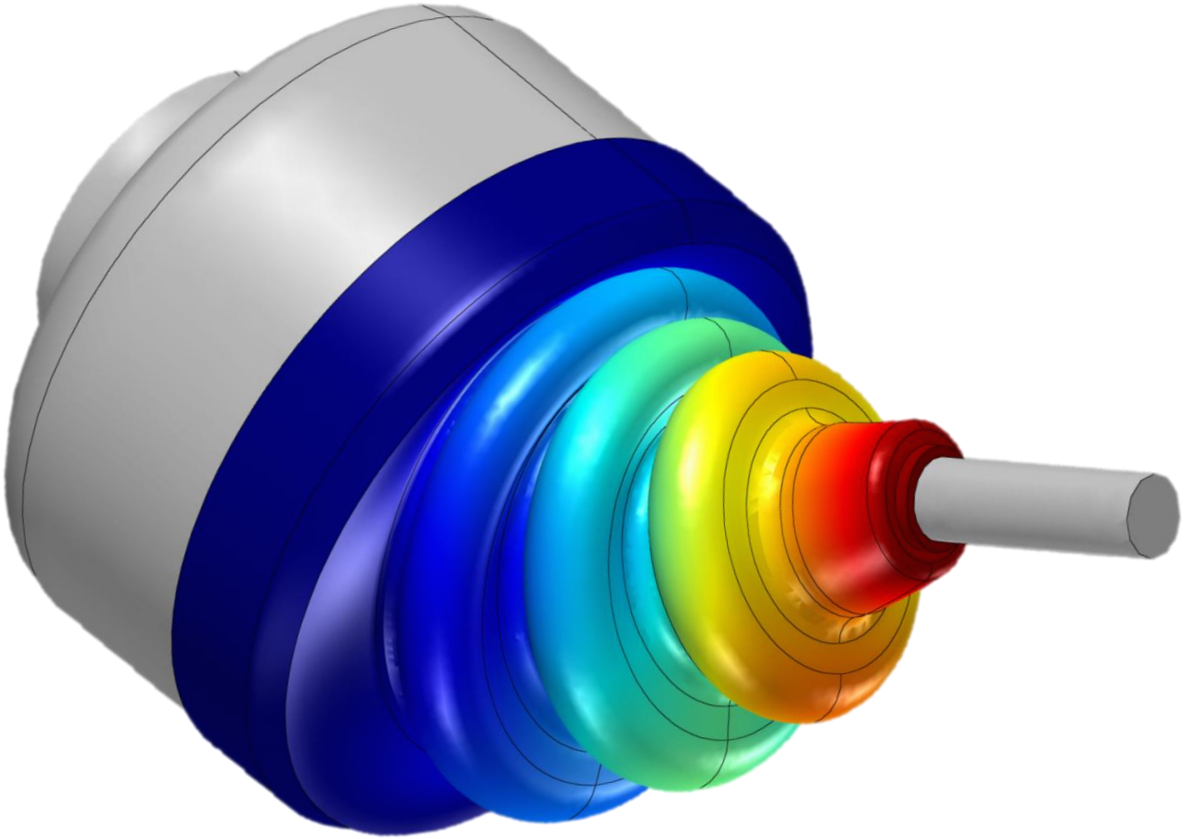
Dynamic Contact & Fatigue Analysis of a CV Boot (Gaiter) Design



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OVERVIEW

- Introduction to CV boots (gaiter)
- Application & industries
- CAD Model
- Model Overview- Contacts
- Model Overview- Fatigue Analysis
- Load-Conditions
- Mesh
- Results

INTRODUCTION-CV BOOTS (GAITER)

- CV boot or gaiter are used as cover on a CV Joint
- The main functions of CV boots are
  - Cover CV joint and protect from contaminants entering and damaging CV joint
  - Helps in retaining grease (lubrication)

Image courtesy: [7]

Image courtesy: [6]

Image courtesy: J.R Merritt Controls, INC.

