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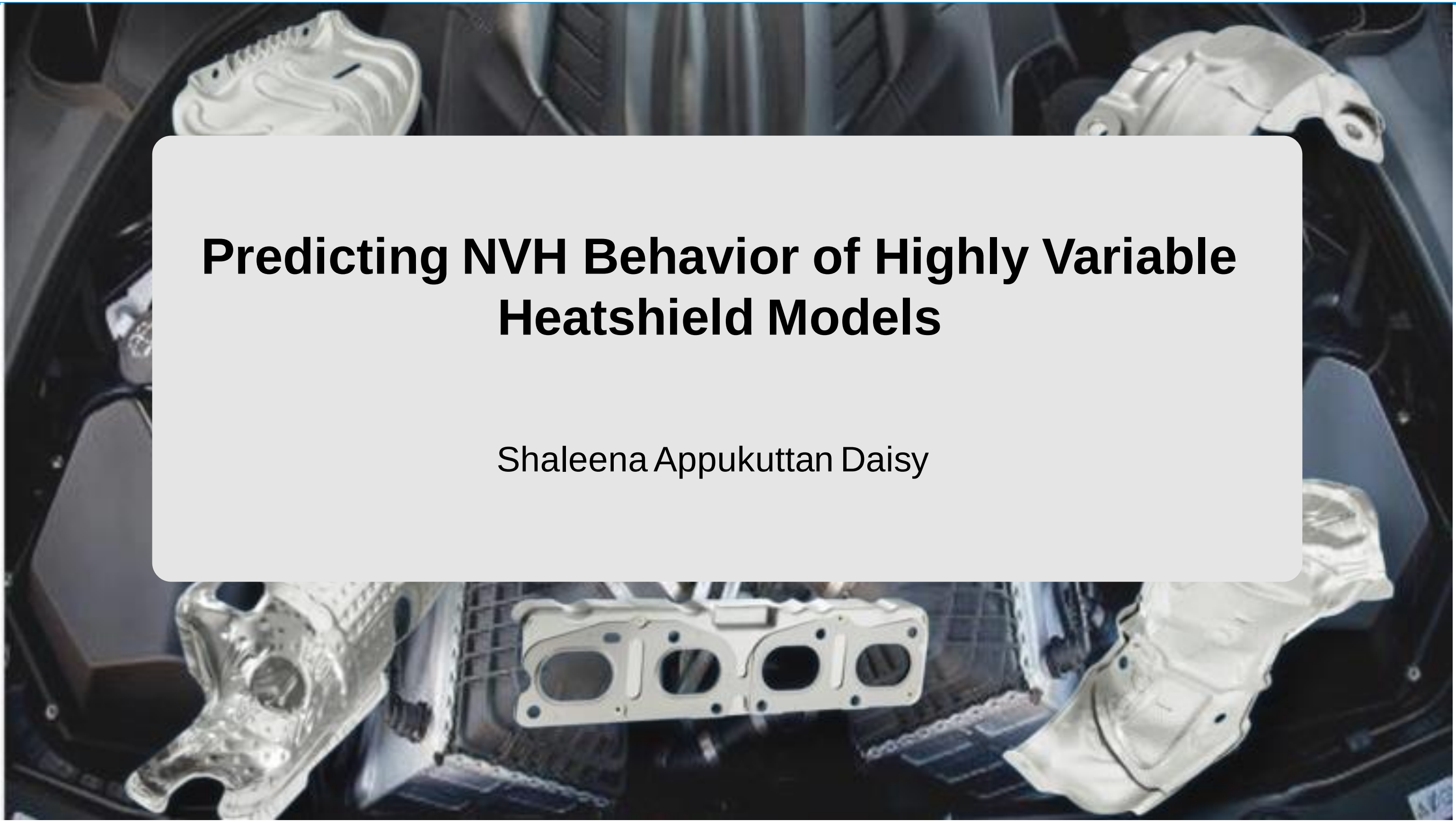

