DESIGN OPTIMIZATION OF BRAKE DISC GEOMETRY USING DOE in ANSYS

MAE 598 Project – 2 Report

By

Divya Sree Naidu

(1219764715)

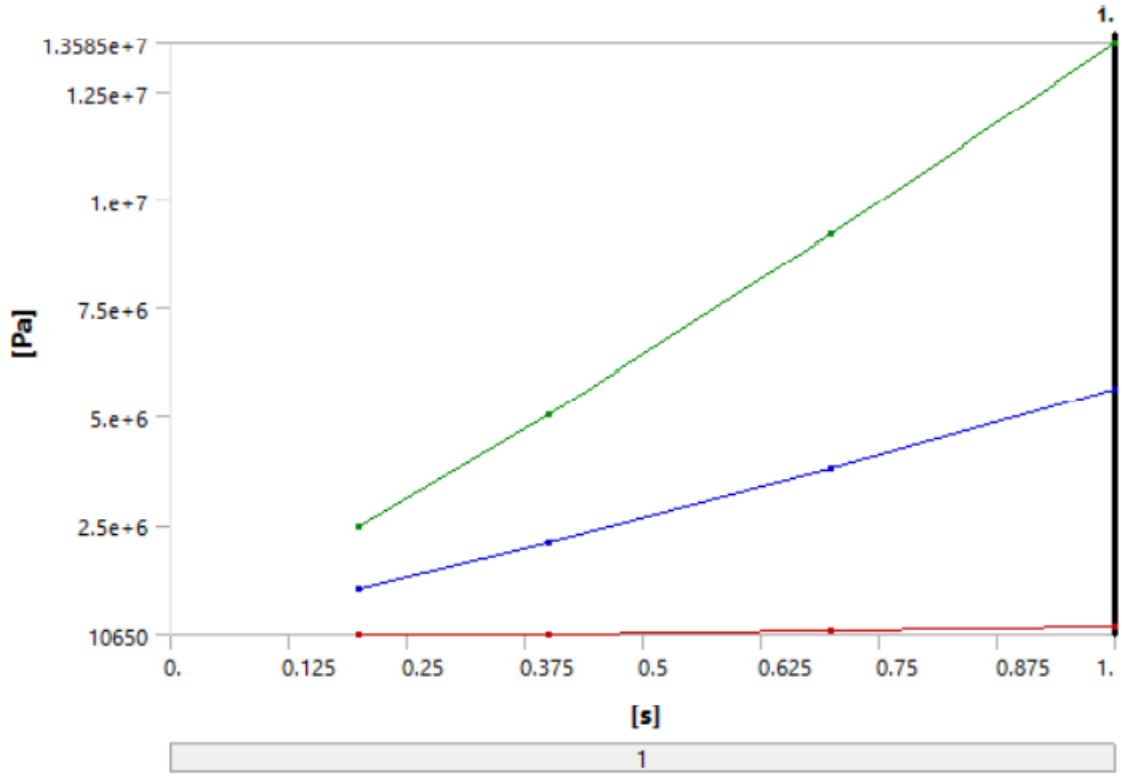
Abstract:

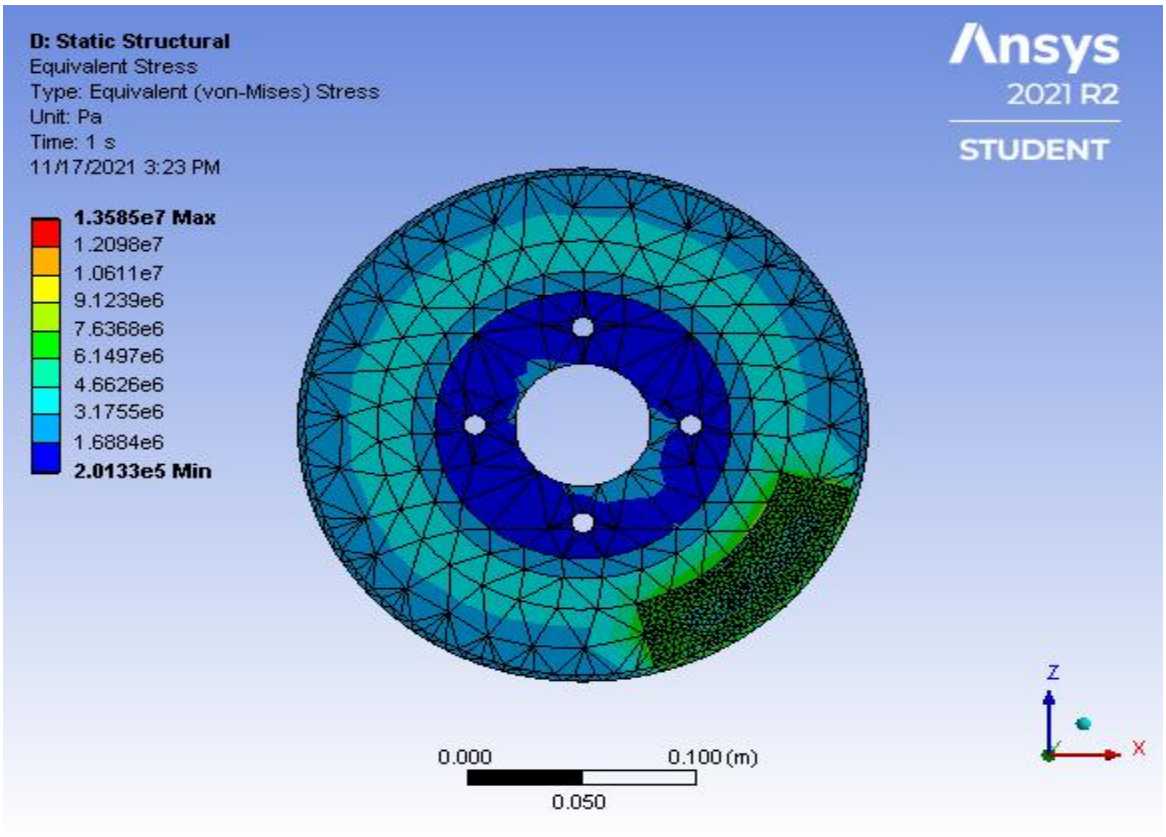
This report talks about the study of optimization of brake disc geometry in a four-wheeler vehicle using Design of Experiments (DOE) in ANSYS. The analysis is conducted on various objects like minimize the maximum stress in the brake disc, design a brake disc for emergency braking conditions with minimal volume, minimize the maximum temperature in the brake disc and maximize the first natural frequency of the brake disc. Before performing the optimization, various analysis like Structural, Modal and Thermal are performed to validate the obtained optimal solution. Response surface is used as Design Exploration method and Latin Hypercube Sampling (LHS) is considered for DOE method. Adaptive Multi-Objective Optimization (AMO) is used as Optimization algorithm.

