SANJIVANI RURAL EDUCATION SOCIETY'S
SANJIVANI COLLEGE OF ENGINEERING KOPARGAON

DEPARTMENT OF ELECTRICAL ENGINEERING

Report
On
Design A 3 phase Induction Motor on Ansys

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Hod Electrical

Introduction:-

1. **Define Requirements:** Determine the motor's specifications such as power rating, speed, voltage, frequency, efficiency, operating conditions, and any special requirements.

2. **Select Core Material:** Choose the appropriate core material based on factors like magnetic properties, cost, and efficiency. Common materials include silicon steel or amorphous steel for high-efficiency applications.

3. **Design the Stator:** Calculate the number of stator slots and winding distribution based on desired performance characteristics. Design the stator winding to achieve the required magnetic field and torque.

4. **Design the Rotor:** Select the type of rotor (squirrel cage or wound rotor) based on the application requirements. Design the rotor bars or conductors to optimize torque production and efficiency.

5. **Magnetic Circuit Design:** Design the magnetic circuit to ensure proper flux distribution and minimize losses. This involves selecting appropriate dimensions for the stator and rotor cores, as well as designing the air gap.

6. **Thermal Analysis:** Perform thermal analysis to ensure the motor can dissipate heat effectively and operate within temperature limits. This involves evaluating materials, cooling methods, and operating conditions.

7. **Mechanical Design:** Design the mechanical components of the motor such as the frame, bearings, shaft, and housing to withstand mechanical stresses and ensure reliable operation.

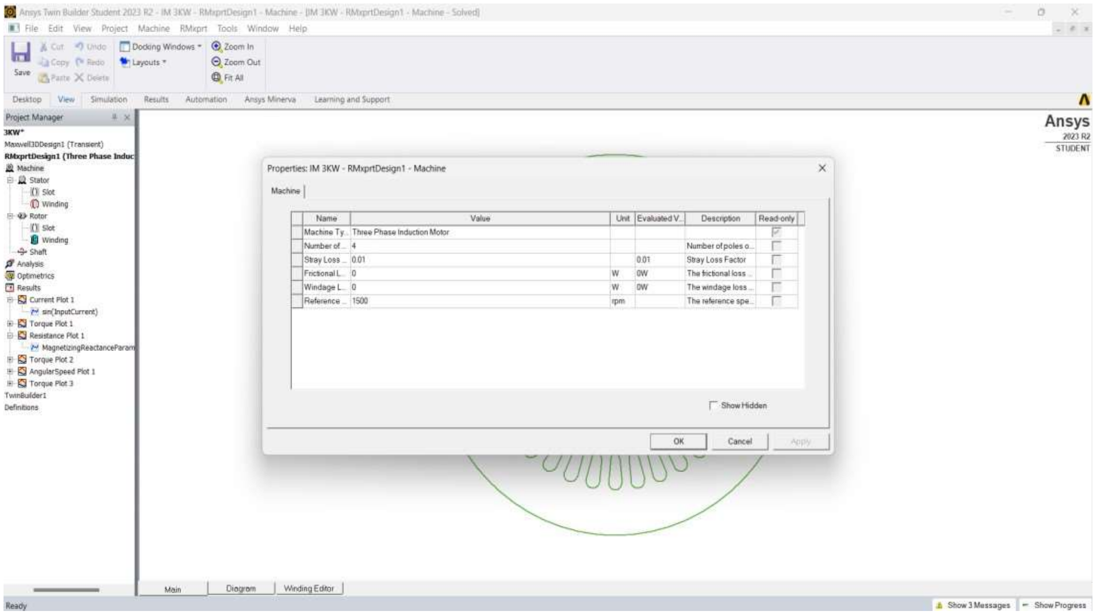
8. **Performance Evaluation:** Use simulation tools or mathematical models to evaluate the motor's performance under

various operating conditions, including starting, running, and transient states.

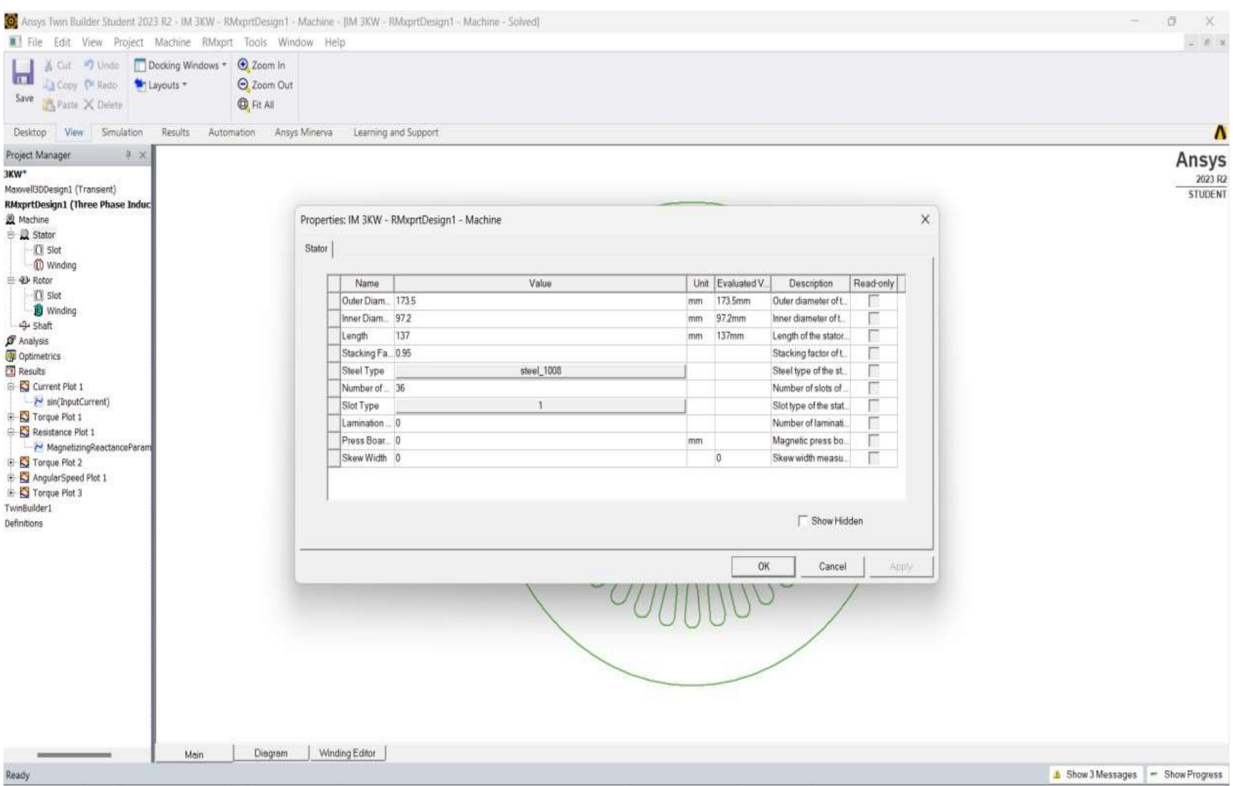
9. **Prototype and Testing:** Build a prototype of the motor and conduct rigorous testing to validate the design and ensure it meets performance and reliability requirements.

10. **Optimization and Iteration:** Iterate on the design based on testing results and feedback to optimize performance, efficiency, and reliability.

STEP 1 :- Select Machine properties. i.e, type of machine, number of slots, etc.



STEP 2 :- Select stator properties



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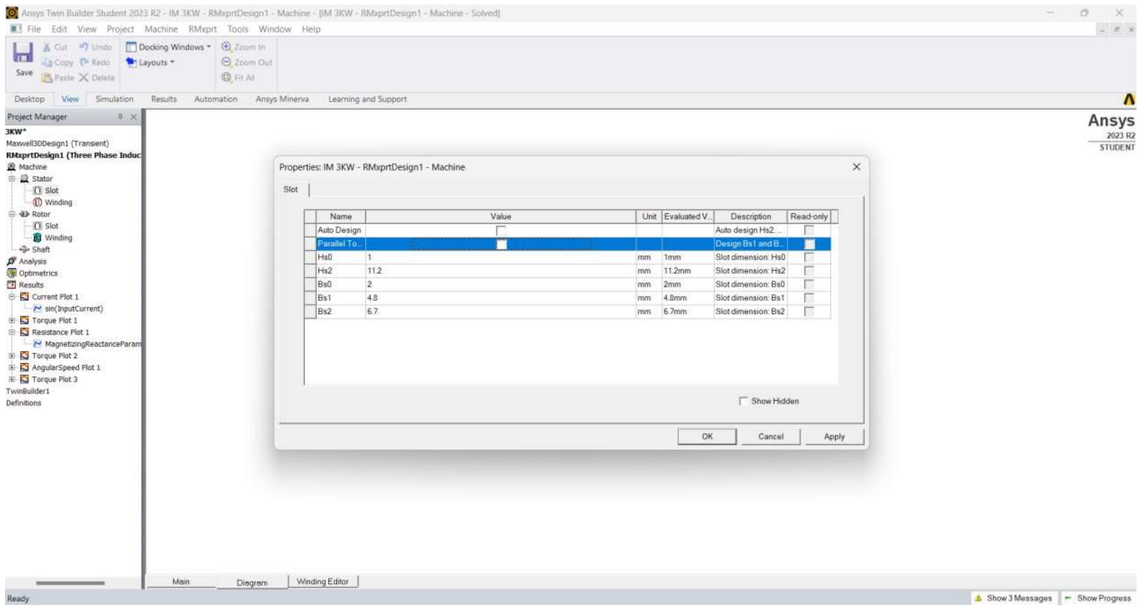
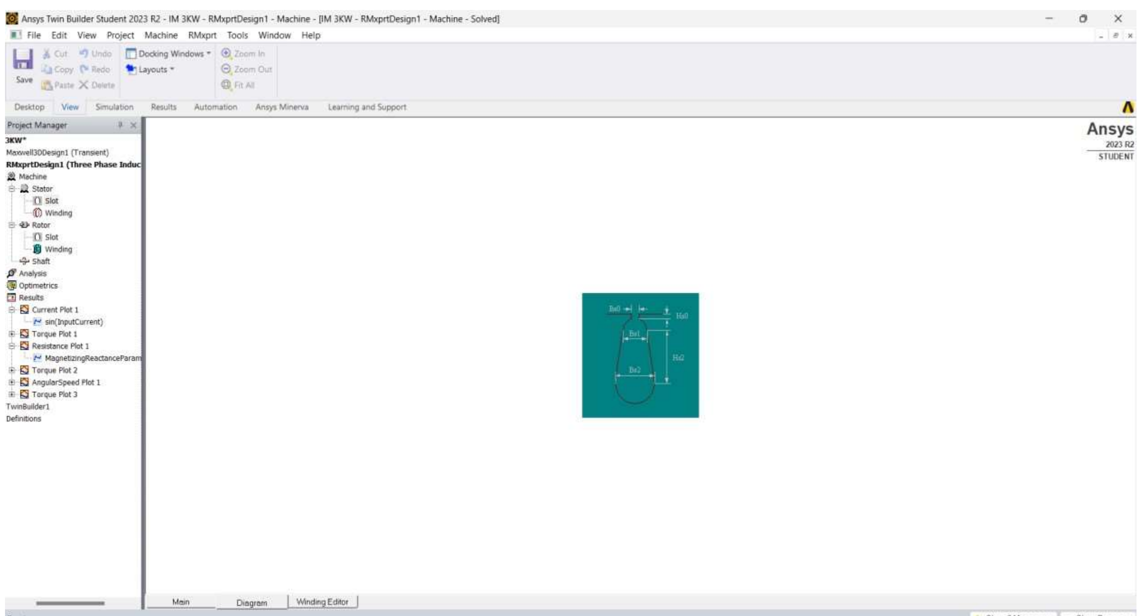
STEP 3: select slot properties. Put values of Hs0, Hs2, Bs0, Bs2 etc



