

United States Patent

5,526,693

Wise

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Oscillating Rotor Curemeter

Abstract

There is disclosed a device for testing the cure properties of a visco-elastic material sample enclosed under pressure between heated dies and on the top only of a rotor. The rotor overlying a cured elastomer sealing and heat-sink member subjects the sample to oscillatory shear, and the torque is measured as an indication of the viscosity of the sample.

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References Cited

U.S. Patent Documents

3387490	Jun., 1968	Wise	73/54.
3479858	Nov., 1969	Umeno et al.	73/843.
3488992	Jan., 1970	Veith et al.	374/48.
3531996	Oct., 1970	Harris et al.	73/865.
4337646	Jul., 1982	Fraleigh	73/54.
4343190	Oct., 1982	Danko et al.	73/54.
4421424	Dec., 1983	Price et al.	374/48.
4539838	Sep., 1985	Fraleigh	73/54.
4552025	Nov., 1985	Barker et al.	73/846.
4829830	May., 1989	Tosaki	73/847.
4953406	Sep., 1990	Putman	73/843.

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Claims

1. In a device for determining the state of cure of a thin section elastomer sample, such device having first and second dies, means to move one die selectively into and out of contact with the other die, a rotor oscillatable through a shaft thereof, and means to measure and record torque in the shaft as an indication of cure, the improvement comprising a deep recess in the first die, the rotor supported in said recess by its shaft which extends from an underside of a head of the rotor and through the first die, and elastomeric means in said recess having an upper surface contiguous with, and matching the contour of, the underside of the rotor head to prevent intrusion of sample materials under the head, said upper surface extending laterally beyond the head of the rotor to form a sample support.
2. The device of claim 1, wherein said upper surface has a diameter substantially greater than a diameter of the head of the rotor.
3. The device of claim 1, wherein said elastomeric means comprises a cured silicone member.
4. The device of claim 1, wherein said recess is cylindrical, and said elastomeric means substantially annular.
5. The device of claim 1, wherein said elastomeric means has a height substantially less than the depth of said recess.
6. The device of claim 1, wherein said elastomeric means forms with the second die a cavity for a sample having a thickness substantially less than a height of said elastomeric means.

Description

Background of the Invention

One classification that may be made of curemeters would include devices wherein one of two heated dies is rotated or oscillated with respect to the other, and the resulting torque of the sample measured. Among prior art patents in this group would be

Veith et al U.S. Pat. No. 3,488,992 (1970)

Uremo et al U.S. Pat. No. 3,479,858 (1969)

Barker et al U.S. Pat. No. 4,552,025 (1985)

Burnin et al U.S. Pat. No. 5,079,956 (1992)

Putman U.S. Pat. No. 4,953,406 (1990)

Danko et al U.S. Pat. No. 4,343,190 (1965)

Tosaki U.S. Pat. No. 4,584,812 (1986)

A second type of curemeters, and one to which the present invention primarily addresses itself, would include devices which utilize two dies, and additionally a third, rotor, member which is oscillated to derive the required test results. This group would include:

rewitt et al U.S. Pat. No. 4,546,438 (1985)

Harris et al U.S. Pat. No. 3,531,996 (1970)

Decker U.S. Pat. No. 3,681,980 (1972)

Price et al U.S. Pat. No. 4,421,424 (1983)

Turner et al U.S. Pat. No. 4,275,600 (1981)

Wise U.S. Pat. No. 3,387,490 (1968)

Beatty et al U.S. Pat. No. 3,182,494 (1965)

Kitchen U.S. Pat. No. 4,559,812 (1985)

Several common threads run through the disclosures of the above-mentioned test devices: the test sample materials are located on top of as well as under the rotor head, i.e. the rotor head is embedded within the rubber samples during testing; and no means are provided for sealing off the sample material from the lower die. (Additionally, in the U.S. Pat. No. 5,221,500 to Gent (1993), there is no test cavity enclosed by a pair of dies, but rather the rotor impinges directly upon the wall of the article being cured).