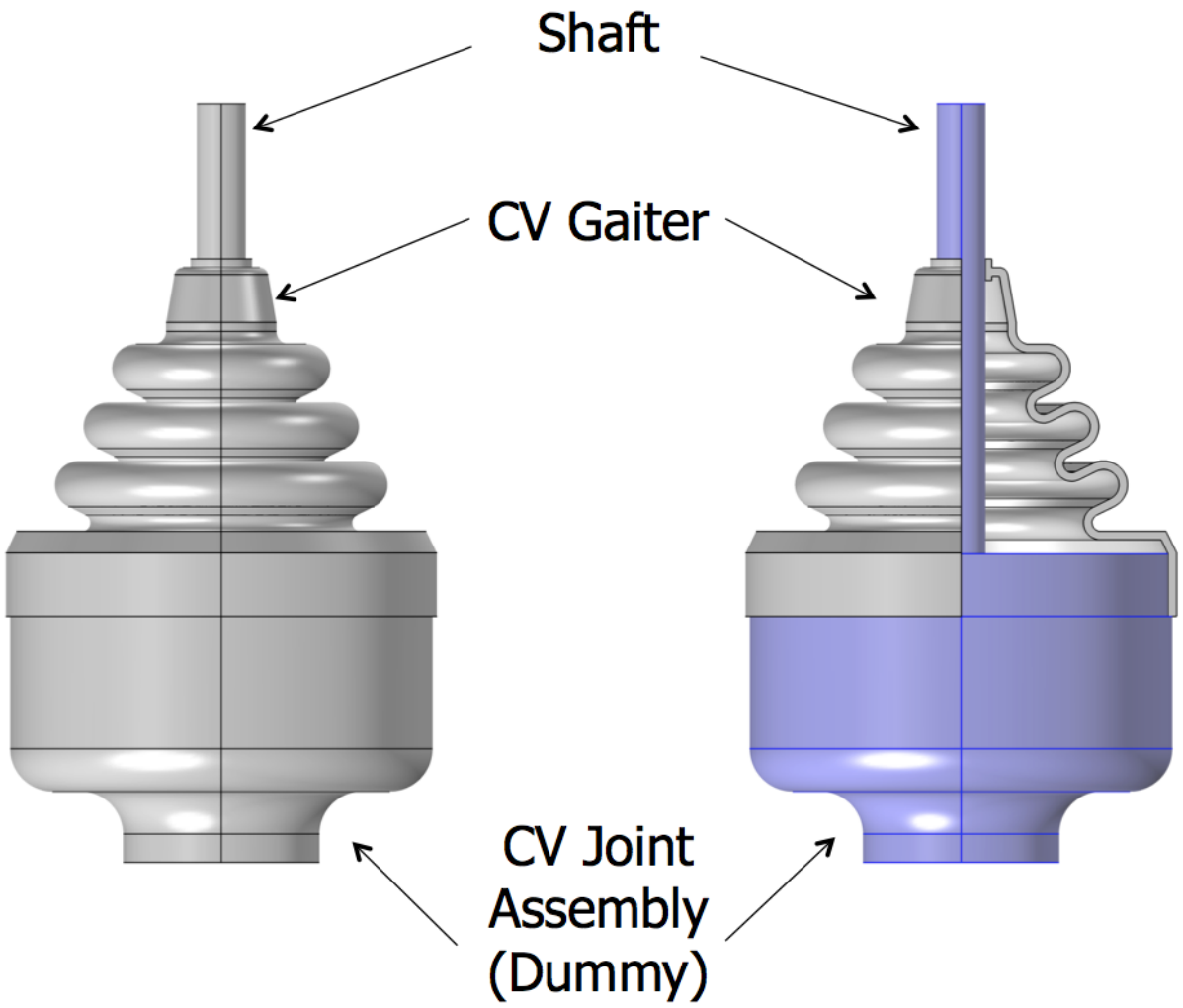
Applications

- Gaiter: Cover for joysticks
- Bellow: Used in many industries to protect mechanical components

