Device for measuring creep at higher temperatures

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Abstract: - Any research and development department has ever met with the need to use a measuring device that they do not have at the time. One of the traditional methods is that such equipment is purchased from specialized companies that make them. In these cases, the question is always whether the funds spent have a large enough return and that the parameters of this machine are sufficient for the measurement. The second option which this article deals with is to design and implement such a device. One area where this option is possible to study is the creep behavior of radiation cross-linked polymeric material at higher temperatures. The influence of radiation crosslinking is studied in many standard short-term tests, but the influence of radiation crosslinking on polymer materials exposed to creep is known only marginally.

Key-Words: - Measuring equipment, construction, creep, measurement, evaluation

1 Introduction

Like all metal materials, polymeric materials also must be tested for properties which will be required during their usage. Physical, chemical and mechanical differences between these materials show the differing requirements on the test device. The design of the testing equipment is nowadays among the most difficult construction tasks due to rising demands on the quality and accuracy of data obtained from measurements. Those and other reasons increase demands on the individual components of the testing equipment which significantly increases costs.

Another significant portion of the total price of the equipment is protecting the know-how of the companies involved in their production. For this reason, a number of equipments are financially inaccessible for many research and development centers, so they design and then implement the testing equipment in its own production. These devices usually do not have a large variety of results, but often only those which are required to evaluate a particular test. The overall construction is therefore directed to specific test specimens, the load and the evaluation method. In the creep test there is a commonly used test specimen shaped as a double-sided shovel of different sizes. The essence of this test is to stress the test specimen with constant power/load, which will pull the specimen for a long time. The primary result of such a test is elongation of the sample measured in time.

1.1 Principle

Another important part in the design will be choosing the type of test. As mentioned in the introduction, creep tests can be performed in two modes, the choice of a mode will have a significant impact on the overall design of the mechanism.

For these reasons, tests under a constant load was chosen for this design of the equipment. Another important prerequisite for this test is temperature. According to ISO 899-1 norm we differ between test at a room temperature and at higher temperatures. For the mentioned test equipment was required to test at higher temperature. The nominal temperature according to the norm should be within $+/-2\,\degree\, C$ which increases demands on thermal regulation.
1.2 Conditions
Each device is limited by the boundary conditions that can be set. Due to the expected use of the device for polymer materials that are radiation modified, the temperature range from 20 °C to 250 °C should be sufficient with a sufficient margin. The load is expected to be in the range of 50N - 1000N by weight. Measuring range is 20 mm with 0.01 mm resolution. The equipment should be lightweight with automatic sensing and recording of data.

2 Construction
Each measuring device consists of a number of groups that perform different functions. According to these groups, the device can be divided into parts.

2.1 Clamp for the sample
Suitable clamping of the sample is one of the more complex design tasks. Mechanical properties of tested materials are different, and therefore require appropriate selection of the clamping device. In addition to commercially available clamping jaws such as tensile testing clamps from the Zwick company, you can design your own clamps. Due to elevated temperatures, self-locking jaws won’t be used since its clamping force could negatively affect the test results.

![Clamping of the sample](image)

Fig. 2 Clamping of the sample

Used jaws are shaped for small testing samples, which are places in recesses and held by two screws.

2.2 Multiple tests
For tests that have costs associated with the operation of the test equipment, designer tries to reduce the cost of a single test. The reduction can be done by reducing operating costs, which are often fixed and cannot be significantly changed. Another possibility is to allocate these costs among multiple tests, making price of one sample smaller. In case of tempering chamber it is suitable to test the samples at the same temperature.

![Fatening mechanism](image)

Fig. 3 Fatening mechanism

Evaluation of the work area temperature chambers with regard to handling and safety areas, four symmetrically placed samples were selected.

2.3 Conception
Small manipulation possibilities for changing of the samples contributed to the design of a small sample supporting frame.

There are four strong jaws attached to the frame with bolts. The testing samples are attached outside of the chamber, then inserted into a fastening mechanism which provide the same position after changing the samples.
2.4 Load
The load of individual samples is performed via a lever mechanism for individual samples, allowing for greater variability in load tests at the same temperature. The lever mechanism is in a ratio of 1:5, with possibility of extension to 1:10.

During testing of materials which are thermally very vulnerable to creep the lever mechanism can be completely removed and direct loading of the samples used.

2.5 Measurement
Measurement of stretching is performed using dial gauges from Mitutoyo with extended measurement range of 25.4 mm and Digimatic connector that allows the computer to communicate with the gauge. The thermal chamber does not allow the probe to touch the jaw, thus stretching is measured outside the temperature chamber. By using these commercially available measuring instruments with sufficient resolution and the maximum permissible error allowed significantly reduce the cost of the equipment. The advantage of using these sensors is in their compactness and almost no requirements for their attachment. Clamping is done using the clamping part with diameter of eight millimeters. Another option how to measure the stretching is using various linear gauges using different principles. After attempts to improve the accuracy of measurement by these methods, they were abandoned because of the high demands for the attachment and adjustment of such sensors.

2.6 Data recording
The digital dial gauges used Digimatic output and were connected to a computer. To ensure high repeatability a dedicated program was made to regularly measure the stretching. The program was written in Python 2.7 and stores the data in a *.txt text file. The recorded data can be easily evaluated in mathematical programs and used to construct a graph.

2.7 Temperature chamber
The basic element of the thermal chamber is an old oven, which has sufficient thermal insulation, oversized sufficiently and appropriately positioned heating system with resistance heating coils. Another advantage is factory-built air fan for high temperature to ensure a homogeneous temperature within the chamber during the entire test. Original bimetal temperature regulator has been replaced by an electronic control unit temperature to maintain the temperature within + / - 2 °C from the nominal temperature. Temperature monitoring for PID controller Ht60B from the company HTH8 was realized by PT100 temperature sensor placed in the oven.

The advantage of this controller is that it is able to connect to computer via RS232 using Modbus communication protocol to control and record control parameters such as the desired temperature and actual temperature.
3 Conclusion

To verify the correct measurement, polypropylene filled with 30% that has been modified radiation cross-linking has been selected. The first measurement of four samples at 90 °C can be seen in Figure No. 7

Figure.7 PP 30% GF temperature 90°C 33kGy

Acknowledgement:
This paper is supported by the internal grant of TBU in Zlin No. IGA/FT/2013/020 funded from the resources of specific university research and by the European Regional Development Fund under the project CEBIA-Tech No. CZ.1.05/2.1.00/03.0089.

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