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Thermal chamber for material testing

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Abstract. The problem of ensuring the correct conduct of the experiment with preservation of the required temperature is considered. The construction of the device is proposed that will allow satisfying the conditions for carrying out tensile tests with an increased or lowered sample temperature.

The basis for evaluating the properties of the material is information on how the material reacts to any load. Knowing the magnitude of the strain created by a given load (voltage), it is possible to predict the response of a particular product to its operating conditions [1].

Strength values of polymers are determined on the tensile machines, on which it is possible to perform tensile, bending and compression tests.

To carry out studies on stretching and to determine the physico-mechanical properties of recycled polyethylene waste, samples were prepared. Samples for testing were made on a milling horizontal machine at a speed of 250 revolutions per minute. After manufacturing, the samples were conditioned for at least 16 hours at a temperature of 23 (± 2) ° C and a relative humidity of 50 (± 5)%. To perform a series of tensile tests, the samples were numbered and the samples were held in the freezer at a temperature of plus 4 ° C for 72 hours. Under conditions of testing at minus 40 ° C, the samples were brought to the required temperature immediately before the start of the tests.

The main task of preparing the samples was to hold at certain temperatures in order to obtain the character of the change in the strength characteristics as a result of the tensile tests, depending on the effect of different temperatures.

Tensile tests were carried out in accordance with GOST 11262-80 "Plastics. Method of tensile testing "and GOST 14359-69" Plastics. Methods of mechanical testing. General requirements ", establishing a method for tensile tests of plastic materials for determining the characteristics of mechanical properties: tensile strength, tensile strength, physical tensile yield stress; Young's modulus.

For a series of tensile tests at a temperature of minus 40 ° C, liquid nitrogen was used to cool the samples. When the samples were cooled to minus 40 ° C, they proceeded directly to the tests. To measure the temperature at the time of the tests, a thermal imager DALILT7 was used.

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The tensile test was carried out on a two-zonal testing machine model UTS 110M-100 of the floor version [2], certificate of approval of the type of measuring instruments No. 34879. Range of measured loads, kN: 0.001 - 100; load measurement error ± 1% (0.5)% of the reading up to 1/100 of the permissible load of the load cell. The loading rate for the samples was 10 mm / min at -40 ° C and 20 mm / min at -4 ° C and +20 ° C.

According to the test results, loading diagrams in the F-l (strain-strain) coordinates were obtained, over which the tensile strength and yield strength were determined (Fig. 1). The relative uniform elongation and relative narrowing was determined from the measurements of the length of the sample after the test.