Industries

- Aerospace
- Automobile
- Electronic & Mechanical consumer products

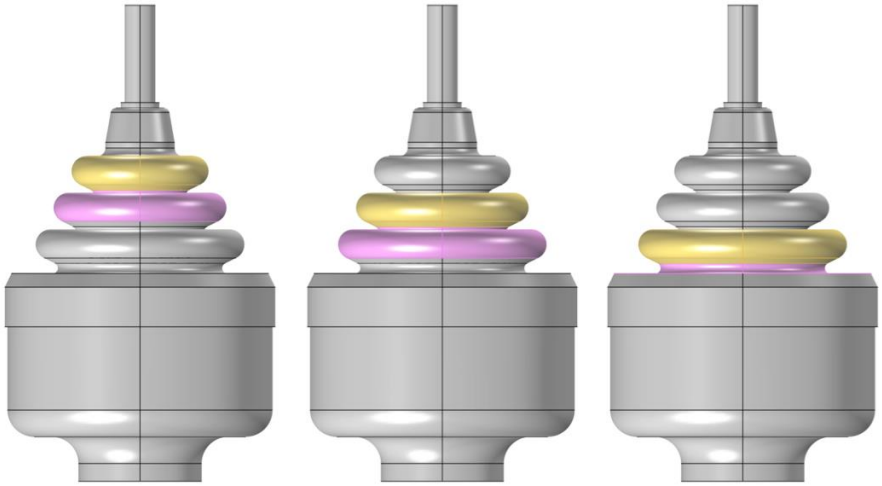
CAD-Simple geometry



Model Overview- Contact Modelling

Source

Destination



Contact pressure in the normal direction

$$T_n = \begin{cases} T_n - p_n d_g & \text{if } d_g \le 0 \\ T_n e^{-\frac{p_n d_g}{T_n}} & \text{otherwise} \end{cases}$$

Where,

g= gap (penetration);
p_n= penalty factor;
p_o= pressure at zero gap;

Contacts Methods

- Augmented Lagrange &
- Penalty methods (New in COMSOL 4.4)

Penalty methods

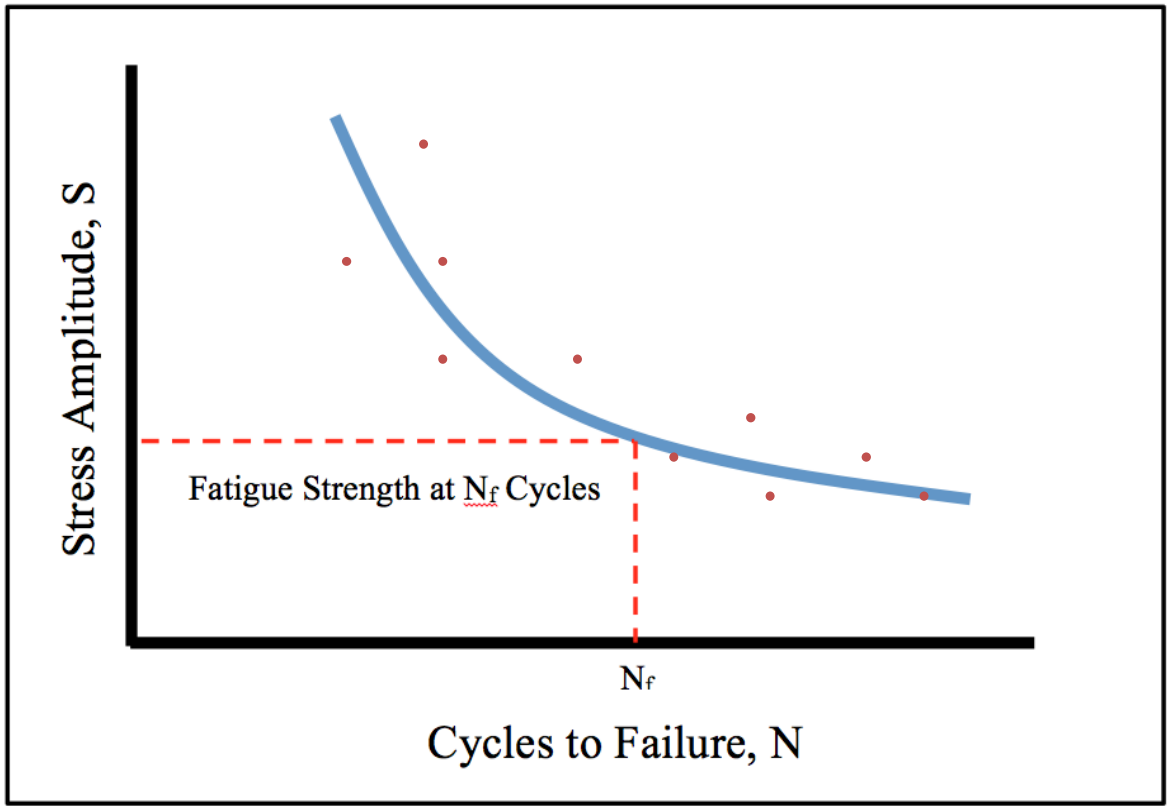
Advantages

- Adds spring element (Stiffness)
- No addition of variable in solver
- Lower degrees of freedom
- Much easier to solve