STEP 4 :- Select slot type or shape according to requirement



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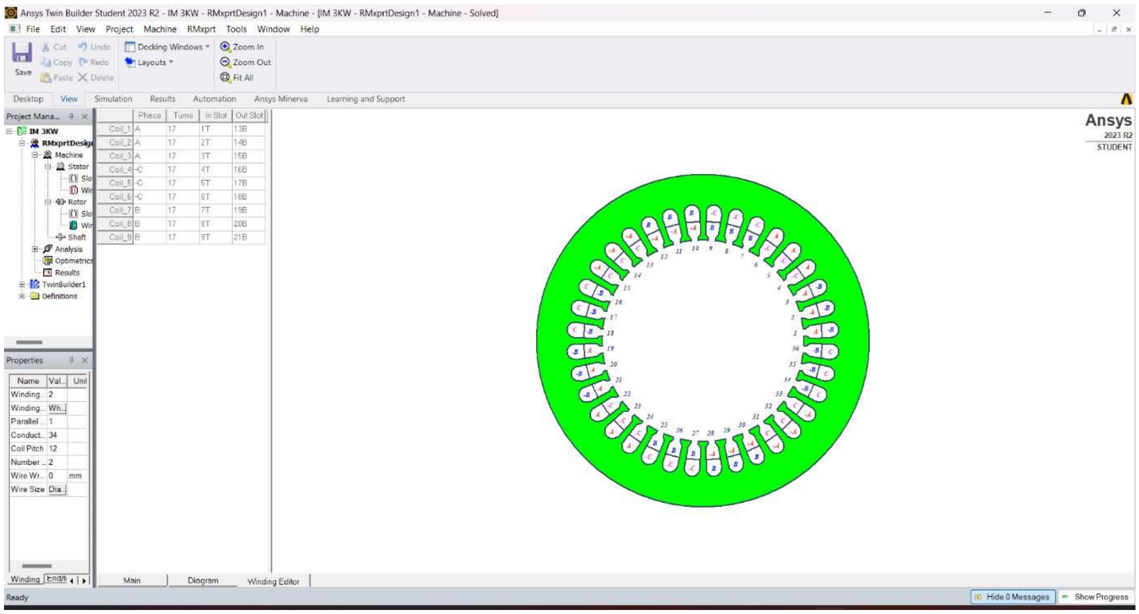
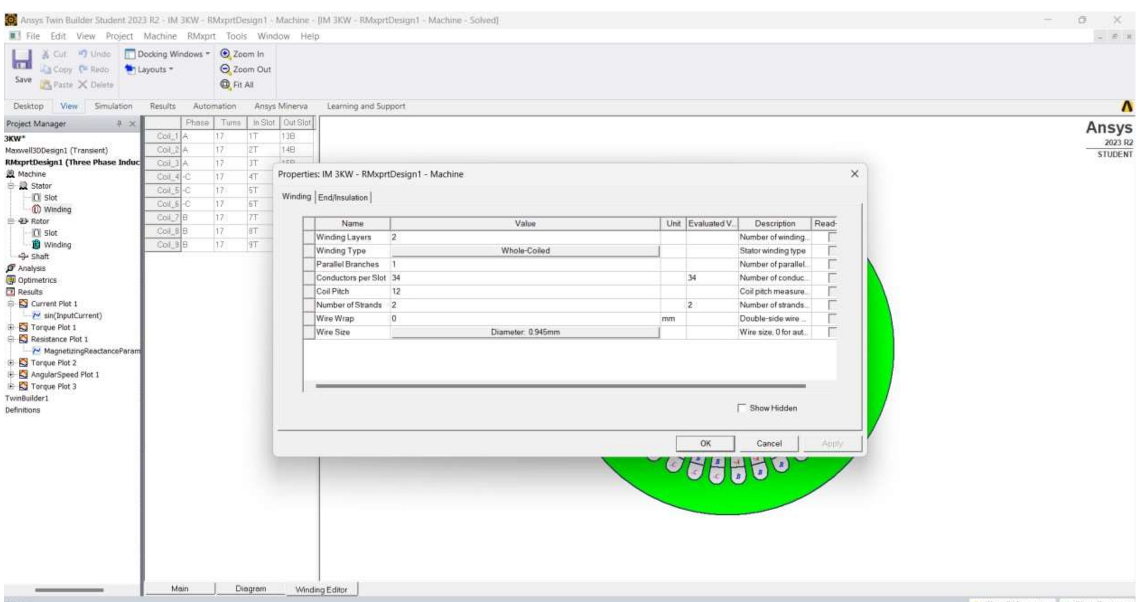
STEP 5 : lets see how Stator design looks



STEP 6 :- Select winding properties



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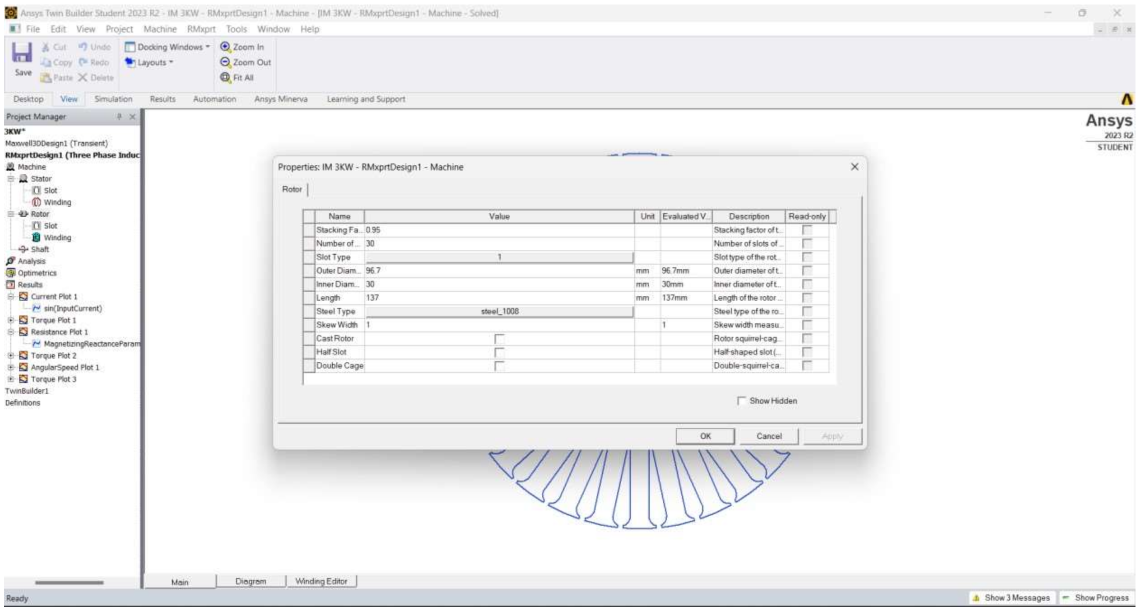
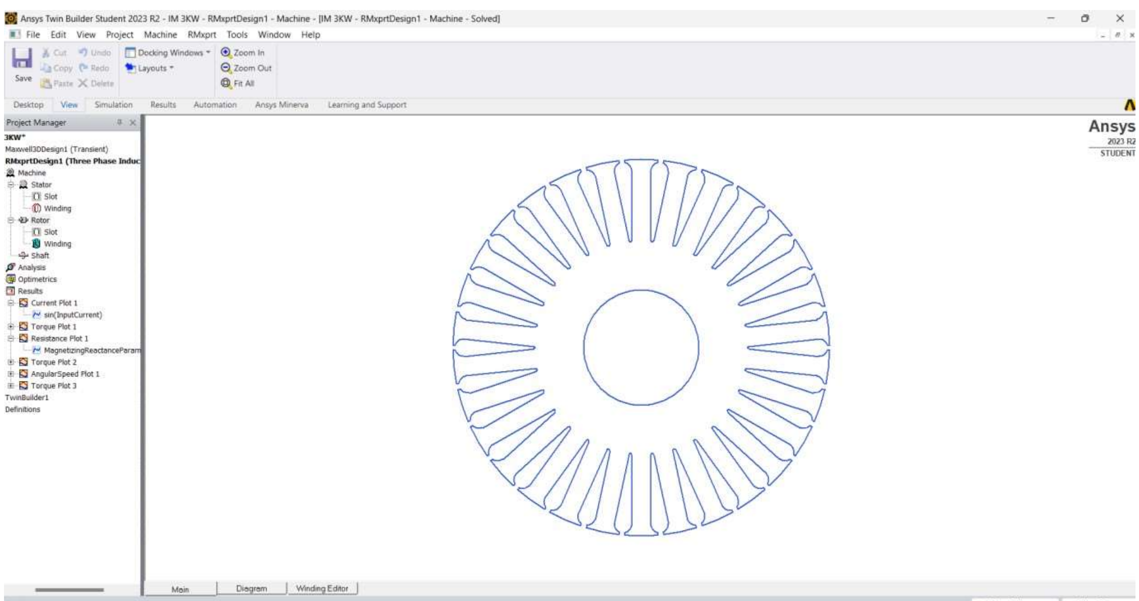
STEP 7 : Select rotor properties



STEP 8 :- Design of Rotor



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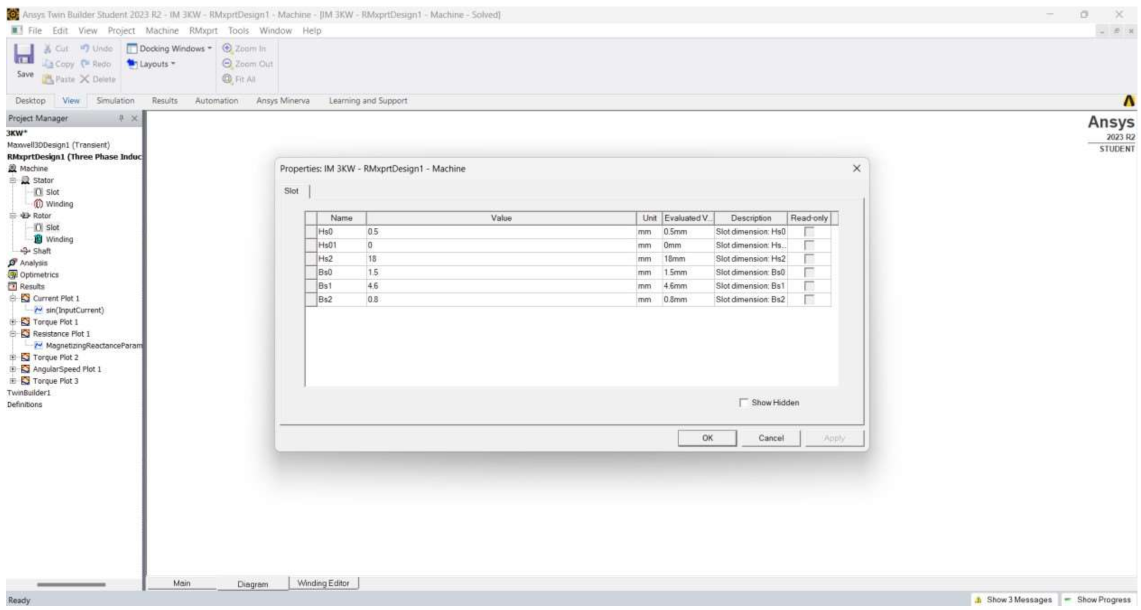
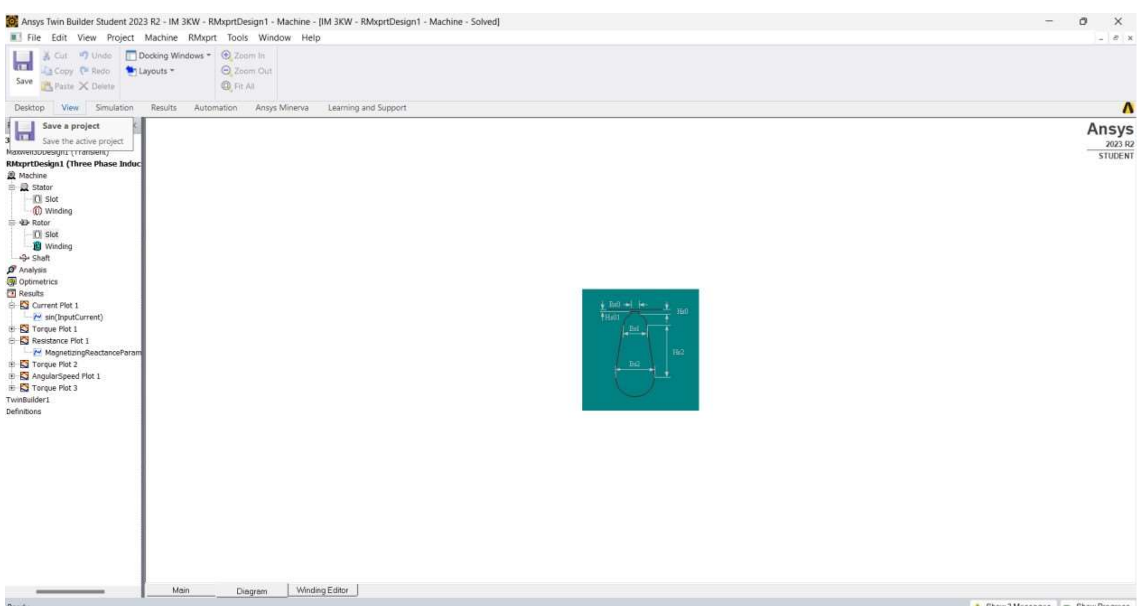
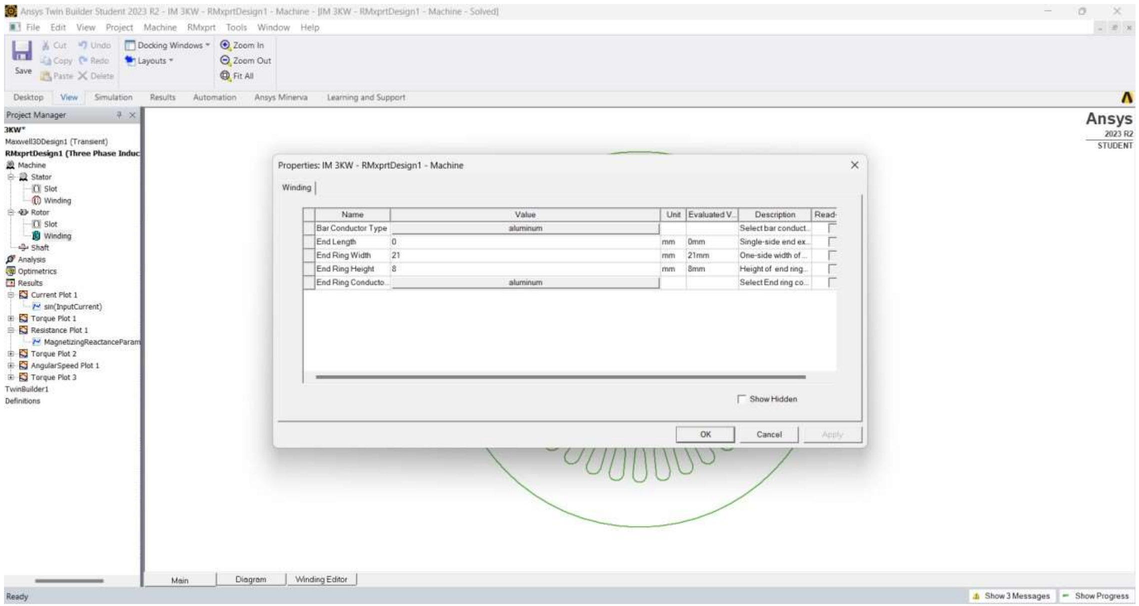
STEP 9 : Properties of Slots