Predicting NVH Behavior of Highly Variable Heatshield Models

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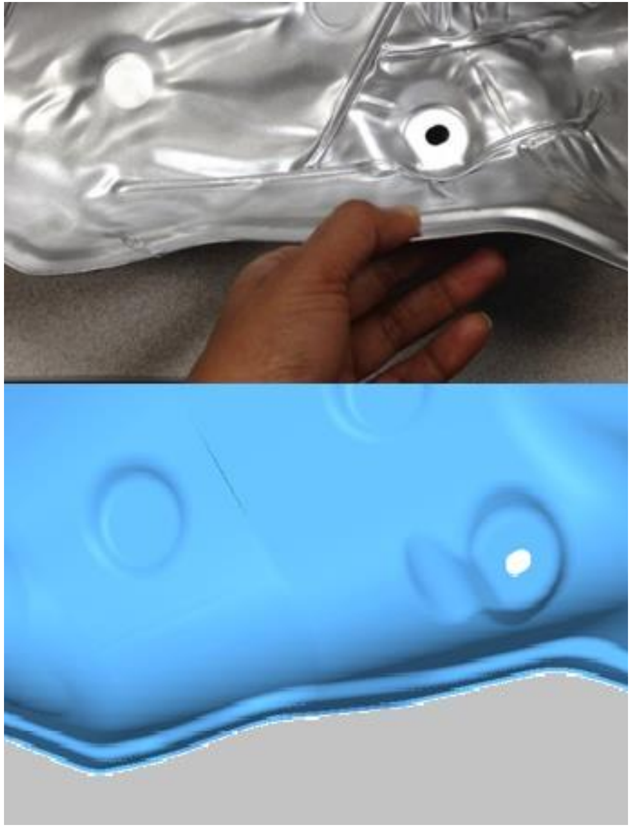
CHALLENGES IN ACHIEVING FREQUENCY AND STRESS CORRELATION IN SHIELDS

Challenge 1 : Part & CAD mismatch

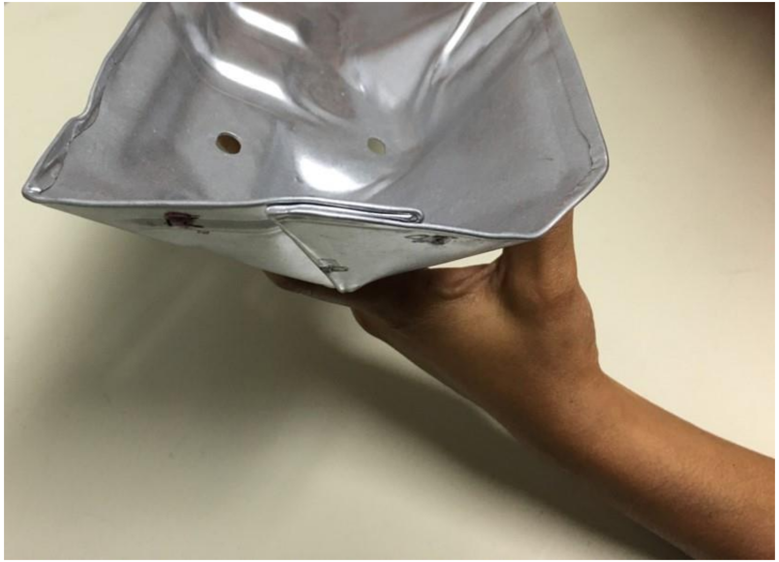
Packaging
Tight packaging spaces leading to complex shapes

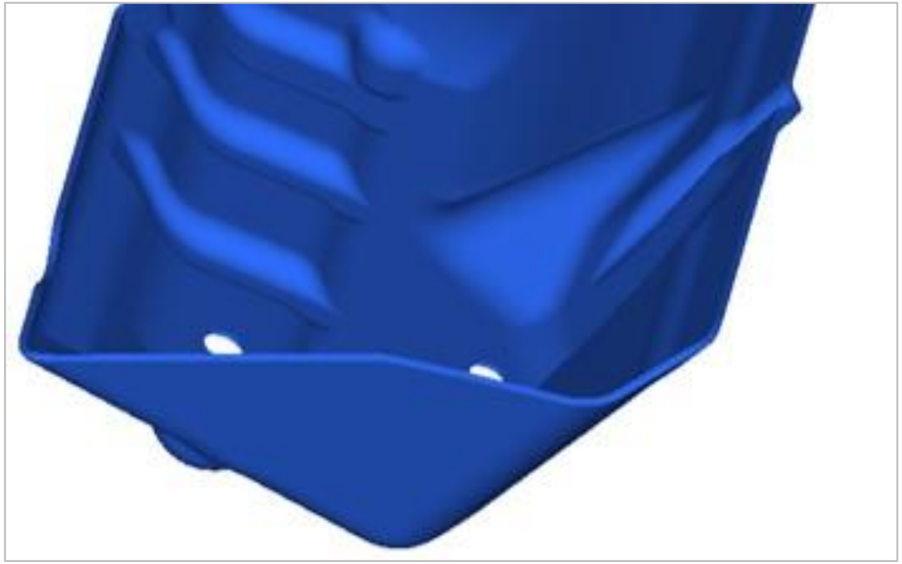
Thinning
Material stretching and thinning during the stamping process