Disadvantages

- Penetration (depending on penalty factor)

Model Overview- Fatigue Analysis 1

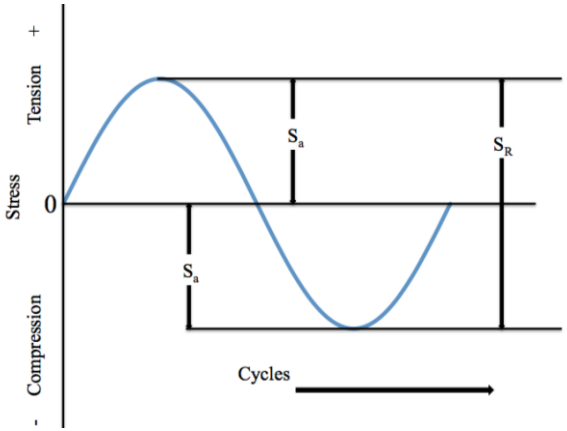


SN Curve (Wohler)

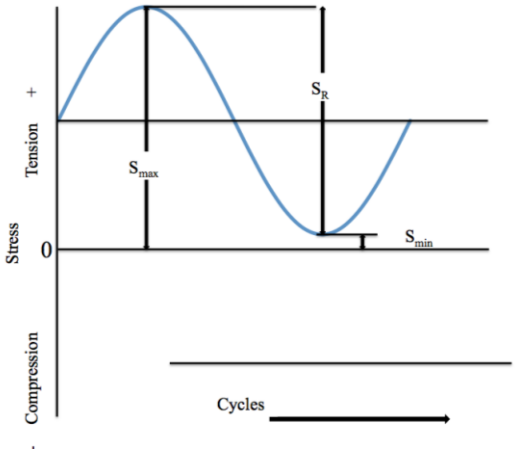
Fatigue

- Weakening of a component due to repetitive application of load
- Material based property
- Failure due to fatigue is represented by SN Curve (Wohler)
- Approximation of large scattered data's obtained from physical test

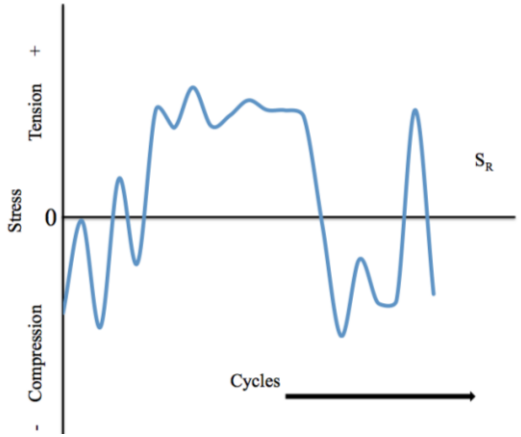
Model Overview- Fatigue Analysis 2



Fully Reversed Cycle



Offset mean load Cycle



Random load case

Different types of load cycles

- Fully reversed load
- Offset mean load
- Random load

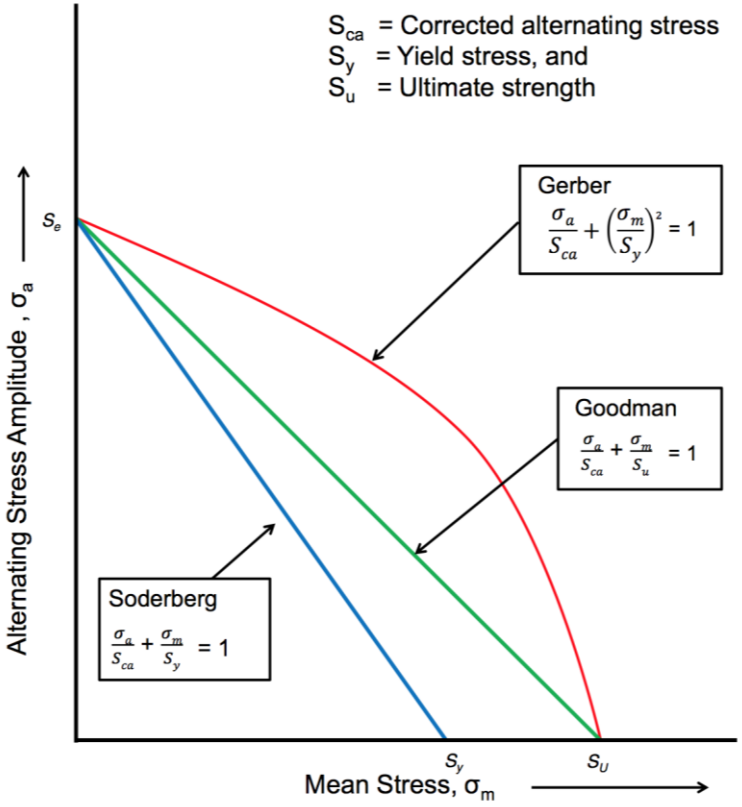
Four major approaches for testing multiaxial fatigue load:-

