MEC-E6007 - Mechanical Testing of Materials

Standardized Testing Lab Report

Group Members

Usama Idrees	**101367888**
Ayesha Zaka	**934176**
Jarno Saruaho	**101366944**

17.05.2024

Table of Contents

Contents

1. Introduction and Background 3
2. Measurement Setup 4
3. Results 6
4. Conclusions 8
5. References 9

1. Introduction and Background

Standardized tests are one of the most widely used tools for determining the material properties of engineering materials. A tensile test is used to find the ultimate tensile strength, tensile modulus and yield strength of materials through test procedures described in standards. The standard followed in this report is SFS-EN ISO 527(1,2,3) for determination of tensile properties of plastics. Based on the information available in the manufacturer's datasheet, the test sample is prepared according to the 1B test specimen type. Compliance to standards is essential for determining the material properties accurately as the standards exactly specify the procedure, test specimen shape, preparation method, testing rate and other parameters that can influence the tensile properties of the material.

A typical tensile test consists of a loading device to which the sample is rigidly clamped. The specimen is then subjected to tensile load along its major longitudinal axis till it fractures or till the stress/strain reaches a specified value. The specimen is carefully manufactured in a so called 'dog bone' shape, which can be seen in Figure 1 and dimensions can be seen in Figure 2. During the test, the values of load and elongation are recorded through strain gauges and extensometers.

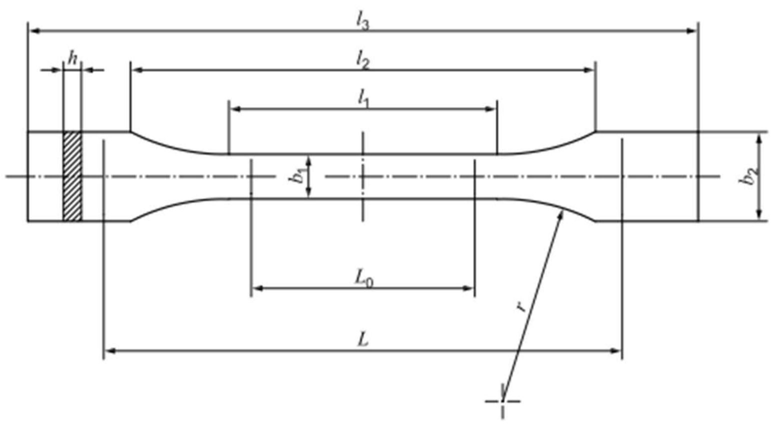

Figure 1 Test specimen shape for type 1A and 1B as defined in SFS-EN ISO 527-2.

Dimensions in millimetres

	Specimen type	1A	1B
l_3	Overall length[a]	170	≥150
l_1	Length of narrow parallel-sided portion	80 ± 2	60,0 ± 0,5
r	Radius	24 ± 1	60 ± 0,5
l_2	Distance between broad parallel-sided portions [b]	109,3 ± 3,2	108 ± 1,6
b_2	Width at ends	20,0 ± 0,2	
b_1	Width at narrow portion	10,0 ± 0,2	
h	Preferred thickness	4,0 ± 0,2	
L_0	Gauge length (preferred)	75,0 ± 0,5	50,0 ± 0,5
	Gauge length (acceptable if required for quality control or when specified)	50,0 ± 0,5	
L	Initial distance between grips	115 ± 1	115 ± 1

[a] The recommended overall length of 170 mm of the type 1A is consistent with ISO 294-1 and ISO 10724-1. For some materials, the length of the tabs may need to be extended (e.g. l_3 = 200 mm) to prevent breakage or slippage in the jaws of the testing machine.

[b] $l_2 = l_1 + [4r(b_2 - b_1) - (b_2 - b_1)^2]^{1/2}$, resulting from l_1, r, b_1 and b_2, but within the indicated tolerances.

Figure 2 Test specimen dimensions for type 1A and 1B specimens as defined in SFS-EN ISO 527-2.

The

2. Measurement Setup

Summary of the test performed can be seen below in Table 1.The measurement setup (see Figure 3) consists of MTS tensile test machine equipped with 30 kN load cell. The test specimen was clamped between the grips of the machine and is tightly secured with the help of position screws mounted on the load cell. The sample is then connected to a mechanical extensometer (provided by the manufacturer of the test machine) that measures the elongation along the longitudinal direction during the experiment. Along with the extensometer, a strain gage (Kyowa KFGS-5-120-C1-11 L1M2R) is also glued (Kyowa CC-33A) to the sample as shown in Figure 4, so that lateral strain can also be measured for calculation of Poisson’s ratio. To attach the strain gage to the sample the surface is first roughened with sandpaper (class #320 sandpaper). Using a solvent the surface is cleaned and a suitable adhesive is then applied to the strain gage before it is positioned on the specimen. The gage is firmly pressed onto the surface of the sample for a minute to ensure adhesion. The gage is then connected to the data acquisition system and strain is read through the software package on the computer screen. Tested material was TECAPEEK manufactured by Ensinger. Below in Table 2 is some mechanical properties of the tested material provided by Ensinger.

