MAE 3270

Modified Torque Wrench Design

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5.2.1 Results

1) Image(s) of CAD model. Must show all key dimensions.

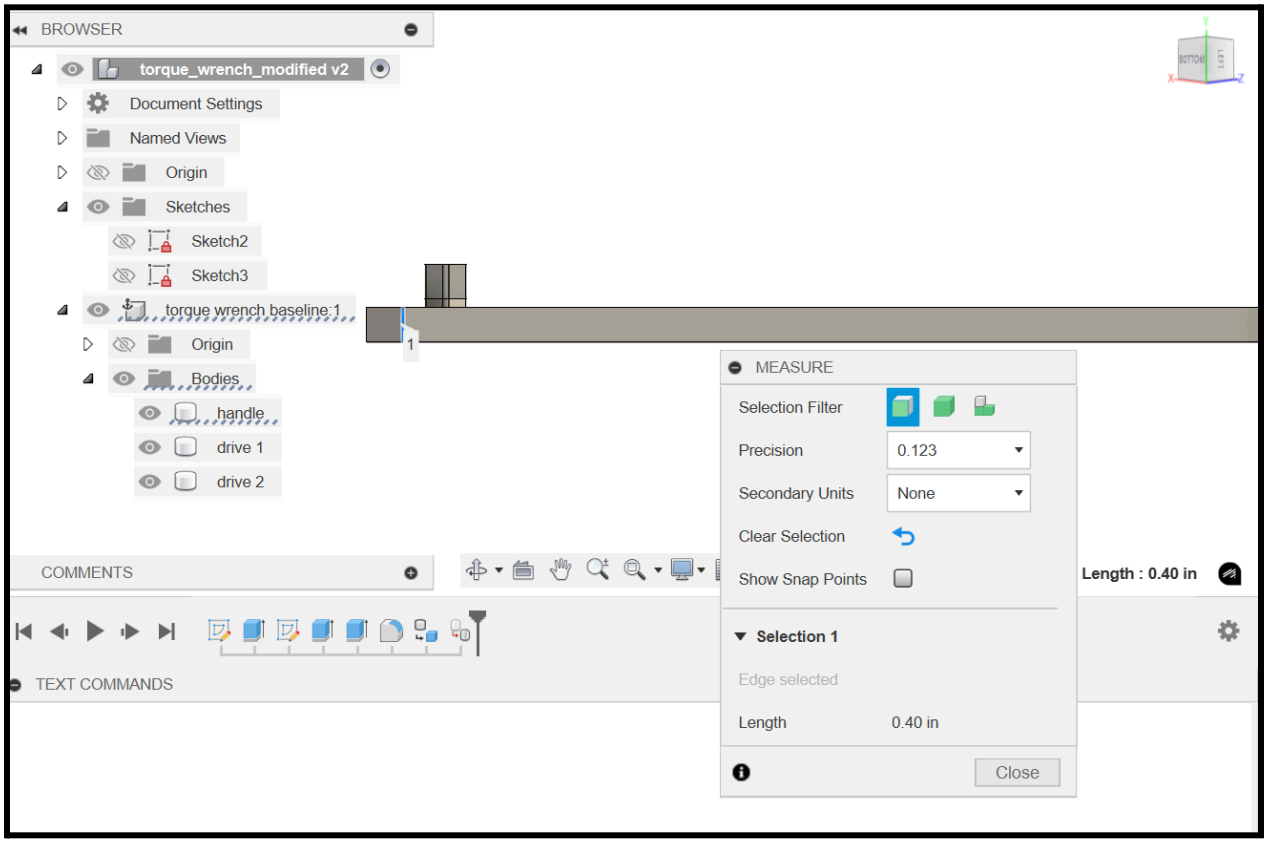

Figure 1: CAD dimension b=0.5” (thickness of modified torque wrench).

