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Influence of Misfit Mechanisms on Jointed Structure Response

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Outline

- Introduction to topic
- Explanation of hardware
- Pressure film technique and results
- Experimental techniques and results with focus on correlation to contact pressure distribution
- Work for the future

Introduction – Bolted Joints

- **Jointed interfaces, specifically bolted joints, are often THE major load path into a subsystem**
- **Jointed interfaces can exhibit**
  - **Nonlinear behavior**
  - **Highly variable response**
- **Accurate modeling of the interfaces, especially including nonlinear stiffness and energy dissipation, is desirable**
- **Experiments on combinations of two different types of joints show that**
  - **The structural stiffness of the tested specimens varies by up to 25%**
  - **The energy dissipation varies by up to nearly 300%.**

Introduction – Contact Pressure Distribution & Nonlinear Interface Behavior

- Geometric features with relatively large characteristic lengths are partly responsible for variability observed in experimental measurements of structural stiffness and energy dissipation per cycle in a bolted joint
- Pressure-sensitive film assembled into interfaces is used here to understand the distribution of interfacial pressures
- Pressure distributions suggest that there is misfit that may influence contact patch geometry and also structural response of the interface
- The misfit is not consistent across nominally machined hardware interfaces
- Misfit mechanisms may be partly responsible for the variability in energy dissipation per cycle of joint experiments.
- => More accurate modeling of these misfit mechanisms will lead to understanding of variability in the interfaces

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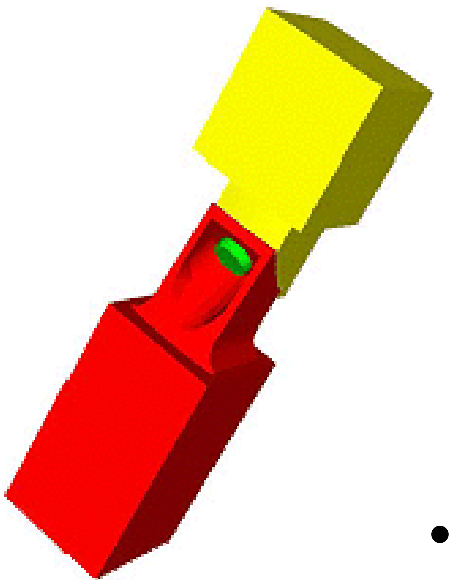
Hardware

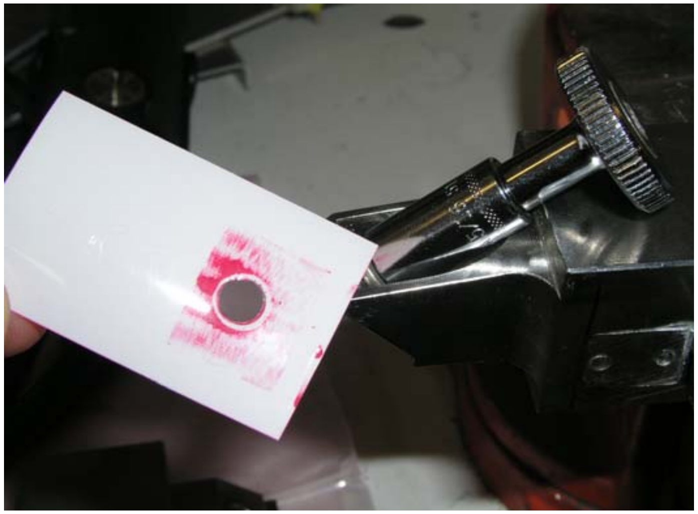
- Three tops & three bottoms =>
  9 hardware combinations



