Braking system design

The design of the braking system is conducted and the system is composed of two major components, the braking disc and the braking pad. In particular, the design iterations of the braking disc is conducted for the purpose of improving the performance. Here are the screenshots of the design iterations.

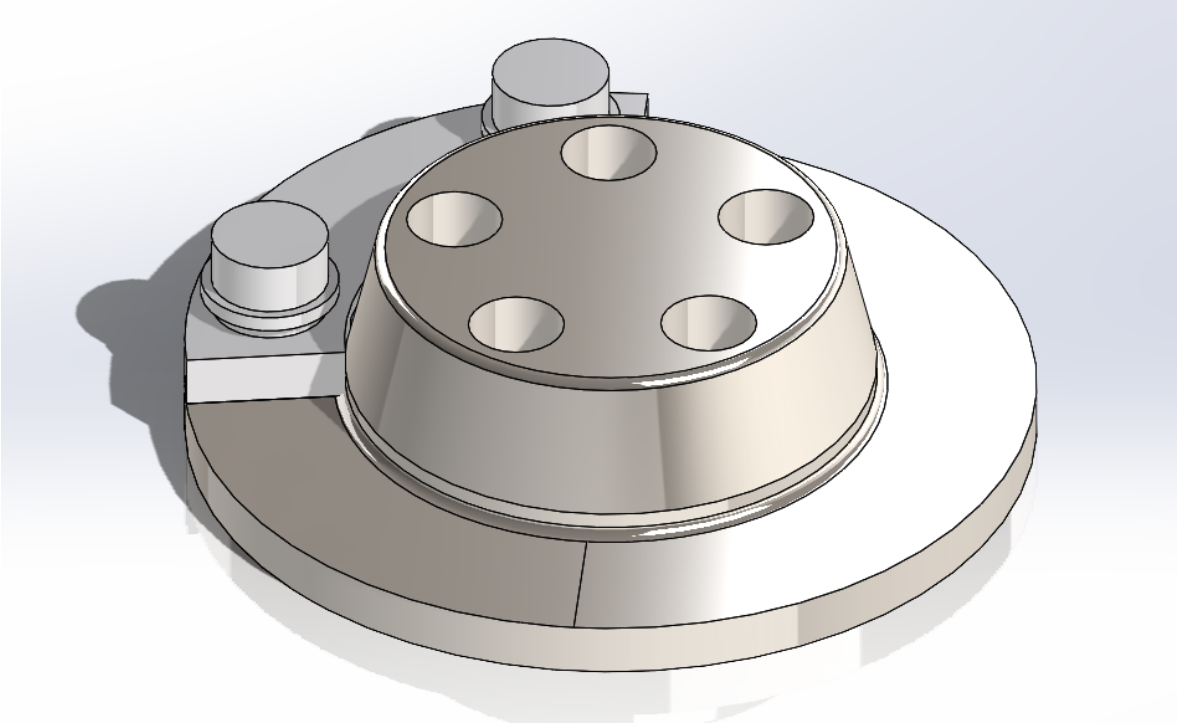


Figure 2.11 Braking disc - Original design

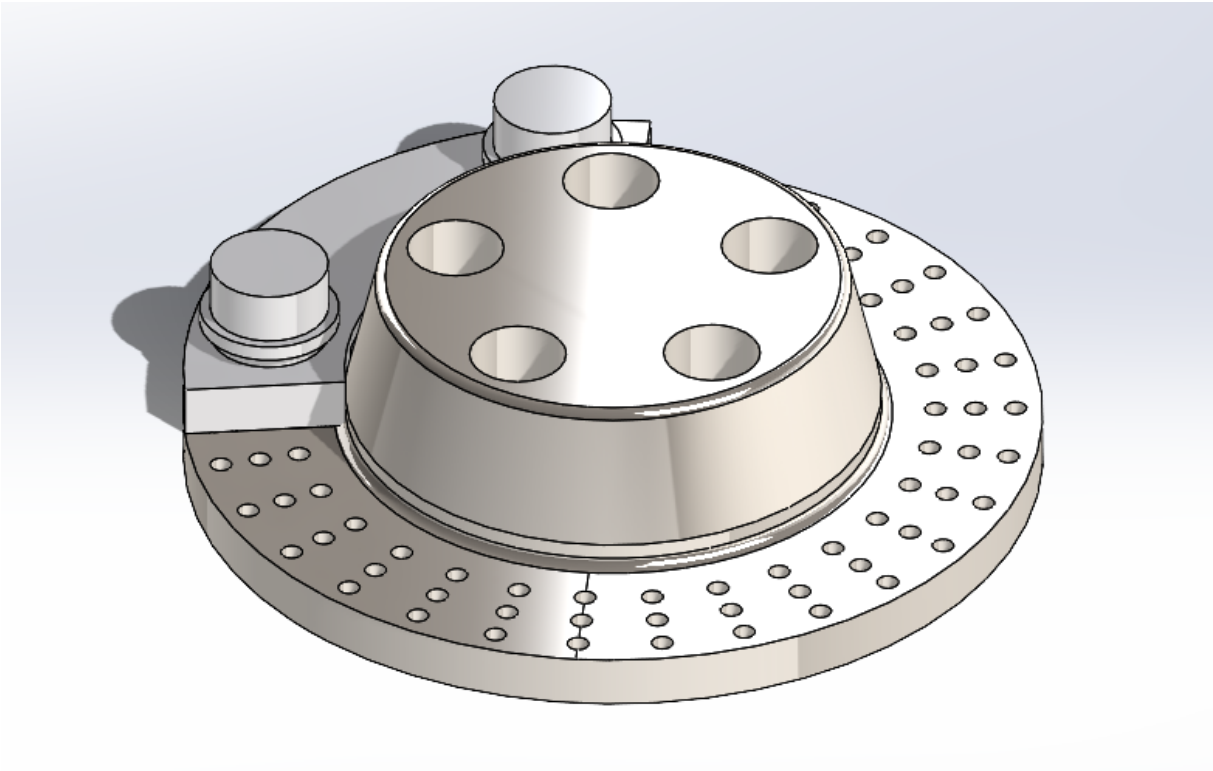


Figure 2.12 Braking disc - Design iteration 1

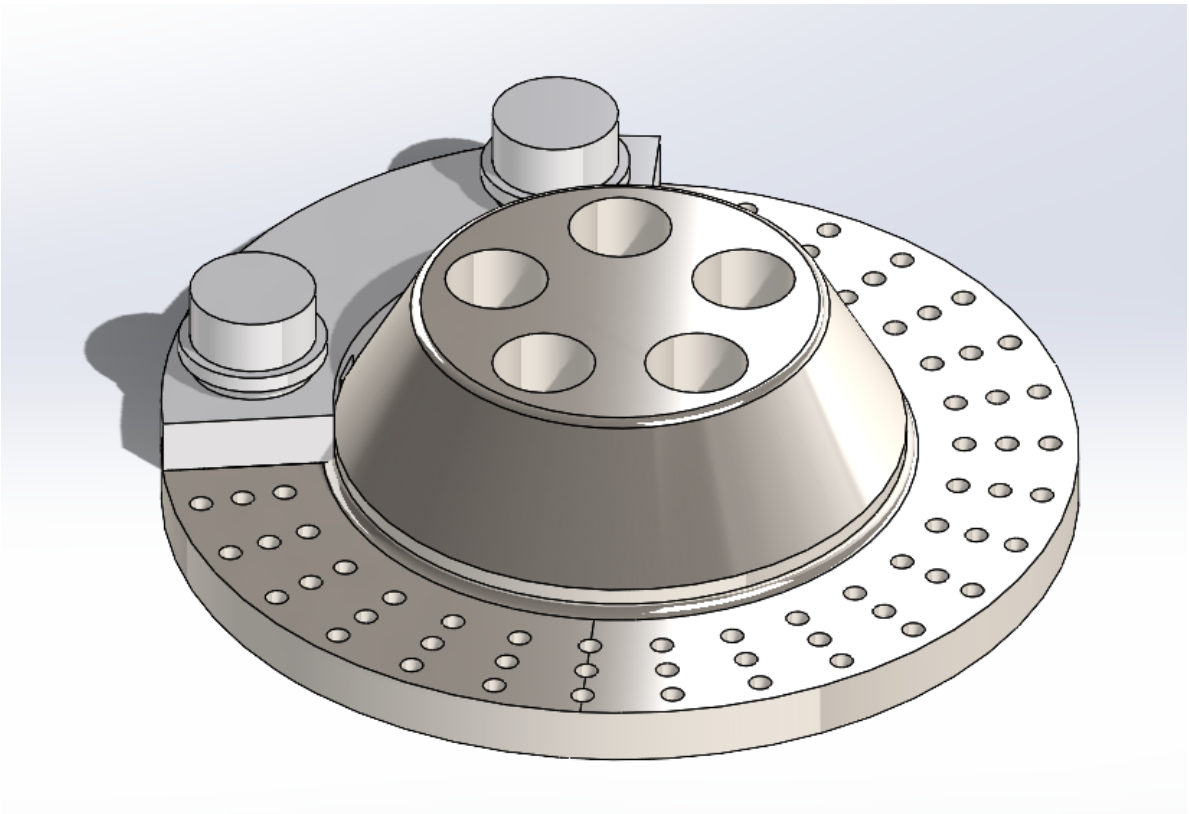


Figure 2.13 Braking disc - Design iteration 2

For the design iterations, the first one makes adjustments to the top surface of the braking disc by drilling a series of holes of diameter of 0.2 inches, for the better performance of heat dissipation. For the second design iteration, the middle part of the braking disc has a reduction in the volume, for the purpose of avoiding severe contact or stress concentration between the braking pad and braking disc.

For the original component, two sets of boundary conditions and three different loading scenarios are selected.

Loading	Boundary Condition#1	Boundary condition #2
Torque 100 Nm; force applied - 500N	Maximum stress: 6.108Mpa Maximum deflection:1.354e-03mm	Maximum stress:3.052Mpa Maximum deflection: 6.209e-04mm
