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

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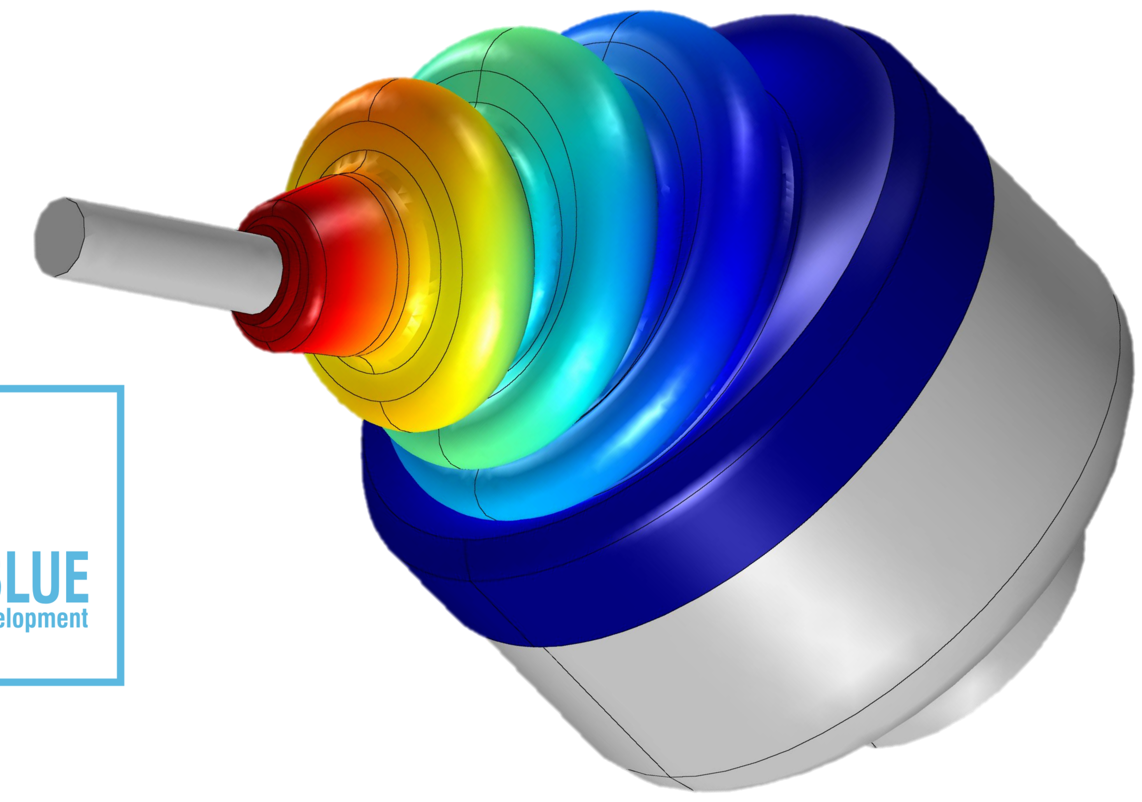


INTRODUCTION

CV boots or gaiters are used as a cover to protect movable components in joint systems, & are commonly used to protect universal joints along drive shafts. Continuous exposure to dynamic motion & contact stresses can dramatically reduce the expected life of these protective covers. With this in mind the design engineers need to ensure that they use minimal contacts under operation. In this paper, we will discuss the dynamic analysis of a CV boot, where the contact behavior and fatigue life of a CV boot under operating conditions is assessed.

AIM

The aim of this study was to develop a dynamic contact & fatigue analysis of a CV boot (gaiter) using Comsol Multiphysics.