When a test device of the above type is opened, a substantial labor and time consuming effort is required to remove the sample therefrom. In practice, it is found necessary to employ metal bars and other tools to break the cured rubber from around the embedded rotor head, and this effort frequently results in tearing of the sample. This then necessitates the disassembly of the rotor from the curemeter to complete the removal of the sample, and the cleaning of any detritus which may have collected around the rotor shaft and die. When the rotor is again inserted, it is extremely difficult to seat it at exactly its former level. Thus, while the previous series of test samples may have yielded a family of test curves fairly closely related, when the testing continues with the rotor replaced, at even a slightly different height, a new curve-series will be generated, slightly differently located. This will be further referred to hereinbelow.

The above procedures unnecessarily prolong the time the device must remain open before it is recharged with a new sample, and the result is a loss of heat which must be recovered when the device again closes. Furthermore, without the heat sink means of the present invention to provide some temperature control, unacceptable heat losses are also experienced from the rotor through its associated drive and support means.

The results of these shortcomings are that the successive testing of samples shows poor reproducibility of results, with test curves, as seen hereafter, which are not closely bunched together.


Summary of the Invention



This invention overcomes the above disadvantages by providing a curemeter having heatable die-members closeable to create a test cavity under pressure for a rubber sample, and an oscillatable rotor between the dies. The undersurface of the rotor head and its shaft are contiguous with, and match the contour of, the surfaces of a cured, elastomeric member, or biscuit, which functions as a heat sink and, at the same time, seals out any intrusion by the sample beneath the rotor head when the cavity is closed and pressurized. The only portion of the rotor head engaging the sample is thus its top surface.

There is disclosed a means and method for testing an elastomeric material by providing for locating a test sample only on top of the rotor head, like a cap thereon, rather than surrounding it top and bottom. This results in thinner-section samples more easily removable from the test device than the prior art samples which embed the rotor head completely.

The object of the invention is therefore to provide a test device from which test samples of thinner section are expeditiously removed from atop the rotor, which needs to remain open for an absolutely minimum time for recharging, and which is provided with sealing and heat-maintenance means; all to increase reproducibility of test results.

Brief Description of the Drawings



 **FIG. 1** is an elevational view, in cross-section, of the assembly forming a substantial portion of the curemeter of the invention, in the open position.

 **Fig. 2** is an elevational view, in cross-section, similar to  **FIG. 1**, but with the curemeter closed.





 **FIG. 3** is a graphical representation of curemeter curves, plotting time in minutes versus torque in inch-pounds, obtained from a prior art device.



 **FIG. 4** is a graphical representation of curemeter curves similar to those of  **FIG. 3**, but obtained from a device according to the invention.

 **FIG. 5** is a partial, cross-sectional view showing a modification of the inventive device.

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Detailed Description of a Preferred Embodiment

In  **FIG. 1** and  **FIG. 2** are shown an assembly suited for use in a curemeter such as described and shown in U.S. Pat. No. 3,531,996 (1970) to Harris et al, in the block diagram of  **FIG. 3**; and in U.S. Pat. No. 4,546,438 (1985), to Prewitt et al, in  **FIG. 1**. Both patents are of the second type mentioned herein before.



Referring specifically to  **FIG. 1** and  **FIG. 2**, there is shown at **10** an assembly having a circular lower metal die **12** and a circular upper metal die **14**, the dies having die-lands **13** and **15**, respectively. Between the dies is supported a metal rotor **16**. Lower die **12** is connected to lower platen **18** by threaded means **20**. Similarly, upper die **14** is connected to upper platen **22** by threaded means **24**.

The dies **12** and **14** are heated by heaters **26**, well-known in the art and not further detailed here, and their temperatures controlled by well-known sensors **28**.

The rotor **16**, of heat-conductive metal, comprises a head **40** having a substantially domed or cone-shaped top face **42**, here shown serrated, and an underside **44** extending at a substantial angle to the longitudinal axis of the rotor **16**. A shaft **46** extending from the underside **44** and through opening **48** in the lower die **12** is secured, as by a threaded collet **50**, to a torque shaft **52** oscillatable by drive and eccentric-means such as shown, for example, in FIG. 1 of U.S. Pat. No. 3,531,996 and in FIG. 1 of U.S. Pat. No. 4,546,438.