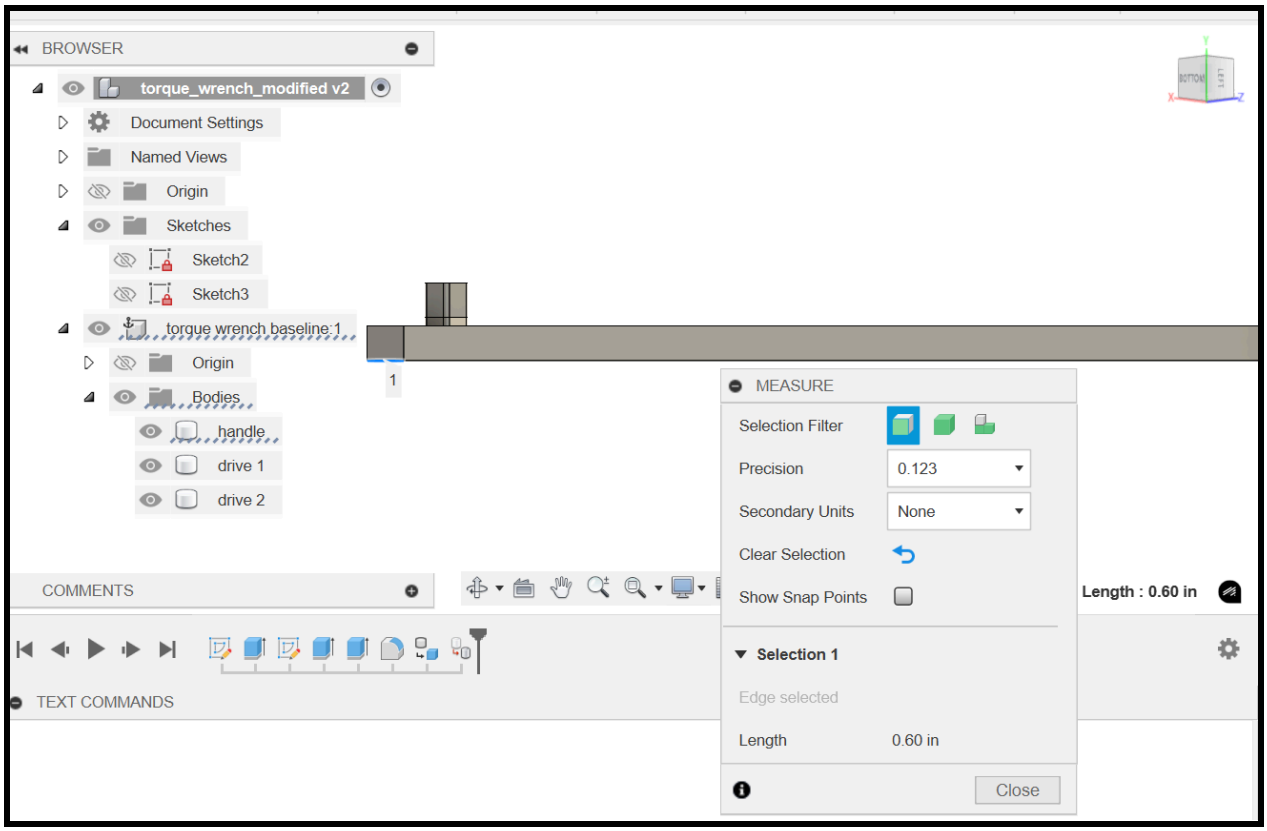

Figure 2: CAD dimension h=0.6” (width of modified torque wrench).

