Composite Impact Damage Investigation with Micro-CT

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Aims
The present study investigated experimentally damage process in polymer composites under the low velocity impact loading. After low velocity impact, internal damages (like delaminations) occurred inside the composite is hard to visualize with classical non-destructive inspection techniques. As an alternative method Micro-CT was used to visualize the internal damage zones with Skyscan 1173 Micro-CT. Inspection of internal damage mechanisms in composites after low velocity impact loading with using Micro-CT has not been reported in literature.

Method
Performances of composite materials have shown their superiority over metals in many applications, such as in aircraft and automobile industries, requiring high mechanical properties as well as low weight. The laminated fiber-reinforced composite plates are known to be susceptible to damage resulting from accidental impact of foreign objects. The behavior of composites under impact has been of significant concern in many advanced engineering structure and components [1-3]. Further developing the understanding of composite materials behavior under impulsive loading conditions is crucial for applications such as transportation of explosive material, collision, and use as armor. Common methods of dynamically loading composite materials are shock wave loading by use of explosives [4] and shock tubes [5-7], high velocity impact loading [8-10], and drop weight impact tests [11,12].

The tested material is a glass fibre reinforced polyester matrix composite produced by TeknoMa in one stacking sequence namely [0/90]s. The volume fraction is approximately 60% in fibres. (0/90)s oriented cross-ply E-glass/polyester laminated composites of 5 mm nominal thickness are used for low velocity drop weight impact testing. The cross-ply laminated specimens are prepared by cutting out 100 mm x 100 mm.

In this study it is aimed to investigate the relationship between the damaged area/volume and impact energies by using damaged impact (front) face, back face dimensions and volumes of the damage cone. This will be an interesting point, because in daily use, engineers should get more knowledge about damaged structure without using non-destructive testing devices at their first inspections after impact. At this point the key question is “which sign will give more meaningful knowledge about the damage level of composite sample at visual inspection?”. In order to understand the damage volume correctly, a new method of non-destructive technique has to be used. We thought Micro-CT visualization of composite will be a good alternative.
For investigation of internal damage occurred in composite after low velocity impact SkyScan 1173 high-energy micro-CT images were taken as slices. In Figure 1 the mid-point micro-CT image of impacted composite is seen. Damage cone geometry and fiber breakages with inter-laminar delaminations can be seen clearly. Damage cone geometry and settlement gave a lot of information about effect of low velocity impact loading.

Slices of micro-CT images taken from impacted composite were connected with image processing program CtVox and 3D model image of composite specimen was gained as seen in Figure 2. This 3D realistic model of impacted composite gives a lot of information about the damage mechanisms and also detailed maps of delaminations occurred. Impacted face and back face of specimen also can be seen clearly with this 3D realistic model and give us a chance of building a relationship between the impact energies and resultant damage cone occurred.
In figure 3, back face of impacted specimen can be seen. Here, fibers those were bended due to low velocity impact and deflection of matrix can be seen clearly.

Figure 4: Micro-CT realistic model of repeatedly impacted glass fibre-reinforced composite.

Results
It is fully understood that Micro-CT images of a damaged composite give a lot of information about damage mechanisms. In addition, micro-CT images have great resolution values which can’t be achieved by other non-destructive inspection techniques. Capability of building a 3D model from micro-CT images is another important advantage which can’t be done with other imagining techniques.

Conclusion
Using micro-CT in materials and mechanical engineering applications will be very helpful in future. No other inspection technique can give such detailed map of internal structure of a material except micro-CT.
References:


