Engineering Design Portfolio

Luke Gensbigler

Mechanical Engineering
University of Wisconsin–Madison

Email: gensbigler@wisc.edu

Table of Contents

Mass Optimization with ParetoWorks .... page 3

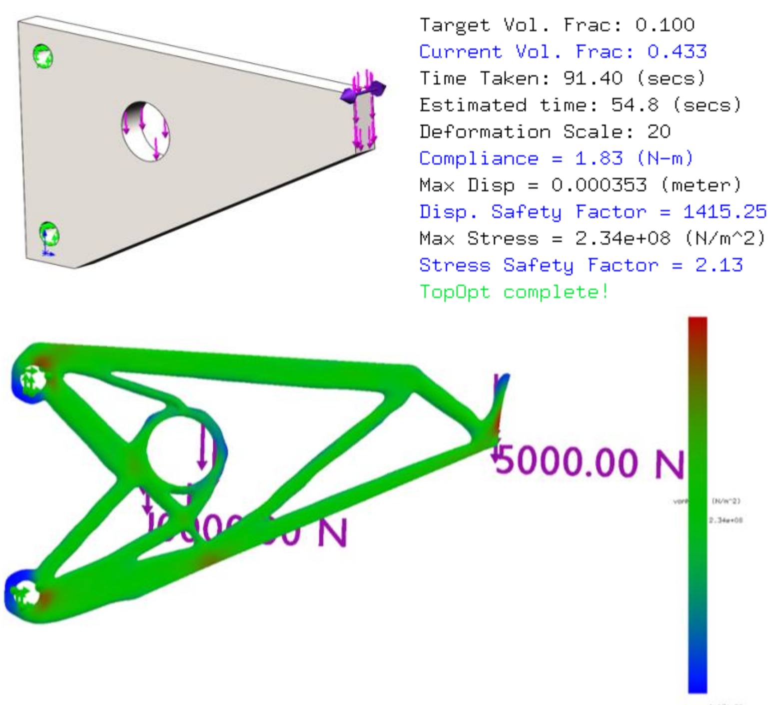
Bracket Fillet Optimization .... page 4

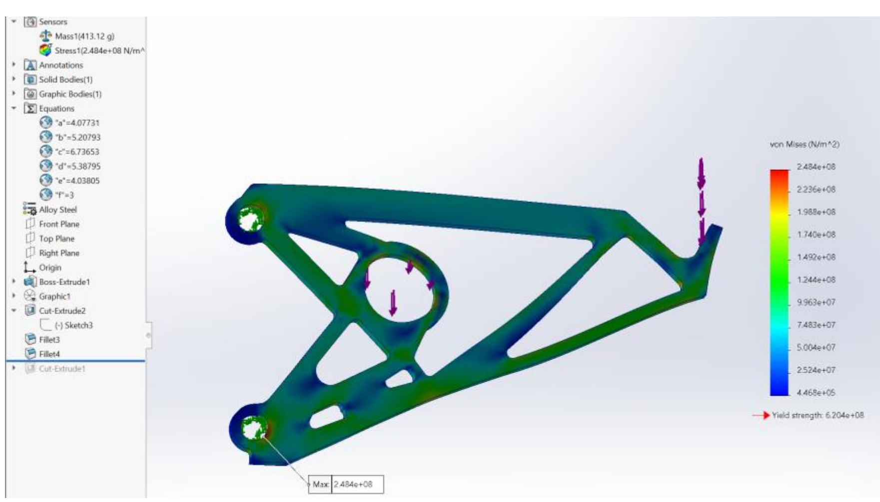
Senior Capstone Project – Magnetic Powder Separator .... page 5

Gear Reducer Design .... page 7

Mass Optimization with ParetoWorks

- Performed multi-objective structural optimization using ParetoWorks to reduce mass while maintaining stiffness and stress limits.
- Defined realistic loading conditions, boundary constraints, and multiple geometric design variables.
- Generated a Pareto front to visualize trade-offs between weight reduction and structural performance.
- Selected an optimized design that achieved significant mass savings without exceeding allowable stress or deflection.
- Demonstrated data-driven design decision-making using optimization tools.

