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SHORT COMMUNICATION

New Instrument for Rapid Testing of Compression Set

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ABSTRACT

A new instrument for the automated determination of compression set has recently been developed by Elastocon AB in conjunction with the Swedish company Forsheda AB. This instrument is now used by Forshedafor the rapid measurement of the state of cure in rubber products. A compression set test, usually taking 22 h at 70°C, can now be completed in only 25 min using a temperature of 150°C.

BACKGROUND

The development of the new instrument began some 5-6 years ago, when the laboratory manager at Forsheda contacted Elastocon to enquire about the possibilities of an instrument to determine the state of cure of rubber products faster than the conventional 22 h compression set test.

Forsheda considered it of vital importance that a reliable test to determine whether products were properly cured, was used, but were looking to reduce the time needed to complete a satisfactory test.

The first option was to investigate the possibility of using the Elastocon stress relaxation tester. However, this proved unsatisfactory due to the fact that when extra cross-links are added to the polymer network, no additional stress is indicated under the constant deformation applied by the relaxation apparatus.

Compression set, on the contrary, measures the ability of the material to recover after deformation and this proved to be very sensitive to continuing cross-linking. How to overcome the problem that a compres-

sion set measurement takes around one day was to try and do the test at a temperature corresponding to the curing temperature over a shorter test time.

Manual experiments with compression set tests at 150°C with 5 min recovery time showed this to be a possible method; however, using these short test times resulted in poor repeatability when carrying out the tests manually.

Forsheda looked at this and alternative techniques for some time and then in 1992 they came back to Elastocon with a request for an instrument for the automatic testing of accelerated compression set. It was agreed that Elastocon would develop an instrument in two stages, the first being to modify a relaxation rig to produce a prototype apparatus for evaluation testing (see Fig. 1).

The prototype was then used to establish whether the theory for rapid compression set at high temperatures worked in practice. Results proved extremely encouraging, the instrument giving excellent sensitivity and repeatability. Design and manufacture of the final instrument then commenced and this resulted in a three station instrument with all components, including the computer, contained in one cabinet, so that the instrument was suitable for use in a production department (see Fig. 2).

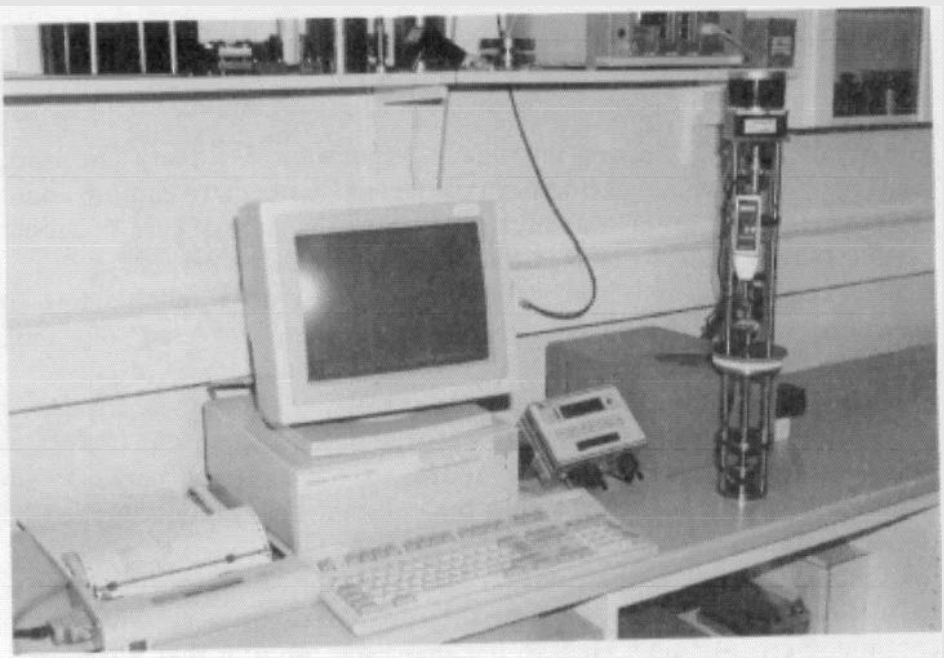

Fig. 1.