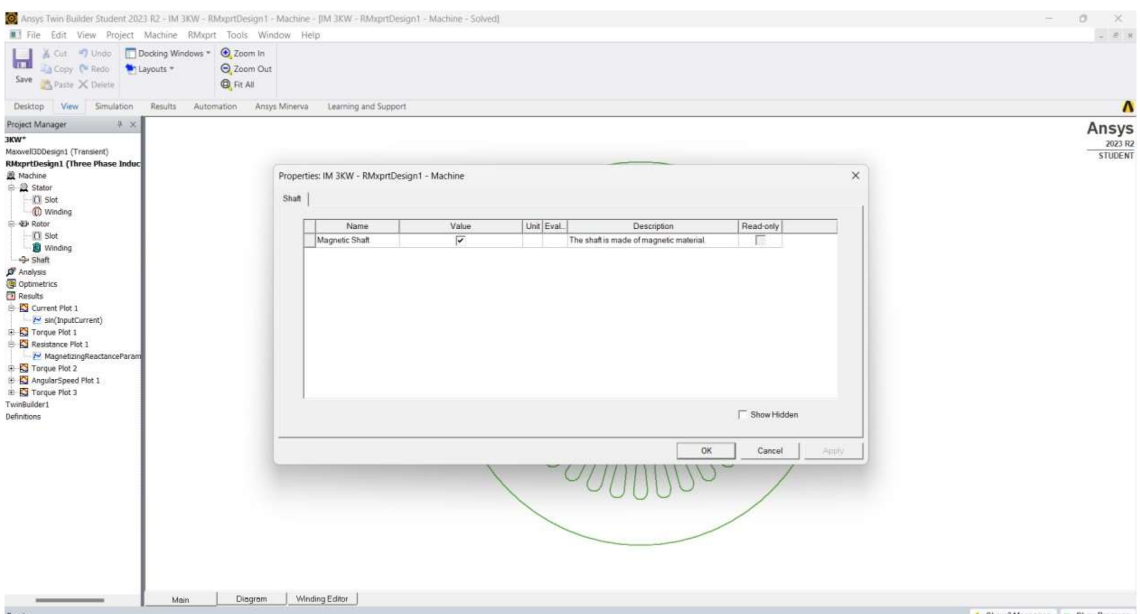
STEP 10 :- Design of Rotor Slots



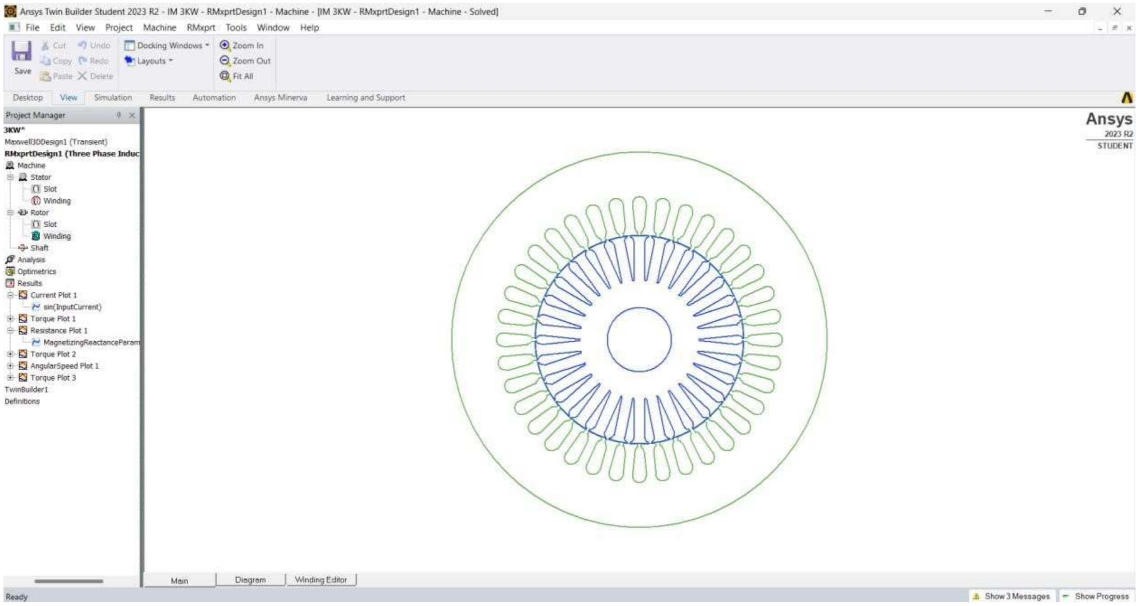
STEP 11 :- Select winding properties



STEP 12 :- Select shaft properties

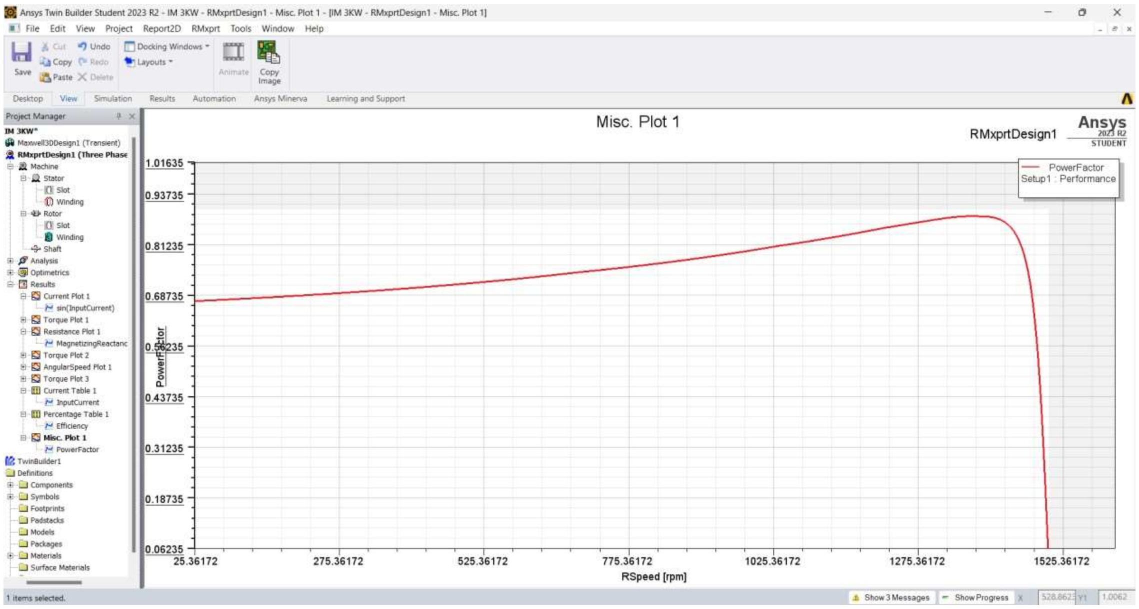


STEP 13 :- Overall look of stator, rotor and shaft