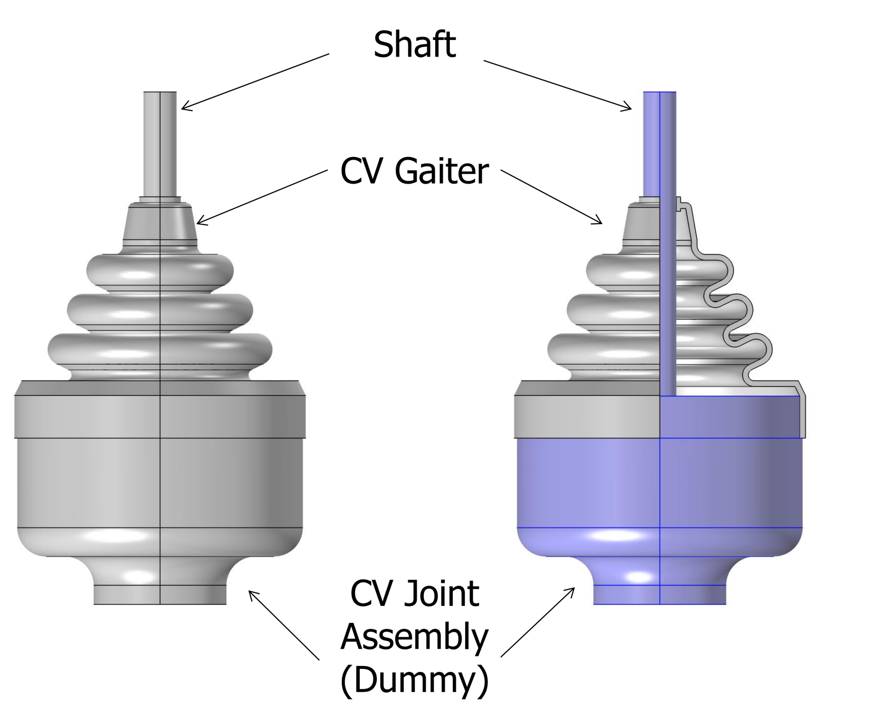


Figure 1. CV gaiter and dummy CV joint. Semi-sectional view of gaiter on left side is shown