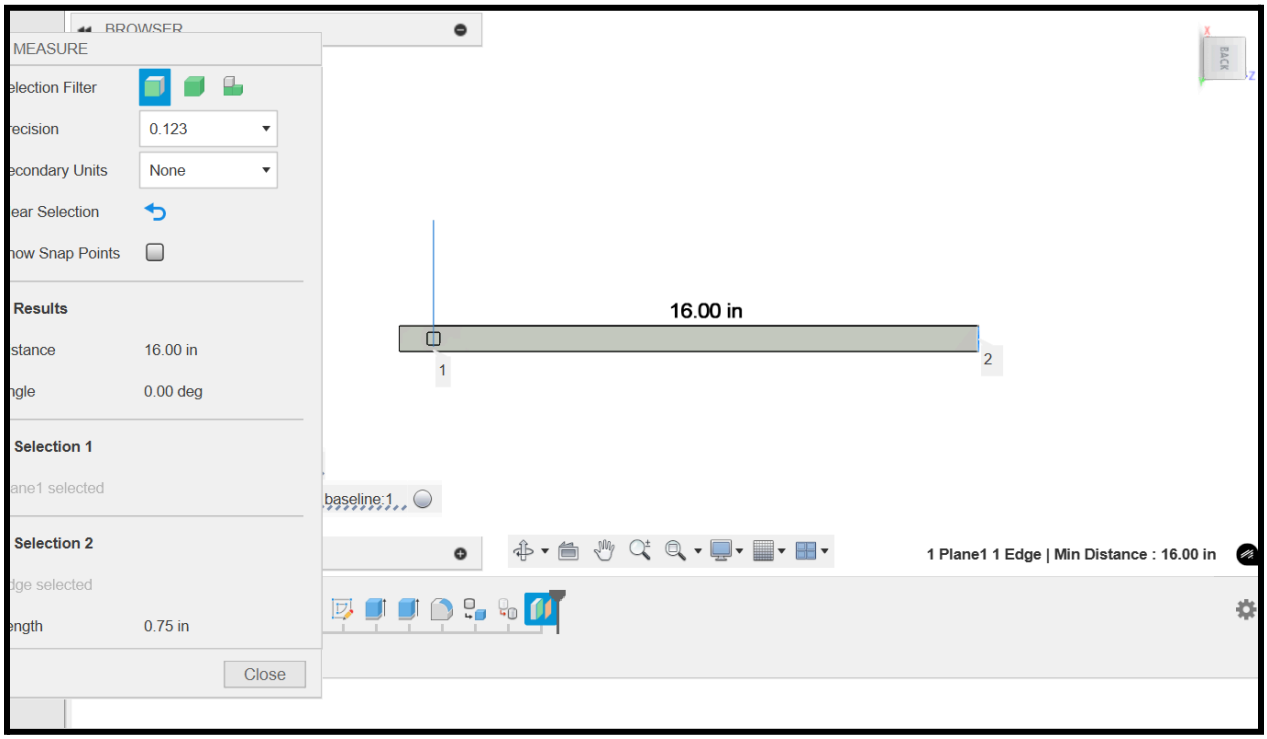

Figure 3: CAD Dimension L=16” (length from drive to where load is applied).

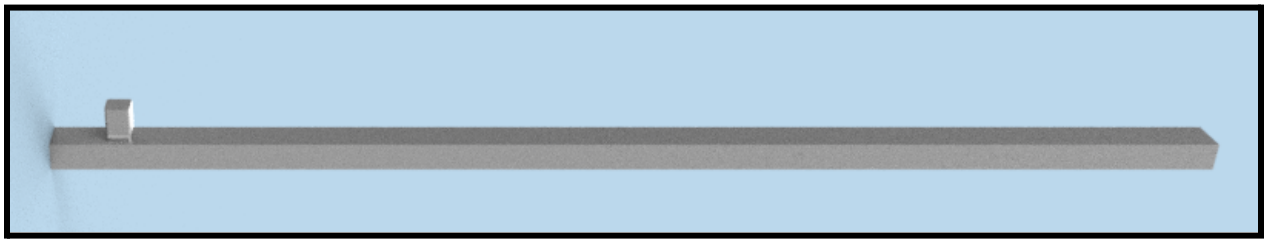

Figure 4: Render of torque wrench.

2) Describe material used and its relevant mechanical properties.

The material chosen is Titanium Beta Alloy (Ti-12 Mo-6Zr-2Fe). The relevant mechanical properties were found using Granta software. Its young’s modulus is 11.1 * 10^6 psi. The poisson’s ratio for this material is 0.33. Its yield strength is 145 ksi and its fracture toughness is 82.3 psi $in^{1/2}$. Lastly, Titanium Beta Alloy’s fatigue strength for 10^6 cycles is 80 ksi. This material was chosen because when tested, it exceeded all the design requirements (output greater than 1.0 mV/V, $X_O > 4$, $X_S > 1.5$). Upon testing nine different materials (including various steel, aluminum, and titanium alloys), this material performed the best. The table (in Figure 6) displays the results from hand calculations for the different requirements for both the baseline design (M42 Steel) and the chosen material, Titanium Beta Alloy (Ti-12Mo-6Zr-2Fe) .