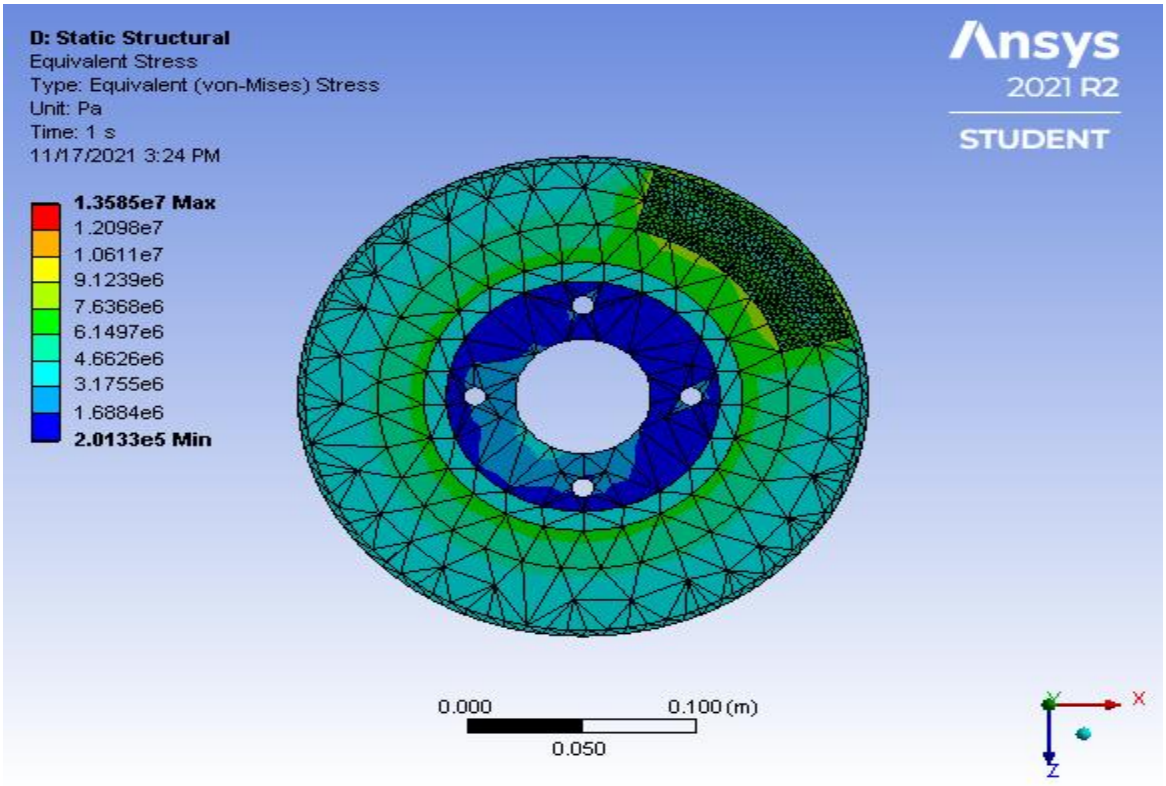
Structural Analysis:

Equivalent Stress (Von-misses)