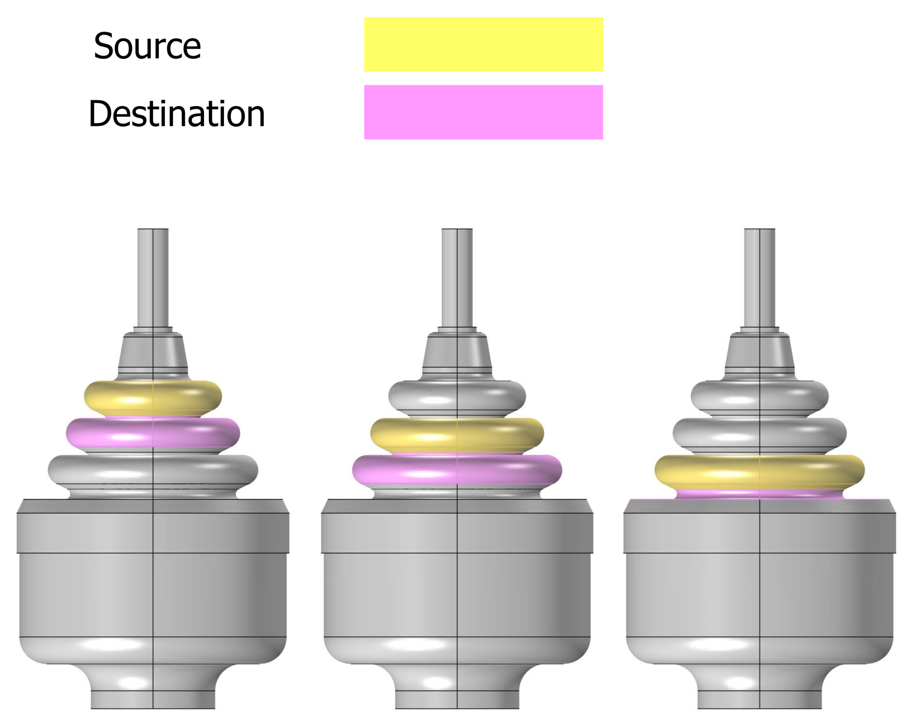


Figure 2. Outer set of Contact pairs, with source and destination section

Equations 1. Penalty method contact pressure calculation

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

Figure 3. Different curve fits in Haigh Diagram

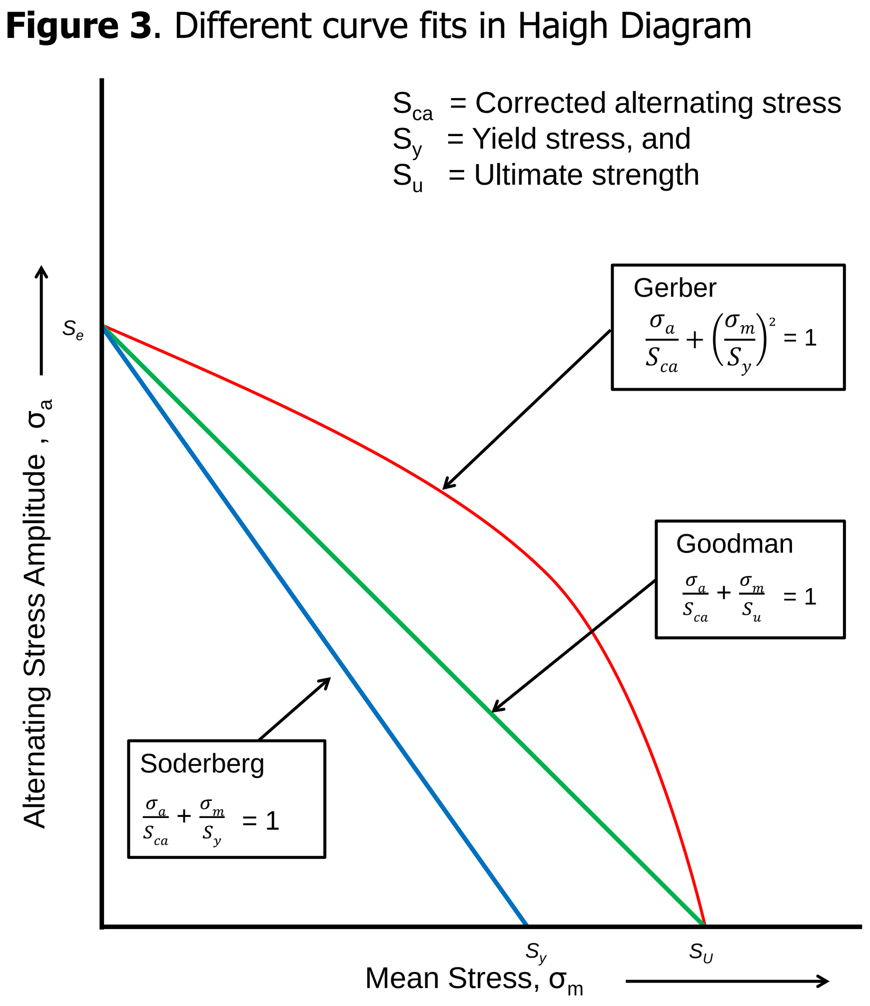


Table 1. Stress ratio values and its corresponding loading conditions [4]

Stress Ratio (R)	Loading Conditions
R > 1	$\|\sigma_{max}\|$ & $\|\sigma_{min}\|$ <0 Negative mean stress.
R = 1	Static loading
0 < R < 1	$\|\sigma_{max}\|$ & $\|\sigma_{min}\|$ >0 &, $\|\sigma_{max}\|$ > $\|\sigma_{min}\|$ Positive mean stress.
R = 0	σ_{min} = 0 Zero to tension loading.
R = -1	$\|\sigma_{max}\|$ = $\|\sigma_{min}\|$; σ_m=0 Fully-reversed loading.
R < 0	$\|\sigma_{max}\|$ < $\|\sigma_{min}\|$, σ_{max} approaching zero
R infinite	σ_{max} =0.

METHOD

COMSOL was used to simulate a frictionless contact model of a CV gaiter using the structural mechanics module. A simple CV gaiter geometry was built in SolidWorks & imported into COMSOL for analysis. The penalty method was utilised to specify the contact force relations between the source & destination surfaces. Selection of Penalty contact method was based on the dynamic load conditions for the given application and reduction in degrees of freedom and computational time. Fatigue modelling was built based on the available data. We have used our in-house fatigue script for modelling based on Wohler Curve (SN Curve) data. Simplified model was ran in time variant load in comparison with real-time situation. Only the effect due to bending along with angular displacement is considered in the current study.

RESULTS

From the data shown below in Figures 4, 5 & 6, it is evident that the stresses are concentrated at the lower section of the CV gaiter. Figure 4 shows the stress due to contact on the outer surface of the CV gaiter at various time points on the lower gaiter section. The maximum first & third principal stresses are located around the trough region, as shown in Figures 5 & 6. Figure 7 corresponds to fatigue failure plot and it can be noted that trough regions are prone to early fatigue failure due to high stress concentration.