Table 1 Summary of the test performed.

Test performed	Uniaxial tensile test
Standards followed	SFS-EN ISO 527-1 SFS-EN ISO 527-2 SFS-EN ISO 527-3
Test speed	1 mm/min
Tested material	TECAPEEK by Ensinger

Table 2 Mechanical properties of the tested material TECAPEEK.

Mechanical property	Parameter	Value	Norm
Modulus of elasticity (tensile)	1 mm/min	4200 MPa	DIN EN ISO 527-2
Tensile strength	50 mm/min	116 MPa	
Tensile strength at yield	50 mm/min	116 MPa	
Elongation at yield	50 mm/min	5 %	
Elongation at break	50 mm/min	15 %	

Figure 3 Test setup used in the exercise.

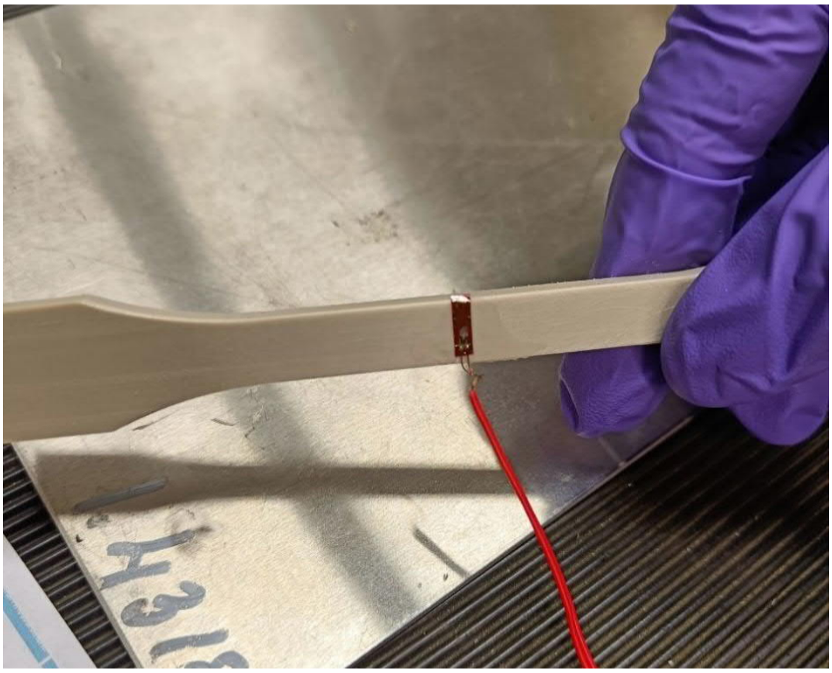

Figure 4 Strain gage glued to the surface of the test specimen.

3. Results

Tensile strength σ_{UTS} is the highest value of stress on the stress-strain curve directly prior to the separation of the specimen. [1] When looking at Figure 5 and gathered data, we get $\sigma_{UTS} \approx$ 81.1 MPa. Total elongation at fracture was ~11.7 mm.

Yield strength σ_y is said to occur when strain achieves yield strain ε_y, and yield strain is located at the first occurrence in a tensile test of strain increase without a stress increase. [1] When looking at the data gathered, the first occurrence of strain increase without stress increase, is located when $\varepsilon = \varepsilon_y = 4.5 - 5\%$. This leads to $\sigma = \sigma_y = 99.9 - 100.1$ MPa.

Young's Modulus is calculated with the slope of the stress/strain curve in the interval between the two strains ε_1 = 0,05% and ε_2 = 0,25% (green dotted line in Figure 5). Stresses at those points were σ_1 = 2.32 MPa and σ_2 = 10.14 MPa. [1] Inputting these values into Equation 1 gives:

$$E_t = \frac{\Delta\sigma}{\Delta\varepsilon} = \frac{\sigma_2 - \sigma_1}{\varepsilon_2 - \varepsilon_1} = \frac{10.14\text{ MPa} - 2.32\text{ MPa}}{0.0025 - 0.0005} \approx 3910\text{ MPa} \qquad 1)$$