FIGURE 4
Model (D4) > Static Structural (D5) > Solution (D6) > Equivalent Stress




D: Static Structural
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: Pa
Time: 1 s
11/17/2021 3:23 PM
1.3585e7 Max
1.2098e7
1.0611e7
9.1239e6
7.6368e6
6.1497e6
4.6626e6
3.1755e6
1.6884e6
2.0133e5 Min
Ansys
2021 R2
STUDENT
0.000
0.100 (m)
0.050
Z
X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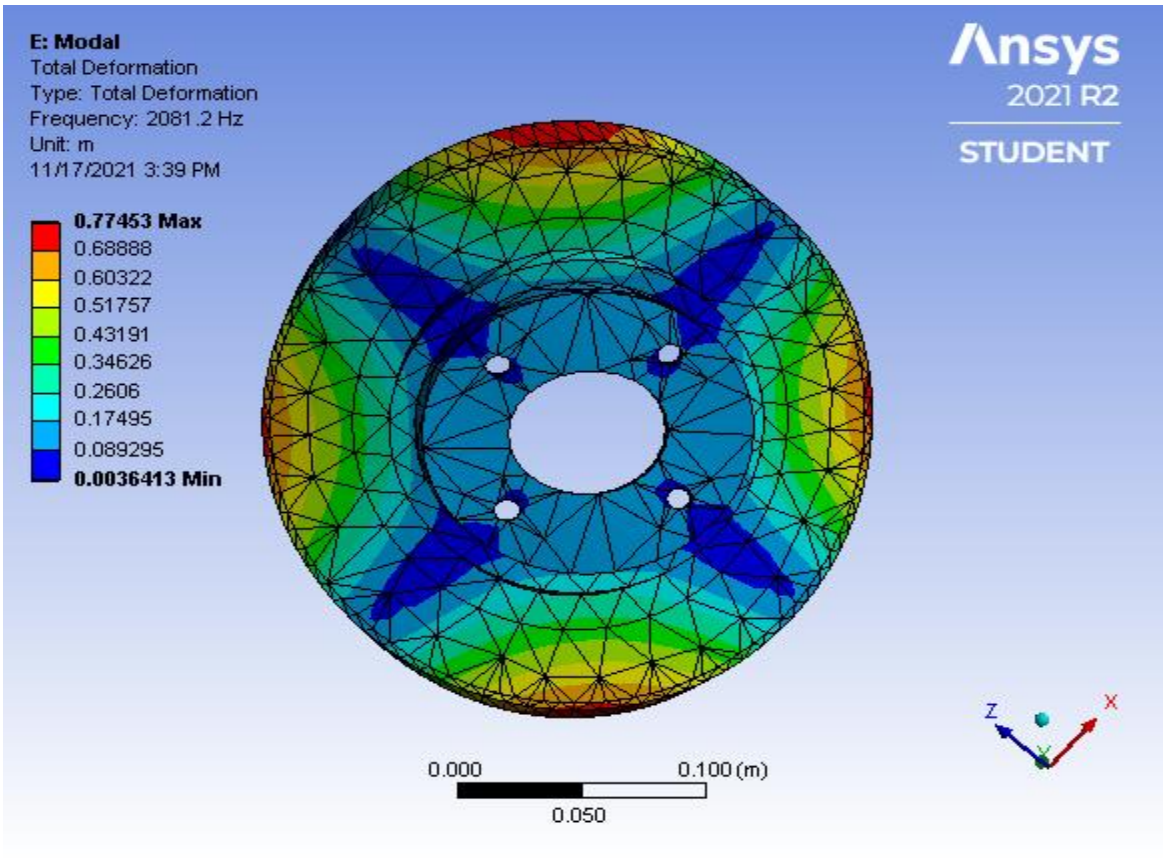
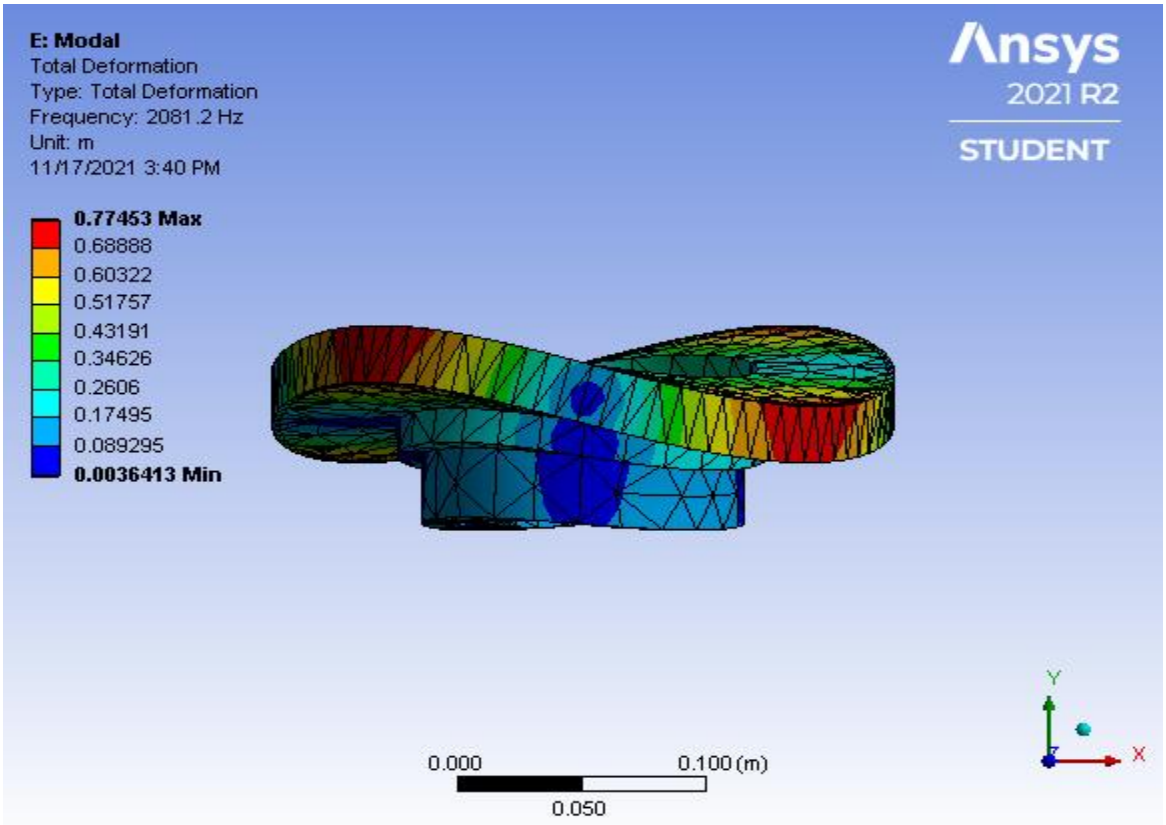
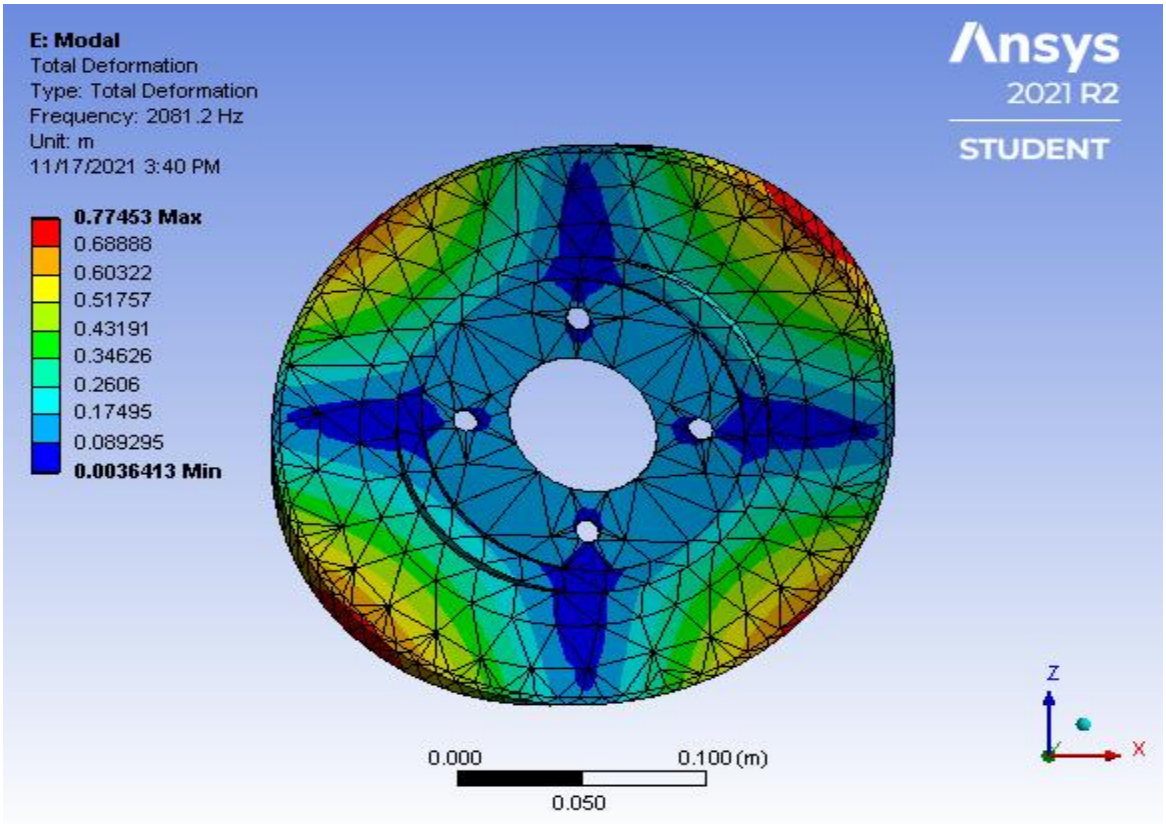
1.6884e6
2.0133e5 Min
Ansys
2021 R2
STUDENT
0.000
0.100 (m)
0.050
Y
X
Z