Patterned Surface
Patterned surface analysis takes long time and effort

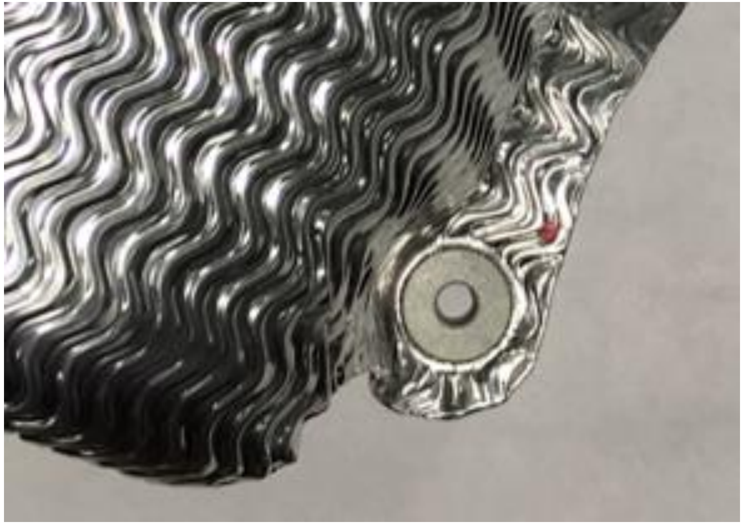


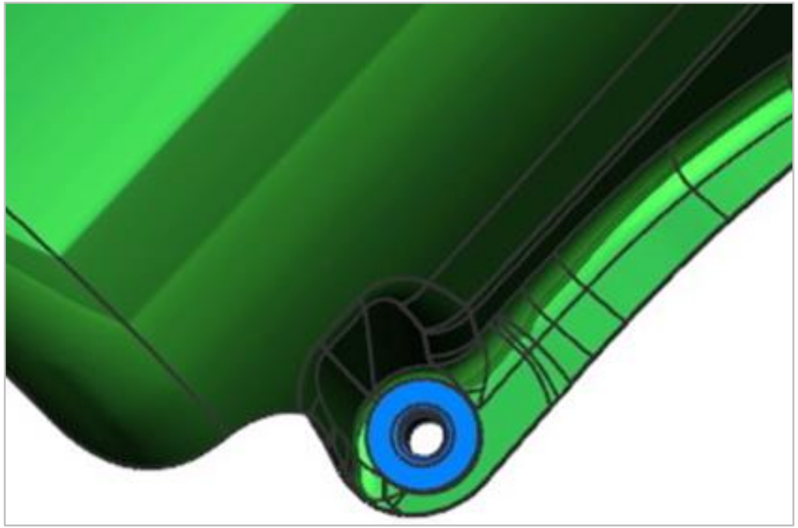
Challenge 1 : Part & CAD mismatch



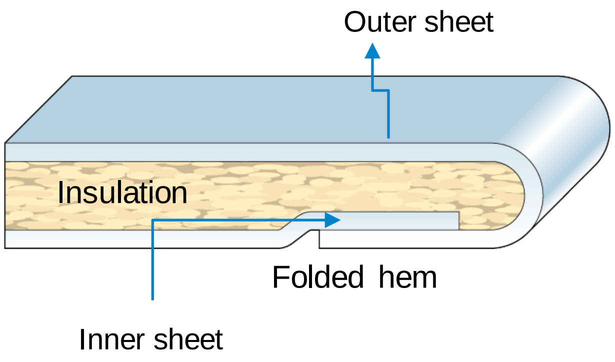


Challenge 1 : Part & CAD mismatch





Challenge 2 : Multi-layer honeycomb structure



Cannot be modeled as a composite

Complex shapes and honeycomb structure presents unique difficulties in mesh generation