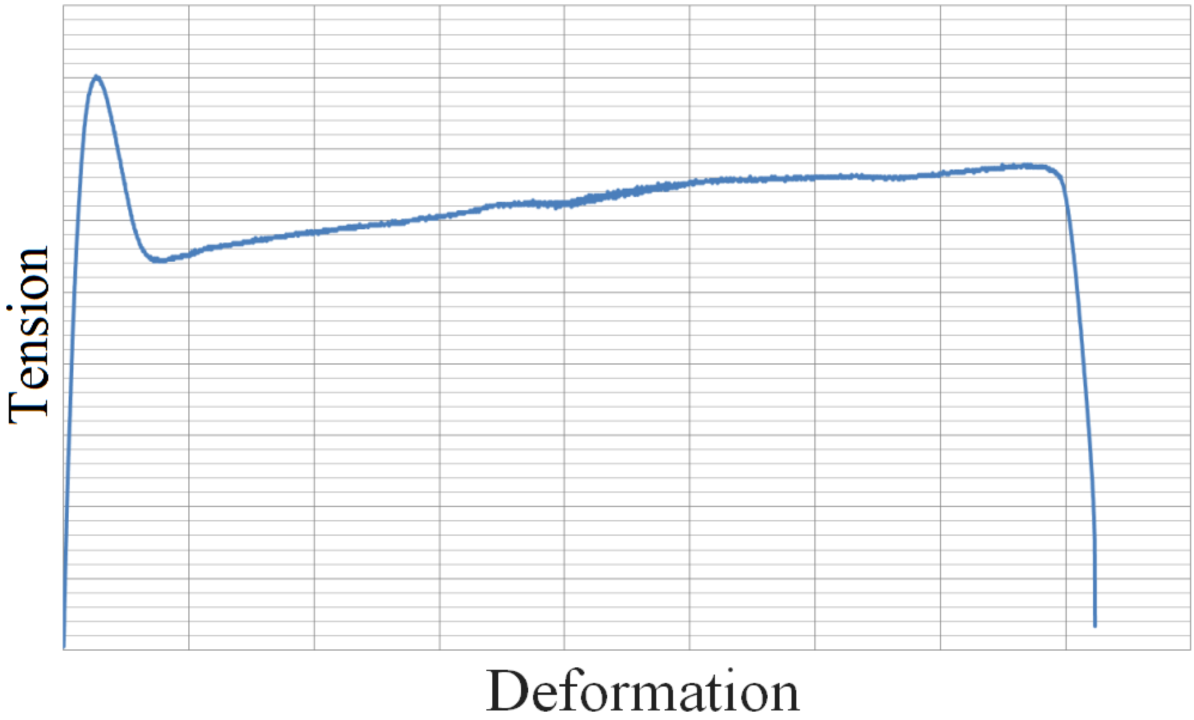

Figure 1. A typical diagram of loading a batch of samples from samples of polyethylene recycled by industrial means

To determine the ultimate strength, yield point, standard formulas were used.

The tensile strength, according to the formula:

$$\sigma_{PM} = \frac{F_{PM}}{A_0} \quad (1)$$

Breaking strength, according to the formula:

$$\sigma_{PP} = \frac{F_{PP}}{A_0} \quad (2)$$

Yield strength in tension, according to the formula:

$$\sigma_{PT} = \frac{F_{PT}}{A_0} \quad (3)$$

where A_0 – area of initial cross section; F_{PM} – maximum tensile load; F_{PP} – load at which the sample collapsed; F_{PT} – tensile load at yield point.

Analyzing the results of the loading diagram of samples from industrial polyethylene recycled at different test temperatures (Figure 1), tests showed that the material has a yield strength.

In all tests, the tensile load at reaching the yield point was greater than the load at which the sample failed, so the tensile strength of the values coincides with the tensile yield strength.

When determining the Young's modulus, the linear section was first determined on the tension diagram, the error of linear approximation was estimated by the least squares (R^2) method, in calculations the linear portion was determined from the condition $R^2 \geq 0.90$.

Table 1 shows the results of tensile tests of polyethylene recycled by industrial processes.

Table 1. Results of tensile tests of polyethylene recycled by industrial process

Parameters	**-40 °C**	**-4 °C**	**NU**
Tensile strength / Tensile yield strength (MPa)			
Test1	28,286	17,222	16,048
Test 2	22,524	18,810	11,310
Test 3	–	21,286	–
Average value	25,405	19,106	13,679
SKO*	4,074	2,048	3,350
Deviation SKO	16,037%	10,719%	24,493%
Breaking strength (MPa)			
Test 1	17,952	15,333	13,571
Test 2	14,810	12,952	8,690
Test 3	–	15,619	–
Average value	16,381	14,635	11,131
SKO	2,222	1,464	3,451
Deviation SKO	13,567%	10,004%	31,007%
Young's modulus (MPa)			
Test 1	320,012	241,06	486,451
Test 2	309,930	186,34	386,22
Test 3	–	344,073	–
Average value	314,971	257,158	436,336
SKO	7,129	80,089	70,874
Deviation SKO	2,263%	31,144%	16,243%

During the research on the fracture, the grippers of the test machine had a large heat capacity, and the test samples had a small thickness, the heat transfer was intensive, the temperature of the stretching region changed rapidly, which directly affects the experimental results. In this connection, the problem arises of ensuring the correct conduct of the experiment while maintaining the necessary temperature.

Based on GOST 14760-69 "Adhesives. The method for determining the strength at break-off (with changes No. 1, 2) "tests at elevated and lower temperatures are prescribed to be carried out in a special chamber intended for these purposes. In this case, the working space of the testing machine should allow the installation of a chamber with extension bars for attaching specimens, which should ensure a reliable centering of the sample in the grippers of the testing machine. The design of the chamber should ensure uniform cooling of the working part of the sample. Cooling the sample to the specified test temperature and the test itself can be carried out in a liquid medium. It is allowed to cool the sample to the specified test temperature and test it in a cooled gaseous medium. As a liquid medium, ethyl rectified alcohol is used in accordance with GOST 18300-87, cooled by carbon dioxide liquid according to GOST 12162-77 or liquid nitrogen in accordance with

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GOST 9293-74, or ice, or liquid nitrogen. Periodic monitoring of the temperature of the test sample at elevated and lower temperatures is carried out with a thermocouple with a potentiometer of accuracy class not lower than 0.5 according to GOST 9245-79.

Cryocameras are known to test machines that contain a thermal insulation housing, a device for introducing refrigerant, a screening cylinder with conical bowls [4-9]. These cameras do not exclude the influence of the pressure difference that occurs, for example, when the cavity of the cryocamera is pumped out, to load the sample. However, they have a low efficiency of cooling the sample due to the introduction of heat to the sample and to the non-cooled jaws.

In order to improve the accuracy and reduce the laboriousness of the test by providing the required conditions for carrying out the tensile test with an increased or decreased temperature of the polymer sample, the following device is proposed.

The diagram of the device is shown in Figure 1. It is proposed to produce a glass in the form of a cylinder with a diameter of 150 mm made of steel. At the bottom of this cylinder will be mounted flat bracket, which will clamp the lower jaws of the test machine. Inside the cup is a bracket that will clamp the bottom of the sample. Dimensions are adjusted with screws. The mechanism of fixing on one axis. The upper part of the sample is the clamp in the intermediate sponge, which is fixed through the bracket in the upper jaw of the tensile machine.

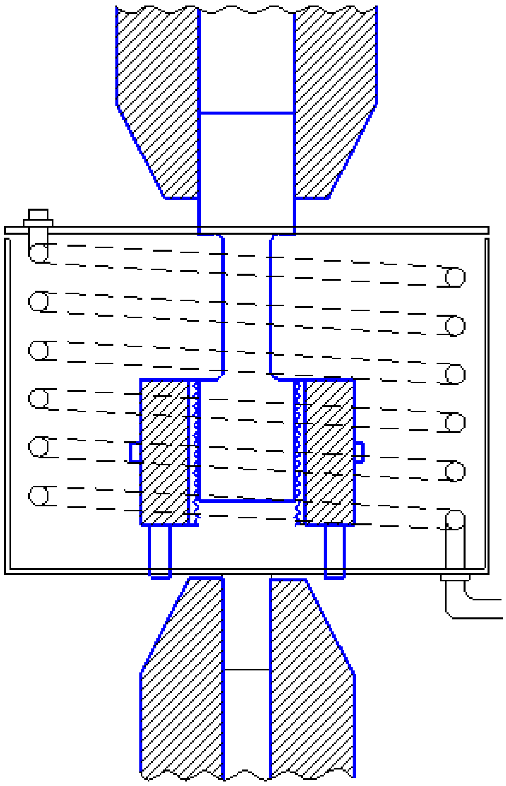

Figure 2 - Diagram of the device

The upper part of the cylinder is closed by a shaped cover with a slot that minimizes heat flows in the inside of the device. The cylinder itself is insulated to reduce losses to the environment. If the lower part is relatively stable, then the upper part is free.

Inside the cylinder is mounted a coil. It is powered by an inverted heat engine. Depending on the requirements, both positive and negative temperatures can be maintained. Additional decrease in temperature is due to liquid nitrogen, whose vapors provide uniform cooling throughout the chamber area. The temperature control is carried out with a thermal sensor mounted in the cylinder.

Thus, the proposed camera allows to increase the cooling efficiency and conditionally stabilize the temperature.

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