Deformation:




E: Modal
Total Deformation
Type: Total Deformation
Frequency: 2081.2 Hz
Unit: m
11/17/2021 3:40 PM
0.77453 Max
0.68888
0.60322
0.51757
0.43191
0.34626
0.2606
0.17495
0.089295
0.0036413 Min
Ansys
2021 R2
STUDENT
0.000
0.100 (m)
0.050
Y
X


E: Modal
Total Deformation
Type: Total Deformation
Frequency: 2081.2 Hz
Unit: m
11/17/2021 3:40 PM
0.77453 Max
0.68888
0.60322
0.51757
0.43191
0.34626
0.2606
0.17495
0.089295
0.0036413 Min
Ansys
2021 R2
STUDENT
0.000
0.100 (m)
0.050
Z
X

Modal Analysis:

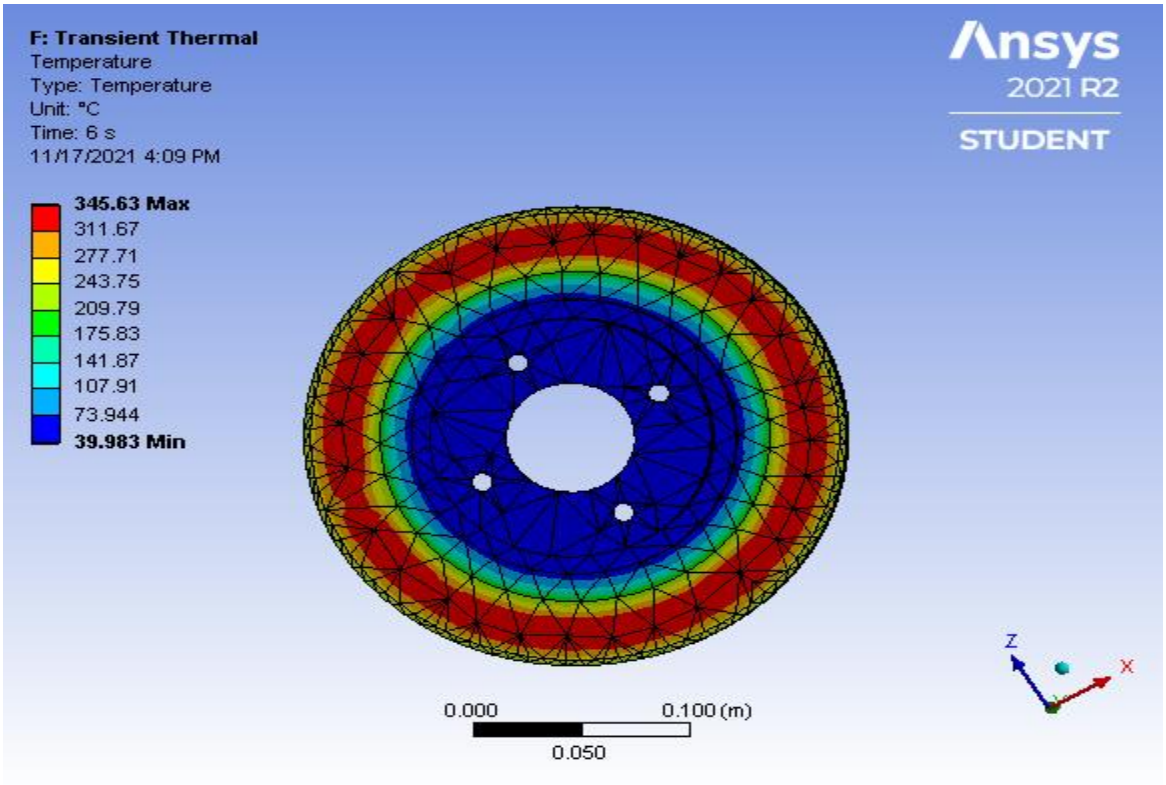
TABLE 18
Model (E4) > Modal (E5) > Solution (E6) > Results