- Equivalent strain
- Equivalent stress
- Energy base &
- Critical Plane

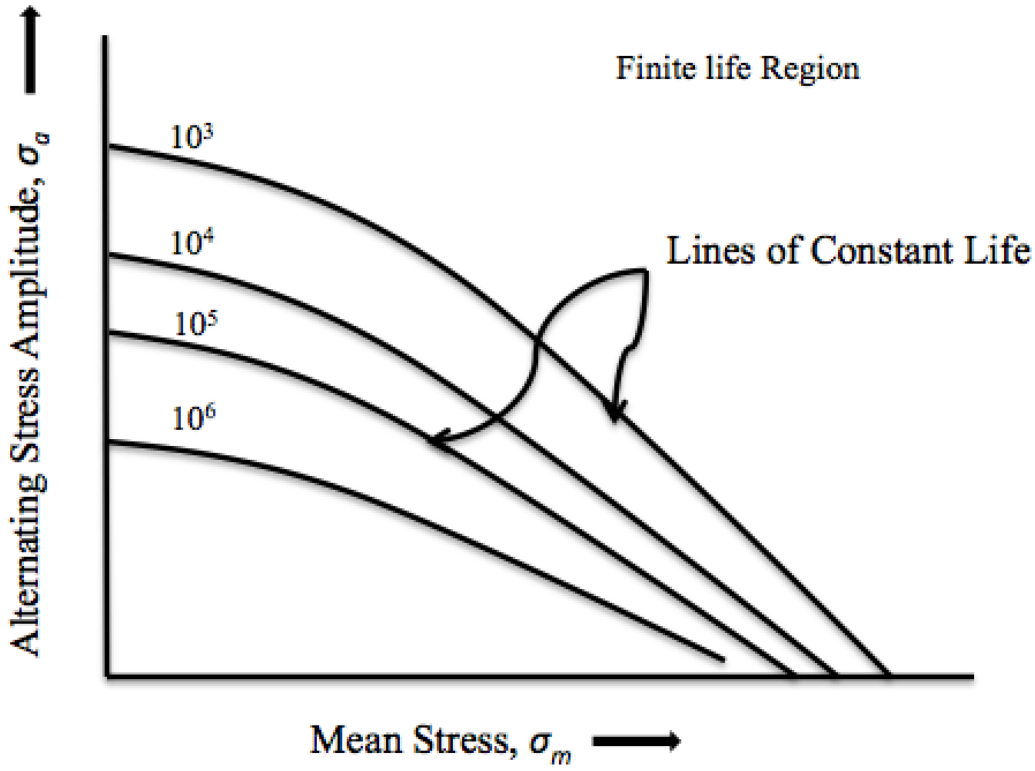
Stress range	$\sigma_r = \sigma_{max} - \sigma_{min}$
Stress amplitude	$\sigma_a = \sigma_r/2 = (\sigma_{max} - \sigma_{min})/2$
Mean stress	$\sigma_m = (\sigma_{max} + \sigma_{min})/2$
Stress Ratio	$R = \sigma_{min}/\sigma_{max}$