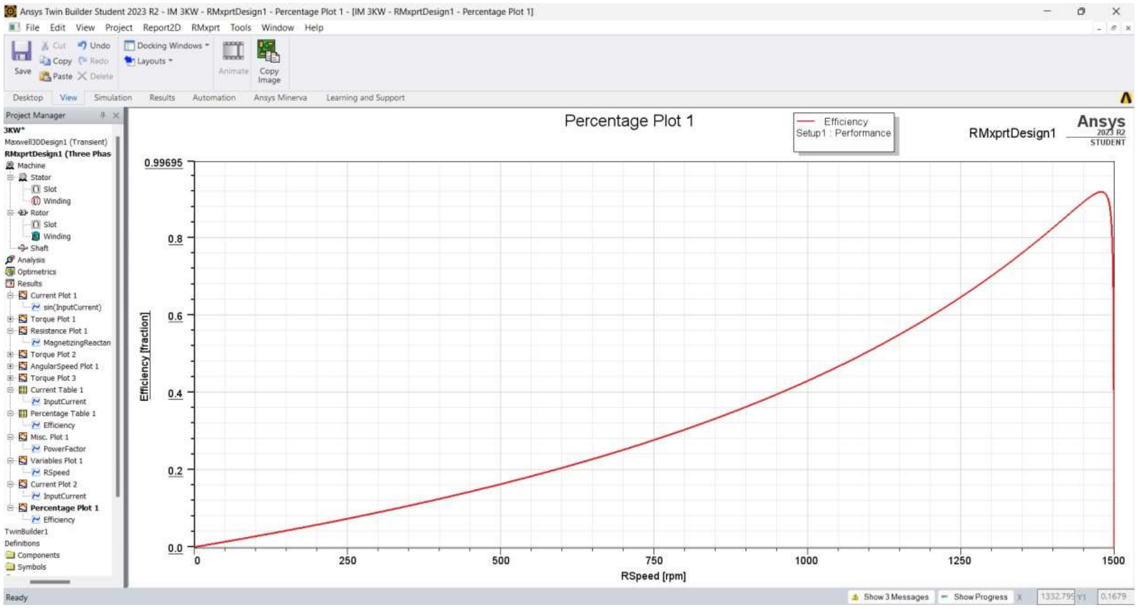
RESULTS :-

1. Power Factor

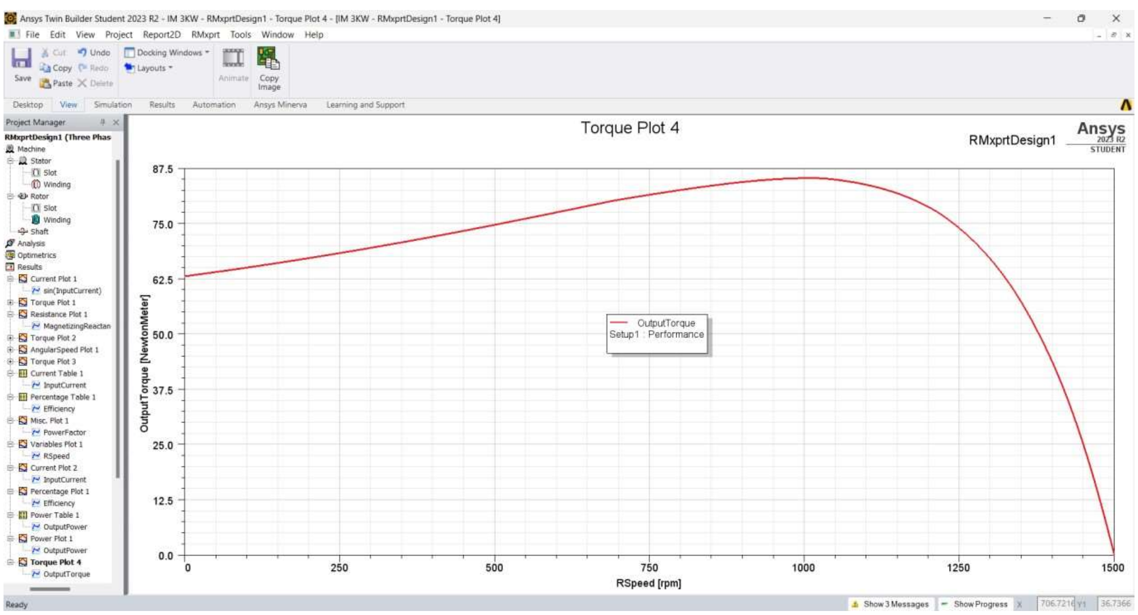


2. Input Current

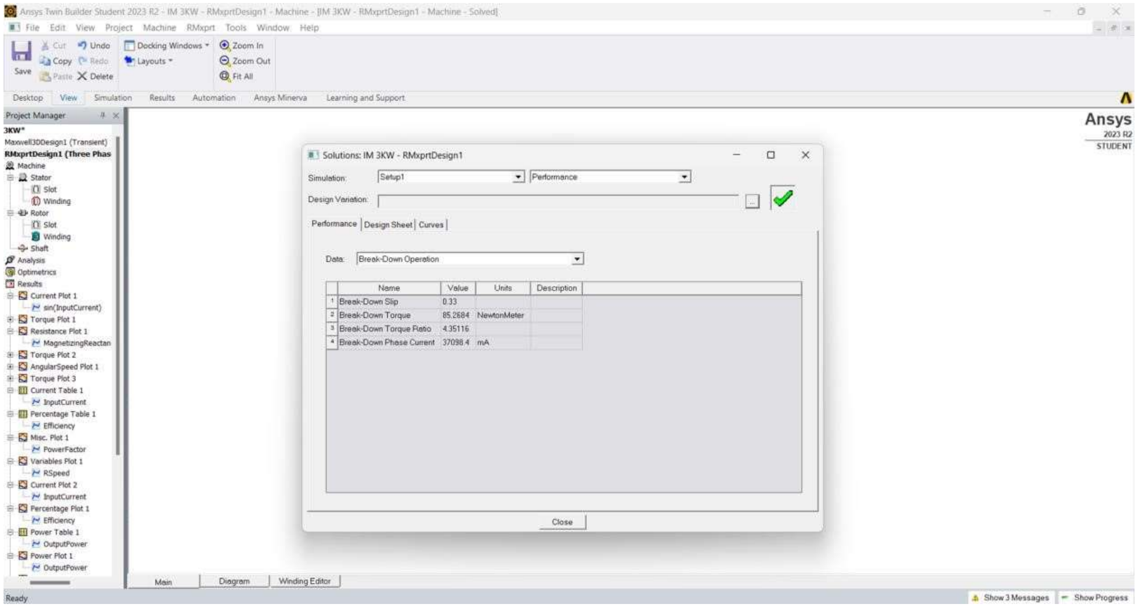
3. Efficiency



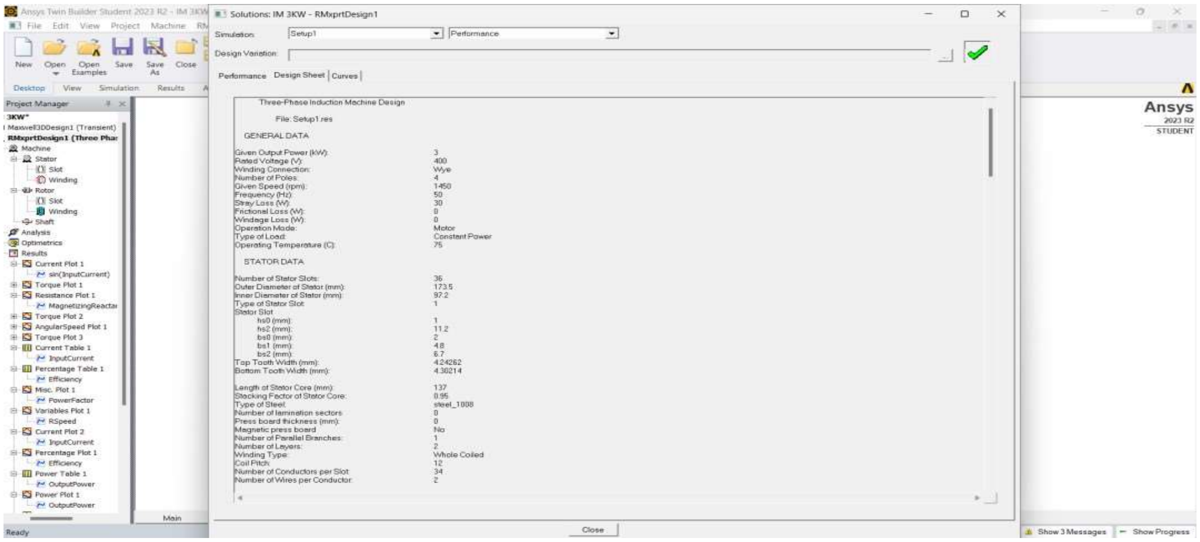
4. Output Torque

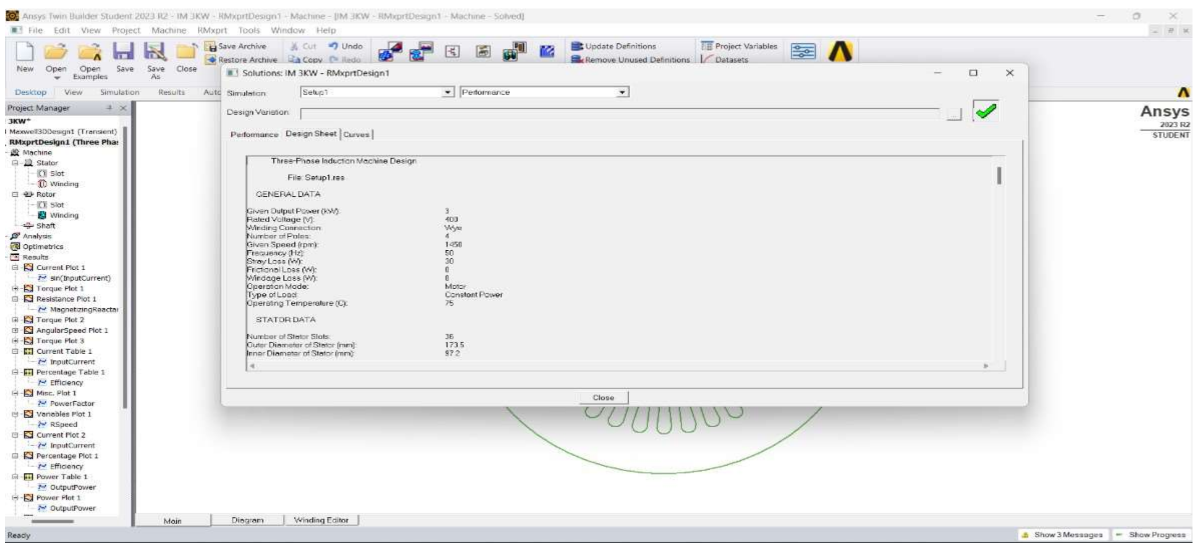


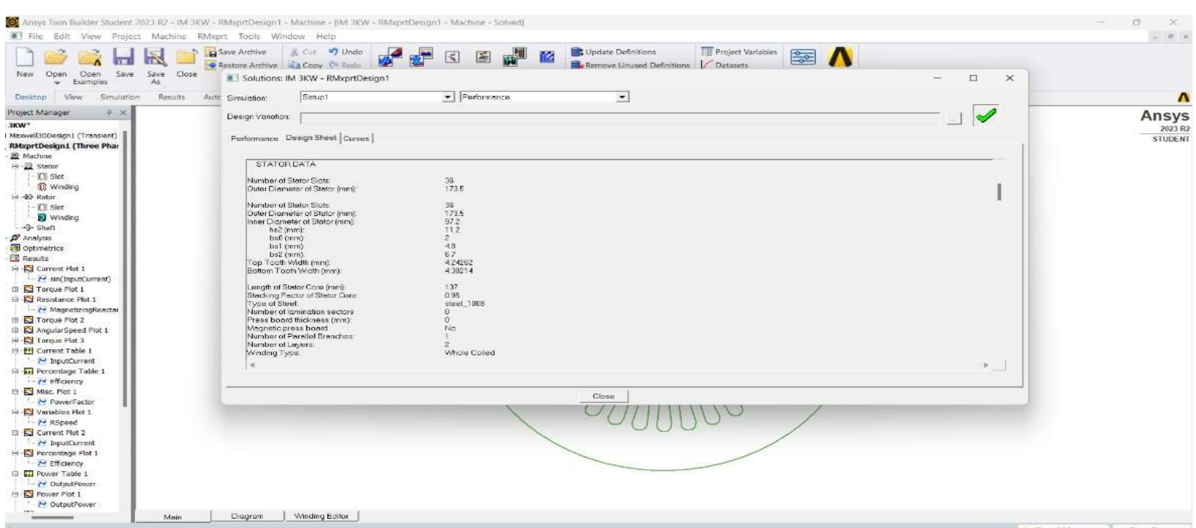