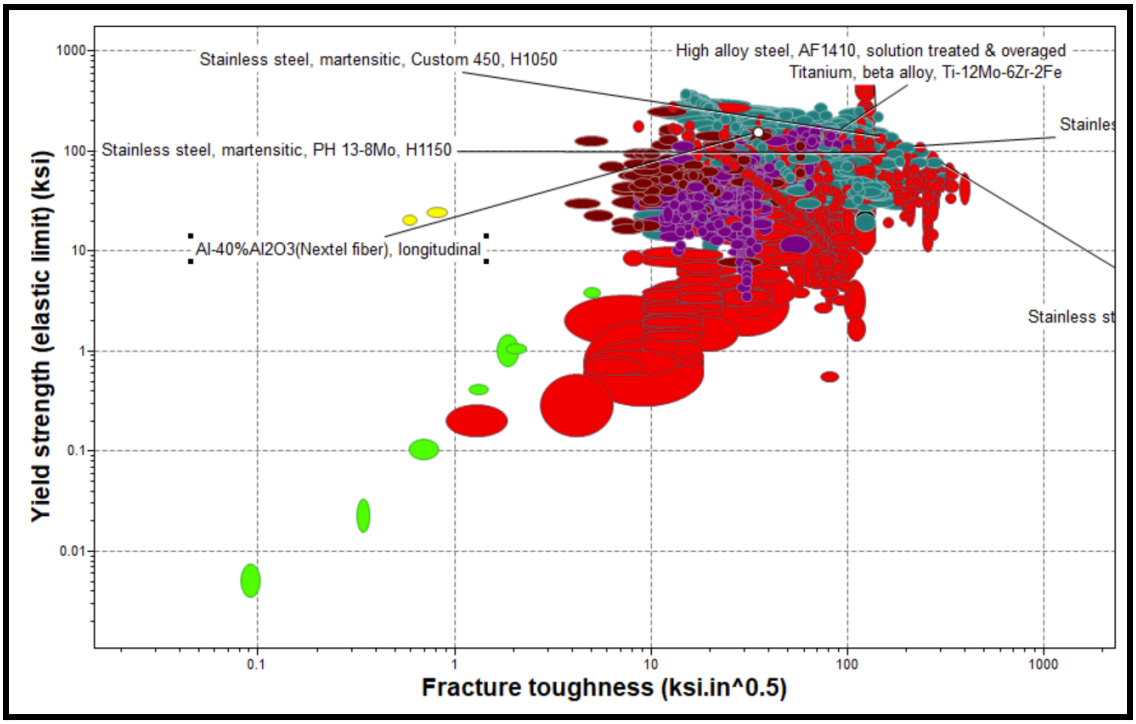

Figure 5: Graph of yield strength vs. fracture toughness for various metal alloys from Granta. Titanium Beta Alloy Ti-12Mo-6Zr-2Fe chosen to fit design requirements while maximizing fracture toughness and yield strength.

Material	Load Point deflection (inches)	Max Normal Stress (psi)	Safety Factor for Strength	Safety Factor for Crack Growth	Safety Factor for Fatigue	Strain at Gauge (microstrain)	Output (mV/V)
M42 Steel	0.091	12800	28.9062	2.9516	8.9844	375	0.38
Titanium Beta Alloy (Ti-12Mo-6Zr-2Fe)	0.6406	25000	5.8000	8.2916	3.2000	2111.5	2.1115

Figure 6: A table comparing the results for the baseline design of M42 Steel and the Titanium Beta Alloy.

3) Diagram communicating how loads and boundary conditions were applied to your FEM model.