Model Overview- Fatigue Analysis

Haigh's diagram showing Gerber, Soderberg and Goodman curve



Lines of constant life Plotted on Haigh's diagram



Three major empirical formulas

- Goodman
- Soderberg
- Gerber

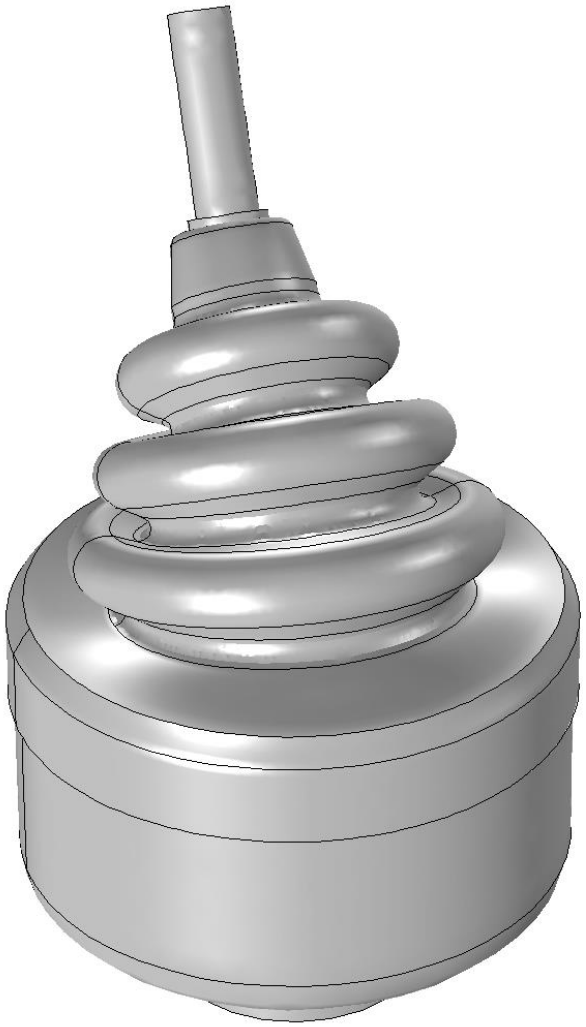
LOAD- CONDITIONS (DISPLACEMENT)

Reality

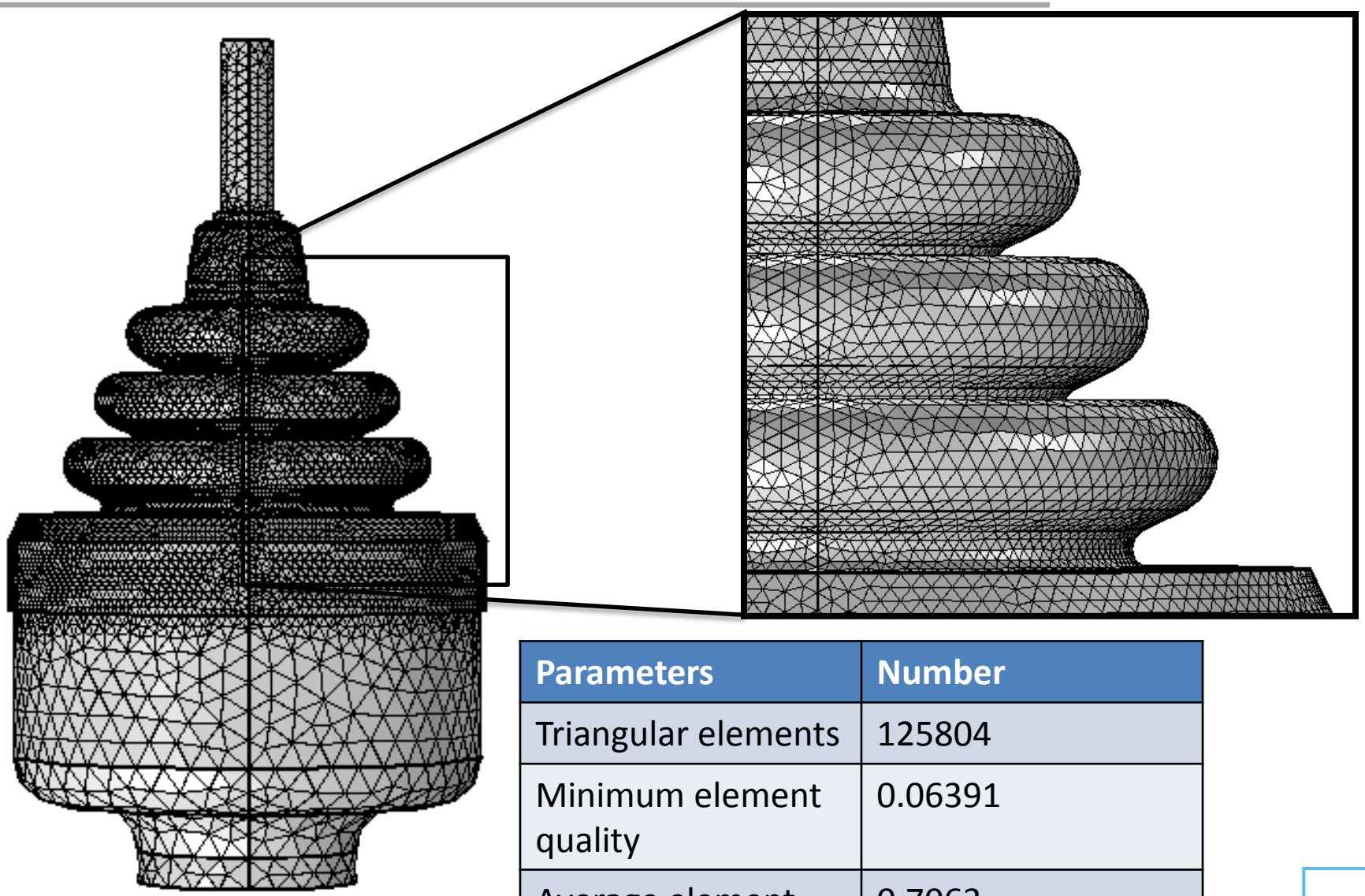
- Combination of multiaxial loads, bending, axial, angular and load due to centrifugal force.

