Composites and Structures Testing

Application Note

Introduction

Composites are increasingly used across a wide range of industries to create lighter structures than their metal equivalents. While steel has a density of 8.1 g/cm^3, carbon fibre only has a density of 1.6 g/cm^3 and potentially a higher yield strength for the same cross section.

The main challenge with most fibre reinforced plastic composites is that the strength of the structure is typically not equal in all directions and depend on the direction of the fibres running through the structure. Sheets of fibres in one direction may be stacked at various angles, or fibre tows are woven together to give a specific load bearing structure or 'architecture'. This allows the composite to be stronger in certain directions, maximizing the weight advantage, but presenting major challenges when testing the structures to prove that they can stand their design loads.

The common industry approach to composites is to use uniaxial tensile testing machines, which were designed for testing metals. While these machines are commonly available, the testing that is carried out is limited to uniaxial loading on an anisotropic material. The stresses on composite structures are often peeling or shearing loads, however conventional testing machines were never built with this kind of testing in mind. If the structures are tested in a way that suits the testing machines, then the loads put on the test samples may be very different than the loads it will see while in service, so the design may be an over or under estimate. This can lead to heavier structures where weight reduction is paramount, or a structure that fails in service due to poor understanding of the performance.

In this application note we explore the benefits of testing composites and structures using a dedicated materials tester.

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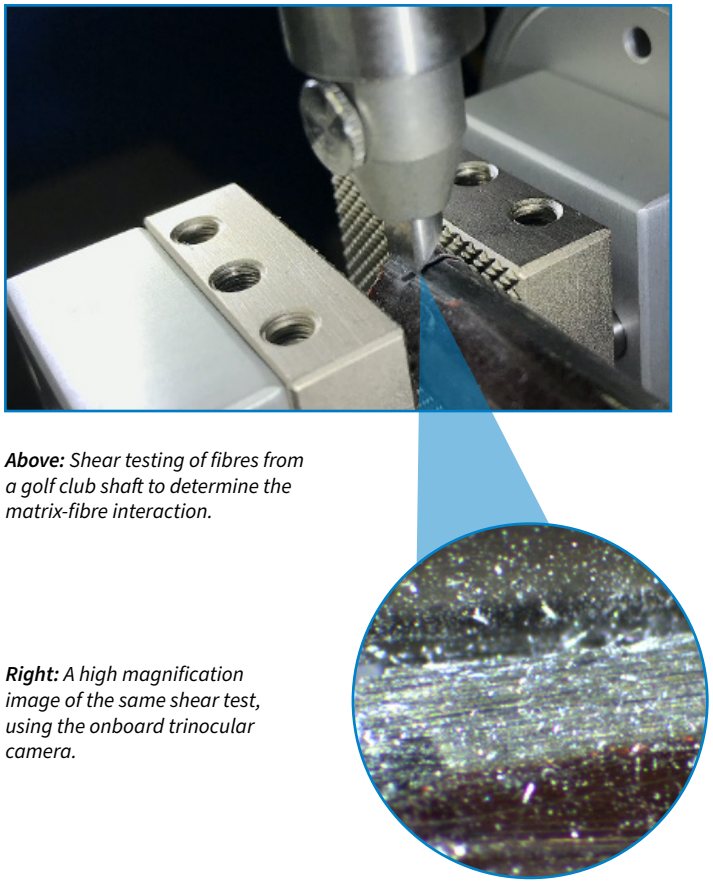
Shear Testing

Instead of manufacturing a testing component that can be pulled in a uniaxial testing frame to investigate shear properties, the shear strength can be determined directly from a component using shear testing. The component is clamped in a workholder mounted on an XY stage and sheared against a tool that measures the load. All of the movement is measured by high precision encoders within the stage, and further measurements of strain can be carried out using independent strain gauges that can interface directly with the materials tester.



Above: *Shear testing of fibres from a golf club shaft to determine the matrix-fibre interaction.*

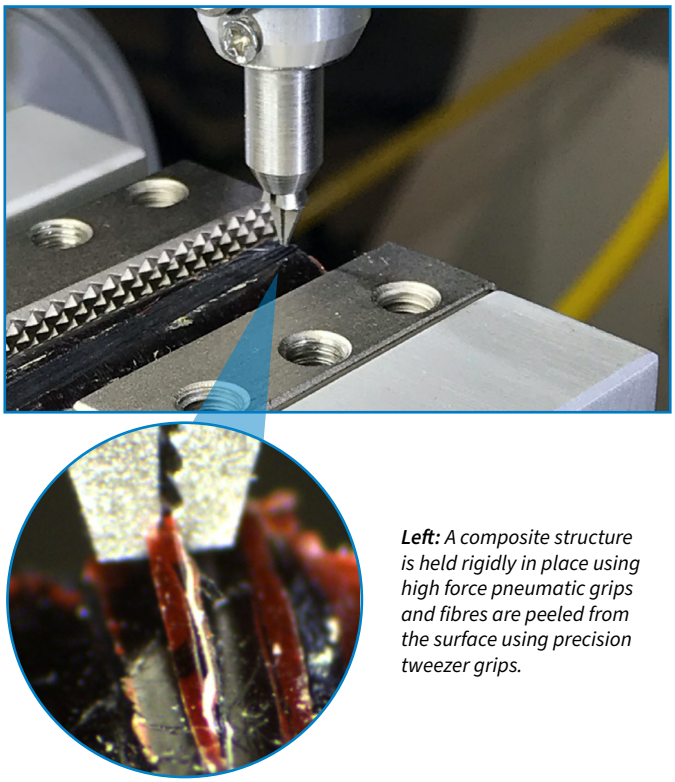
Right: *A high magnification image of the same shear test, using the onboard trinocular camera.*

Peel Testing

Many components can only be peel tested by manufacturing materials with two flexible sides that can be peeled at 90°, or one very flexible part that is bent around 180° and pulled away from the component. These tests are difficult to set up and were only developed to make use of uniaxial machines.