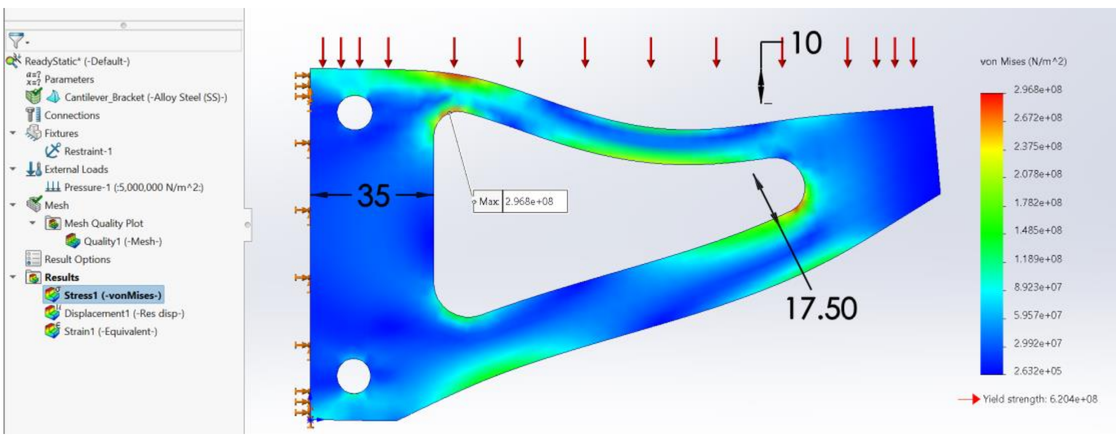


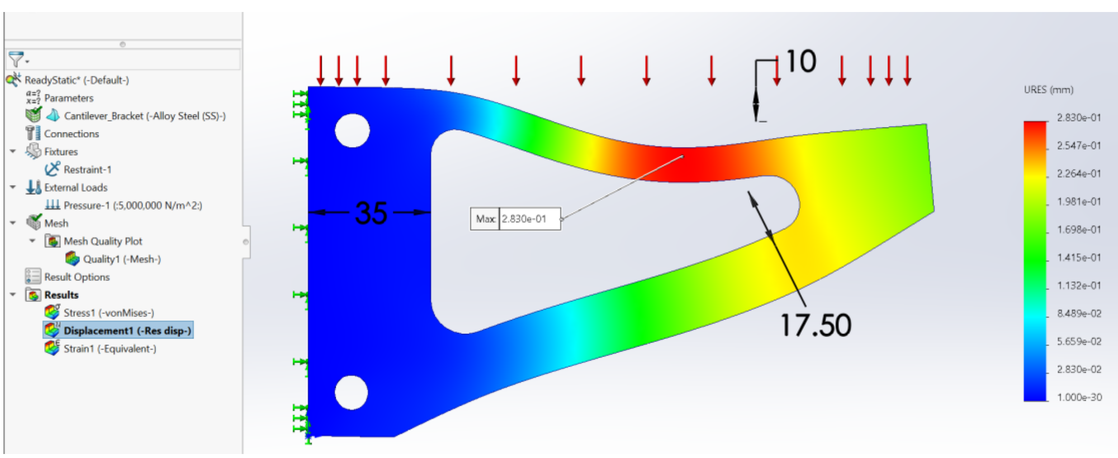


Bracket Fillet Optimization

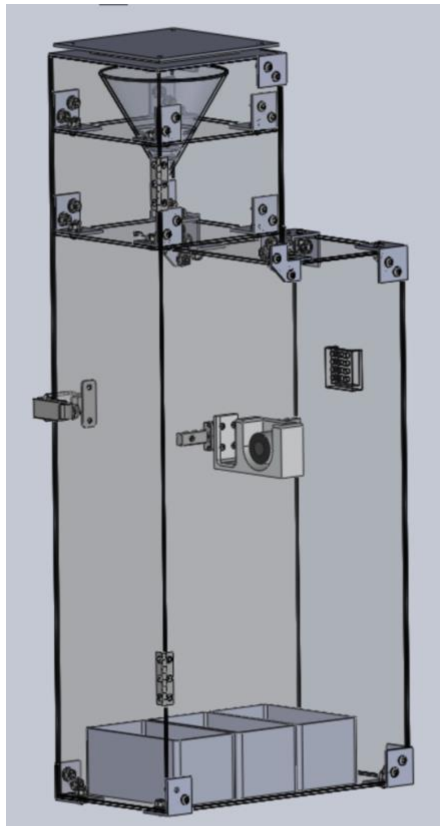
- Conducted a SOLIDWORKS Design Study to optimize fillet radius in a structural bracket.
- Used fillet radius as a parametric variable to reduce stress concentrations.
- Targeted a factor of safety near 2 while minimizing unnecessary material.
- Evaluated von Mises stress and displacement results across design iterations.
- Produced an optimized bracket geometry validated through finite element analysis.