Object Name	*Total Deformation*
State	Solved
Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
Mode	7.
Identifier	
Suppressed	No
Results	
Minimum	3.6413e-003 m
Maximum	0.77453 m
Average	0.32819 m
Minimum Occurs On	Solid
Maximum Occurs On	Solid
Information	
Frequency	2081.2 Hz

TABLE 19
Model (E4) > Modal (E5) > Solution (E6) > Total Deformation

Mode	Frequency [Hz]
1.	0.
2.	
3.	
4.	2.0187e-003
5.	3.9598e-003
6.	5.8548e-003
7.	2081.2
8.	2087.2
9.	3628.9
10.	3649.5

Thermal Analysis:


F: Transient Thermal
Temperature
Type: Temperature
Unit: °C
Time: 6 s
11/17/2021 4:09 PM
345.63 Max
311.67
277.71
243.75
209.79
175.83
141.87
107.91
73.944
39.983 Min
Ansys
2021 R2
STUDENT
Z
X
0.000
0.100 (m)
0.050

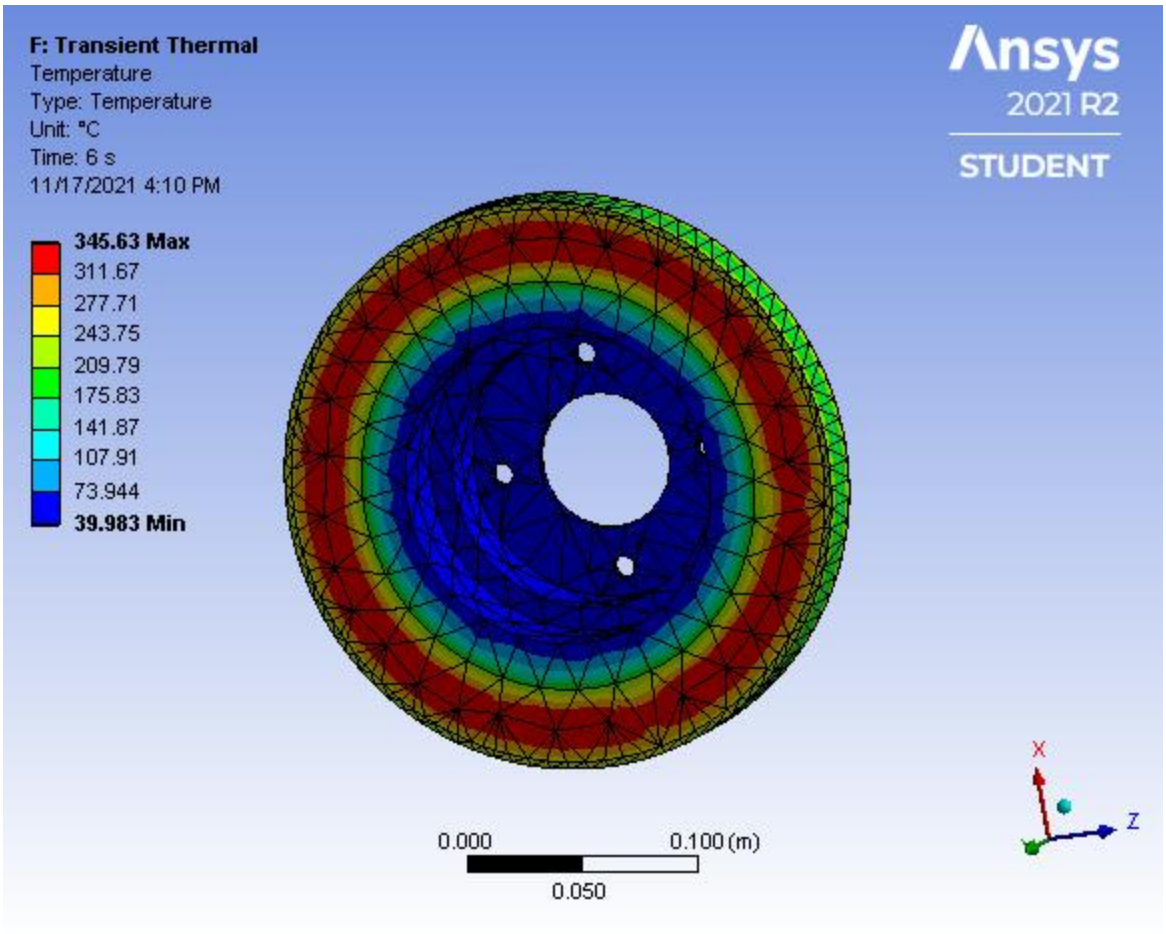

F: Transient Thermal
Temperature
Type: Temperature
Unit: °C
Time: 6 s
11/17/2021 4:10 PM
345.63 Max
311.67
277.71
243.75
209.79
175.83
141.87
107.91
73.944
39.983 Min
Ansys
2021 R2
STUDENT
0.000
0.100 (m)
0.050
X
Z

