Creep test evalutation

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Keywords: Median, arithmetic average, creep, measurement results, radiation crosslinking

Abstract

Many methods of result interpretation were developed while testing materials. We can often see evaluation using graphs, tables, numerical expression with effort to present the results of research as clearly as possible to the reader. One of the factors that can negatively affect this interpretation is the number of tested samples. With sufficient number of samples, ordinary arithmetic average is used and standard deviation is used to express uncertainty of measurement. But what to do when we only have small number of measurements? Can big deviation affect the results of the experiment? This article will try to answer this question.

Introduction

In practice, we can have cases, in which measurement can be quite an investment per one sample or the measurement takes a very long time and that means we can't repeat it for its time uniqueness. Because of these reasons we will focus on the creep tensile test, which suffers from the aforementioned problem, especially because it belongs to a category of very long measurements. Length of one measurement can even be a few years, that makes it unrepeatable.[1-4]

Polymer materials have in comparison to metal materials, in which the creep effect takes place after few years, bigger tendency to flow. We distinguish creep tests to tensile, by pressure or by bending. The most commonly used is the uniaxial tensile. This test can be performed in two modifications, with constant weight and constant tension. Method with constant tension is technically more complex and requires better measuring equipment that has to regulate the tension depending on how the sample changes diameter so the stress would be constant in the testing part of the sample.[5,6]

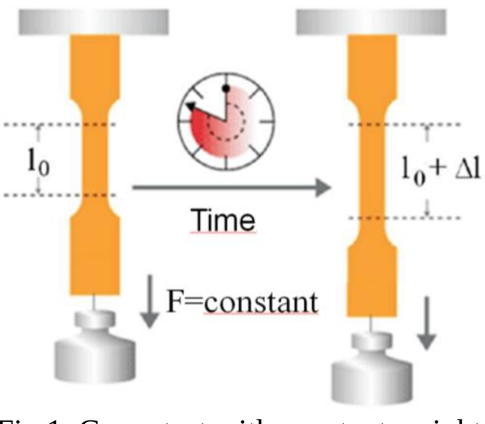

Fig.1. Creep test with constant weight

The second more often used and simpler method is to use constant weight. When using this method, the sample is being pulled by a certain force, which doesn't change during the measurement. A weight pulled by gravity is often used.

Method

Polyamid 6 was chosen as a material for this test and example of the possible interpretations. This material belong to category of construction materials and is known for its good mechanical properties, as in statically and dynamically stressed parts. Good sliding properties, high abrasion resistance and good damping properties makes it one of the most widely used construction material. Polyamid are semi-crystalline plastics with crystalline portion of 20 – 40%. Because of that, we can find it mostly in parts that are more mechanically stressed. Radiation crosslinking is used for standard and construction materials, to which this processing gives properties of high-tech materials. The advantage of this modification is that finished products with final shape are processed, materials that do not directly create the final part, like runner system remains, are not processed. Final products are processed at room temperature and normal pressure so the final product is no more stressed by temperature.

To make a sample of a possible data interpretation it was necessary to make and test samples to get the data. To make a creep tensile test (ISO 899-1) at room temperature, small testing parts, type 1BA, were inject molded on Arburg Allrounder 170U.

Table 1. Process parameters

Mold temperature	90°C
Nozzle temperature	265°C
Injection speed	60mm/s
Injection pressure	80MPa
Switching point	8mm
Packing pressure	70MPa
Cooling time	15s
Drying	4 hours at 80°C

Molded parts were cleaned off of runner system remains and sent for radiation crosslinking to BGS company in Germany.

As we can read from tensile curve, yield strength for this material is 75MPa. Given to the planned creep test, which will take 1000 hours, this value was reduced to 23MPa, by which every of the eight samples were pulled.

To get the data from the creep test, a machine of own production was used. It has dial indicators with resolution of 0.001mm and range of 12.7mm

Values of elongation in individual times were recorded with a connected computer and a single purpose program that recorded the value every 60 seconds. Temperature and humidity were monitored during the whole measurement.

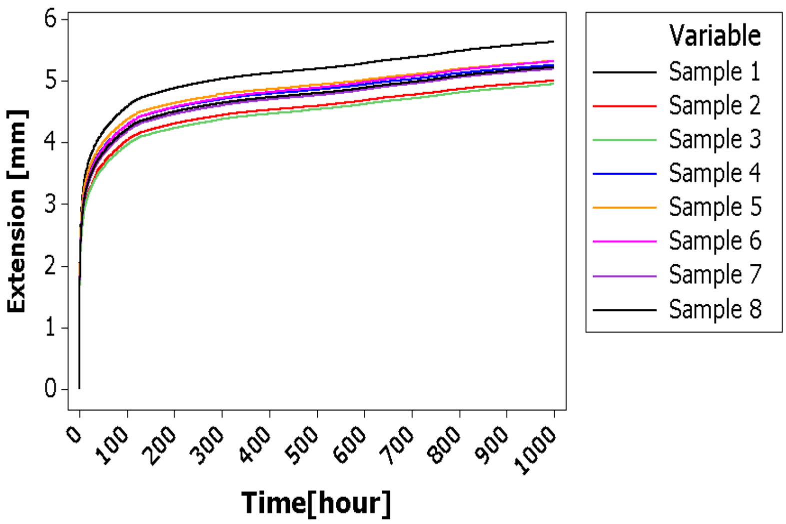

Fig. 2. Creep curves PA6, 66kGy

We can see the results of one measurement with crosslinking dose of 66kGy on the picture 3, where we can clearly see a typice creep curve for this test that took 1000 hours.

Deviation of measurement can also be seen here. It is constant from about 200 hours. These gathered data, as any other data, have to be checked for coarse and deviated values that affect the results of this measurement. Given the small number of measurements (8), mean of median estimates and estimates of arithmetic averages is used. Ordinary normality test couldn't have been used here because of the small number it wouldn't have its needed explicitness. Because of this, we will check if the data have the same character during the whole measurement. The check was made by method of comparing the means, estimate of median and estimate of arithmetic average.

Because of the small number of measurements it was advantageous to use the 1,5 IQR test, but if the test would be more repeatable and the normality wouldn't be denied, it would be possible to use parametric Grubbs test.

As we can see on picture 4, given the position of both curves we can conclude that the data have the same character. As another possibility of a check, boxplot diagram was used which was for clearer graph applied to data with 100 hours period. We can see a very similar result for all measurements in time. After comparing both creep curves it is obvious that Polyamid 6 irradiated with 66kG elongated about twice as much as Polyamid 6 irradiated with 198kGy. To check if this difference is statistically significant, or it can be attributed to random errors that come up during measurement, they will be check by a hypothesis test.