		Current	Initial	Optimal	Iteration 1	
DV1		17.5mm	25mm	17.5mm	25mm	2
DV2		10mm	25mm	10mm	25mm	1
DV3		35mm	50mm	35mm	35mm	3
R		9.000000	6.000000	9.000000	7.000000	7
URES	< 0.5mm	2.830e-01 mm	8.244e-02 mm	2.830e-01 mm	8.594e-02 mm	1
Stress1	< 300 N/mm^2	2.968e+02 N/mm^2 (MPa)	1.209e+02 N/mm^2 (MPa)	2.968e+02 N/mm^2 (MPa)	1.292e+02 N/mm^2 (MPa)	2
Minimum Factor of Safety1	Is close to 2	2.090e+00	5.133e+00	2.090e+00	4.803e+00	2





Senior Capstone Project – Magnetic Powder Separator



- Developed a mechanical system to separate mixed Fe-Si (ferromagnetic) and SS316 (paramagnetic) powders generated during dual-material additive manufacturing.
- Designed a controlled powder feed path within an enclosed housing to ensure repeatable particle trajectories.
- Implemented a custom electromagnet to generate high magnetic field gradients that redirect ferromagnetic particles into a separate collection bin.
- Targeted ≥ 99% material purity for separated powders to enable reuse in additive manufacturing processes.
- Integrated physics-based modeling results with mechanical design to guide final system geometry and magnet placement.

Senior Capstone Project – Particle Simulation Model

- Modeled single-particle motion using Newton's second law, including gravity, buoyancy, drag, magnetic, adhesive, and capillary forces.
- Distinguished force dominance between Fe-Si particles (strong magnetic response) and SS316 particles (negligible magnetic force).
- Implemented the full force balance framework in MATLAB to predict particle trajectories through the separator.
- Performed parametric sweeps on particle radius, magnetic field strength, and magnet position.
- Used simulation results to estimate separation efficiency and inform mechanical design decisions.

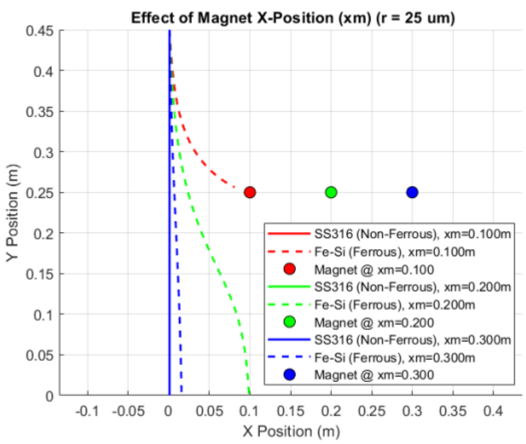


Figure 2a Parametric sweep of x_m for fixed B_0, y_m, and r.

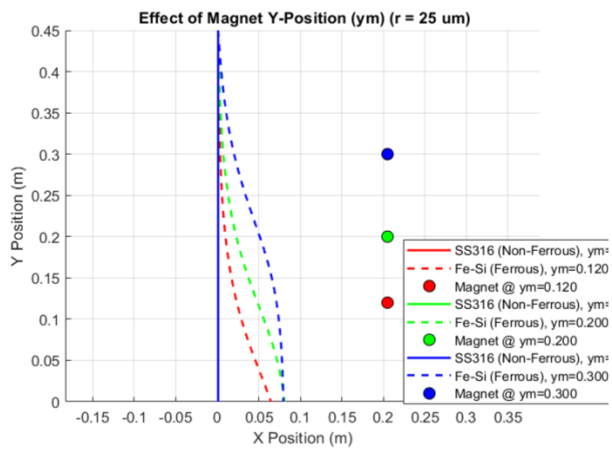


Figure 2b. Parametric sweep of y_m for fixed B_0, x_m and r.

Gear Reducer Design

- Designed a two-stage gear reducer for a moped drivetrain, accounting for torque transmission and gear force paths.
- Calculated gear forces, bearing reactions, and combined bending-torsion stresses along both shafts.
- Applied fatigue design methods including S-N curves, Marin modifying factors, and stress concentration effects.
- Determined final shaft diameters to meet infinite-life fatigue criteria with appropriate safety factors.
- Selected manufacturable materials and commercially available bearings for a complete, realistic drivetrain design.