The materials tester can clamp very small features with its pneumatic jaws and peel material away from the component at a constant angle of 90° by moving the stage in tandem with the z-axis. This provides a true 90° peel test.

Epoxy resins are affected by moisture, which penetrates into the matrix from the surface. The ability to test fibre-matrix interactions at a microscale allows for an investigation into the depth that the composite has been affected, instead of only testing the bulk properties.



Left: *A composite structure is held rigidly in place using high force pneumatic grips and fibres are peeled from the surface using precision tweezer grips.*

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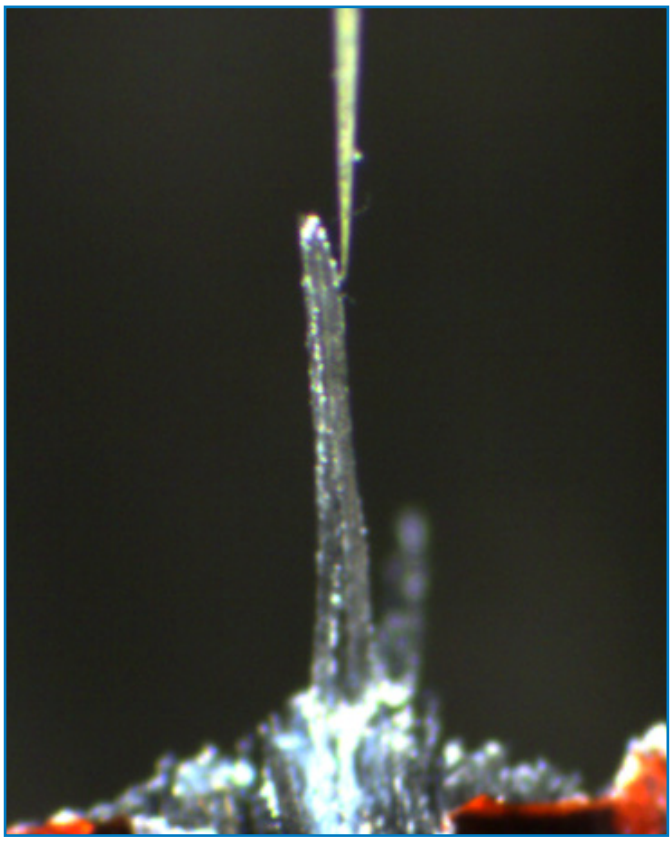
Bend Testing

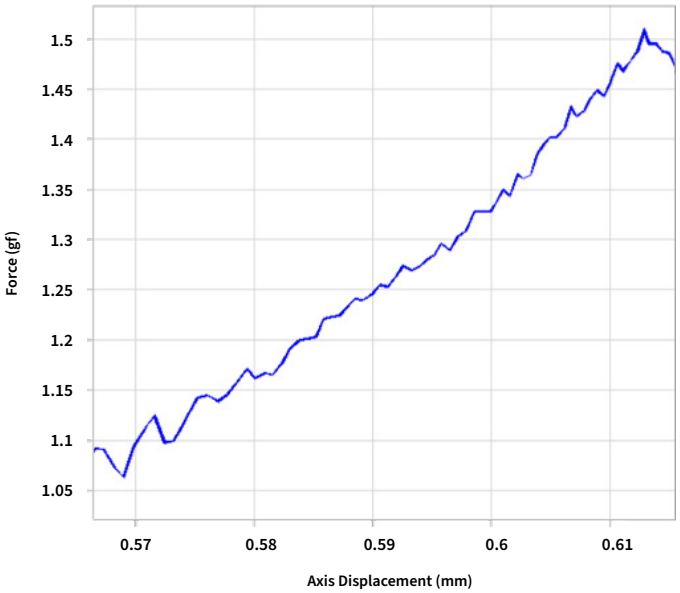
While bend testing is more commonly available on conventional machines, the materials tester can interface with acoustic emission instruments, to allow cracking prior to component failure to be detected. This gives a valuable additional insight.

DAGE Paragon™ Materials software automatically co-ordinates the materials tester and acoustic emissions instrument by sending a trigger signal as soon as a user defined pre-load is achieved.

As well as conventional bending, DAGE Prospector™ can be fitted with micro hooks that can be used to lift fibre tows so that the stiffness can be measured.



Lifting a 100 micron wide strip of carbon fibre from a damaged component using a micro hook to investigate local materials properties.



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Advantages to the Composites Industry

Uniaxial tensile testers are great for bulk material measurements, however they are much less suitable for final product characterization.

- Test samples have to be specially manufactured for testing. This costs time and money and is not appropriate for testing high volume manufacturing.
- Test samples may not exhibit the same behavior as the final composite or structure.

With a DAGE Materials Tester, the real component can be tested in peel, shear, tension, compression or torsion. Even biaxial testing is possible to test mixed mode loading performance.

- Test the actual component, not a specially manufactured test sample.
- Perform accurate 90° peel testing.
- Get more information from your bend test with acoustic emissions.

The Prospector™ Micro Materials Tester is an extremely versatile platform for performing composite materials characterization.

For more information, speak with your Nordson representative or contact your Nordson regional office

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