- One top & three bottoms =>
  3 hardware combinations

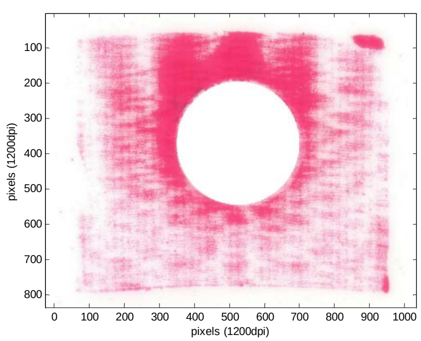
How to make prints

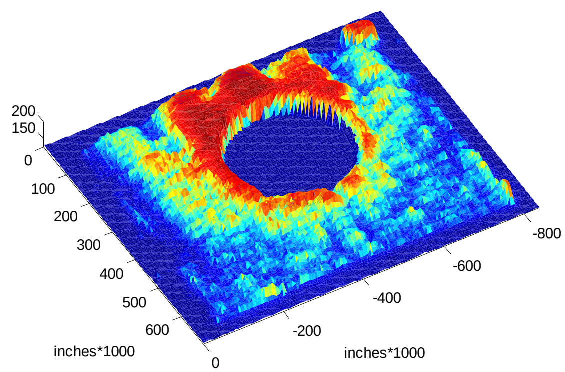
- Impresion instructions:
  - Be careful
- Scan instructions:
  - 1200 dpi
  - 24-bit color
  - No automatic color adjustment, no enhancing, no exposure adjustment

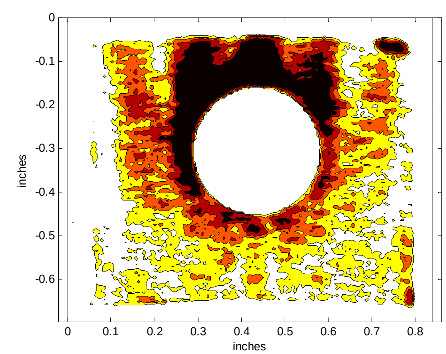


Example results

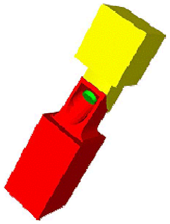
- **Once scanned, the images can be processed in many ways**
- **This presentation does not suggest techniques for quantifying surface character, but would be an area for some great future work**



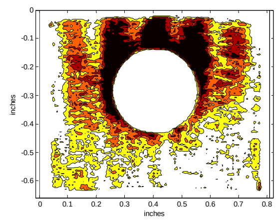
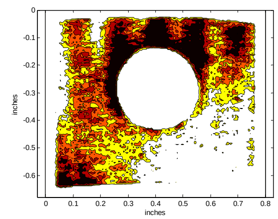
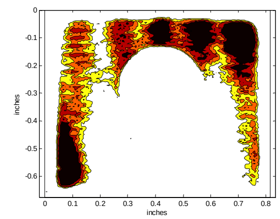
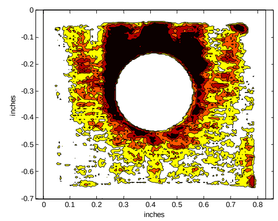
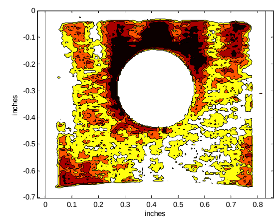
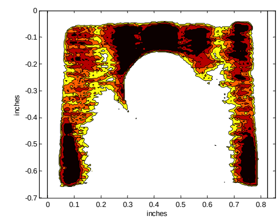
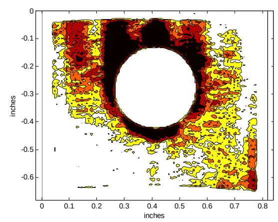
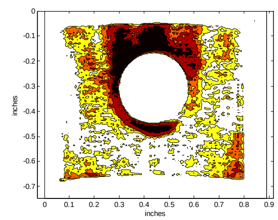
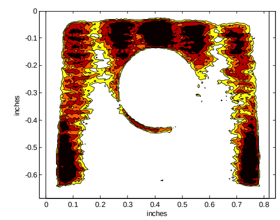