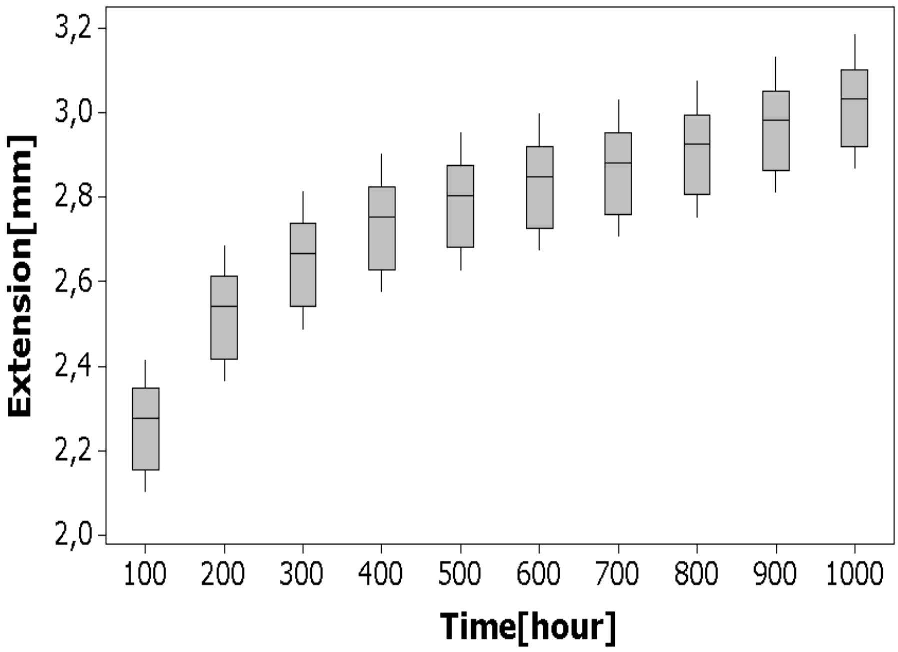

Fig.3 Boxplot graph for PA6 – 198kGy

Non-parametric tests test other hypothesis about the distribution the basic file than is the hypothesis about its parameter. Their solution is not dependent on the type of distribution of the basic file, so unlike parametric tests, the results are not dependent if the chosen model of distribution was chosen as is the distribution in the real basic statistical file. Data checked with this method can now be evaluated using median trend line and the belt of the variation.

Non-parametric test have therefore broader application than parametric tests. Their disadvantage is that they are less significant than analogical parametric tests. This means that they are less likely to reveal a situation, where the null hypothesis does not stand. To get the same significance we have to use more measured data than would be necessary with parametric test.

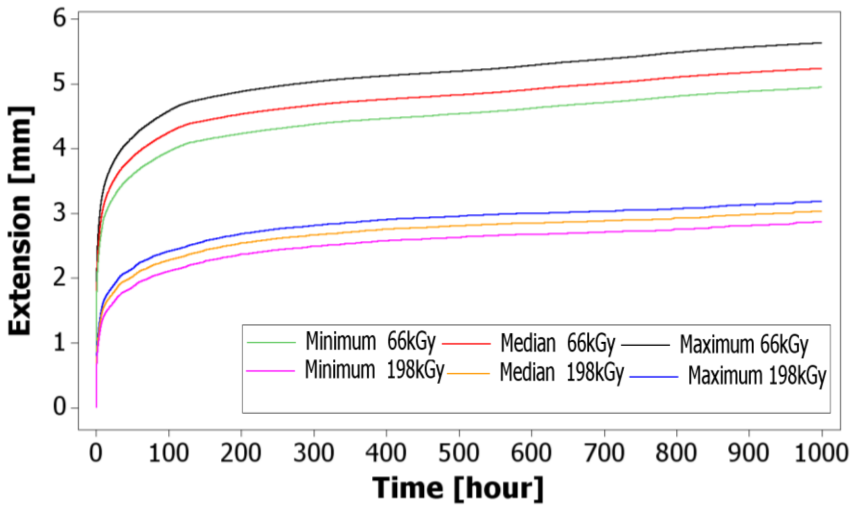

Fig.4. Comparison PA6 66kGy with PA6 198kGy

This test can solve questions that are similar to these tested by two-sided t-test with means of two populations. We have two independent selections coming from the basic files. We are testing null hypothesis

$$\text{H0: } \tilde{X}_{66} = \tilde{X}_{198} \quad (1)$$

$$\text{HA: } \tilde{X}_{66} \neq \tilde{X}_{198}. \quad (2)$$

Based on the results of testing if the medians come from the same basic file we can reject the null hypothesis in favor of the alternative hypothesis and say that the difference between them is not due to random error with a probability of 95%.

Conclusion

This article demonstrates possible interpretations of creep test that was performed on eight samples. Even though the difference can be seen by the naked eye, the effect of irradiation on creep properties can be affected by subjective impression of the observer. Because of that, two hypotheses were stated and tested by Mann-Whitney methods. Using this method, it was conclusively demonstrated the effect of the amount of radiation crosslinking dose on creep properties of material. This method can be used to compare materials that do not allow for larger amount of samples for parametric evaluation of measured data while keeping a sufficient significance of the results.

Acknowledgment

This paper is supported by the internal grant of TBU in Zlin No. IGA/FT/2014/016 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 and Technology Agency of the Czech Republic as a part of the project called TA03010724 AV and EV LED luminaire with a higher degree of protection.

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