Figure 4. Contact stresses on the outer surface of CV gaiter at different time points during load cycle

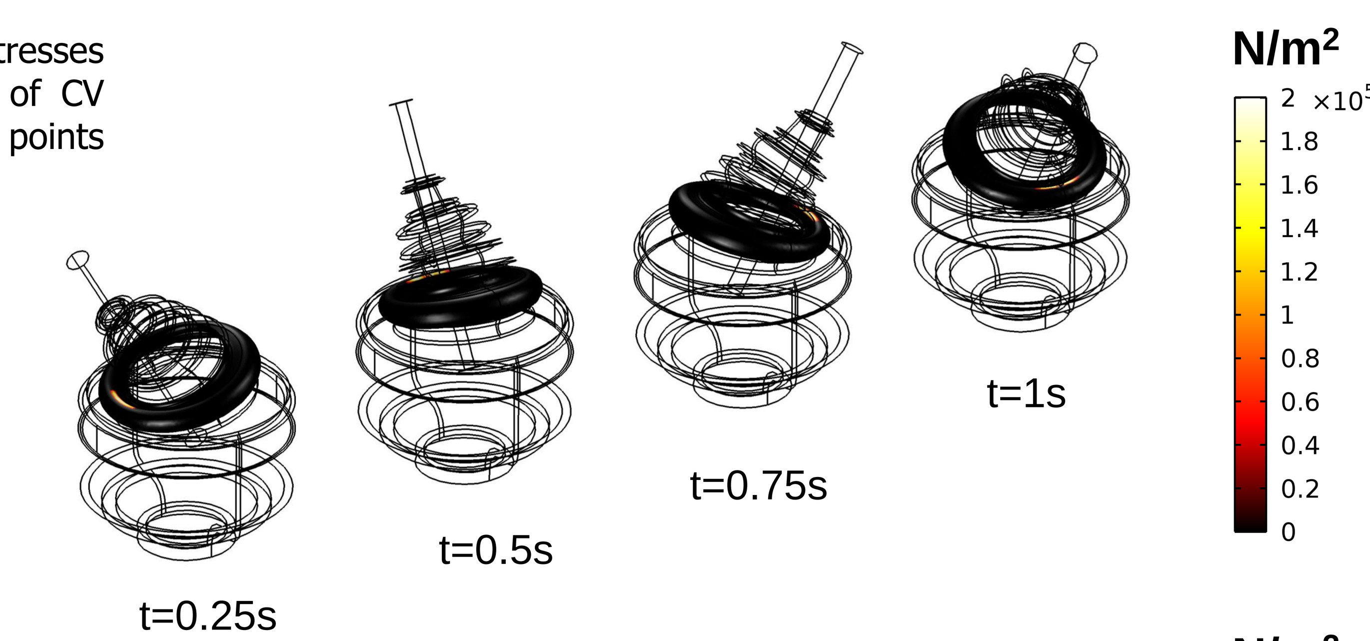


Figure 5. First principal stress plot of CV gaiter at different time points during load cycle