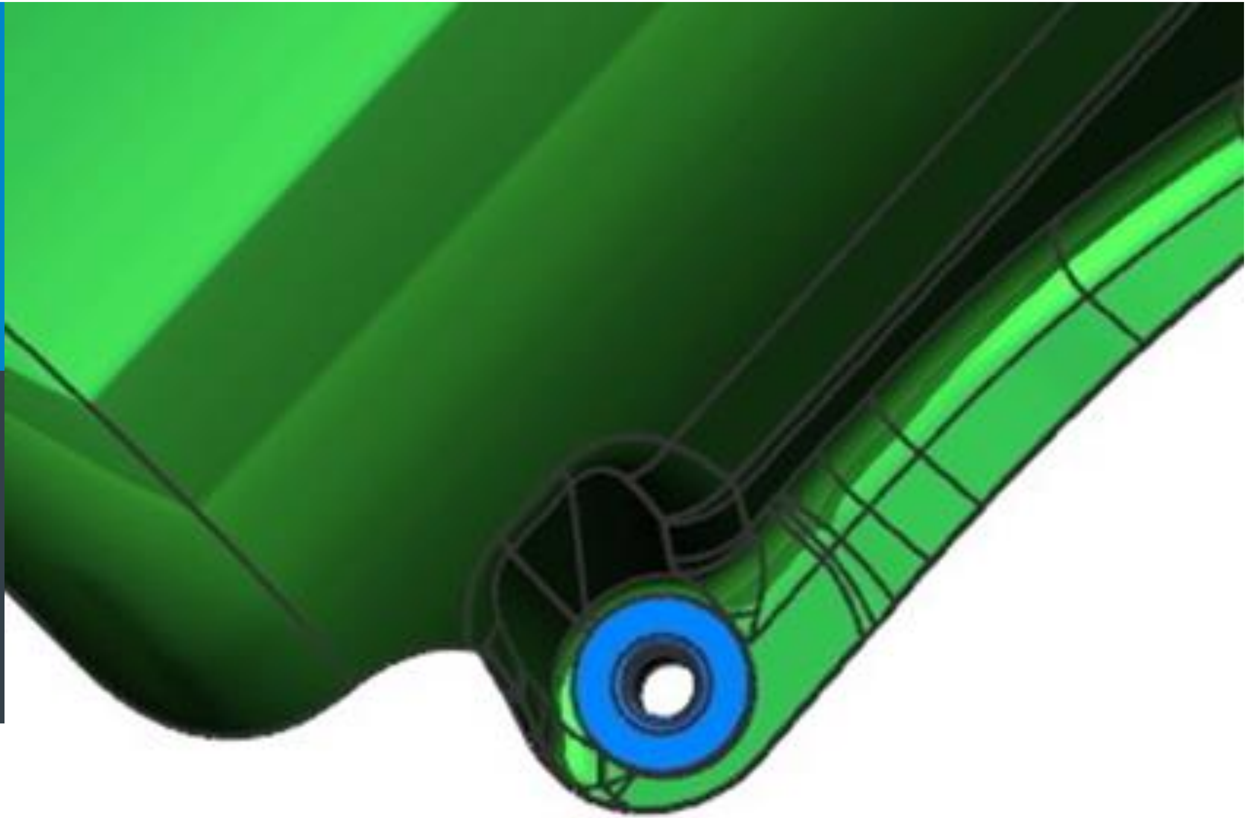
Challenge 3 : Nonlinear behavior in attachment point