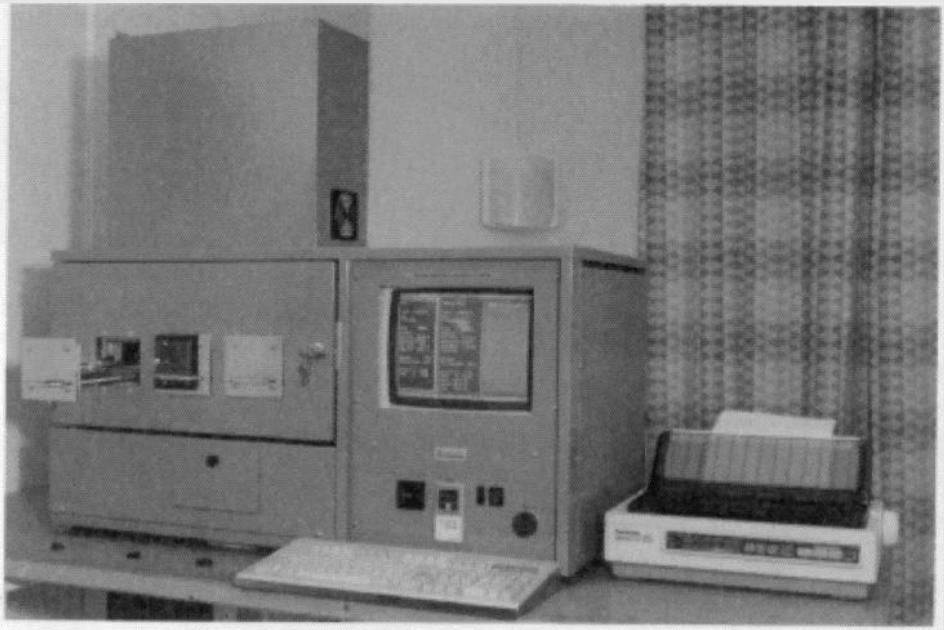

Fig. 2.

HOW THE INSTRUMENT WORKS

The quick set tester consists of a three station testing rig built into an oven. The instrument is controlled by a built-in PC computer. The screen of the PC is divided into three windows, one for each testing station. The temperature range of the oven is 40 to 225°C and the movement range of the pistons of the testing rig is 25 mm, with forces up to 2000 N. The testing stations are individually driven by stepper motors, with a speed range of 0 to 200 mm/min.

The test specimens can be up to 50 mm in length and 25 mm thick. They can be a whole product or a part of a product.

The test sequence is as follows. The sample identification is typed into the computer, and the sample is placed on the sample feeder, which is then pushed into the oven. The test starts and the instrument applies a preload on the sample and measures the sample height. The sample is then compressed to a specified compression during a specified time. After the test period the sample is released for recovering during a short time, after which the sample height is measured once again and the compression set is calculated. The computer checks in a specification file if the sample is approved or not and the background of the screen window changes colour

from blue to green or red, depending on the result. The result is saved on the hard disc and can also be printed.

EVALUATION OF THE TEST SEQUENCE AND CORRELATION

When evaluating a suitable test sequence for their compounds, Forsheda made tests at 140 and 150°C. They found that a compression time of 20 min was sufficient (see Fig. 3). Figure 4 shows the correlation between the standard compression set test at 22 h/70°C compared with quick set

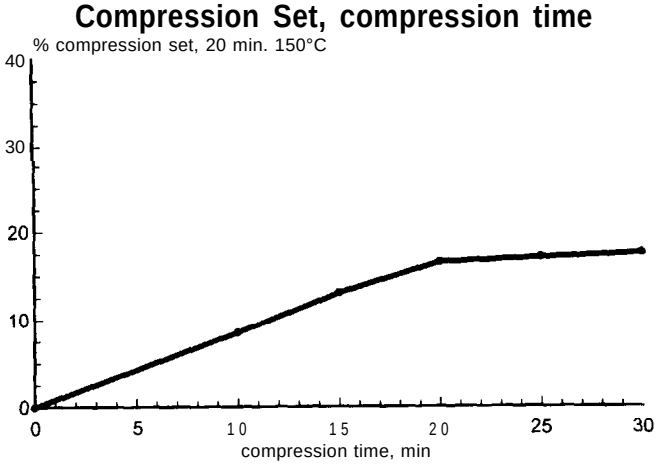

Fig. 3.