Torque 200 Nm; force applied - 250N	Maximum stress:8.645Mpa Maximum deflection:1.216e-03mm	Maximum stress:6.091Mpa Maximum deflection: 1.242e-03mm
Torque 75 Nm; force applied - 750N	Maximum stress:6.379Mpa Maximum deflection: 1.916e-03mm	Maximum stress:3.068Mpa Maximum deflection: 6.211e-04mm

Table 2.1 Original part static analysis - BC and loading selection

The highlighted part corresponds to the case with the biggest maximum stress and deflection, and this set of boundary conditions and loading will be utilized for subsequent analysis.

	Original	Iteration #1	Iteration #2
Maximum	8.645Mpa	23.33Mpa	25.63Mpa

Stress			
Maximum displacement	1.216e-03mm	1.378e-03mm	1.686e-03mm
Does the part yield?	No	No	No

Table 2.2 Static analysis for design iterations

For the subsequent analysis of static loading, here is a table showing the change in maximum stress and displacement. Unfortunately, the maximum stress does increase but it shall not be an issue since the yielding point of the component is not reached(assuming the material of the braking disc is Aluminum 6061 with the yielding stress of 276 Mpa).

For the modal analysis of the original part, two sets of analysis are conducted, with the first one with no restraints and the second one with fixed geometry of the upper part of the braking pad. It can be observed that the resonance shall not be an issue, assuming that the typical natural frequency for braking disc is approximately 350 Hz, as the minimum natural frequency of the part is 9758 Hz according to the table.

Study name:Frequency -BC1			
Mode No.	Frequency(Rad/sec)	Frequency(Hertz)	Period(Seconds)
1	9758	1553	0.0006439
2	32773	5216	0.00019172
3	39188	6237	0.00016033
4	51966	8270.7	0.00012091
5	57568	9162.2	0.00010914
6	64770	10309	9.70E-05
7	66753	10624	9.41E-05
8	67695	10774	9.28E-05
9	83368	13268	7.54E-05
10	88777	14129	7.08E-05
11	96177	15307	6.53E-05
12	1.06E+05	16841	5.94E-05

Table 2.32 Modal analysis - Free with no restraints

Study name:Frequency -BC2			
Mode No.	Frequency(Rad/sec)	Frequency(Hertz)	Period(Seconds)
1	13429	2137.2	0.0004679
2	31701	5045.4	0.0001982
3	36013	5731.6	0.00017447
4	52196	8307.2	0.00012038
5	65362	10403	9.61E-05
6	65921	10492	9.53E-05
7	80973	12887	7.76E-05
8	82969	13205	7.57E-05
9	89783	14289	7.00E-05
10	99336	15810	6.33E-05
11	1.10E+05	17452	5.73E-05
12	1.19E+05	18888	5.29E-05

Table 2.32 Modal analysis - fixed geometry of braking pad upper surface

For the thermal static analysis, the boundary condition is set by assigning 110 degree fahrenheit for the braking disc and 225 degree fahrenheit for the braking pad.