Contacts

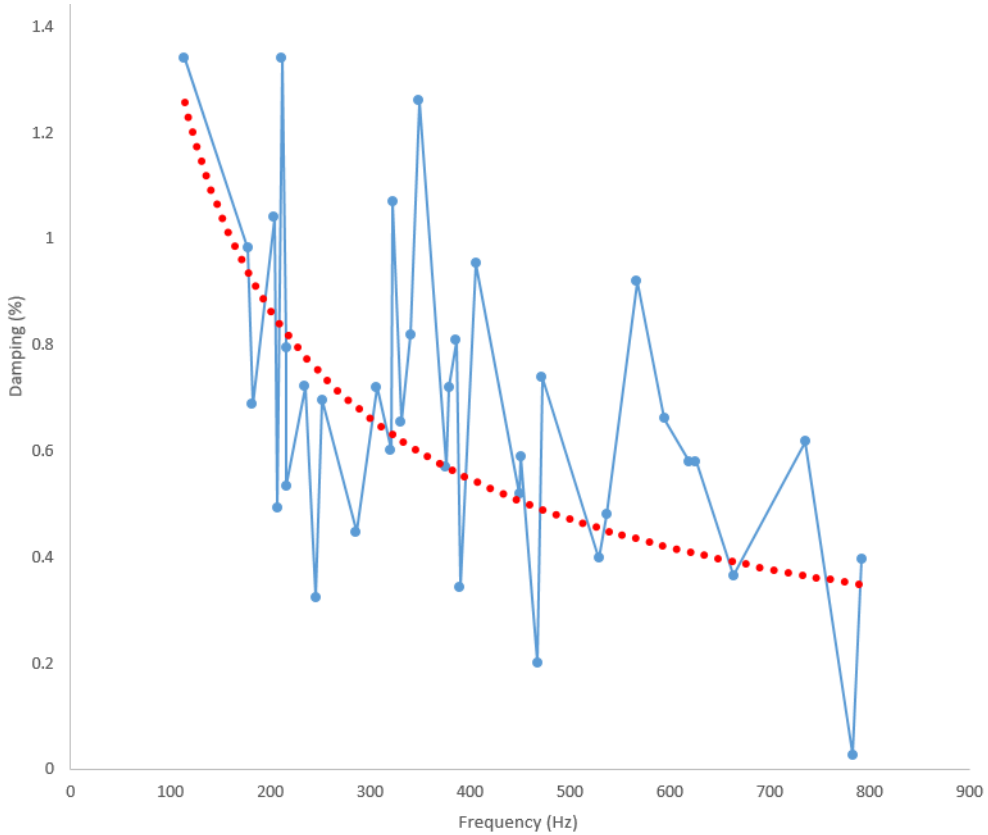
Constantly changing contact status

Isolators

Complex isolator geometries

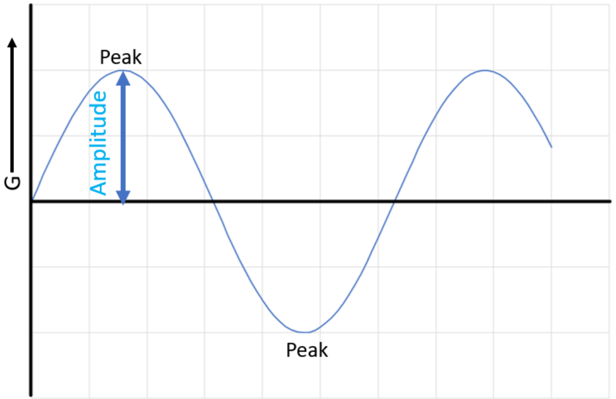


Challenge 4 : Highly variable damping



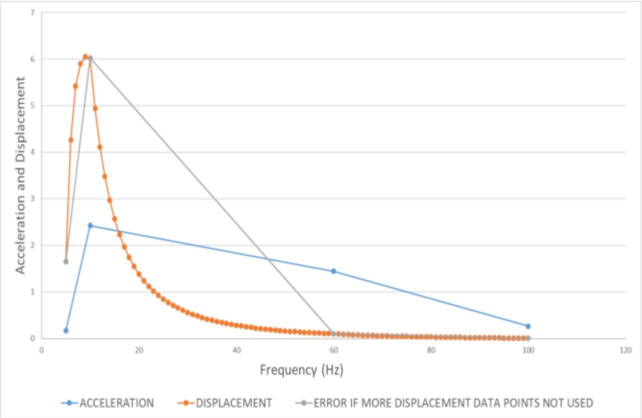
Other possibilities of errors

Vibration Inputs - Amplitude



- ABAQUS uses *amplitude input
- Not to confuse with peak-to-peak

Acceleration vs Displacement

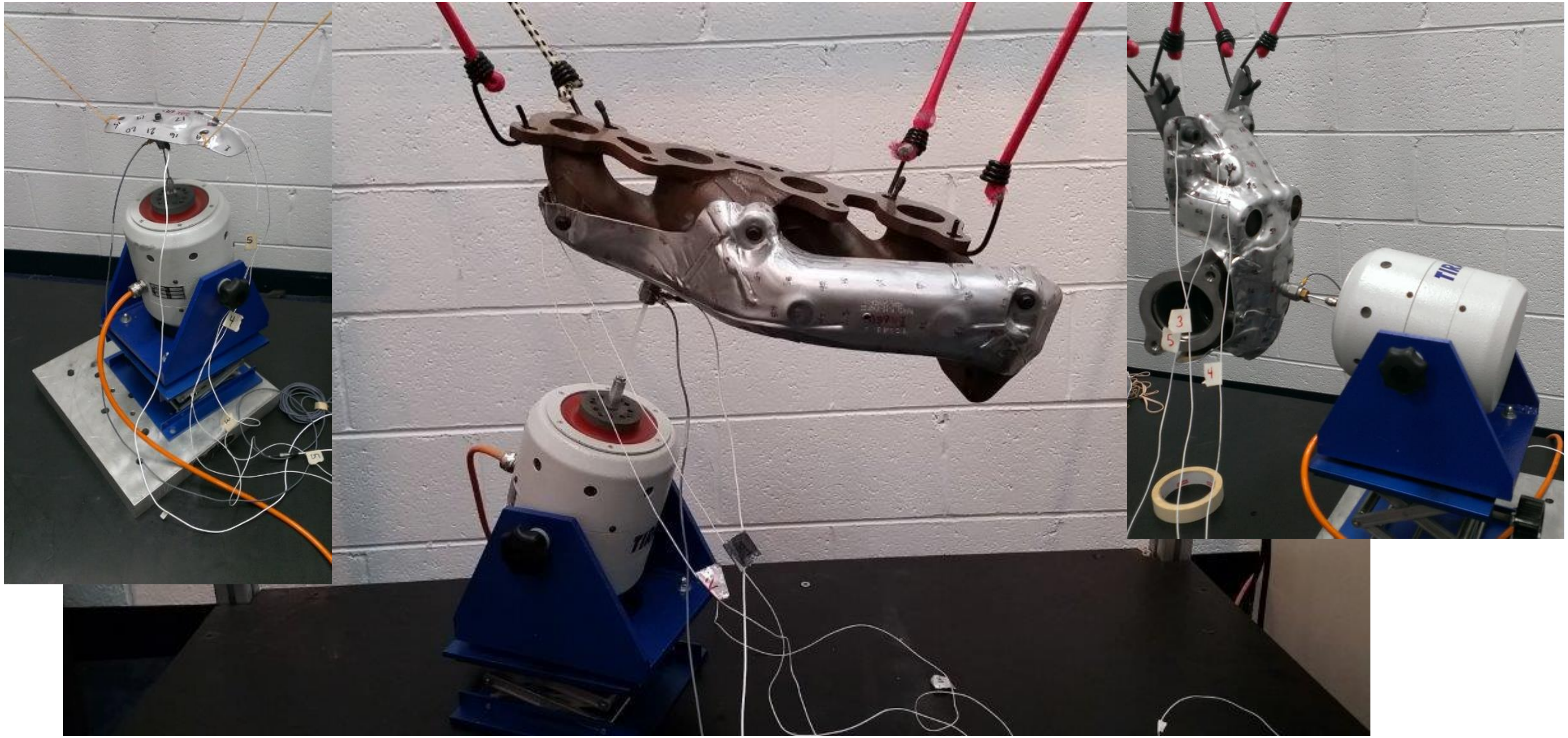


Model Orientation

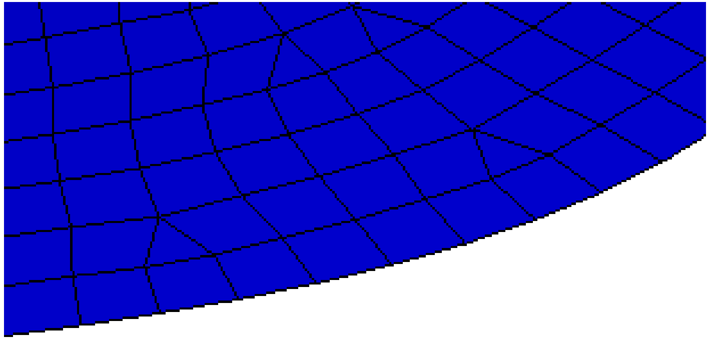
