A/mm²): 9.96006

Specific Electric Loading (A/mm): 21.7762

Stator Thermal Load (A²/mm³): 216.892

Rotor Bar Current Density (A/mm²): 3.39231

Rotor Ring Current Density (A/mm²): 20.1315

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): 7.28506e-006

Equivalent Ring Inductance (H): 1.22365e-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 m²): 0.0258669