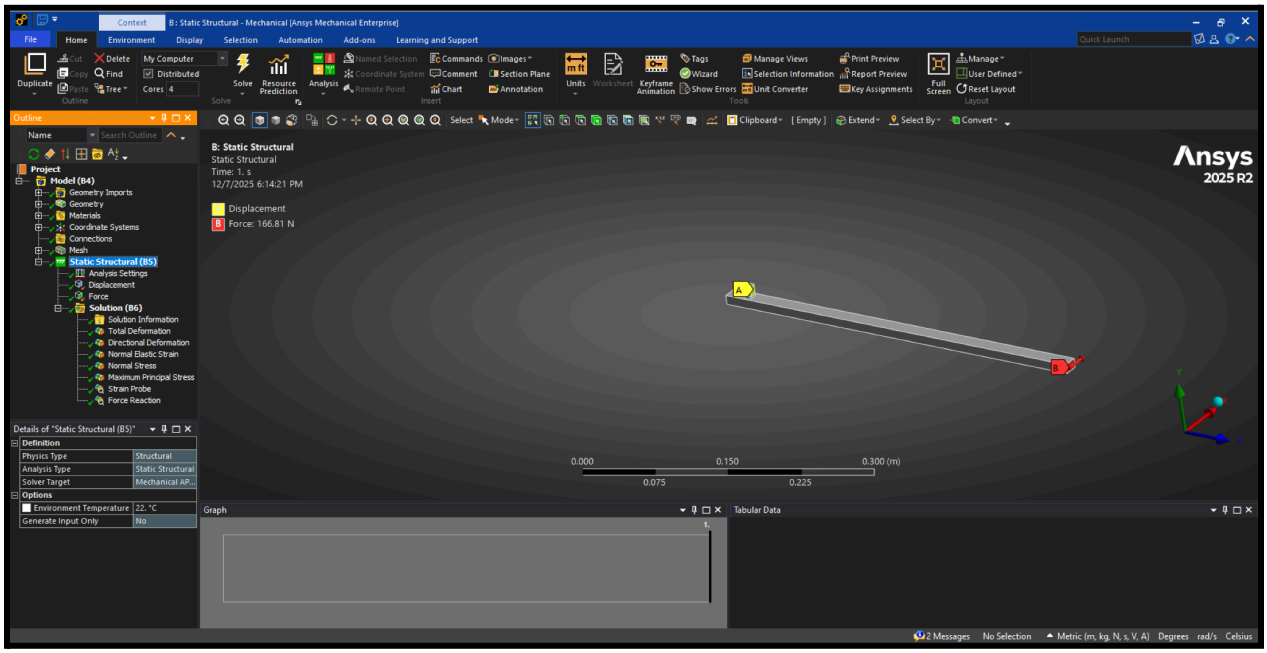

Figure 7: The deflection was held zero at point A (yellow) and the load was applied at point B (red).

4) Normal strain contours (in the strain gauge direction) from FEM

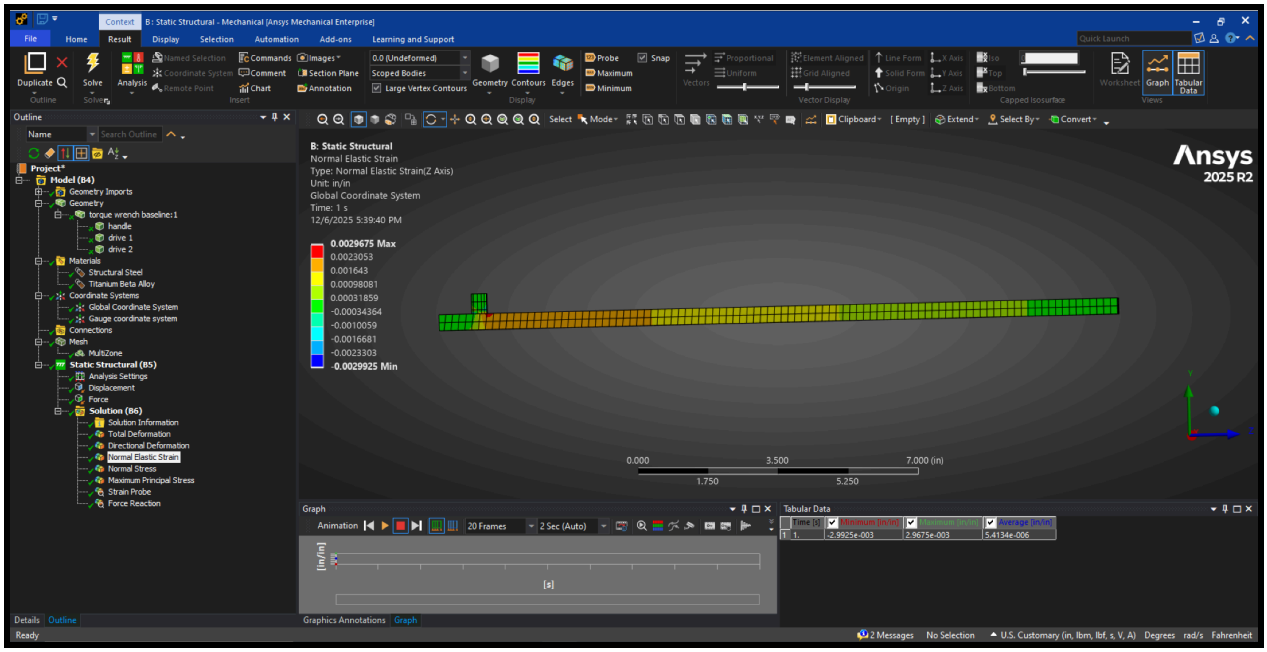

Figure 8: Normal strain contour in the strain gauge direction.