Lower die **12** is provided with a deep cylindrical recess **60**, which is fitted with an annular heat-sink and sealing member **62**, preferably made of cured, low modulus silicone rubber; it has a main axial height **64** which is less than the depth **66** of the recess, leaving a small cylindrical portion **68** at the top of the recess, as explained hereafter. The top surface **70** of the member **62** is substantially contiguous with, and matches the contour of, the underside **44** of the rotor head **40** which it engages.

The peak of the rotor top surface **42** is leveled with the lower die-land **13**. The top surface **70** extends laterally beyond the head **40** of the rotor, forming a small annular sample-support surface portion **72** of the member **62** which separates the rotor head from the cylindrical wall portion **68**, and also prevents metal-to-metal contact between the recess wall and the rotor head.

When the dies **12** and **14** are moved into closed position, a test cavity **80** (see  **FIG. 2**) is created substantially between the portion **68** of the lower die **12**, the seal portion **72**, the rotor top surface **42**, and the recess **82** in the upper die **14**. The sample formed therein is seen at **84** in  **FIG. 1**, and has an edge thickness **86** substantially less than the main height **64** of the seal member **62**. In a useful relationship, the seal height **64** is approximately three times the edge thickness **86**. This ensures that, as the oscillation proceeds, the rotor head will tend to flex the heat-sink/seal material, rather than slipping over its surface. Although the seal contributes some torque to the sample measurement, a correction for this can be readily, if desired, be calculated, using the technique described by Gent and Xie [Rubber Chemistry & Technology, 66, 83 (1993)].




The volume of sample material charged into the device is usually slightly greater than the capacity of the cavity **80**, and the closing together of the dies under pressure will therefore normally result in a small amount of the sample being squeezed out or extruded between the die-lands **13** and **15**.


The top surface of portion **72** of the heat sink/sealing member **62** is lower than the level of the die-land **13** by the amount of portion **68** to ensure that seal material will not be squeezed out between the die-lands together with any excess sample material.

In  **FIG. 3** is shown graphically a number of tests conducted according to ASTM Standard Test Method D2084-91, wherein the biconical head of a disk rotor is completely embedded in a rubber sample. The curves generated are the typical S-curves obtained with ASTM D2084-91; since the sample totally surrounds the biconical rotor-head, its volume and gauge are shown to cause the torque to range upwards toward 35 inch-pounds. Time is plotted toward 12 minutes.

It will be noted that one family of curves is designated "A". It represents a number of test-cycles, the last one of which necessitated removal of the rotor from the curemeter in order to remove all of the cured sample. The rotor and the area of the lower die where the rotor shaft is inserted was cleaned off, and the rotor re-inserted in the curemeter, but now it was not possible to fix its axial location exactly as before.

Consequently, the next sample, shown by curve "B" and representing a family of test results which will obtain until the rotor must next be removed for servicing, is seen to show an entirely new range of values. Reproduceability of test results is thus poor. Even the curves of family "A" show, for example minimum torque values ranging over almost one-half inch-pound.

In  FIG. 4, the same rubber compound as in  FIG. 3 is subjected to testing in the device of the invention, the sample here being thinner than in the previous tests, since it is loaded into the curemeter only on the top of the rotor, and is sealed from intrusion under the head of the rotor by the contiguous seal/heat-sink. Thus, the torque values extend only toward 25 inch-pounds. It will be noted that the family of curves "C" tracks closely, and there are no rogue aberrations as in  FIG. 3. Good reproduceability of test results has now been obtained. Minimum torque values vary less than approximately one-third inch-pound.

 FIG. 5 shows a modification wherein the rotor head 100 has a planar underside 102 contiguous with, and matching the contour of, the top planar surface 104 of the seal 106. The laterally extending annular band portion 105 is shown canted slightly toward the bottom of the recess.

Although the dies 12 and 14 are shown as circular, the recess 60 and its wall section 68 as cylindrical, and the heat sink/seal 62 and band 72 as annular, it will be understood that other shapes may be used successfully, and that other modifications may occur to those skilled in the art without departing from the scope of the invention.

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