FIGURE 4

Model (F4) > Transient Thermal (F5) > Solution (F6) > Solution Information > Temperature - Global Maximum

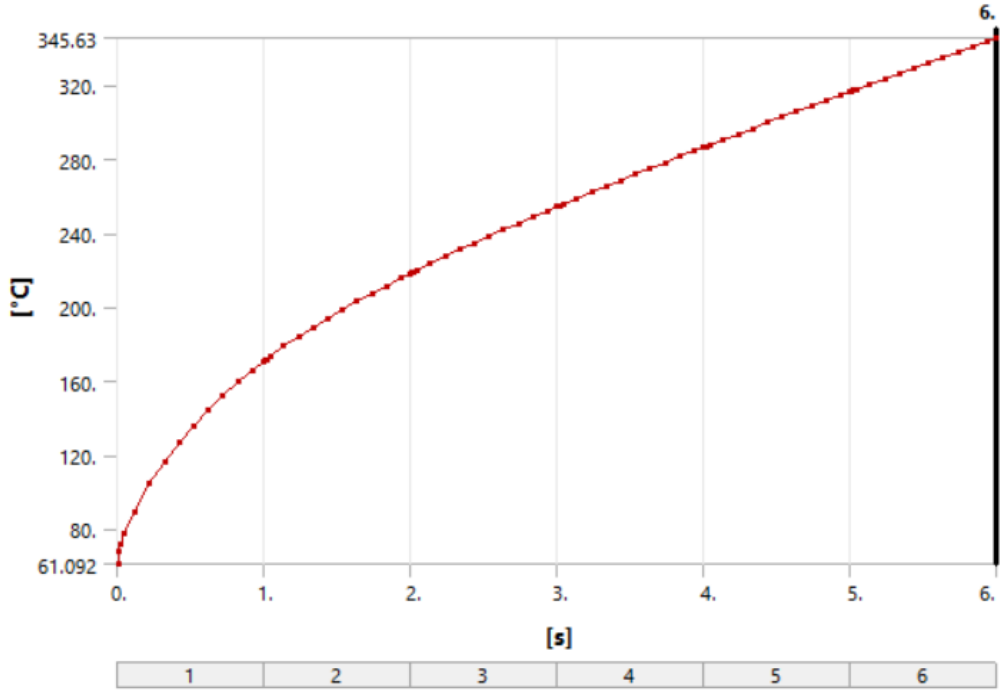


FIGURE 5

Model (F4) > Transient Thermal (F5) > Solution (F6) > Solution Information > Temperature - Global Minimum