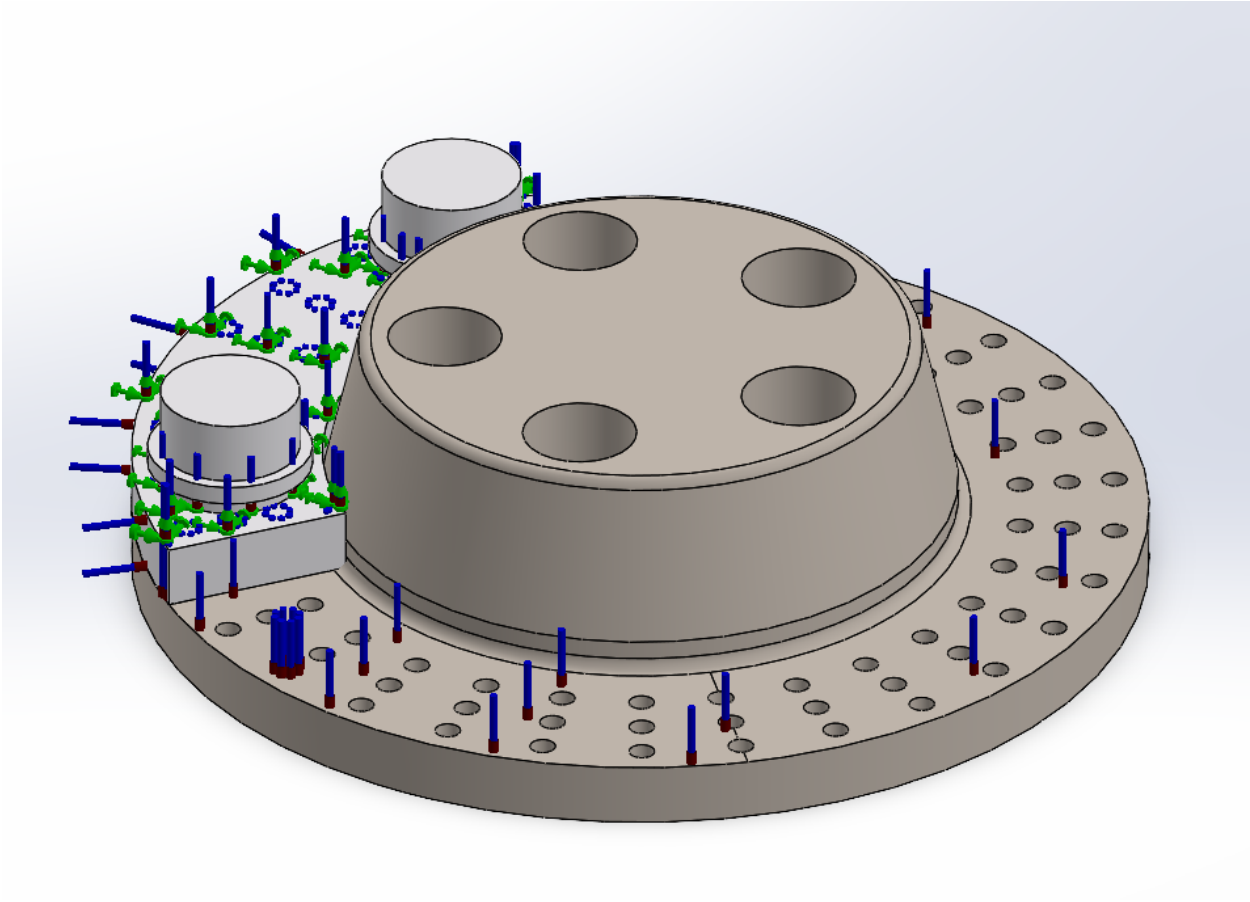


Figure 2.2 Temperature boundary condition for thermal static analysis

	Original	Iteration #1	Iteration #2
Maximum Stress	272Mpa	274Mpa	213Mpa
Maximum displacement	1.034e-02mm	5.417e-03mm	1.125e-02mm
Does the part yield?	No	No	No

Table 2.4 Static analysis for design iterations

Fortunately, the maximum stress has decreased as a result of computing the design iterations of the braking disc. Here are the screenshots of the stress plots for thermal static loadings.