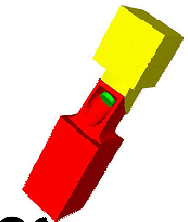
Results



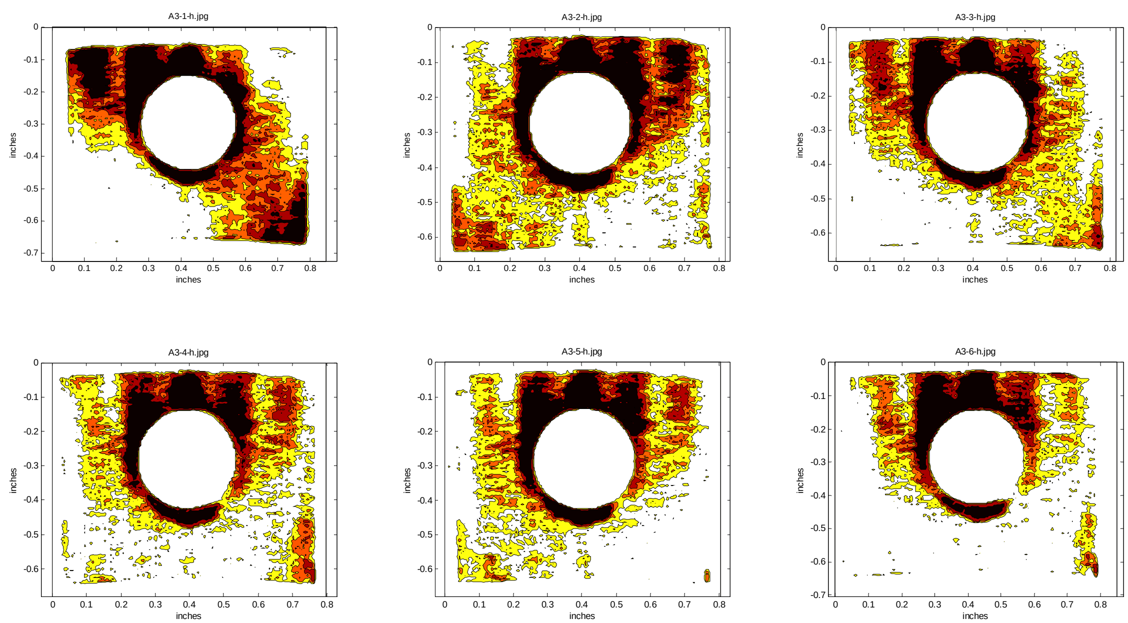
- **Representative prints from each of the nine combinations taken from single-leg hardware**

	A	B	C
1			
2			
3			

Results – Assembly variability



- **The pressure distribution in the same interface can be different for different assemblies**



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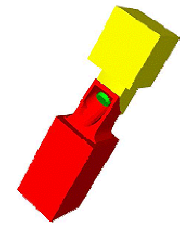
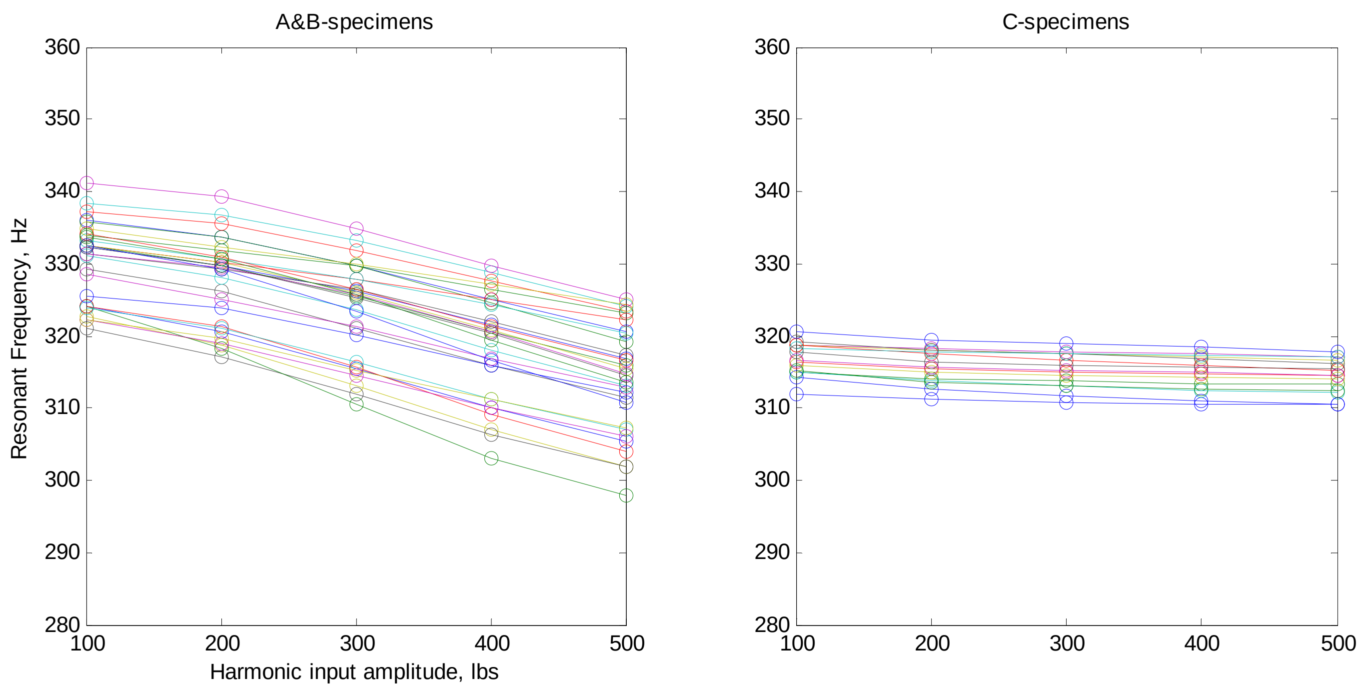
Affects on Stiffness Nonlinearity