5. Breakdown Operations

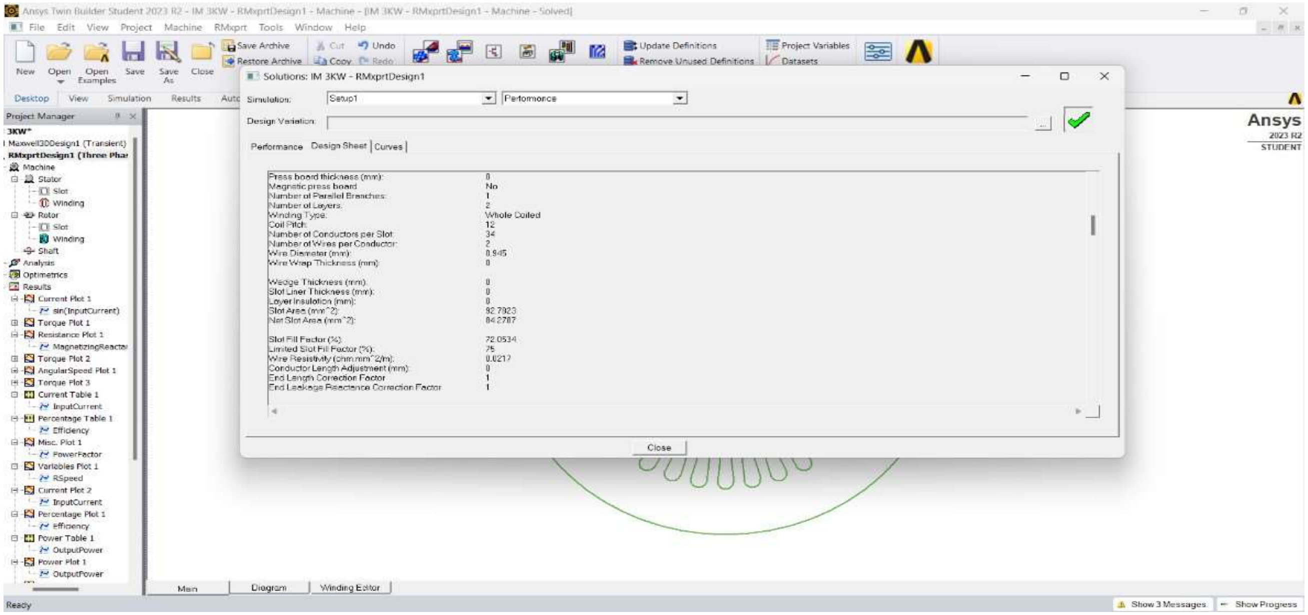


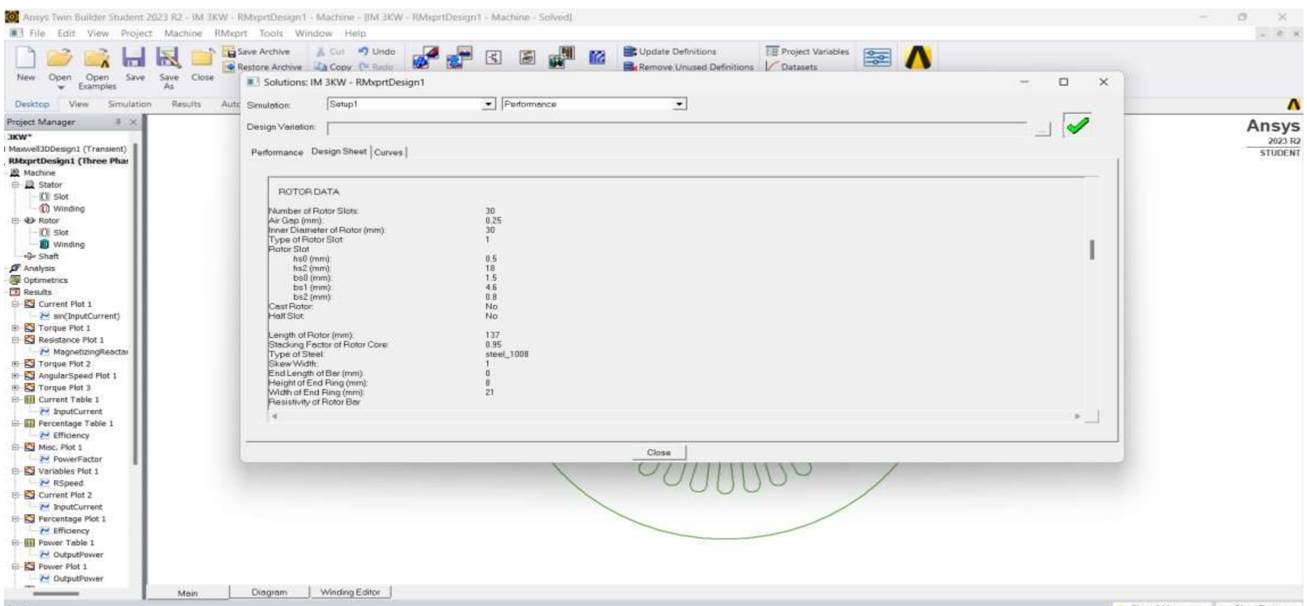
Design sheet :-

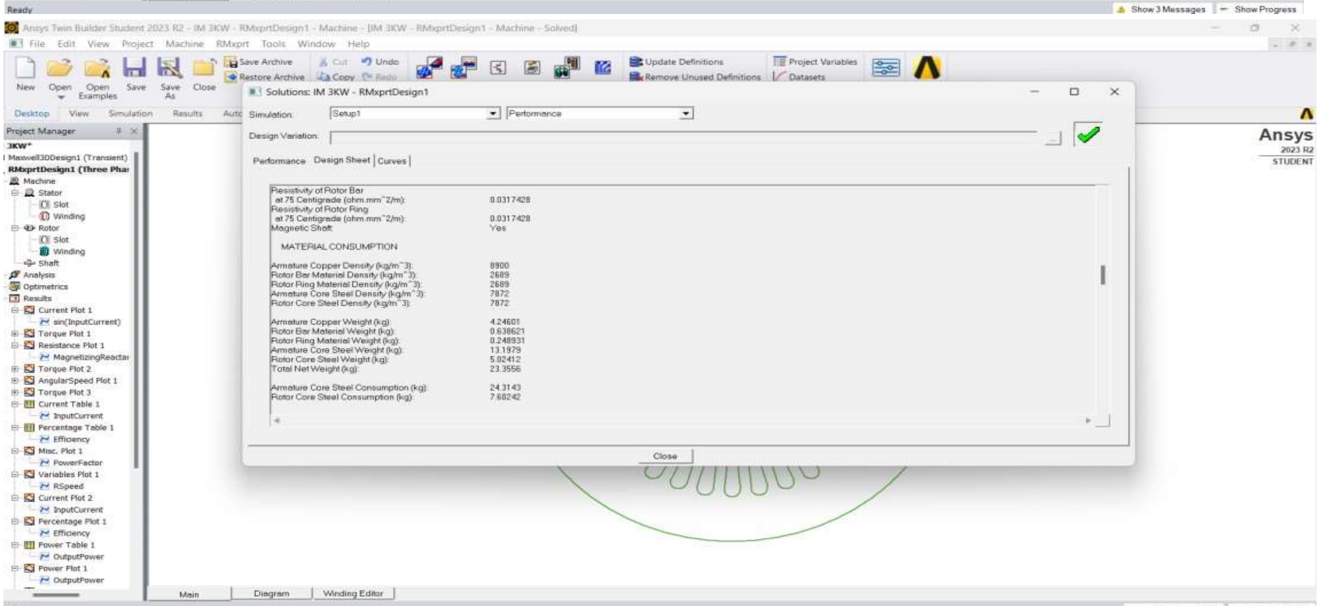


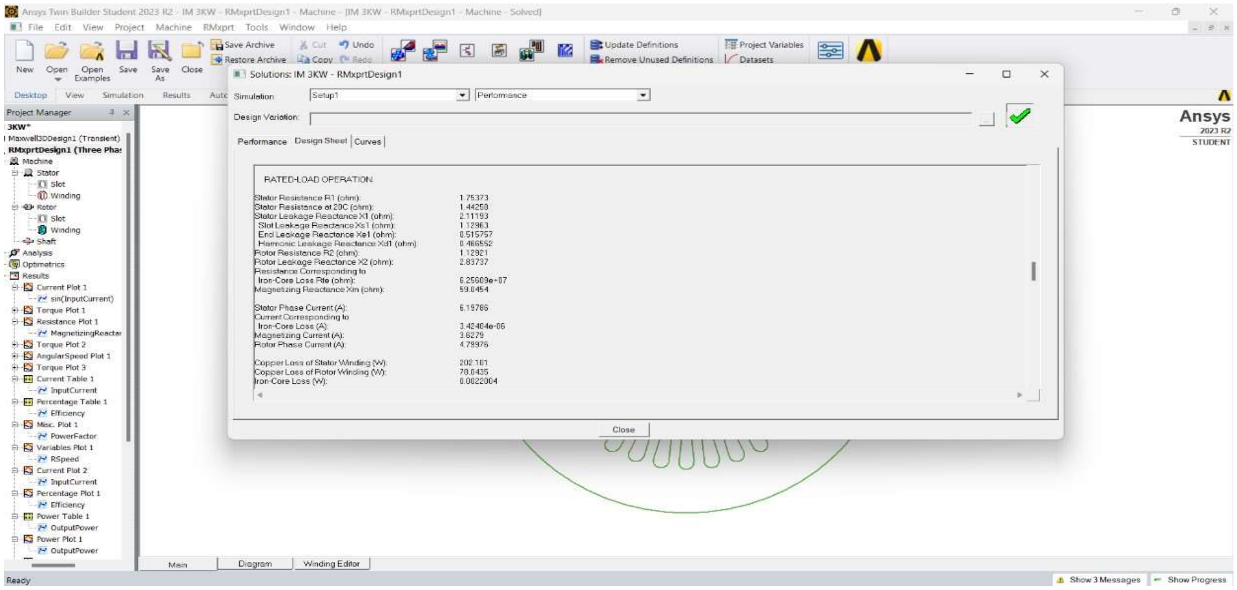
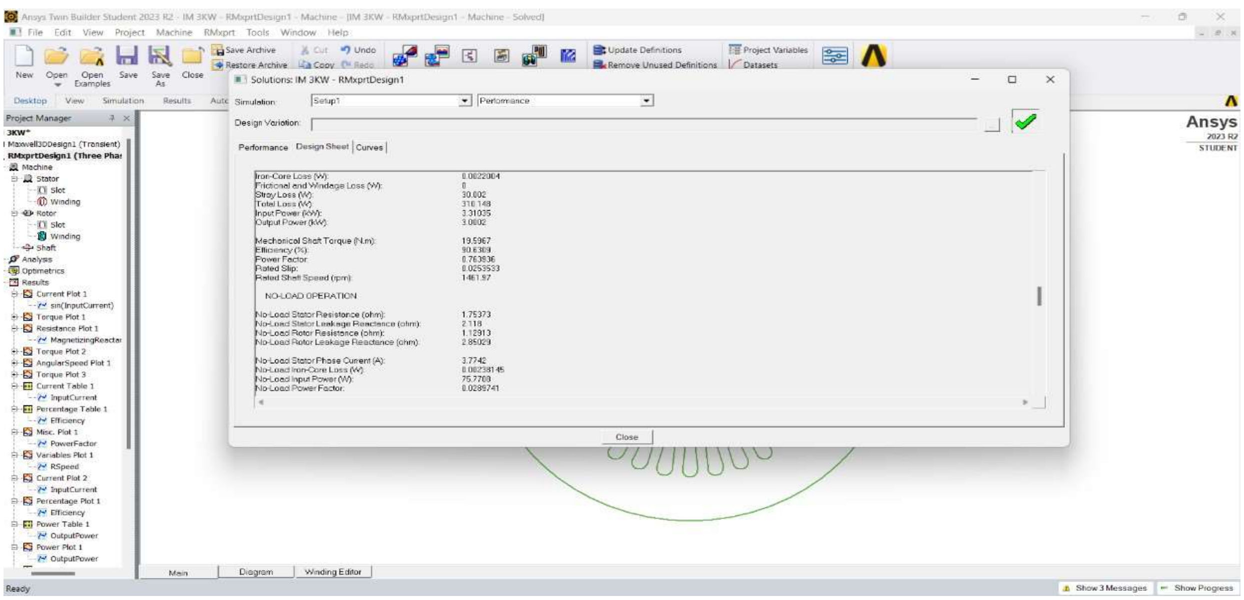
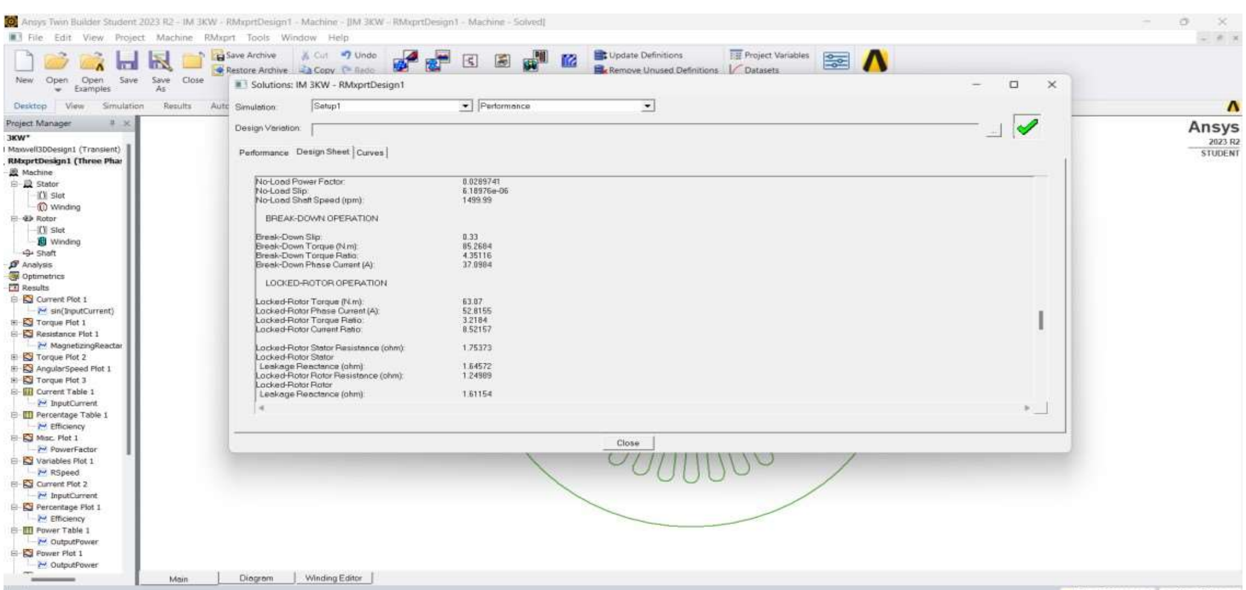