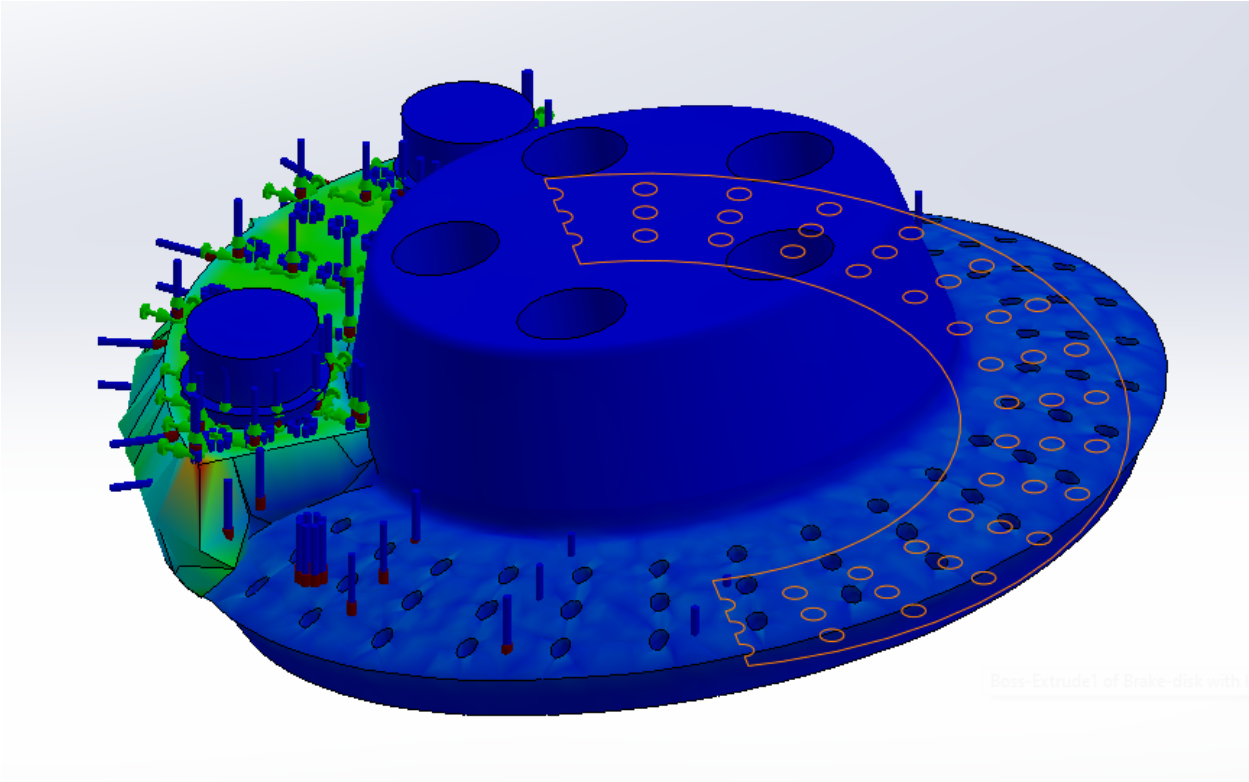


Figure 2.31 Stress plot - Thermal static analysis (iteration one)

