**Structural Integrity: Materials Testing**
***Photoelasticity***

Photoelasticity is an experimental technique that allows us to view the stress state inside a material.

Some transparent materials can be made to show an optical effect called *birefringence*, where the refractive index of the material is different in different directions as the result of a stress.

This is viewed experimentally using a polariscope, comprising a light source at the left in this view and two polarizing filters, between which the sample is positioned.

This epoxy disc is being loaded in compression in the polariscope. As the load is applied, dark fringes appear in the disc when viewed through the second polarizing filter and the density of the fringes increases as the load is increased.

Each fringe is a contour of equal shear stress, telling us about the difference in principal stresses in the disc.

The number of fringes is proportional to the magnitude of the stress. Noting the number of fringes developed as the disc is loaded allows us to calculate the value of the stress in the disc.

This experiment is using light with a single wavelength: orange sodium light in this case.

Switching to white light – containing a range of wavelengths – produces a more colourful fringe pattern. The coloured fringes from a white-light experiment can allow for easier calibration of the stress values.

The fringe pattern can also give information about where the stress is concentrated in the sample: areas with a high fringe density show a large stress concentration.

Now let's look at a more complicated sample. Here a hook has been manufactured from the same epoxy material as the disc. It is loaded by applying a tensile load through some circular rollers.

The vertical black lines that cut across the top and bottom of the hook are opaque wires through which the load is applied.

Again, we can see how the fringes develop with increasing load.

Across the right-hand portion of the hook itself, there will be a bending load produced, with the stresses highest on the outer surfaces. Note how the fringes appear to originate from these points.

Photoelastic analysis is widely used for problems in which stress or strain information is required for extended regions of the structure. It shows the locations of highly-stressed areas and, equally important, it discerns areas of low stress where material is being utilized inefficiently.

Photoelasticity doesn't just apply to mock-ups like this. Photoelastic coatings can be placed on real components to allow stresses to be visualized directly.