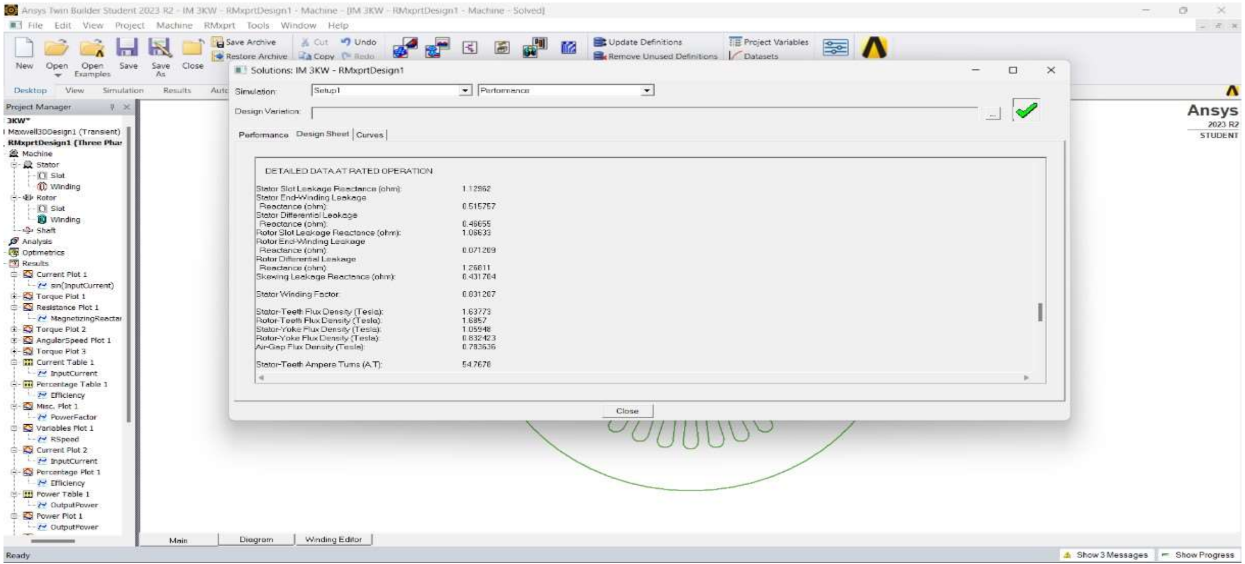


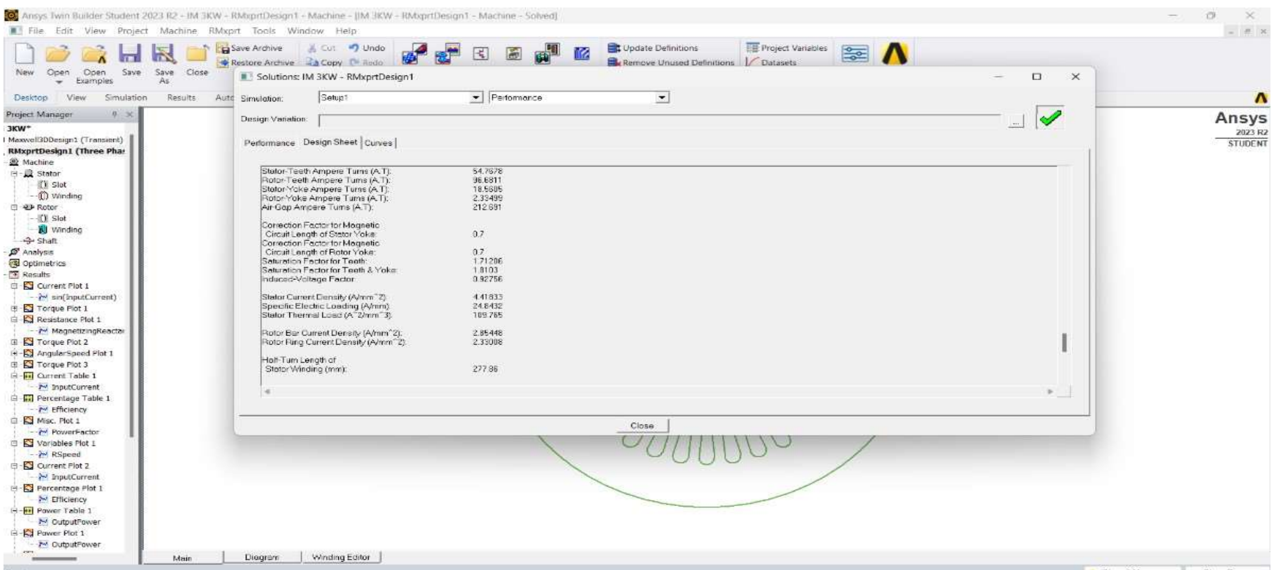

Solutions: IM 3KW - RMxprtDesign1
Simulation: Setup1
Performance
Design Variation:
Performance
Design Sheet
Curves
Press board thickness (mm): 0
Magnetic press board: No
Number of Parallel Branches: 1
Number of Layers: 2
Winding Type: Whole Coiled
Coil Pitch: 12
Number of Conductors per Slot: 34
Number of Wires per Conductor: 2
Wire Diameter (mm): 0.945
Wire Wrap Thickness (mm): 0
Wedge Thickness (mm): 0
Slot Liner Thickness (mm): 0
Layer Insulation (mm): 0
Slot Area (mm^2): 92.7923
Net Slot Area (mm^2): 84.2787
Slot Fill Factor (%): 72.0534
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
Close

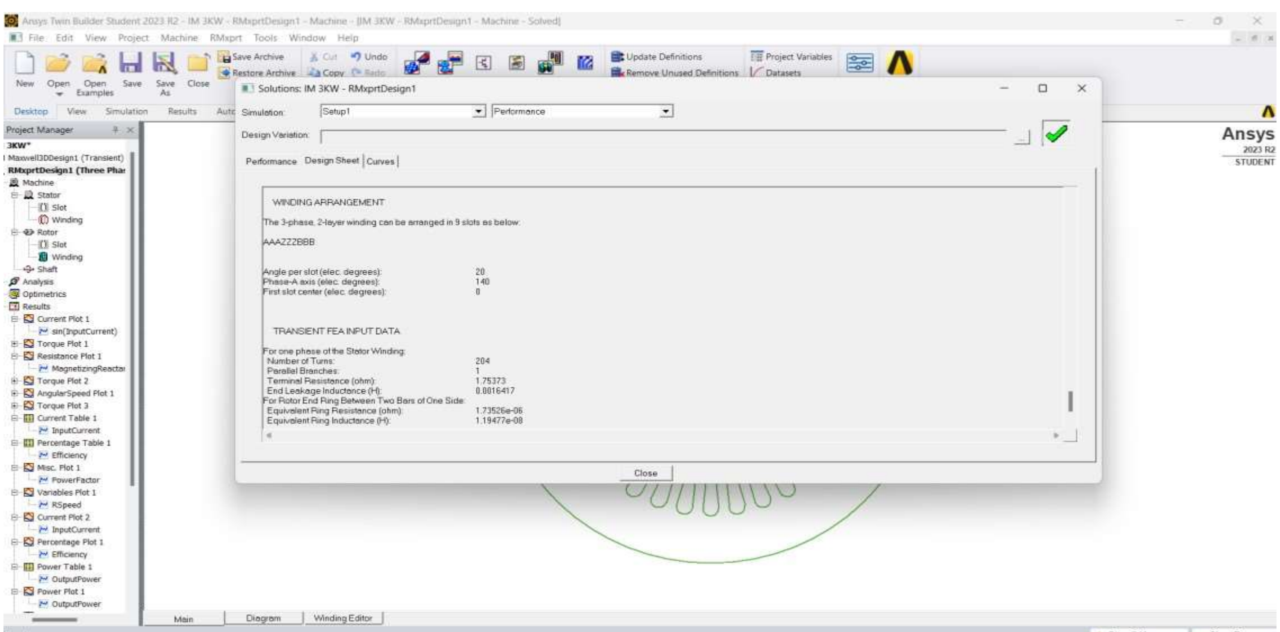

Solutions: IM 3KW - RMxprtDesign1
Simulation: Setup1
Performance
Design Variation:
Performance
Design Sheet
Curves
ROTOR DATA
Number of Rotor Slots: 30
Air Gap (mm): 0.25
Inner Diameter of Rotor (mm): 30
Type of Rotor Slot: 1
Rotor Slot
hs0 (mm): 0.5
hs2 (mm): 18
bs0 (mm): 1.5
bs1 (mm): 4.6
bs2 (mm): 0.8
Cast Rotor: No
Half Slot: No
Length of Rotor (mm): 137
Stacking Factor of Rotor Core: 0.95
Type of Steel: steel_1008
Skew Width: 1
End Length of Bar (mm): 0
Height of End Ring (mm): 8
Width of End Ring (mm): 21
Resistivity of Rotor Bar
Close


Solutions: IM 3KW - RMxprtDesign1
Simulation: Setup1
Performance
Design Variation:
Performance
Design Sheet
Curves
Resistivity of Rotor Bar
at 75 Centigrade (ohm.mm^2/m): 0.0317428
Resistivity of Rotor Ring
at 75 Centigrade (ohm.mm^2/m): 0.0317428
Magnetic Shaft: Yes
MATERIAL CONSUMPTION
Armature Copper Density (kg/m^3): 8900
Rotor Bar Material Density (kg/m^3): 2689
Rotor Ring Material Density (kg/m^3): 2689
Armature Core Steel Density (kg/m^3): 7872
Rotor Core Steel Density (kg/m^3): 7872
Armature Copper Weight (kg): 4.24601
Rotor Bar Material Weight (kg): 0.638621
Rotor Ring Material Weight (kg): 0.248931
Armature Core Steel Weight (kg): 13.1979
Rotor Core Steel Weight (kg): 5.02412
Total Net Weight (kg): 23.3556
Armature Core Steel Consumption (kg): 24.3143
Rotor Core Steel Consumption (kg): 7.60242
Close

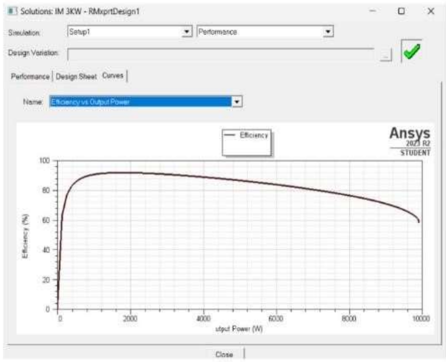

Solutions: IM 3KW - RMxprtDesign1
Simulation: Setup1
Performance
Design Variation:
Performance
Design Sheet
Curves
RATED-LOAD OPERATION
Stator Resistance R1 (ohm): 1.75373
Stator Resistance at 20C (ohm): 1.44258
Stator Leakage Reactance X1 (ohm): 2.11193
Slot Leakage Reactance Xs1 (ohm): 1.12963
End Leakage Reactance Xe1 (ohm): 0.515757
Harmonic Leakage Reactance Xd1 (ohm): 0.466552
Rotor Resistance R2 (ohm): 1.12921
Rotor Leakage Reactance X2 (ohm): 2.83737
Resistance Corresponding to
Iron-Core Loss Rfe (ohm): 6.25609e+07
Magnetizing Reactance Xm (ohm): 59.0454
Stator Phase Current (A): 6.19786
Current Corresponding to
Iron-Core Loss (A): 3.42404e-06
Magnetizing Current (A): 3.6279
Rotor Phase Current (A): 4.79976
Copper Loss of Stator Winding (W): 202.101
Copper Loss of Rotor Winding (W): 78.0435
Iron-Core Loss (W): 0.0022004
Close

Solutions: IM 3KW - RMxprtDesign1
Simulation: Setup1
Performance
Design Variation:
Performance
Design Sheet
Curves
Iron-Core Loss (W): 0.0022004
Frictional and Windage Loss (W): 0
Stray Loss (W): 30.002
Total Loss (W): 310.148
Input Power (kW): 3.31035
Output Power (kW): 3.0002
Mechanical Shaft Torque (N.m): 19.5967
Efficiency (%): 90.6309
Power Factor: 0.763936
Rated Slip: 0.0253533
Rated Shaft Speed (rpm): 1461.97
NO-LOAD OPERATION
No-Load Stator Resistance (ohm): 1.75373
No-Load Stator Leakage Reactance (ohm): 2.118
No-Load Rotor Resistance (ohm): 1.12913
No-Load Rotor Leakage Reactance (ohm): 2.85029
No-Load Stator Phase Current (A): 3.7742
No-Load Iron-Core Loss (W): 0.00238145
No-Load Input Power (W): 75.7708
No-Load Power Factor: 0.0289741
Close

Solutions: IM 3KW - RMxprtDesign1
Simulation: Setup1
Performance
Design Variation:
Performance
Design Sheet
Curves
No-Load Power Factor: 0.0289741
No-Load Slip: 6.18976e-06
No-Load Shaft Speed (rpm): 1499.99
BREAK-DOWN OPERATION
Break-Down Slip: 0.33
Break-Down Torque (N.m): 85.2684
Break-Down Torque Ratio: 4.35116
Break-Down Phase Current (A): 37.0984
LOCKED-ROTOR OPERATION
Locked-Rotor Torque (N.m): 63.07
Locked-Rotor Phase Current (A): 52.8155
Locked-Rotor Torque Ratio: 3.2184
Locked-Rotor Current Ratio: 8.52157
Locked-Rotor Stator Resistance (ohm): 1.75373
Locked-Rotor Stator
Leakage Reactance (ohm): 1.64572
Locked-Rotor Rotor Resistance (ohm): 1.24989
Locked-Rotor Rotor
Leakage Reactance (ohm): 1.61154
Close

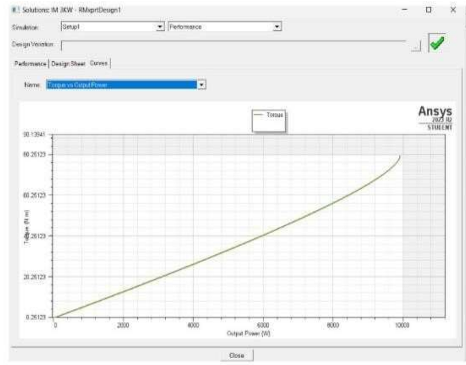

Solutions: IM 3KW - RMxprtDesign1
Simulation: Setup1 Performance
Design Variation:
Performance Design Sheet Curves
DETAILED DATA AT RATED OPERATION
Stator Slot Leakage Reactance (ohm): 1.12962
Stator End-Winding Leakage Reactance (ohm): 0.515757
Stator Differential Leakage Reactance (ohm): 0.46655
Rotor Slot Leakage Reactance (ohm): 1.06633
Rotor End-Winding Leakage Reactance (ohm): 0.071209
Rotor Differential Leakage Reactance (ohm): 1.26811
Skewing Leakage Reactance (ohm): 0.431704
Stator Winding Factor: 0.831207
Stator-Teeth Flux Density (Tesla): 1.63773
Rotor-Teeth Flux Density (Tesla): 1.6857
Stator-Yoke Flux Density (Tesla): 1.05948
Rotor-Yoke Flux Density (Tesla): 0.832423
Air-Gap Flux Density (Tesla): 0.783636
Stator-Teeth Ampere Turns (A.T): 54.7678
Close

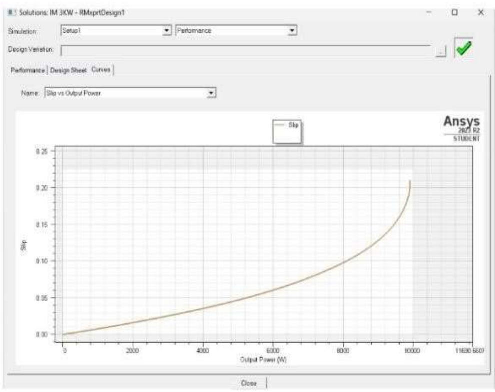

Solutions: IM 3KW - RMxprtDesign1
Simulation: Setup1 Performance
Design Variation:
Performance Design Sheet Curves
Stator-Teeth Ampere Turns (A.T): 54.7678
Rotor-Teeth Ampere Turns (A.T): 96.6811
Stator-Yoke Ampere Turns (A.T): 18.5605
Rotor-Yoke Ampere Turns (A.T): 2.33499
Air-Gap Ampere Turns (A.T): 212.691
Correction Factor for Magnetic Circuit Length of Stator Yoke: 0.7
Correction Factor for Magnetic Circuit Length of Rotor Yoke: 0.7
Saturation Factor for Teeth: 1.71206
Saturation Factor for Teeth & Yoke: 1.8103
Induced-Voltage Factor: 0.92756
Stator Current Density (A/mm^2): 4.41833
Specific Electric Loading (A/mm): 24.8432
Stator Thermal Load (A^2/mm^3): 109.765
Rotor Bar Current Density (A/mm^2): 2.85448
Rotor Ring Current Density (A/mm^2): 2.33008
Half-Turn Length of Stator Winding (mm): 277.86
Close