Poisson's ratio ν is the ratio of the strain change $\Delta\varepsilon_h$, in one of the two axes normal to the direction of extension, to the corresponding strain change $\Delta\varepsilon_a$ in the direction of extension, within the linear portion of the longitudinal versus normal strain curve. [1] If you look at Figure 6, the linear portion can be seen with the values needed, and using Equation 2 with those values we get:

$$\nu = -\frac{\Delta\varepsilon_h}{\Delta\varepsilon_a} = -\frac{\varepsilon_{h2} - \varepsilon_{h1}}{\varepsilon_{a2} - \varepsilon_{a1}} = -\frac{-0.0138}{0.04} \approx 0.34 \tag{2}$$

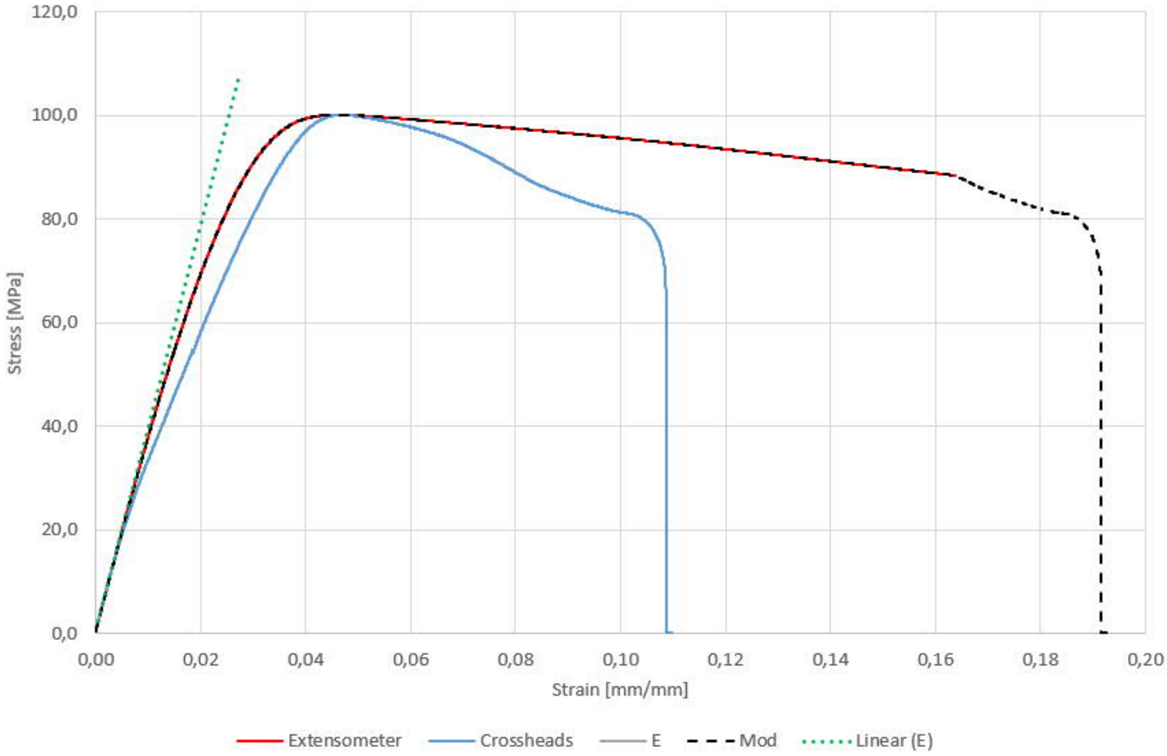

Figure 5 Strain vs Stress curve from testing the material.