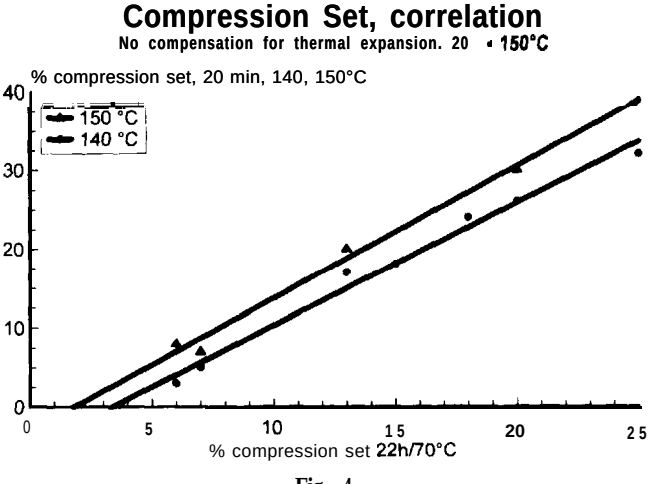

Fig. 4.

tests at 140 and 150°C. The figure shows that standard compression set results between 6 and 25% gives quick set results of 3 to 38%.

It appears that the quick set test gives higher values for the compression set and a larger difference between the lowest and highest values, which means a good resolution.

The quick set test differs from the standard compression set by higher test temperature, shorter recovery time and recovery at test temperature, and the original height is measured on a cold sample, while the finished height is measured on a warm sample. All these factors contributes to a difference in test results between the quick set method and standard compression set.

The fact that the height measurements are done at different temperatures, gives, due to the thermal expansion, compression set results which are 5–8% too low. Forsheda has chosen not to compensate for this and instead take this into consideration when setting the limits. It is otherwise easy to add a compensation for this in the software. If a sample is tested without compression, the result will show the thermal expansion of the rubber. It is then easy to add a correction per material in the software.

Figure 5 shows the compression set after different recovery times. The figure shows the recovery to be very rapid at high temperatures.

Forsheda has chosen a test cycle at 150°C, with 20 min compression time, 25% compression and 3 min recovery time.

REPEATABILITY

Table 1 shows the repeatability when running a series of tests on 10 mm high cross sections from an extruded profile. The result is very good,

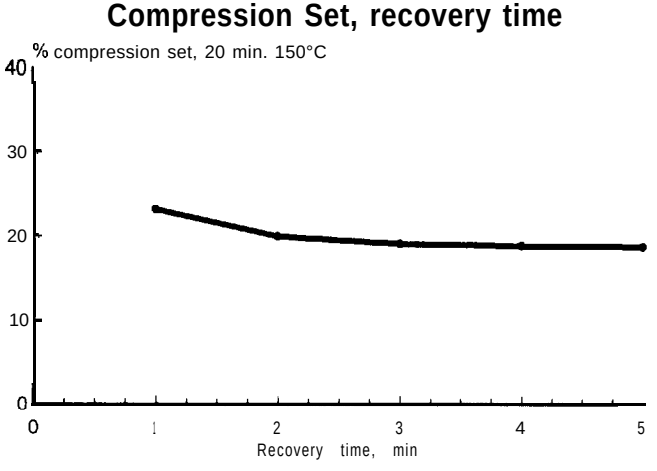

Fig. 5.

TABLE 1
Repeatability (%) for Compression Set

Sample	*Station*			*Mean*
	1	2	3	
1	15·1	15·9	13.4	14·8
2	14·1	13.3	15.4	14.3
3	12.2	12.9	13.6	12-9
4	14·3	13.8	12.8	13.6
5	13.8	13.8	12·9	13·5
Mean	13·9	13.9	13.6	13.8
s	1·07	1.16	1·05	0·7

considering the possible errors when doing this rapid compression set testing. The areas already recognised as possible causes of error are: lack of sample uniformity, particularly the relationship between the top and bottom faces, which should be parallel, variation in sample loading time, variation in the material and the precision of the instrument when doing the height measurement.

FUTURE DEVELOPMENT AND USE

As the instrument can measure force and height and control the temperature and testing speed, it can be used to measure properties other than compression set. It is possible to consider relaxation tests, creep tests, tension set and modulus at different temperatures and amplitudes, Another possibility is to use the instrument as a 'parallel plate plastometer' for the testing of polymers and uncured compounds. There are many possibilities, and, in most cases, additions are only needed in the software; however, in some cases, slight modifications may be needed in the instrument.