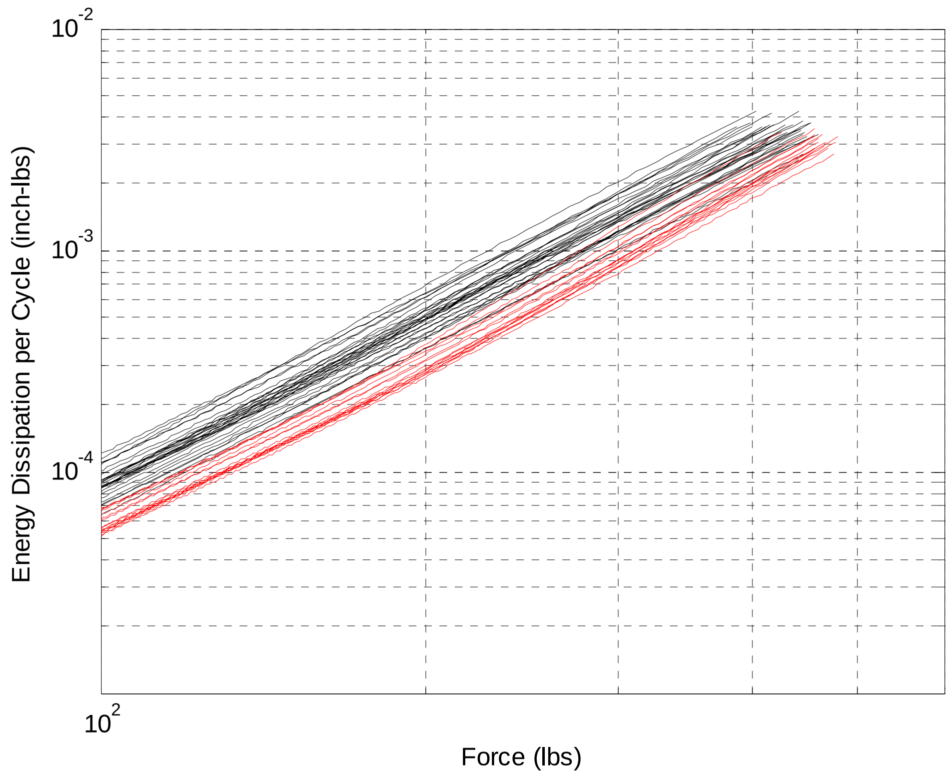


- **Character of stiffness versus load amplitude (dynamic) is very different for C-specimens**