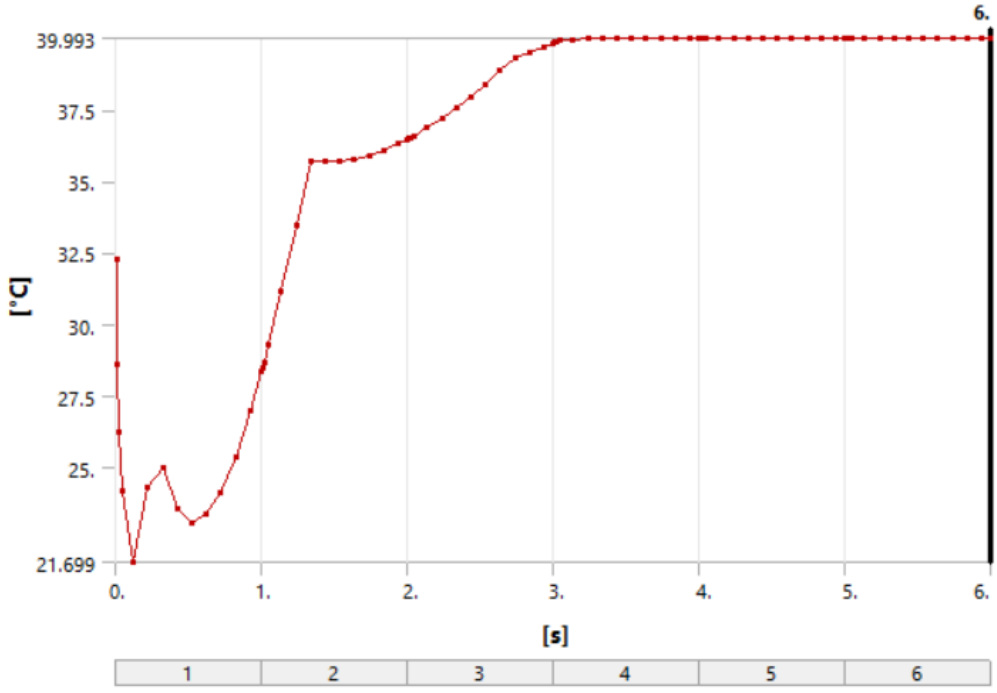
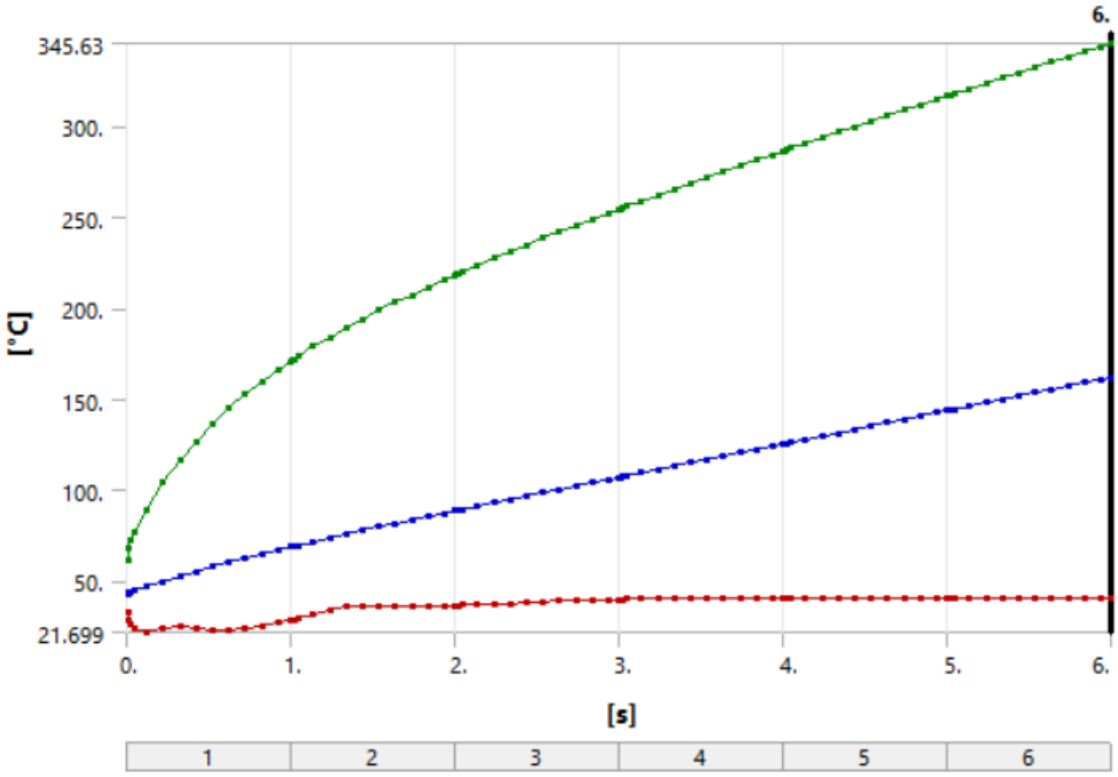
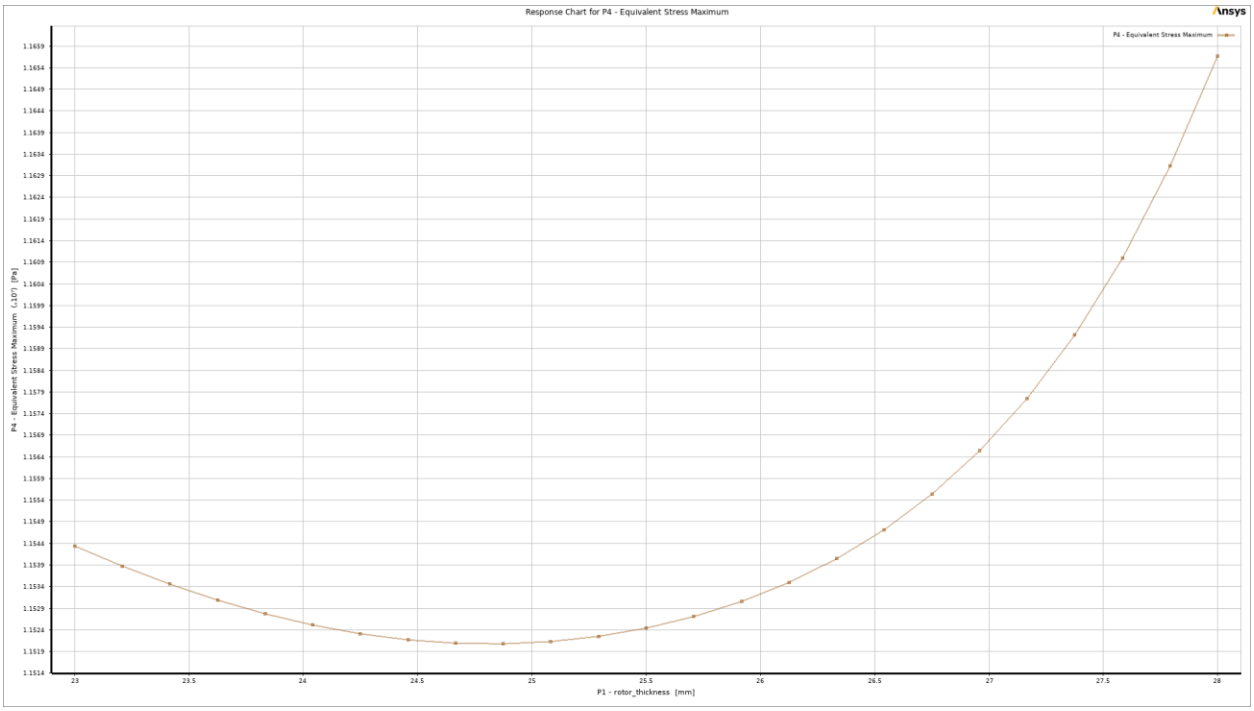


