TMA AS PROBLEM-SOLVING TOOL: DETERMINATION OF TACK POINT OF A MATERIAL

Problem

A material scientist was involved in the quality control evaluation of an elastomer material used in the fabrication of ejection molded components. After having heated the mold to cure the elastomer and letting it cool, some elastomer mixes exhibited a stickiness and excess flashing which inhibited its release from the mold. In order to eliminate the time and expense involved testing different blends, inhibitors, releases, etc. in the mold, the scientist wished to be able to perform a quick comparative study without having to go through the molding process.

Solution

A feature of the stress-strain thermomechanical analyzers offered by Seiko Instruments is computerized control of both the load applied to the sample and sample displacement. This can be accomplished by three means: 1) Constant loading, 2) Linear loading, and 3)Sinusoidal Loading.

Using sinusoidal loading, the probe can be programmed to uniformly come into contact with the sample, apply a predetermined force, and then uniformly lift off the sample. This sinusoidal loading and unloading of the probe can also be performed as the sample is heated at a linear heating rate. Using this technique, the sample can be cooled to a temperature below which it becomes tacky and the probe constantly touched and released from the sample as it is heated. When the sample becomes tacky, there should be resistance to the removal of the probe which would be detectable in the length displacement data.

In order to compare the elastomer samples and test this technique, an expansion probe was selected for use based on its tip surface area. The probe was then offset so it applied 0.1 g force to the sample and cycled ±1 g at a frequency of 0.05 Hz while heating the sample at 10°C/min. This actually pushes the probe down onto the sample with 1.1 g force and removes it with a 0.9 g force since the initial force on the probe is 0.1 g.

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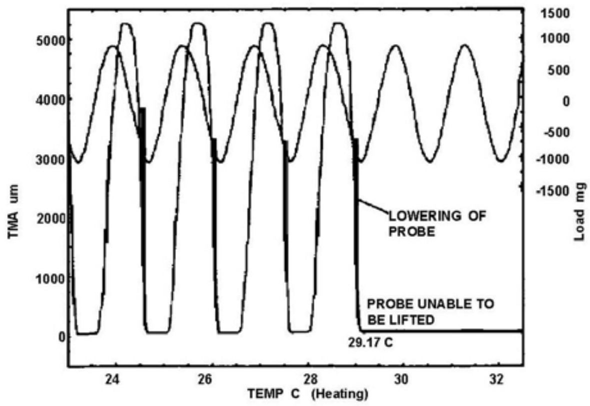

Figure 1

Displayed in Figure 1 are the TMA/SS150C results obtained on elastomer 'E'. The dash curve represents the cyclic, 0.05 Hz, application of force. A negative force value represents a downward force on the probe. The solid curve represents the probe displacement. The TMA/SS150C has a displacement range of $\pm$5000 μm, therefore when the probe is lifted off the sample with a positive force, maximum displacement should be observed. No negative displacement is observed since there is not sufficient force being applied on the probe to compress the sample. This plot shows the probe sticking to elastomer 'E' at 29.2°C. The sticking temperature obtained on a duplicate test of this sample was 28.8°C.

Since the analysis proved to be reproducible, a comparison was then made with samples 'S' and 'T' when tested under the same conditions. Sticking of the probe occurred at -22.6°C with 'S' and 7.3°C with elastomer 'T'. This stickiness order, 'S' > 'T'> 'E', correlated with the observed increase in flashing of the molded component and difficulty of release.

The above procedure provided a comparative means of determining the temperature at which a material became tacky. The TMA system can just as easily be programmed to perform a step type loading and release of the probe. This could then compare the force level required to cause a material to become tacky when held at a constant temperature. Figure 2 displays the results of just such a test performed at ambient temperature.

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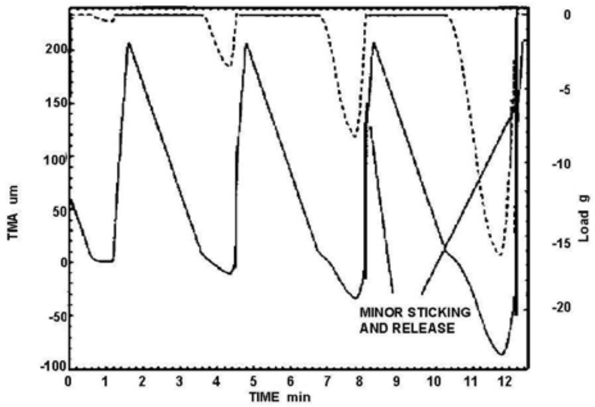

Figure 2

The upper curve shows the force level applied to the probe while the solid curve displays the resultant effect on the elastomer. This thermogram illustrates the step loading of 1, 4, 8, and 16 g force on the probe and the compression effect on the sample. The spike seen in the displacement curve, at 8 and 12 minutes is due to the sudden release of the stuck probe from the sample. Comparisons of elastomer samples using this technique also correlated with that observed during the actual molding process. Another indication this technique would be a viable aid in predicting performance was that the modulus calculated based on elastomer deflection and force agreed very favorably with the literature values for the tested sample.

Summary

The Seiko TMA, with its versatility in force loading capability, provided a quick, easy and reliable means of aiding in the prediction of the performance of the elastomer during the molding process. The time and expense incurred to test the various elastomeric compositions in the molding process was reduced significantly by being able to perform a quick TMA analysis and make a reasonable prediction of its performance.

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