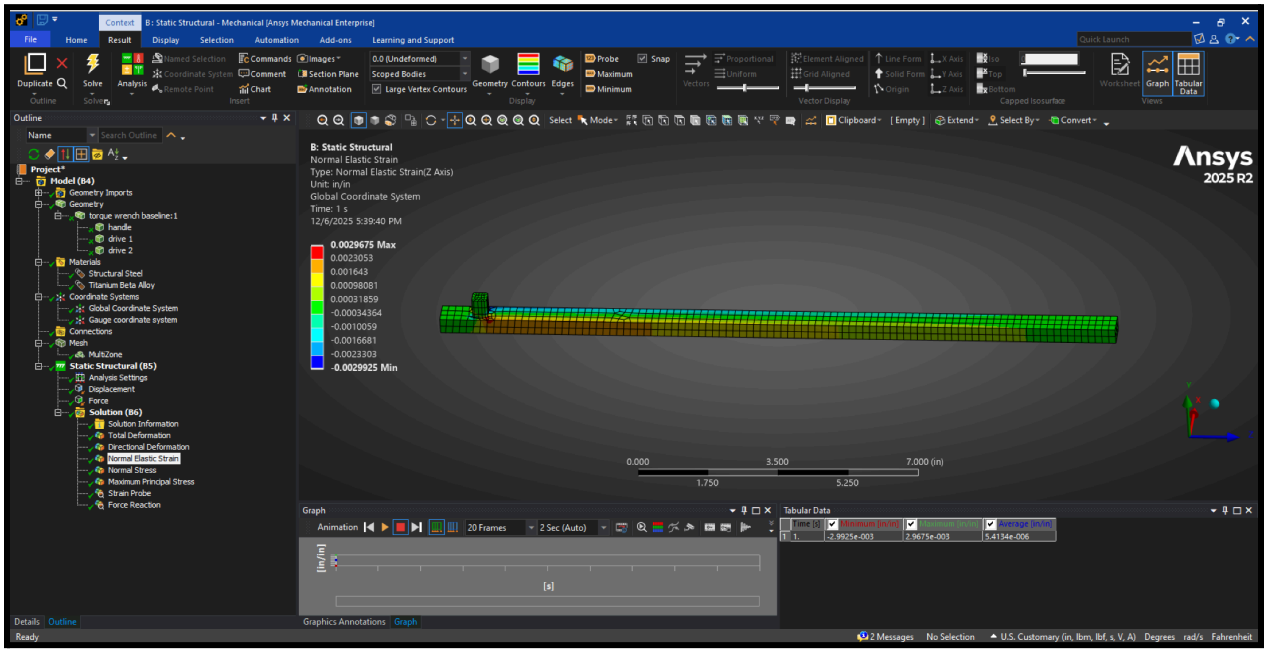

Figure 9: Isometric strain contour.