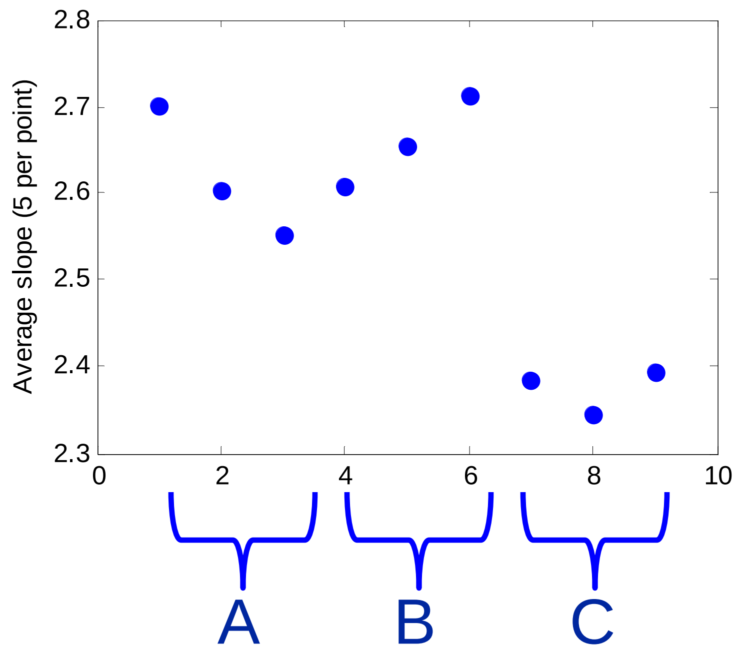
Effects on Energy Dissipation Variability

- The overall variability in energy dissipation, which can be quantified as a function of input load, is about 300%.
- But, almost half of the variability comes from the C-specimen



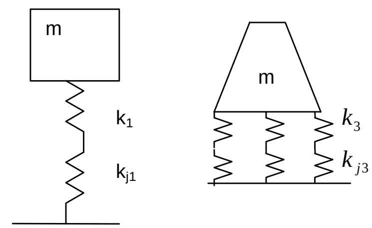
Effects on Energy Dissipation Variability

- The degree of nonlinearity, or slope of energy dissipation versus force curve, is lower for the C-specimens

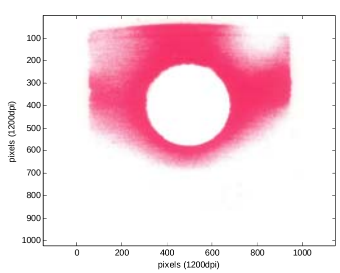


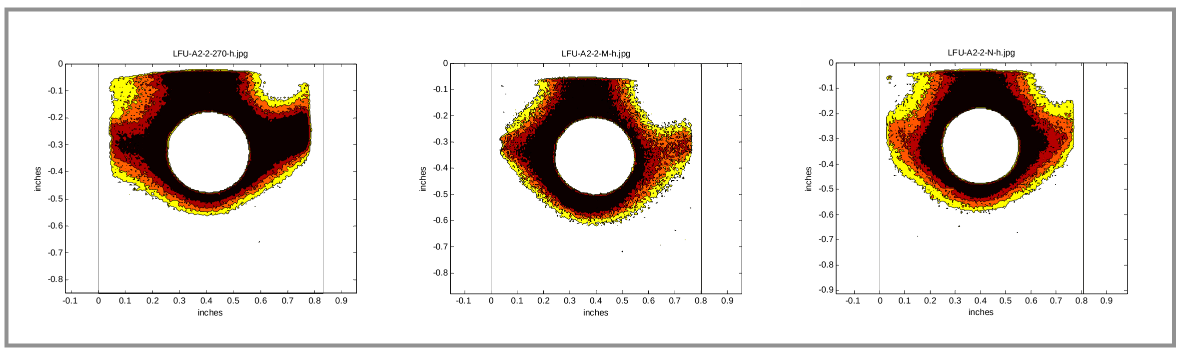
Stiffness change in other configurations

- **Interface stiffness for the same bolted joint geometry is different when multiple joints are used in a single structure:**
  Almost half the stiffness



Approximate Single Leg Harmonic Experiment Joint Stiffness: k_{j1}=8.8 x 10^6 lbs/inch
Approximate Three Leg Hardware Joint Stiffness: k_{j3}=4.9 x 10^6 lbs/inch





Leg 1 Leg 2 Leg 3

Conclusions

- **Observed pressure distributions suggest that there are misfit mechanisms that influence contact patch geometry and therefore, structural response of the interface**

- **Misfit is not consistent across nominally machined hardware interfaces**

- **Misfit is partly responsible for the variability in energy dissipation per cycle of joint experiments.**

Future work

- This paper merely breaks the surface of the body of work that could be explored
- Numerical studies to replicate the observations seen here, and in other experiments
- Better quantification of surface character and relation to observed variability in response