Assumptions

- Combination of bending and angular displacement load



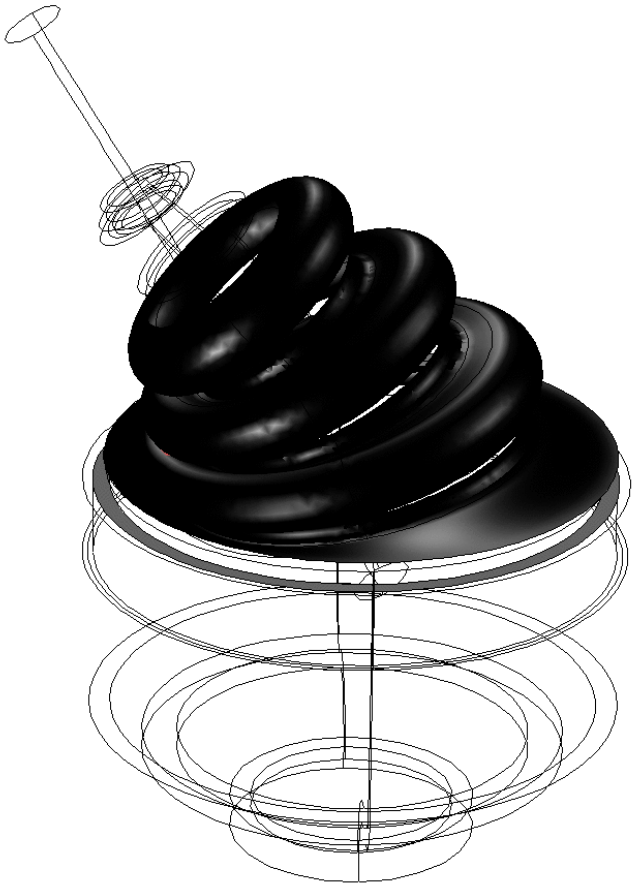
MESH



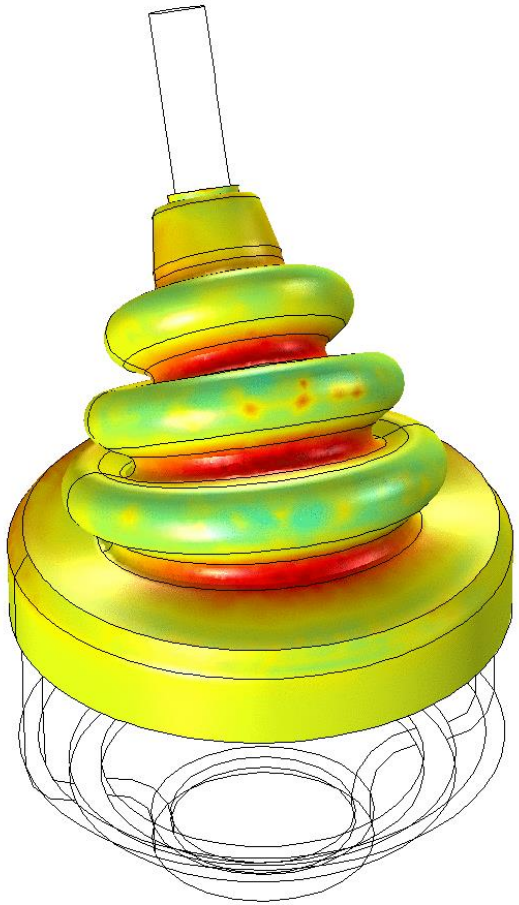
Parameters	Number
Triangular elements	125804
Minimum element quality	0.06391
Average element quality	0.7063

