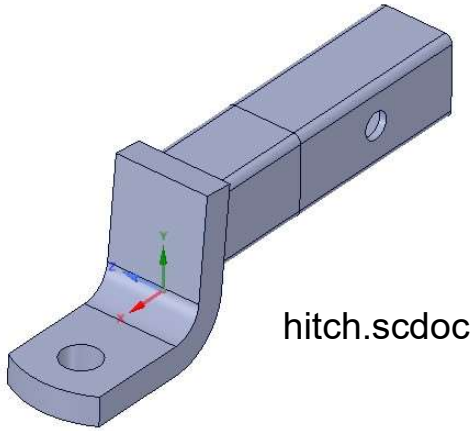
Assignment 4 - Fatigue of a Trailer Hitch

Goal: Perform a fatigue analysis of a trailer hitch. The homework will consist of 3 parts:

A. Perform a stress analysis on the required base load cases. Converge the stress results to an accuracy of 5%
B. Perform a fatigue analysis for 4 configurations calculating the fatigue life and factor of safety. Identify any load cases not meeting the design requirements.
C. Propose design modifications that will result in an improved fatigue safety factor as compared the results in Part B. Include geometry and result plots of the modified design.



hitch.scdoc

- Standard trailer hitch
- 7.6 cm drop or rise
- 22,000 N max towing capacity
- 2,500 N tongue weight

Fatigue Loadings and Supports

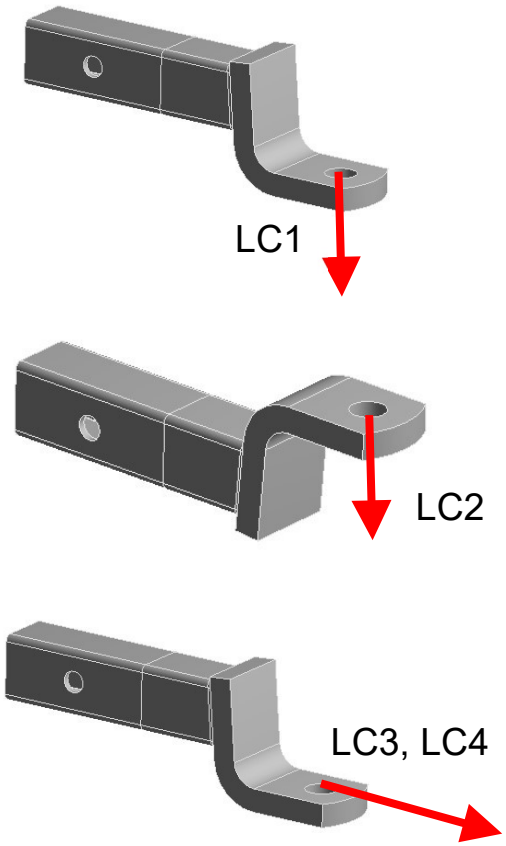
LC1: Tongue Load of 2500 N, Drop, design life = infinite(1e6)
Load is applied and then removed

LC2: Tongue Load of 2500 N, Rise, design life = infinite(1e6)
Load is applied and then removed

LC3: Trailer Load Small Hill: 5,000 N, design life = 1e5 cycles
Load is applied and then reversed in opposite direction

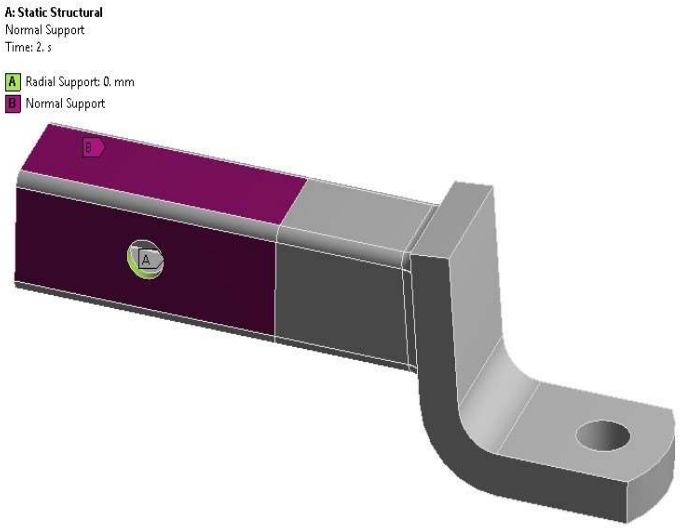
LC4: Trailer Load Steep Hill: 11,000 N, design life = 5000 cycles
Load is applied and then reversed in opposite direction