CAD Model orientation vs orientation in which G inputs received from customer

SOLUTION APPROACH

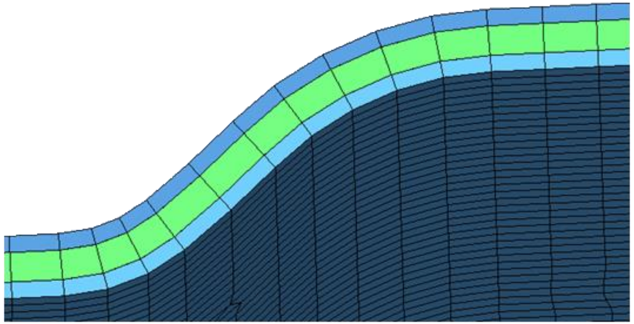
Frequency and mode shape measurement set-up



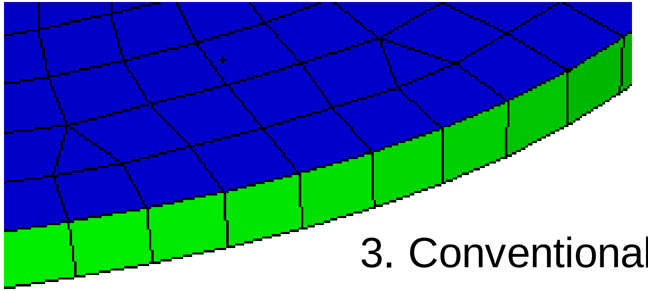
Modeling approaches in FEA



1. Composite shell



2. Continuum-Continuum-Continuum shell



3. Conventional-Continuum-Conventional shell

Additional details captured on FEA model

- Modeled foldovers and beads
- Forming analysis to obtain close match to final shape
- Used damping from test results
- Dynamic analysis instead of mode superposition analysis

Conclusions

- Approach is problem-dependent. No ‘one size fits all’ solution possible.

- For simple models subject to free-free conditions, a composite shell model would suffice. But for cases with complex bending scenarios, a layered continuum shell model should be considered.

- For non-linear scenarios, dynamic vibrational cycling is a possible alterative to linear frequency extraction analysis.

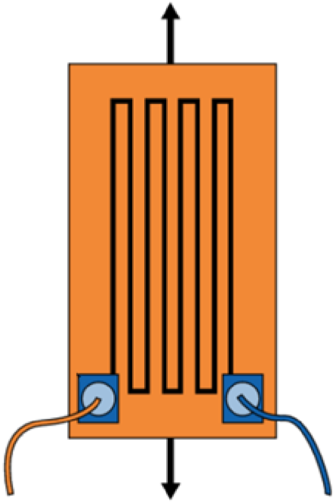
Additional work – strain gauge measurements

