FLUID STRUCTURE INTERACTIONS RESEARCH GROUP

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A new tool to identify defects in adhesively bonded joints

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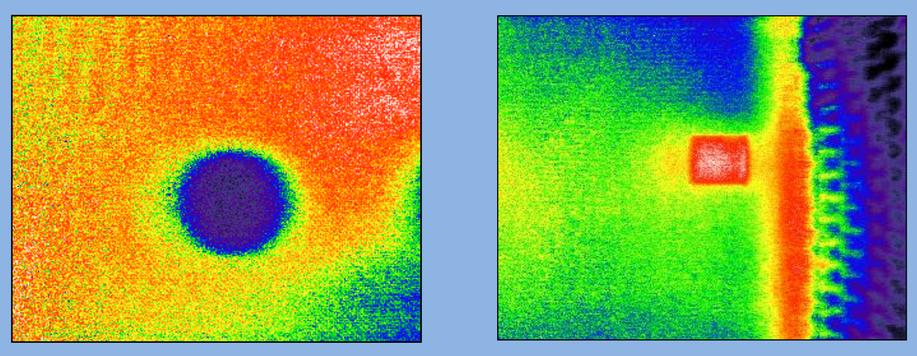
Project setting

• Adhesive joints have many advantages over the mechanical alternative including weight saving and excellent stress transfer.
• The ability to reliably assess defects in adhesive bonds is crucial to allow the wider use of composite materials, particularly in structural applications.

Aims

• To develop a non destructive method to assess the integrity of adhesive bonds using pulsed phase thermography (PPT).
• PPT has had previous success detecting defects in materials, easily detecting voids and inserts.
•There has been very limited research into its potential application to adhesive joints, particularly detection of more complex defects such as kissing bonds.



• Figure 1: Phase images of circular PTFE and square Teflon insert defects in CFRP and e-glass respectively.

Pulsed phase thermography (PPT)

• Figure 2: Illustration of PPT.

• A pulse of heat is applied to the surface of a sample and the temperature response of that surface is monitored using an infrared camera.
• The surface temperature will uniformly decrease if the thermal conductivity through the thickness is uniform across the sample.
• If a volume of differing thermal conductivity is present within the sample an area of different temperature will be observed on the surface above this due to a variation in the rate of conduction through the sample.
• Thermography data is recorded in a series of k thermograms over an observation period following the pulse.
• The data for is transformed from the time domain to the frequency domain using a 1D fast Fourier transform (FFT), Equation 1.

$$F_n = \sum_{k=0}^{N-1} T(k) e^{2\pi i k n / N} = \mathrm{Re}_n + i\,\mathrm{Im}_n$$

• Phase values for each pixel may then be calculated from these real and imaginary components, Equation 2.

$$\phi_n = \tan^{-1}\left(\frac{\mathrm{Im}_n}{\mathrm{Re}_n}\right)$$

•From these phase values a maximum phase image is obtained.

Kissing bonds

• A kissing bond is adhesively bonded but holds little of the strength usually associated with that bond.
• Commonly known as a 'Zero volume disbond'.
• Indistinguishable from a good bond using Ultrasonic C-scan.

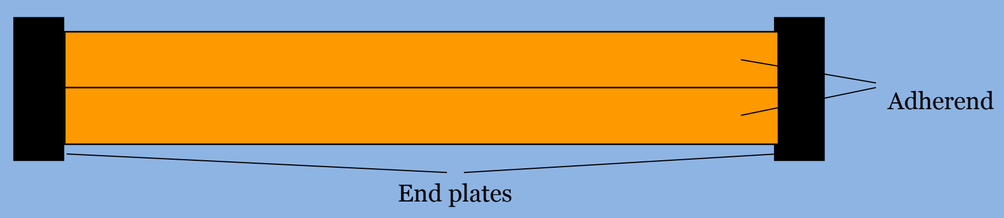
Could be caused by:

- Incorrect surface preparation
- Residual stress
- Moisture ingress
- Contamination
- Curing process

• Or a combination of above factors

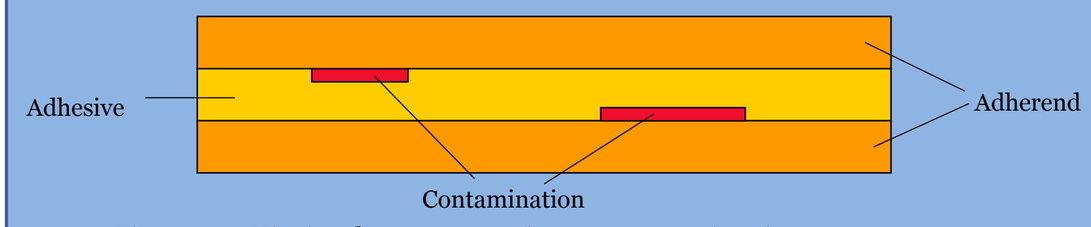
Recreating kissing bonds in the laboratory

• **Surfaces held together**



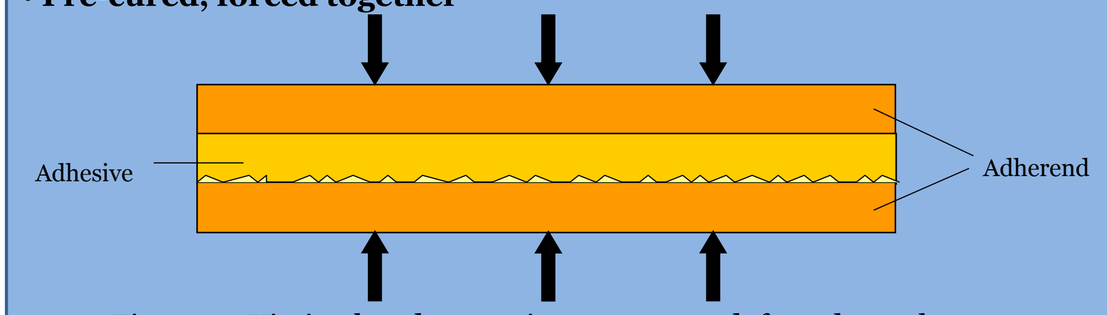
- Figure 3: Kissing bond recreation 1, surface held together.
- Two pieces of resin attached to end plates, held in close contact.
- Aim to see if PPT can be used to distinguish between 2 pieces of thickness x/2 and one piece of thickness x.

• **Contamination**



- Figure 4: Kissing bong recreation 2, contamination.
- Contaminations applied in construction of joints.
- Thickness of contamination << thickness of adhesive
- Contaminations used:
  - Oils/greeses
  - Dust/talc
- Also,
  - Pre-cured patches

• **Pre-cured, forced together**



- Figure 5: Kissing bond recreation 3, pre-cured, forced together.
- Adhesive allowed to cure before second adherend pressed onto surface and held in place for tests.

Future work

• Develop method for reliable recreation of kissing bonds in laboratory.
• Optimise PPT technique for specific bonds in laboratory.
• Establish thresholds of minimum detectable defects and maximum tolerable defect.
•Create efficient data processing method able to handle the large volume of data efficiently.

FSI Away Day 2011

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