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Is Non-Destructive Inspection of Adhesive Joints Possible with Certainty?

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Wolfgang Pauli said “God made solids, but surfaces were made by the Devil”.

The objective of non-destructive inspection [NDI] is to assess the strength of a component without breaking it. Such inspection may be during or at the end of the manufacturing process, or during service in which the component may have been degraded.

In adhesively-bonded joints, any manufacturing process will inevitably introduce some number of defects in the end product. It is almost impossible to produce an error free joint even under stringent controls. Entrapped air, foreign bodies, grease or dirt create disbonds in the joint. No load can be transferred through areas that are disbonded. Consequently, load has to be transferred through alternative neighbouring paths, increasing the amount of stress in these areas. It is important to know how these defects could affect the strength of the bonded component. Non-destructive techniques capable of identifying defective areas could then be used, and the strength of the defective components could be estimated. The effect of adding artificial defects on the strength of single lap joints (SLJ), has been investigated.

But there is another problem. Structural adhesive joints contain a polymeric adhesive which is designed to cure to a relatively hard state. The adhesive also needs to create a strong bond between itself and the substrate[s] to which it is applied. The condition of the cured adhesive, such as its chemistry and voidage, can be assessed by various techniques, mainly ultrasonic or sonic, but that is only part of the story. If the bond between the adhesive and the substrate is weak, the joint may fail prematurely. We know that good surface preparation is essential, but that may be compromised during manufacture. This has led to the concept of the “kissing bond” in which the adhesive is properly cured and is in good contact with the surface, but there is little or no adhesion strength. The question then is to locate and size these kissing bonds in order to assess their importance. Since there is no void, conventional NDI techniques such as ultrasonics and x-rays are useless. Although kissing bonds probably exist, there is no satisfactory way of creating them in the laboratory. PTFE tape creates a disbond which can be detected but this is because there is a physical barrier and it is NOT a kissing bond.

The nature and importance of kissing bonds will be discussed, together with how to simulate them in the laboratory.