Stress reported by strain gauge: Unidirectional σ_{xx}

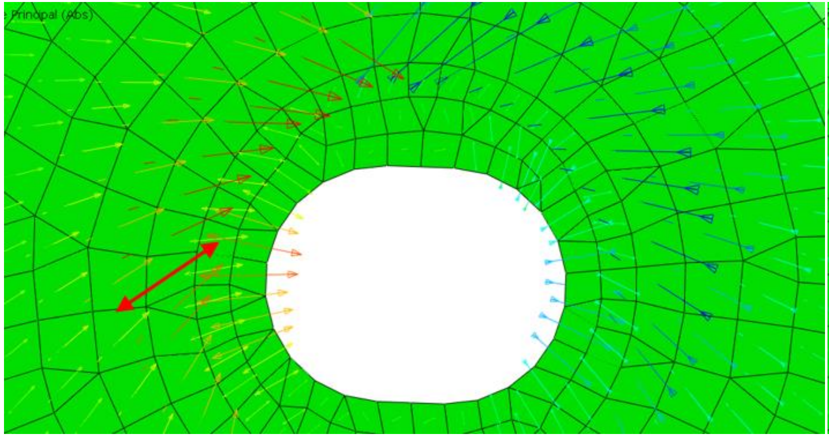
$$\sigma_{\mathrm{VM}} = \sqrt{\boxed{\sigma_{xx}^2} + \sigma_{yy}^2 + \sigma_{zz}^2 - \sigma_{xx}\sigma_{yy} - \sigma_{yy}\sigma_{zz} - \sigma_{zz}\sigma_{xx} + 3\left(\tau_{xy}^2 + \tau_{yz}^2 + \tau_{zx}^2\right)}$$

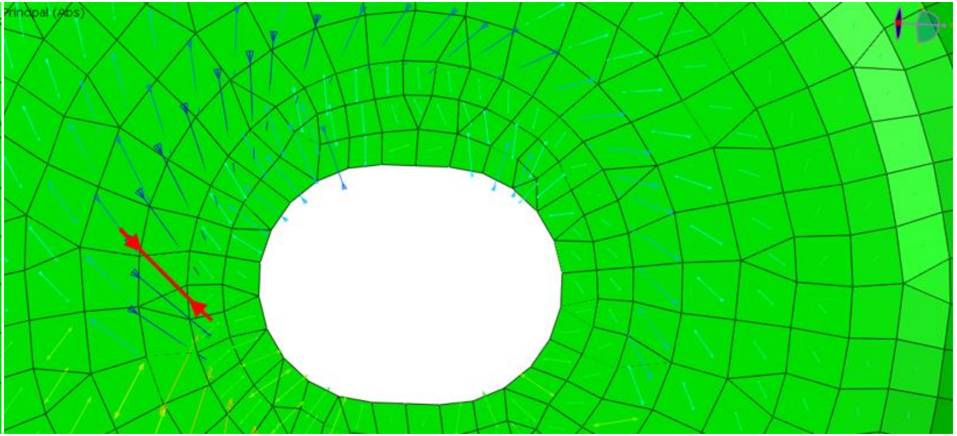
$$\sigma_{\mathrm{VM}} = \sqrt{\boxed{\sigma_{xx}^2} + \sigma_{yy}^2 - \sigma_{xx}\sigma_{yy} + 3\,\tau_{xy}^2}$$ (biaxial state of stress)

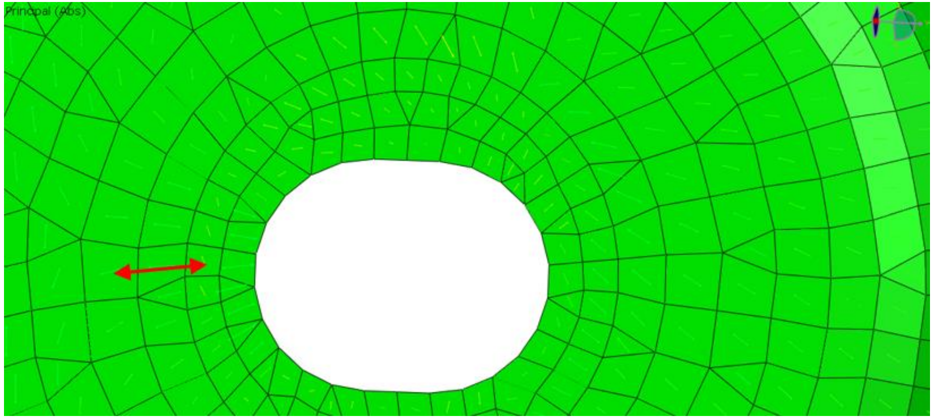
$$\sigma = E\varepsilon$$



Max in-plane principal stress direction is not constant across all frequencies and all loading cases.







Thank you.

DANA

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