5) Contour plot of maximum principal stress from FEM

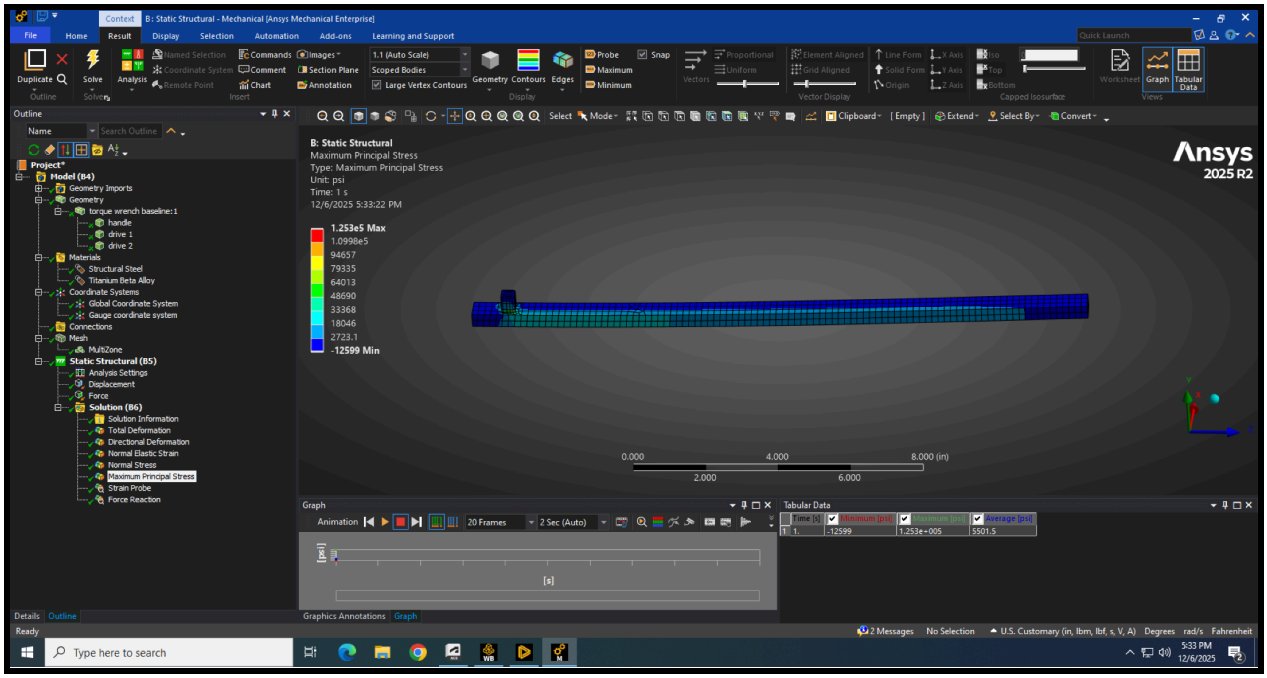

Figure 10: FEM of the maximum principal stress.

6) Summarize results from FEM calculation showing maximum normal stress (anywhere), load point deflection, strains at the strain gauge locations

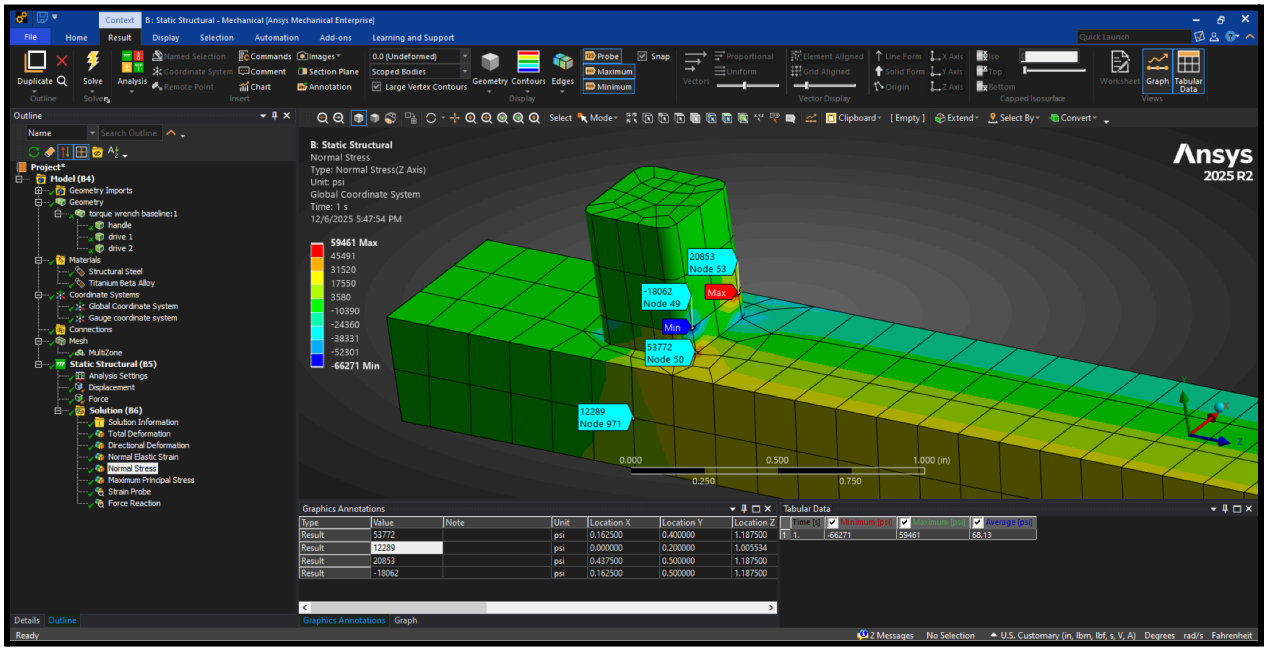

Figure 11: FEM of the normal stress.

From FEM, the maximum normal stress of the modified torque wrench is **59,461 psi**.

