Testing at high temperature

Imetrum Systems can be used to test specimens at elevated temperature and the following information provides guidance for successful testing. Our Systems are compatible with a chamber/oven, a clam-shell furnace and inductive heating. A suitable window or viewing port is required so the specimen is visible to the camera.

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Camera, lens and filter

Choose the camera and lens to achieve the required Field of View in the usual way. However, bear in mind that the camera and lens must be mounted outside of any temperature enclosure and at a safe distance from any heat source so the working distance must be sufficient to achieve this. This can mean a working distance of more than 300mm. At very high temperatures (typically more than 400°C) the specimen may start to emit light (infra-red and visible). In this case you should use an appropriate filter on the lens or camera to filter out the emitted light. Contact your usual Imetrum representative for an appropriate filter for high-temperature testing that can be mounted inside the camera. This filter will reduce the amount of light entering the camera so you may need to use more lights to compensate.

Light

Try to follow the usual setup with the light, shining at about a 45-degree angle and providing even illumination over the entire, extended sample length. Many chamber windows are quite narrow, so if you are viewing through a chamber window then you may be able to achieve a better angle for your light by placing it above or below the camera rather than to the side.

If the light angle is too small the camera may see a bright reflection of the light in the window glass – this is not a good thing, so monitor it and adjust the position of the light if necessary. The quality of integrated oven lights has improved over the years. If your oven has a bright, even light that does not flicker and does not cast shadows over the specimen then it can supplement (and sometimes replace) an external light.

Specimen preparation

You should decide between speckles or blobs according to the usual rules. However, the method used to mark the specimens must be able to withstand the required temperature range. As a guide:

- Up to 300°C – standard spray paints are often suitable up to a few hundred degrees centigrade
- Up to 600°C – high-temperature spray paints (e.g. exhaust manifold paint) are available and can survive long-term tests such as creep tests
- Up to 1500°C – specialist alumina or zirconia paints are available that can withstand extremely high temperatures of over 1000°C

If you are measuring large strains (i.e. more than a few percent strain) then there are some further alternative options:

- Manufacture notches or tags on the sides of the specimen. Illuminate the background behind the specimen and set the exposure so the specimen appears dark, and the background appears light. Use the silhouette of the notches/tags as the pattern for the targets. A sample with two triangular tags on each side is shown in Figure 1. For this to work the background must be completely plain with no patterning visible.

- Similar to above, but instead of notches/tags, wrap wire or a spring around the specimen to create the silhouette pattern. A spring can cope better with the thermal expansion of the specimen. As above, the background must be plain with no pattern.

Figure 1: Specimen with triangular tags on the sides

Video Gauge™ setup

Set up the measurements in Video Gauge™ as usual but use an increased zero-setting period. This will help filter out any noise caused by convection currents while measuring the initial gauge length. Ideally, the zero-setting period should include about 100 frames, so if the camera is running at 17Hz then a zero-setting period of 6 seconds or more would be good.

Test procedure

Follow the standard test procedure but take into account the following extra points:

- Ensure the chamber is well-sealed (door seals, and bungs around where load columns enter the chamber). This prevents hot air from escaping and drawing in cold air to replace it. If this happens it will cause convection currents that increase the noise on the measured data.
- Allow adequate time for the temperature in the chamber to stabilise. If the chamber contains a mixture of hot and cold air, then there will be convection currents that may cause noise on the measured data.
- Pre-load the specimen to pull the load-train taut. This is vitally important if you are using a General Purpose lens.
- After starting the test in Video Gauge™, wait for the zero-setting period to elapse before starting the UTM.

Things to watch out for

If the chamber is not well-sealed or the temperature is not given time to stabilise then the chamber will contain a mixture of hot and cold air. This will result in convection currents and the image may appear to 'shimmer' (just like heat-haze/mirage on a hot day). Depending on the level of shimmer it may even be noticeable in the image. The shimmering will result in an increased level of random noise on the measurements.

Following the above advice should minimise these effects and they are rarely significant; any residual random noise can usually be filtered out by applying a sliding average filter to the data as a post-process step.

At very high temperatures, the light emitted from the specimen can cause the image to be over-exposed. In these cases, you should adjust the exposure once the specimen is up to temperature, then snapshot and start test.

Example test results

In the example below in Figure 2, an aluminium specimen was heated from 25°C to 175°C. The expansion of the specimen was measured using a strain gauge in Video Gauge™. From this data the coefficient of thermal expansion of the sample was calculated as 22.6E-6 (as expected for aluminium). This confirms the accuracy of the data.

The convection currents in the oven have caused a little noise on the data (RMS of about 60 micro-strain) - though bear in mind the scale of the graph is quite small, so the noise looks bigger than it is. This noise is easily reduced by applying a sliding average filter as shown in Figure 3.

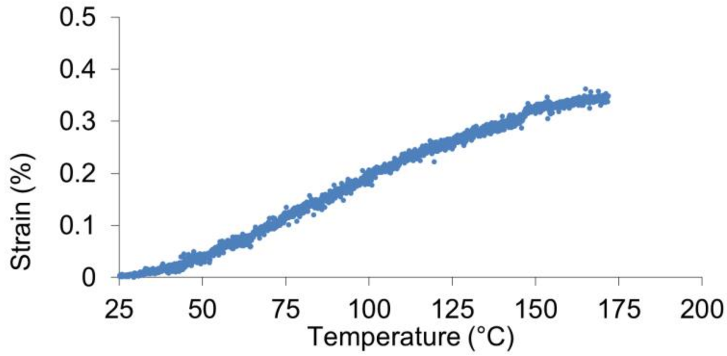

Figure 2: Expansion of aluminium as heated from 25°C to 175°C

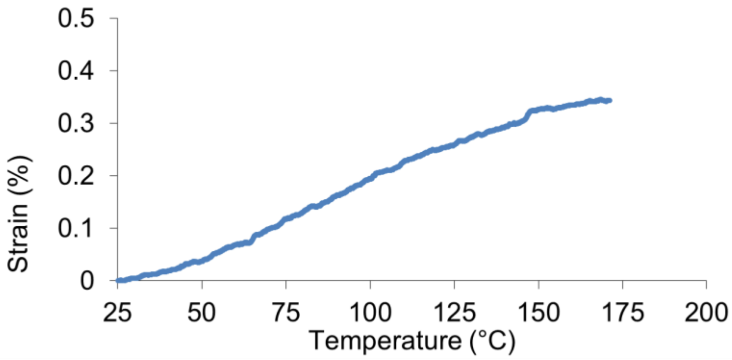

Figure 3: Data after applying a sliding average filter to remove noise caused by convection currents