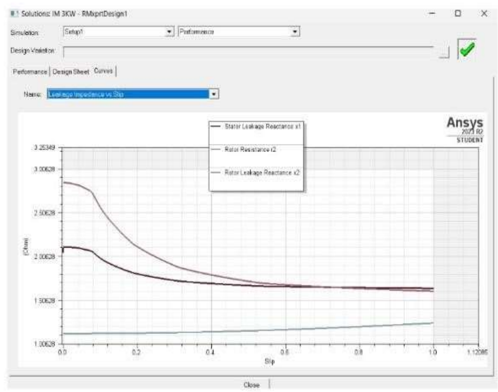

Solutions: IM 3KW - RMxprtDesign1
Simulation: Setup1 Performance
Design Variation:
Performance Design Sheet Curves
WINDING ARRANGEMENT
The 3-phase, 2-layer winding can be arranged in 9 slots as below:
AAAZZZBBB
Angle per slot (elec. degrees): 20
Phase-A axis (elec. degrees): 140
First slot center (elec. degrees): 0
TRANSIENT FEA INPUT DATA
For one phase of the Stator Winding:
Number of Turns: 204
Parallel Branches: 1
Terminal Resistance (ohm): 1.75373
End Leakage Inductance (H): 0.0016417
For Rotor End Ring Between Two Bars of One Side:
Equivalent Ring Resistance (ohm): 1.73526e-06
Equivalent Ring Inductance (H): 1.19477e-08
Close

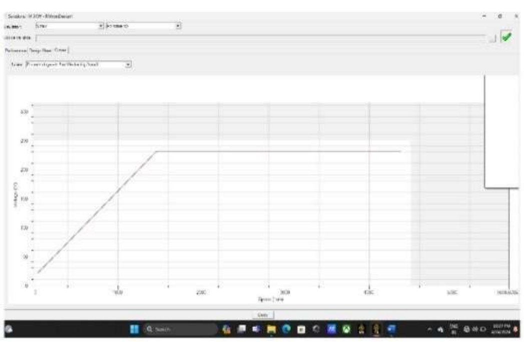
Outputs :-

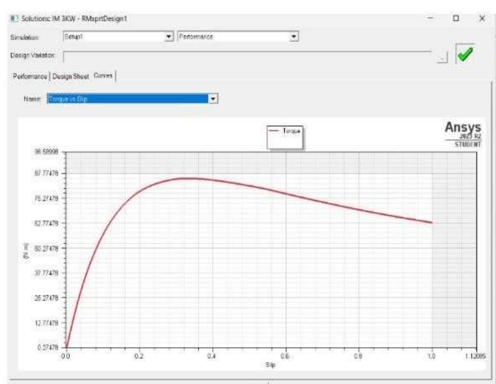

Solutions: IM 3KW - RMxprtDesign1
Simulation: Setup1 Performance
Design Variation:
Performance | Design Sheet Curves
Name: Efficiency vs Output Power
Efficiency
Ansys 2023 R2 STUDENT
Efficiency (%)
Output Power (W)
Close

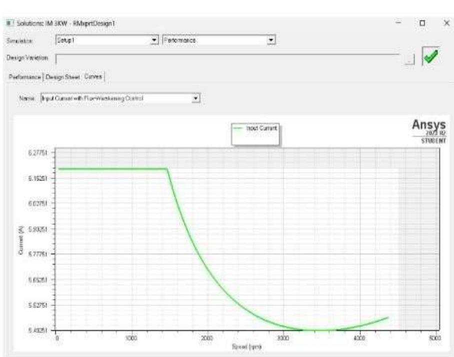

Solutions: IM 3KW - RMxprtDesign1
Name: Torque vs Output Power
Torque
Ansys 2023 R2 STUDENT
Output Power (W)
Close

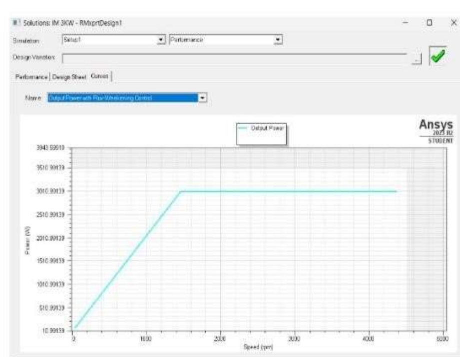

Solutions: IM 3KW - RMxprtDesign1
Simulation: Setup1 Performance
Design Variation:
Performance | Design Sheet Curves
Name: Slip vs Output Power
Slip
Ansys 2023 R2 STUDENT
Output Power (W)
Close

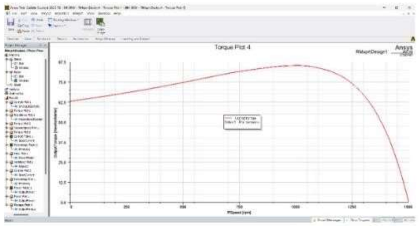

Solutions: IM 3KW - RMxprtDesign1
Simulation: Setup1 Performance
Design Variation:
Performance | Design Sheet Curves
Name: Leakage Impedance vs Slip
Stator Leakage Reactance x1
Rotor Resistance r2
Rotor Leakage Reactance x2
Ansys 2023 R2 STUDENT
(Ohm)
Slip
Close

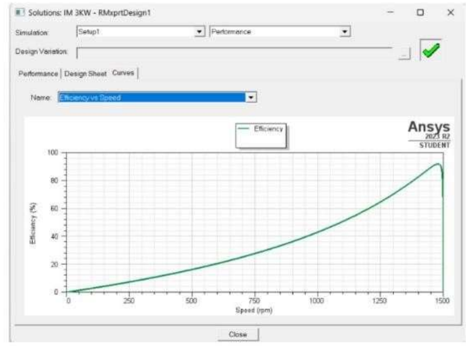


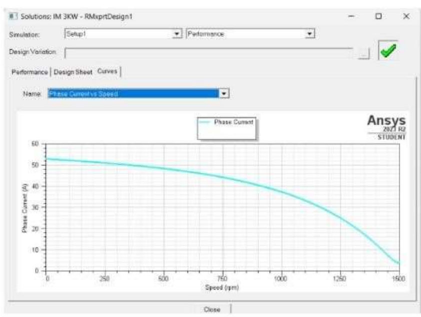

Solutions: IM 3KW - RMxprtDesign1
Simulation: Setup1 Performance
Design Variation:
Performance | Design Sheet Curves
Name: Torque vs Slip
Torque
Ansys 2023 R2 STUDENT
Slip
Close

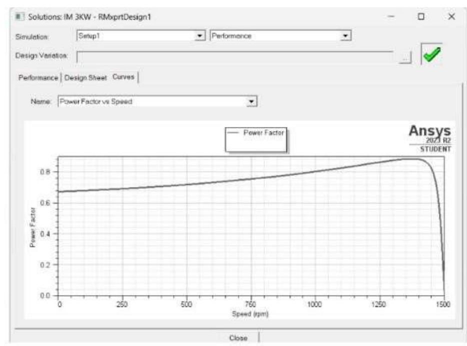

Solutions: IM 3KW - RMxprtDesign1
Simulation: Setup1 Performance
Design Variation:
Performance | Design Sheet Curves
Name: Input Current with Flux-Weakening Control
Input Current
Ansys 2023 R2 STUDENT
Current (A)
Speed (rpm)
Close

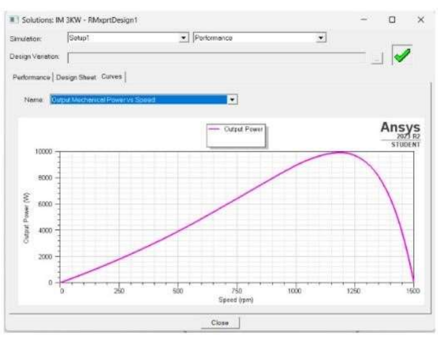

Solutions: IM 3KW - RMxprtDesign1
Name: Output Power with Flux-Weakening Control
Output Power
Ansys 2023 R2 STUDENT
Power (W)
Speed (rpm)
Close

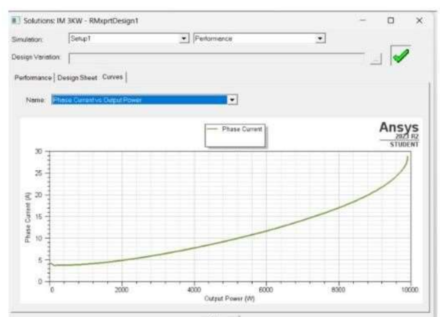

Torque Plot 4
RMxprtDesign1
Ansys

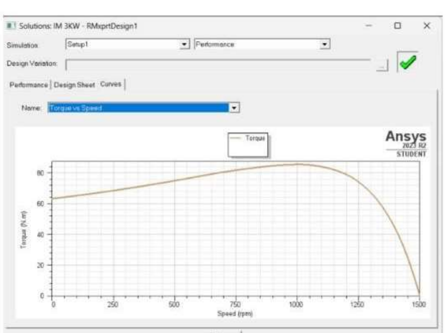

Solutions: IM 3KW - RMxprtDesign1
Simulation: Setup1 Performance
Design Variation:
Performance Design Sheet Curves
Name: Efficiency vs Speed
Efficiency
Ansys 2023 R2 STUDENT
Efficiency (%)
Speed (rpm)
Close

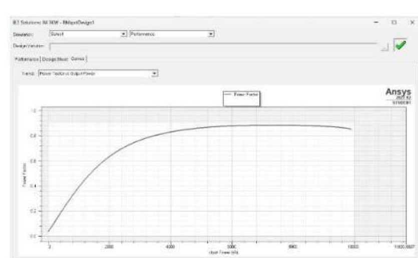

Solutions: IM 3KW - RMxprtDesign1
Simulation: Setup1 Performance
Design Variation:
Performance Design Sheet Curves
Name: Phase Current vs Speed
Phase Current
Ansys 2023 R2 STUDENT
Phase Current (A)
Speed (rpm)
Close

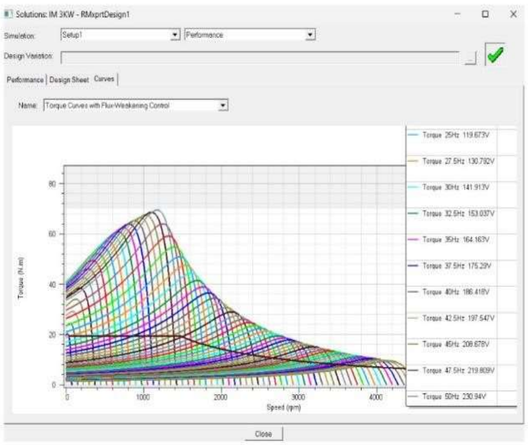

Solutions: IM 3KW - RMxprtDesign1
Simulation: Setup1 Performance
Design Variation:
Performance Design Sheet Curves
Name: Power Factor vs Speed
Power Factor
Ansys 2023 R2 STUDENT
Power Factor
Speed (rpm)
Close

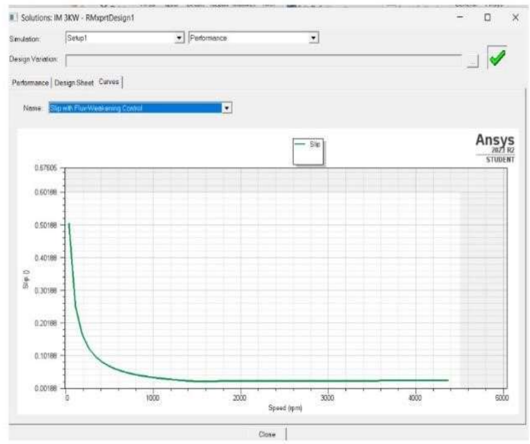

Solutions: IM 3KW - RMxprtDesign1
Simulation: Setup1 Performance
Design Variation:
Performance Design Sheet Curves
Name: Output Mechanical Power vs Speed
Output Power
Ansys 2023 R2 STUDENT
Output Power (W)
Speed (rpm)
Close