RESULTS- DISPLACEMENT

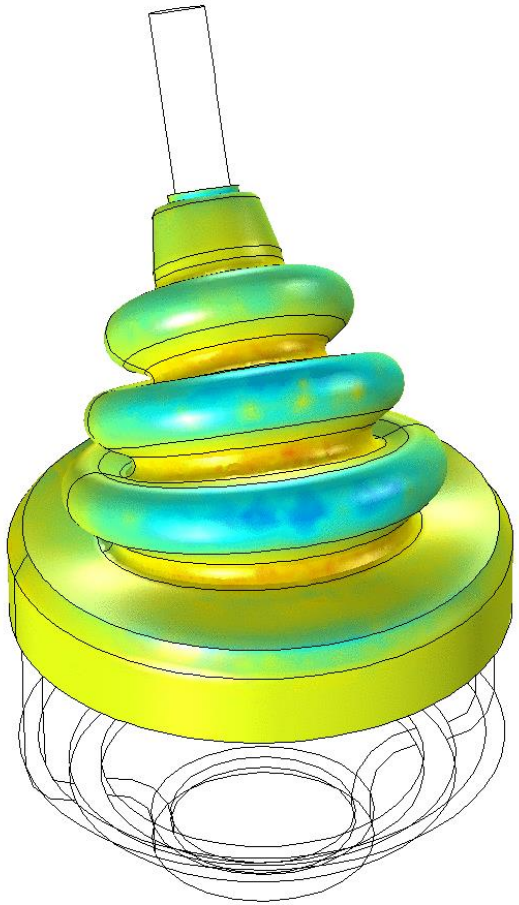
Results- Contact Stress



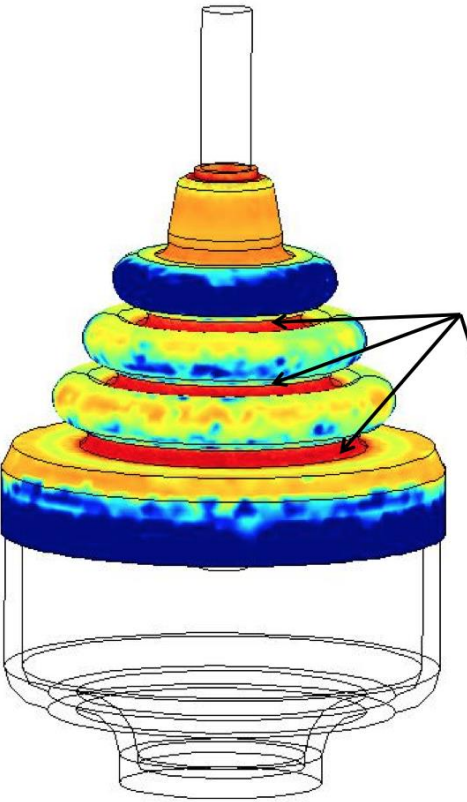
Results- First Principle Stress



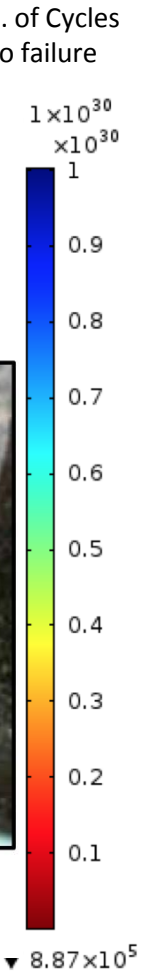
Results- Third Principle Stress



Results- Fatigue Data



Early Fatigue Failure (trough region)



Conclusion & Discussion

Conclusion

- The fatigue results obtained match the general failure trends observed in the CV gaiter under operation

Future Work

- Model validation against physical test data &
- Implementation of more realistic load estimations within the COMSOL Model.

REFERENCE

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Thank You

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