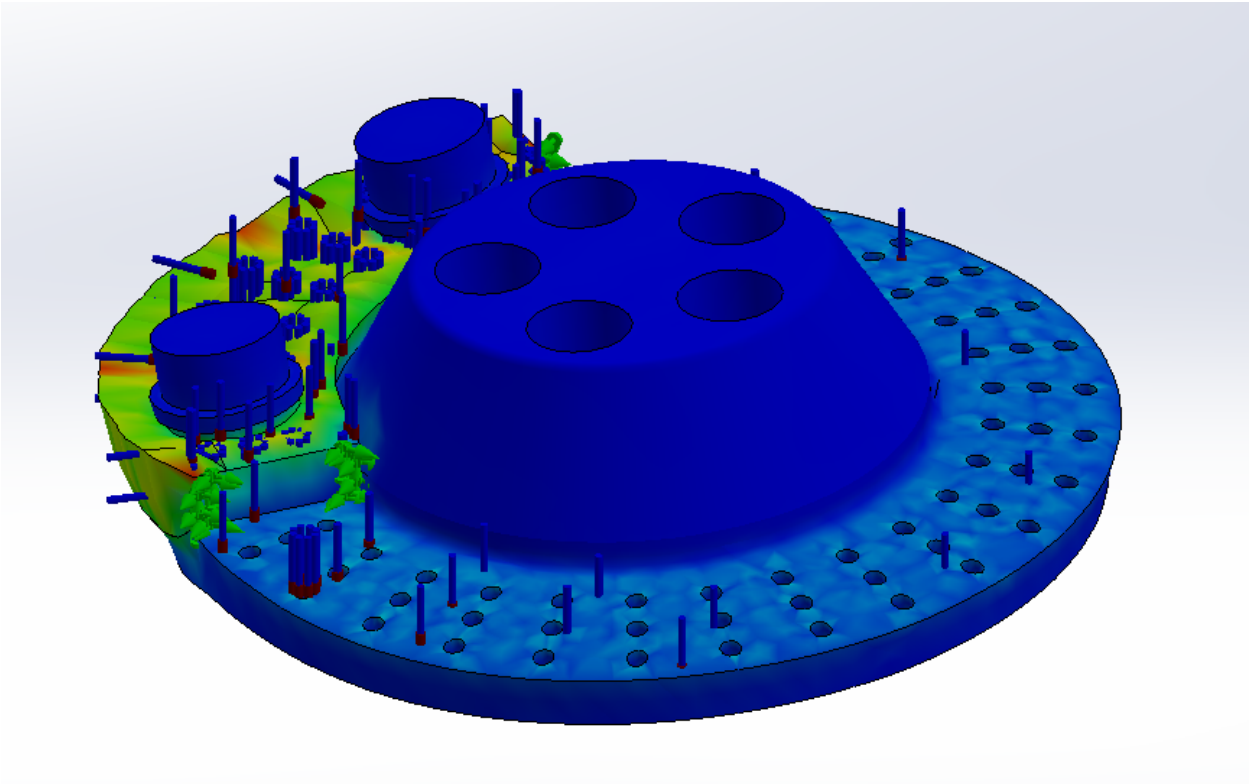


Figure 2.32 Stress plot - Thermal static analysis (iteration two)

Lastly but not least, for the fatigue analysis, the S-N curve of the aluminum 6061 is used for referencing purposes, as the material of the braking disc would be aluminum. Assuming that the design iteration two will be utilized for production of the braking system in the future with a maximum stress of 212 Mpa, it can be deduced that the fatigue life i.e. the number of cycles under the given stress to reach fatigue would

be approximately 10^7 cycles.

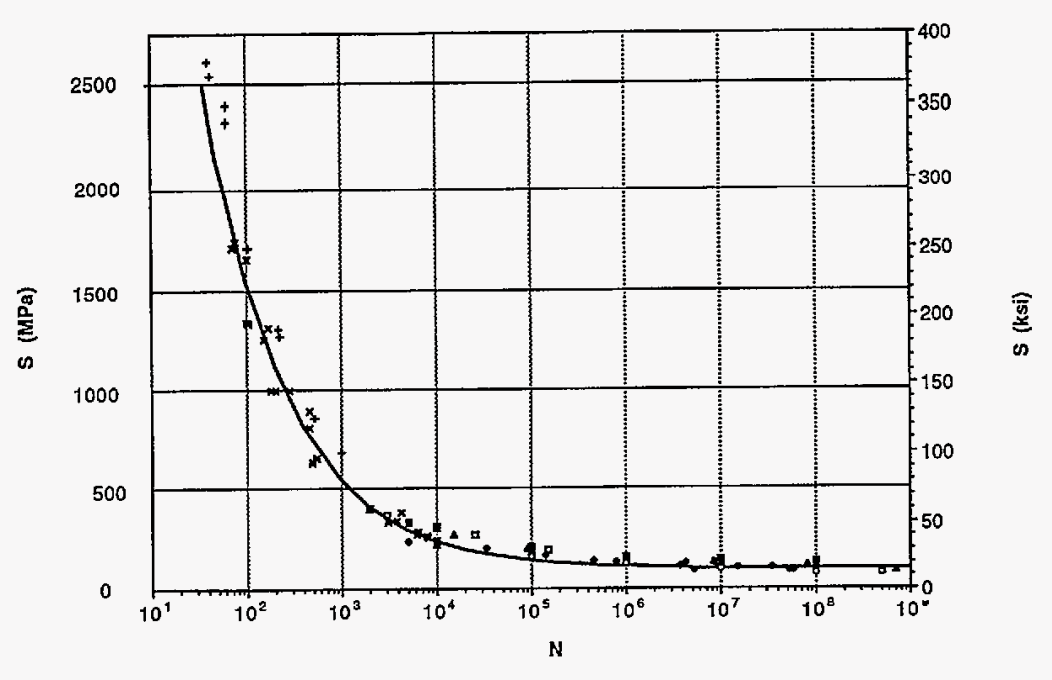


Figure 2.4 S-N curve of Aluminum 6061