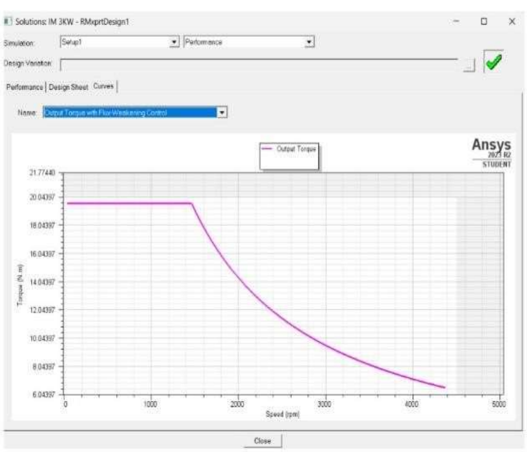

Solutions: IM 3KW - RMxprtDesign1
Simulation: Setup1 Performance
Design Variation:
Performance Design Sheet Curves
Name: Phase Current vs Output Power
Phase Current
Ansys 2023 R2 STUDENT
Phase Current (A)
Output Power (W)
Close

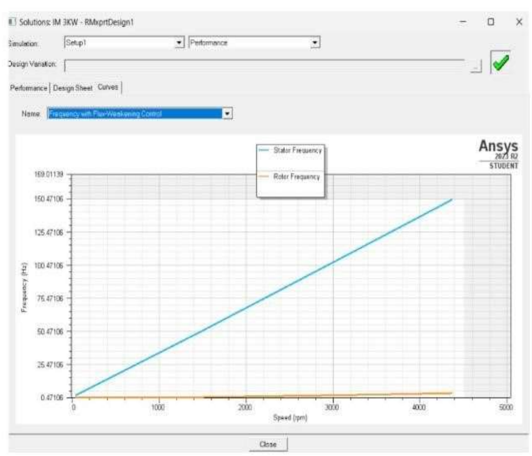

Solutions: IM 3KW - RMxprtDesign1
Simulation: Setup1 Performance
Design Variation:
Performance Design Sheet Curves
Name: Torque vs Speed
Torque
Ansys 2023 R2 STUDENT
Torque (N.m)
Speed (rpm)
Close


Solutions: IM 3KW - RMxprtDesign1
Ansys
Close

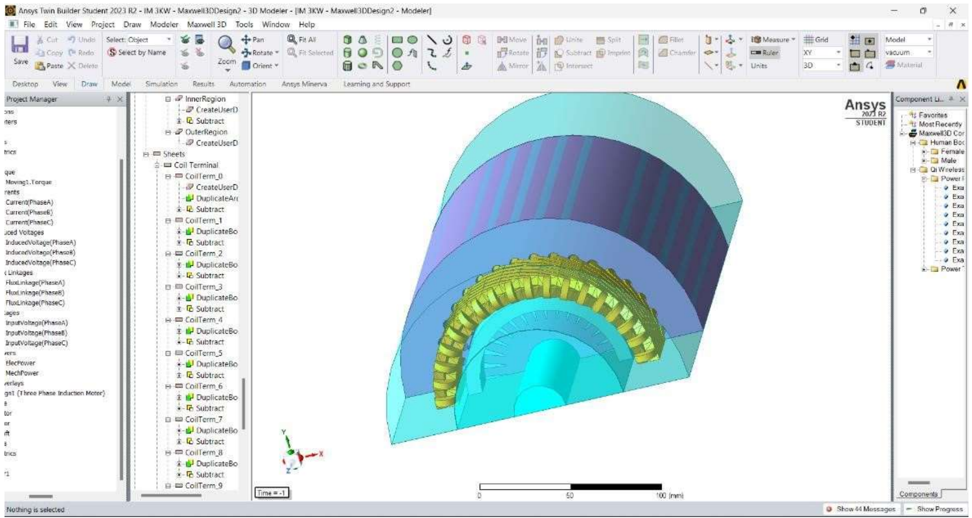

Solutions: IM 3KW - RMxprtDesign1
Simulation:
Setup1
Performance
Design Variation:
Performance
Design Sheet
Curves
Name:
Torque Curves with Flux-Weakening Control
Torque 25Hz 119.673V
Torque 27.5Hz 130.792V
Torque 30Hz 141.913V
Torque 32.5Hz 153.037V
Torque 35Hz 164.167V
Torque 37.5Hz 175.29V
Torque 40Hz 186.418V
Torque 42.5Hz 197.547V
Torque 45Hz 208.678V
Torque 47.5Hz 219.809V
Torque 50Hz 230.94V
Torque (N.m)
Speed (rpm)
Close

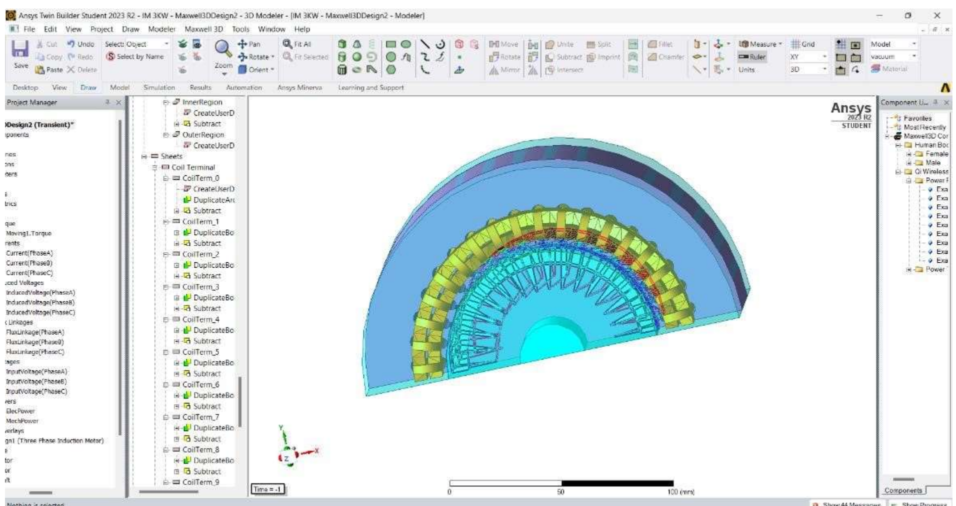

Solutions: IM 3KW - RMxprtDesign1
Simulation:
Setup1
Performance
Design Variation:
Performance
Design Sheet
Curves
Name:
Slip with Flux-Weakening Control
Slip
Ansys
2023 R2
STUDENT
Slip ()
Speed (rpm)
Close

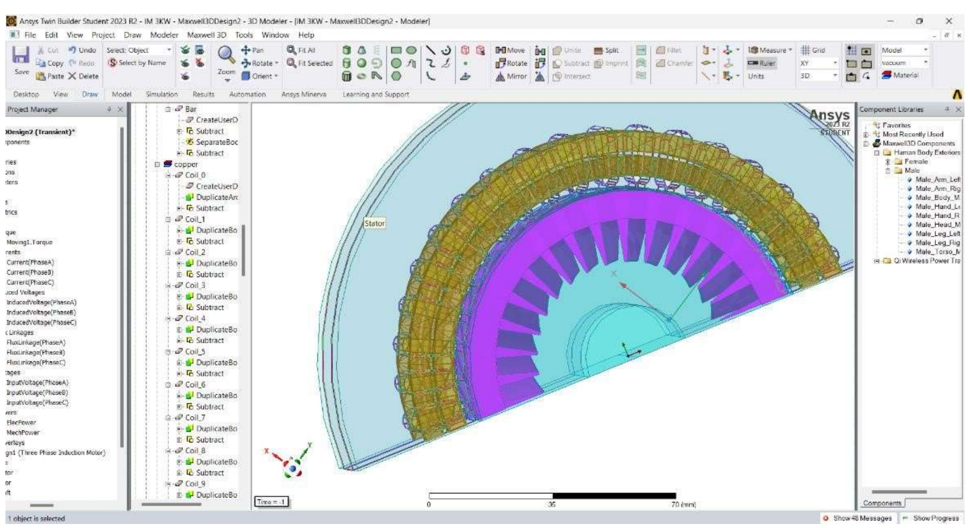

Solutions: IM 3KW - RMxprtDesign1
Simulation:
Setup1
Performance
Design Variation:
Performance
Design Sheet
Curves
Name:
Output Torque with Flux-Weakening Control
Output Torque
Ansys
2023 R2
STUDENT
Torque (N.m)
Speed (rpm)
Close

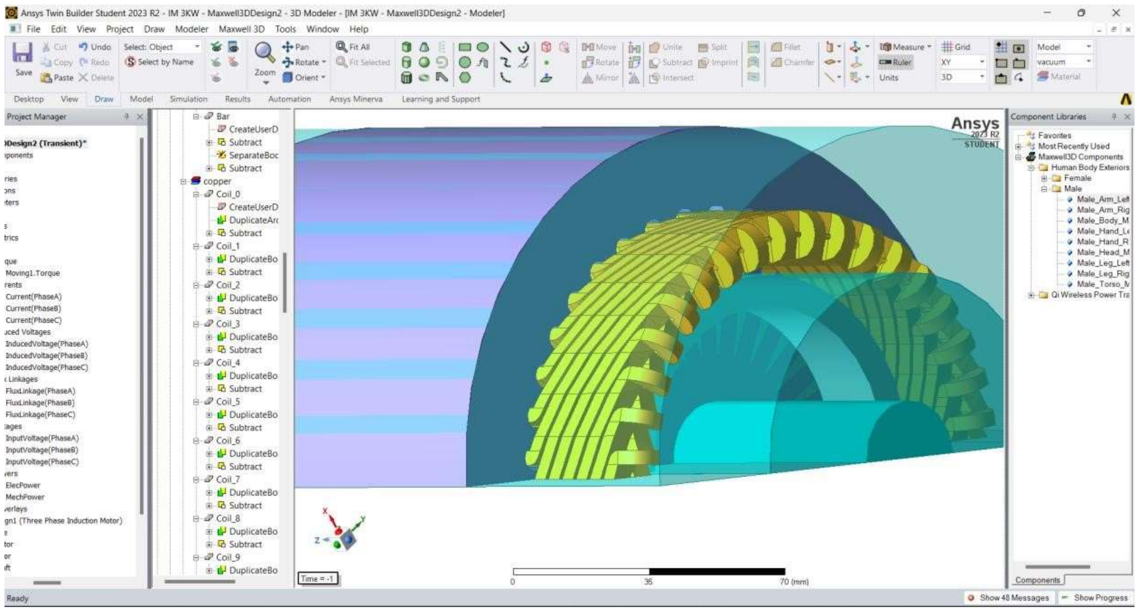

Solutions: IM 3KW - RMxprtDesign1
Simulation:
Setup1
Performance
Design Variation:
Performance
Design Sheet
Curves
Name:
Frequency with Flux-Weakening Control
Stator Frequency
Rotor Frequency
Ansys
2023 R2
STUDENT
Frequency (Hz)
Speed (rpm)
Close

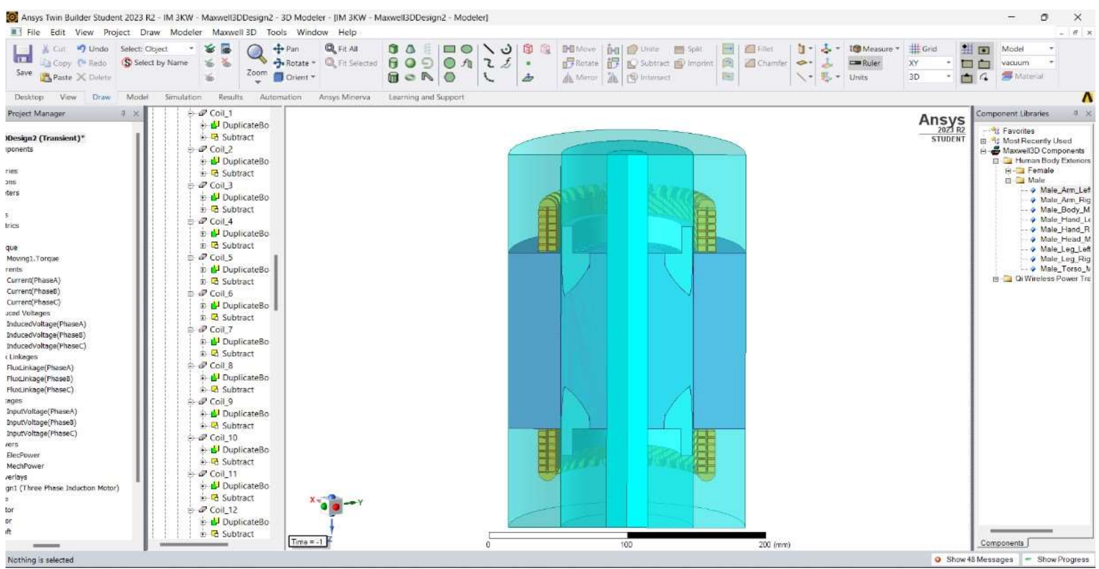
Final look of motor











Conclusion:-

The ANSYS simulation successfully modeled the electromagnetic performance and operational characteristics of the 3-phase induction motor. The analysis provided detailed insights into the motor's magnetic flux distribution, torque, efficiency, and thermal behavior under various load conditions. By simulating real-world scenarios, we identified potential areas for performance improvement and optimized the motor design for better efficiency and reduced losses. The design process demonstrated the capability of ANSYS to accurately predict the motor's performance, enabling the creation of a reliable and efficient motor suitable for industrial applications. This project highlights the effectiveness of using advanced simulation tools like ANSYS in the design and optimization of electrical machines.