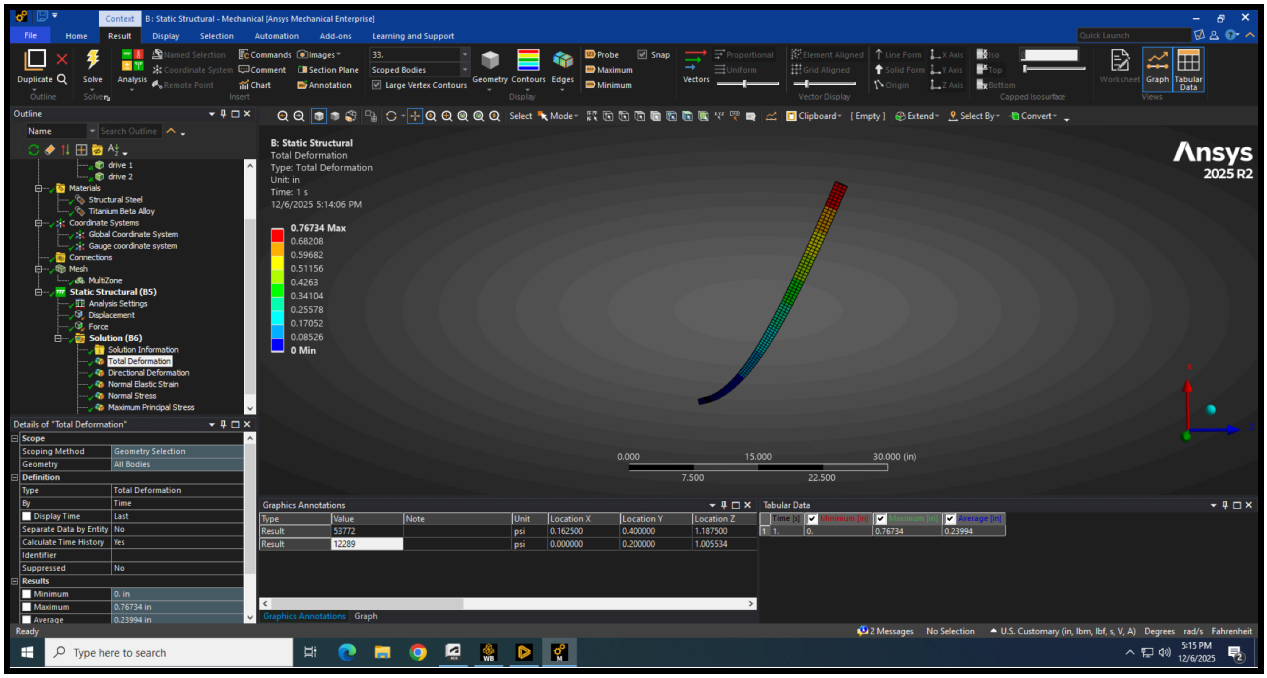

Figure 12: FEM of the total deformation.

From the FEM, the load point deflection is **0.76734 inches** (load is applied at the end, which is the point of maximum deflection).

Details of "Strain Probe"

Definition	
Type	Strain
Location Method	Coordinate System
Orientation	Global Coordinate System
Location	Gauge coordinate system
X Coordinate	6.0659e-034 in
Y Coordinate	0.2 in
Z Coordinate	2. in
Suppressed	No
Options	
Result Selection	All
Display Time	End Time
Results	
Normal - X Axis	-6.9675e-004 in/in
Normal - Y Axis	-6.9686e-004 in/in
Normal - Z Axis	2.1115e-003 in/in
XY Shear	1.2161e-007 in/in
YZ Shear	3.1575e-007 in/in
XZ Shear	3.3152e-006 in/in
Equivalent (von-Mises)	2.1115e-003 in/in
Maximum Principal	2.1115e-003 in/in
Middle Principal	-6.9672e-004 in/in
Minimum Principal	-6.9688e-004 in/in
Intensity	2.8084e-003 in/in

Figure 13: A table of results for the strain probe at the strain gauge locations.

From the FEM, the strain at the strain gauge locations was **2111.5 microstrain**.

7) Torque wrench sensitivity in mV/V using strains from the FEM analysis

The torque wrench sensitivity is selected from the FEM based on the strain at the location of the center of the strain gauge. Based on the strain gauge bridge equations, for a half-bridge the sensitivity in mV/V is equal to the strain x 1000. This means the torque wrench sensitivity for the modified torque wrench is: **2.1115 mV/V.**

8) Strain gauge selected (give type and dimensions). Note that design must physically have enough space to bond the gauges.

The strain gauge selected is the SGD-1.5/120-LY13. The dimensions of this strain gauge is 4.7mm by 3.4mm (maximum height and width of selected gauge). This fits within our modified torque wrench design requirements and leaves ample space to properly bond the gauges.