Apply the loads to the cylindrical hole, where the ball would be attached



Part A: Stress Calculations

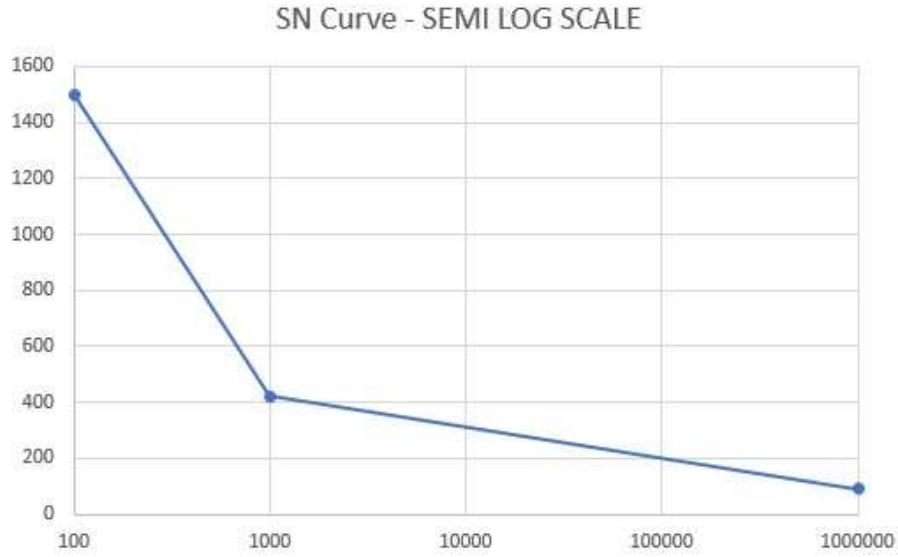
1. Constrain the 2 pinned faces in the radial direction only and the 4 flat faces which contact the receiver in the normal direction only
2. Use a global mesh size of 5mm to identify the critical location of peak local Von-Mises stress **as well as** a location of an artificial stress singularity on a result plot.
3. Add appropriate mesh controls (e.g. Face Mapped mesh, No adaptive sizing, and Face Sizing) and obtain converged stresses to within 5% for each load case. Do you need to consider all 4, or will a subset be sufficient (does the stress location change with either the direction of the load or its magnitude)?
4. Report the peak converged equivalent stress for the 4 load cases in the master result table and include required plots in appendix



Material Properties

- E = 200 GPa
- Nu = .3
- Density = 7850 kg/m^3
- Ultimate Strength = 460 MPa
- Stress Life Fatigue Properties using **Semi log scale** (life is log, stress amplitude is linear)

cycles	stress amplitude (Mpa)
100	1500
1000	420
1.00E+06	90



Part B: Fatigue Calculations

1. Perform a fatigue analysis on each of the 4 load cases. For each case report life, safety factor, and equivalent alternating stress in the master table.
2. Identify which fatigue cases would fail to meet the design life
3. For LC 3 and LC4, report the damage (LC1/LC2 are designed for infinite life)
4. Explain why the fatigue results differ from LC1 and LC2 at the critical location.

NOTES:

1. Be sure to set the Loading type to the appropriate setting based on the Load Case
2. The scale factor entry on the fatigue tool can be a handy way to avoid running the static analysis over to change a load magnitude for linear analysis
3. When appropriate use following fatigue tool settings:
    a. Goodman mean stress correction
    b. Signed Von-Mises Stress Component

Part C: Redesign the hitch for the new geometry

1. Propose design modifications that will result in an improved fatigue safety factor as compared the results in Part B.

2. Include geometry and result plots of the modified design

Master Result Table

Result Case	Peak Stress (MPa)	Life	Damage	Safety Factor	Fatigue Equivalent Alternating Stress (MPa)
Load Case 1			N/A		
Load Case 2			N/A		
Load Case 3					
Load Case 4					