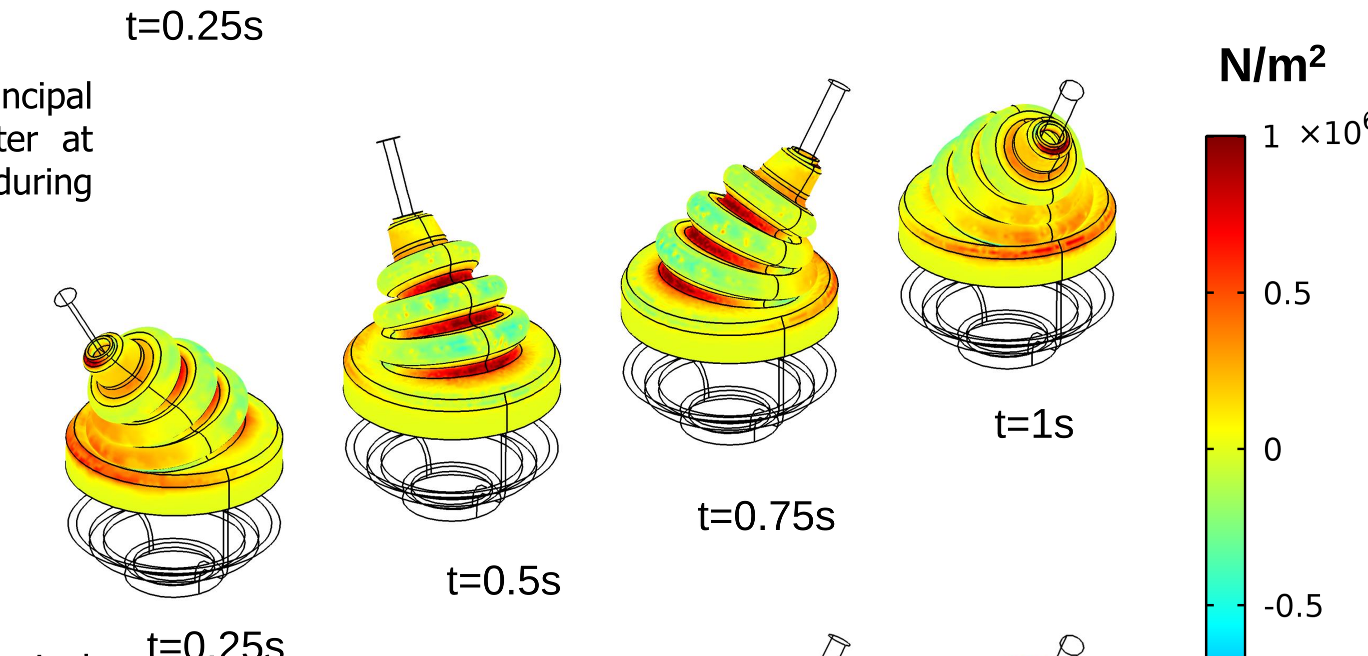
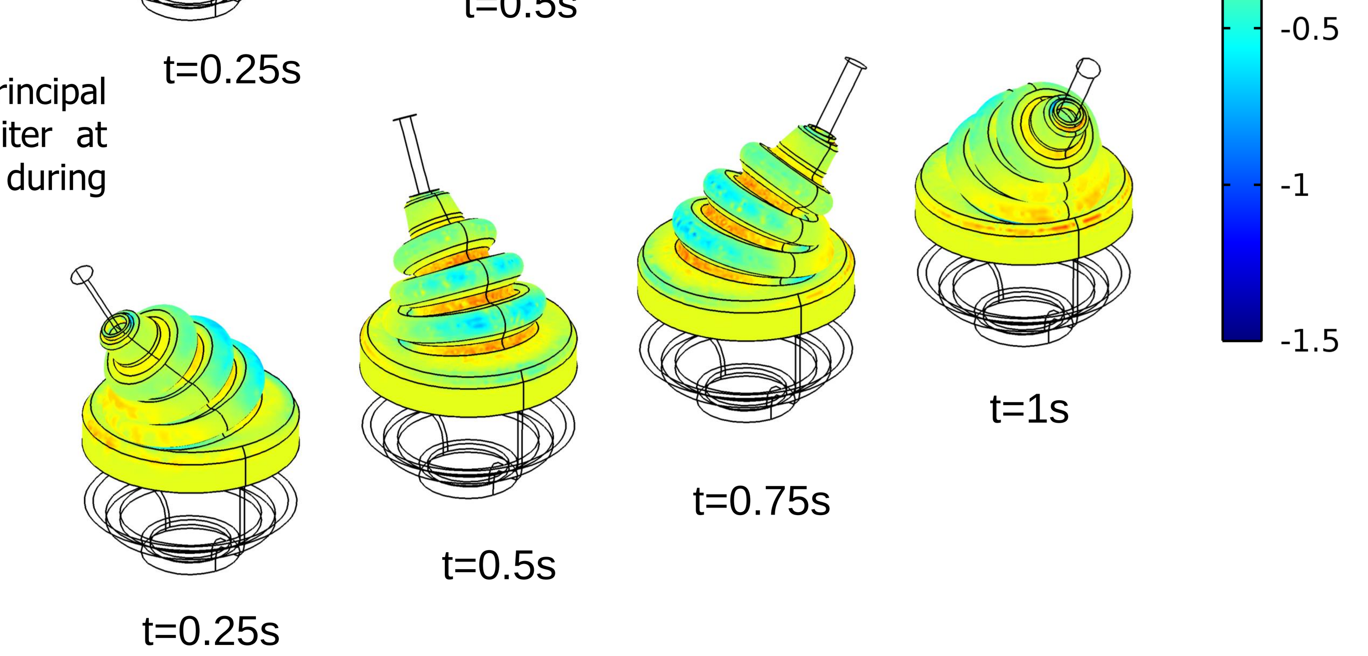