FIGURE 6
Model (F4) > Transient Thermal (F5) > Solution (F6) > Temperature

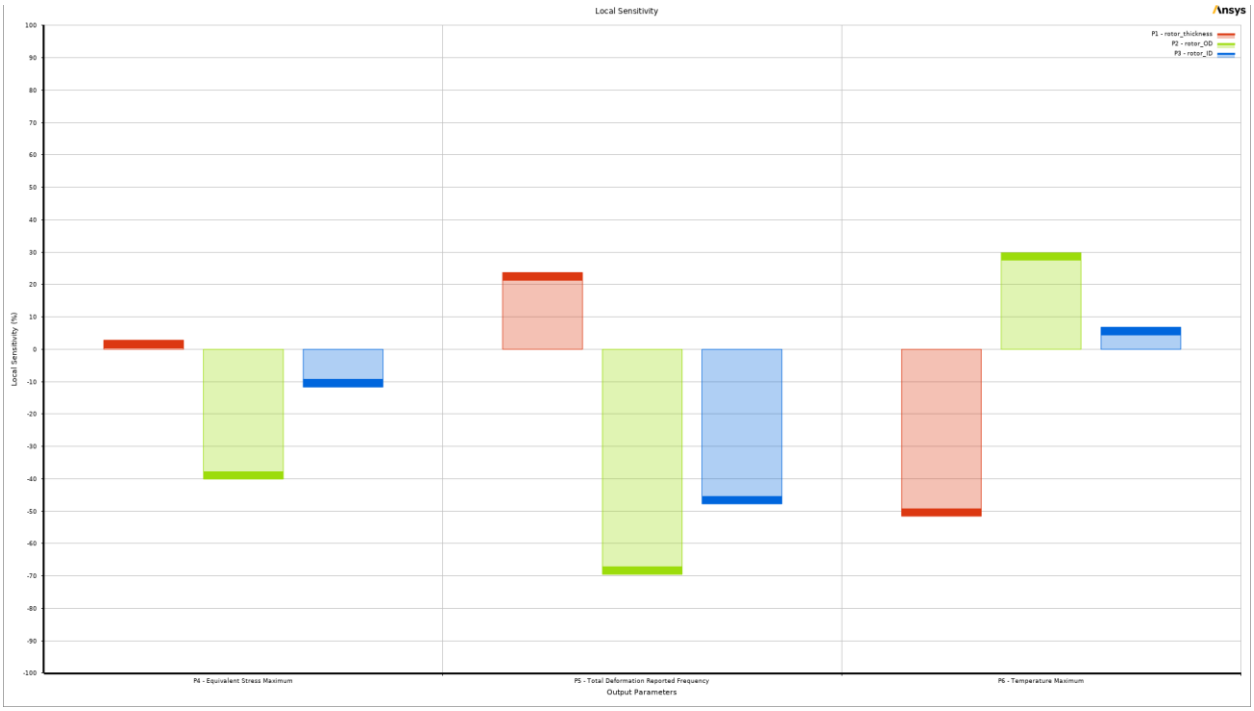


Optimization:

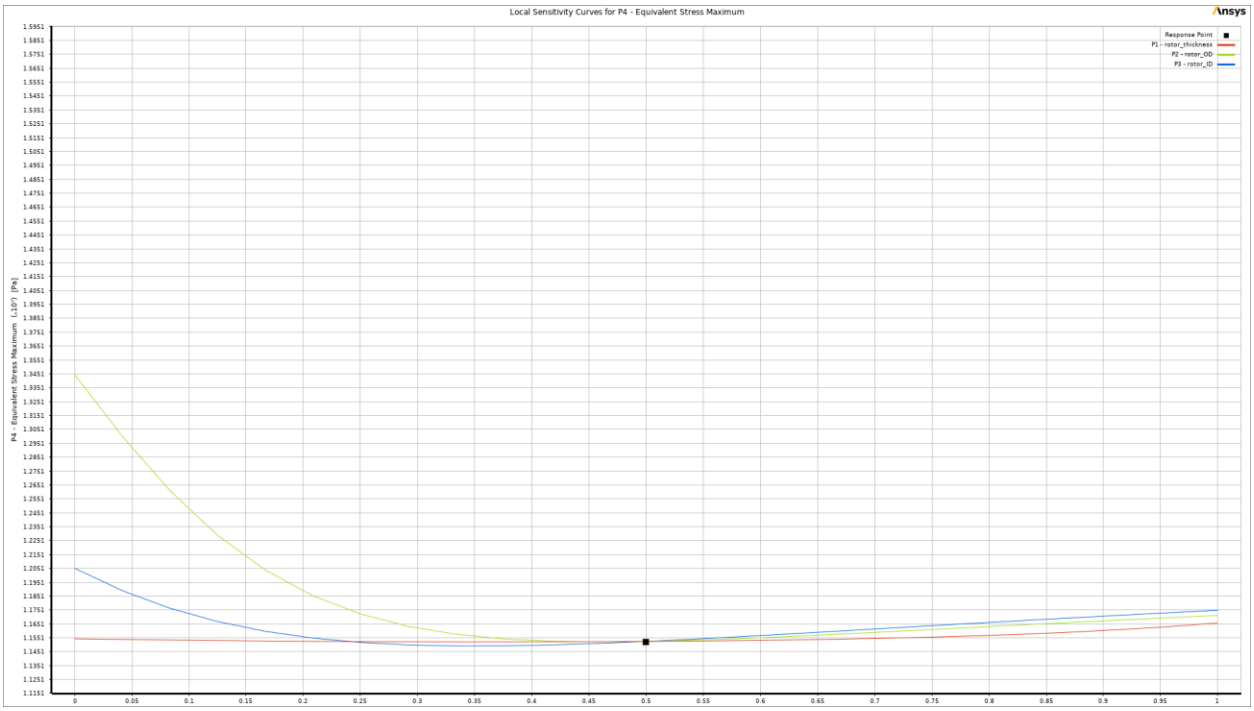
Response:



Local Sensitivity:



Local Sensitivity Curve:



Response Points:

Table of Outline A25: Response Points

	A	B	C	D	E	F	G
1	Name	P1 - rotor_thickness (mm)	P2 - rotor_OD (mm)	P3 - rotor_ID (mm)	P4 - Equivalent Stress Maximum (Pa)	P5 - Total Deformation Reported Frequency (Hz)	P6 - Temperature Maximum (C)
2	Response Point	25.5	131.5	76	1.1525E+07	1876.1	343.6
*	New Response Point						

Spider Chart

1. P4 - Equivalent Stress Maximum (x 10⁷)
2. P5 - Total Deformation Reported Frequency (x 10³)
3. P6 - Temperature Maximum