Figure 6. Third principal stress plot of CV gaiter at different time points during load cycle



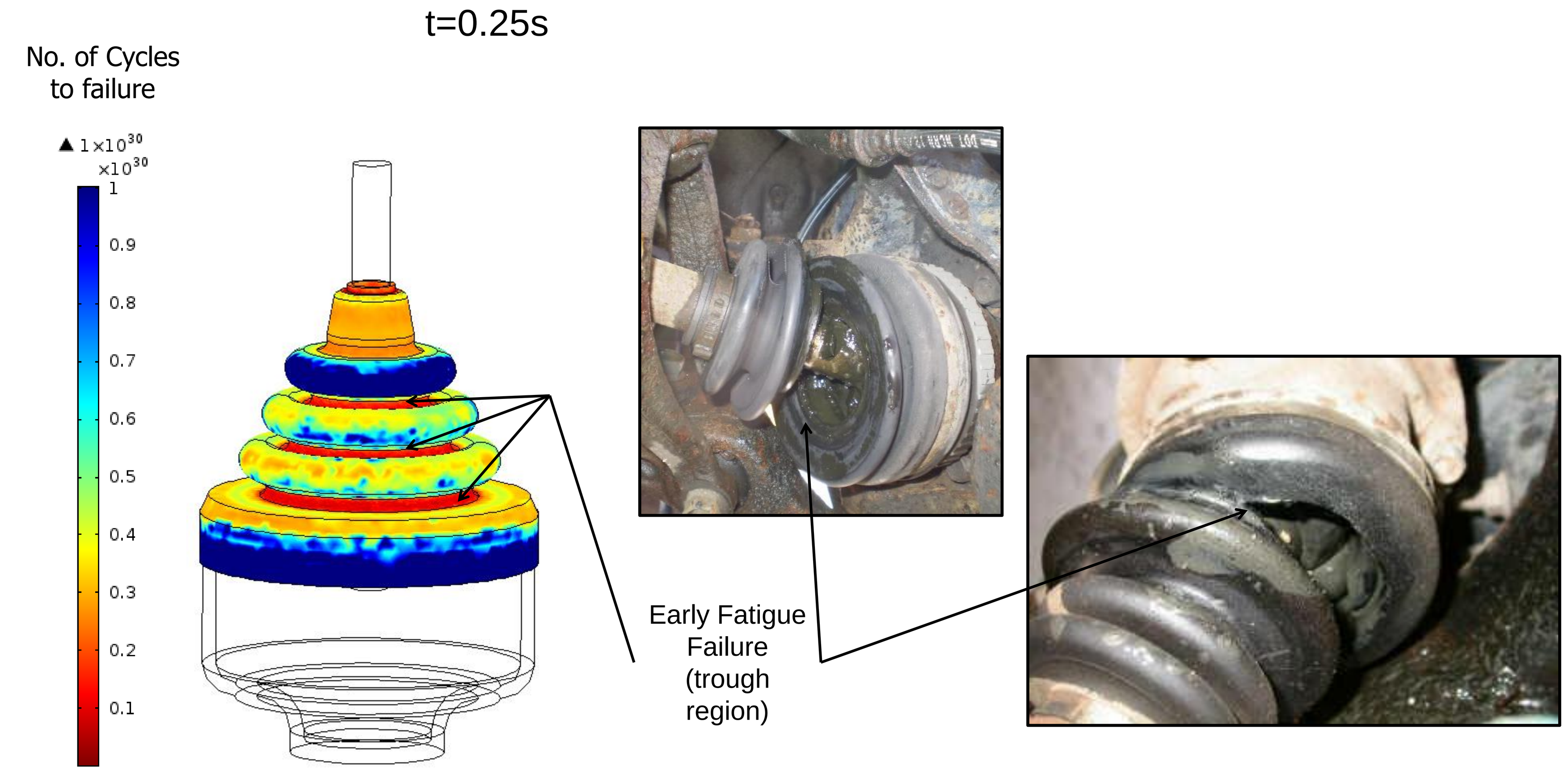


Figure 7. Fatigue plot obtained from COMSOL and compared with damaged model for pattern comparison [5-6]

DISCUSSION & CONCLUSION

The fatigue results obtained match the general failure trends observed in the CV gaiter under operation, as shown in Figure 7. Future work will include validation against physical test data & implementation of more realistic load estimations within the COMSOL Model.

References:
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