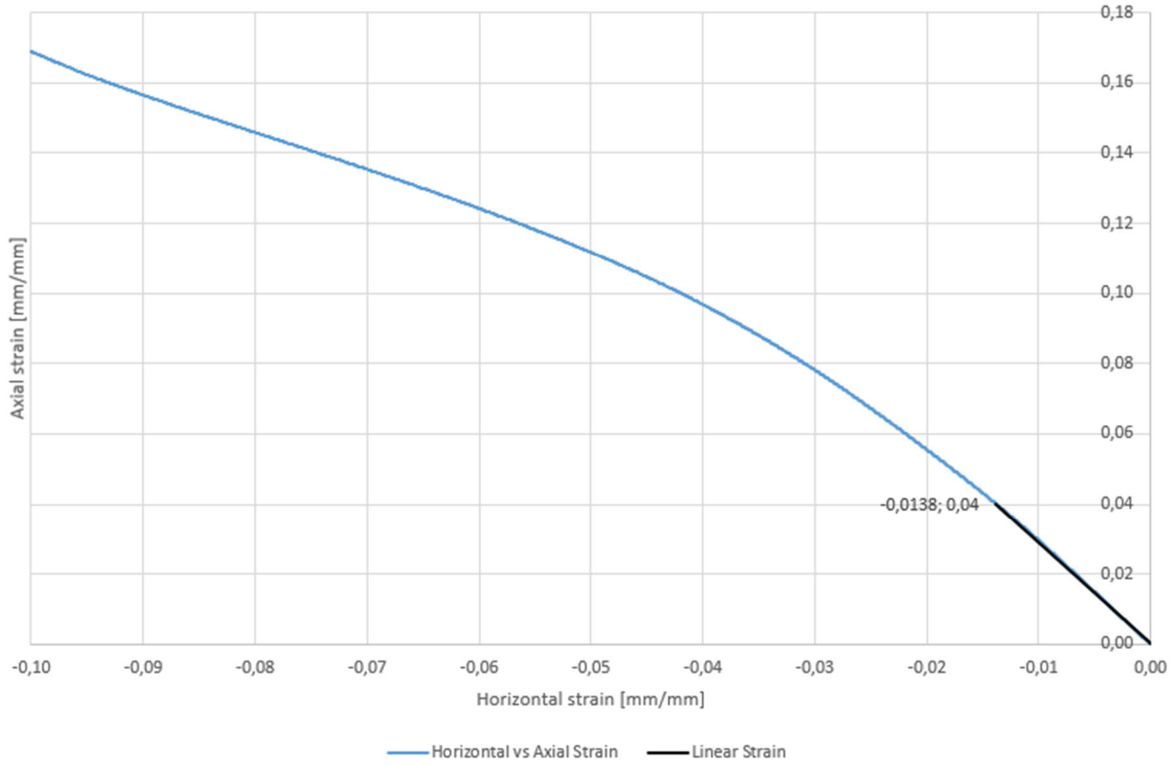

Figure 6 Horizontal vs axial strain of the test specimen.

4. Conclusions

There were talks, that the test should have been done in two parts, first the elastic phase with a test speed of 1 mm/min and after that do the rest of the test with a test speed of 50 mm/min. This way the test speed would have followed the given speeds of the manufacturer (see Table 2) and the comparison to those values given would have been more accurate.

According to the calculated results Poisson's ratio is approximately 0.34 which is approximately a correct value as compared to original reference which is 0.37 [2]. So, the percentage difference is 8%. Moreover, the calculated value of elastic modulus is 3910 MPa which is within reasonable accuracy of manufacturer's listed value of 4200 MPa. Below in Figure 7, you can see that the strain gage was positioned quite well in the middle, so the results should be quite reliable.

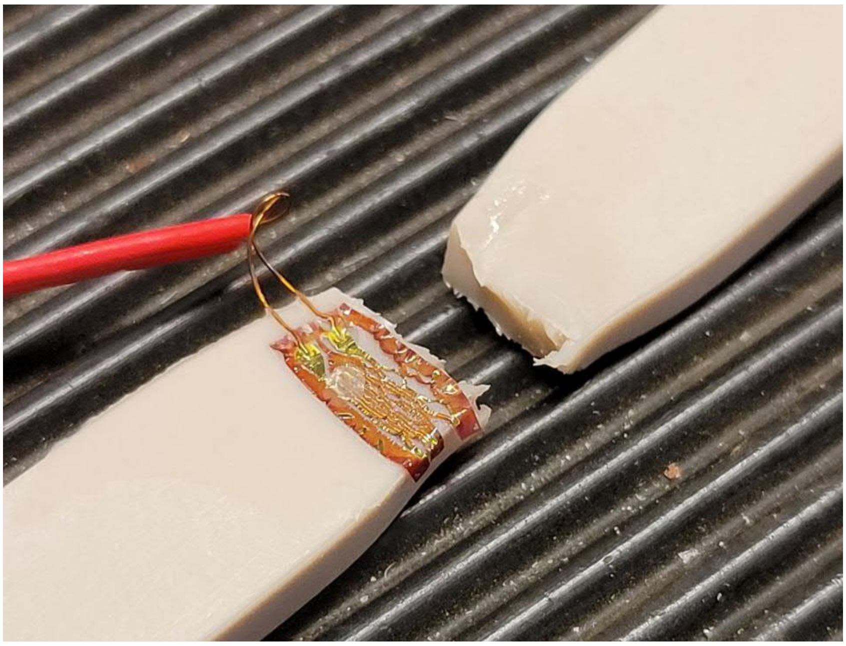

Figure 7 Picture of the fractured test specimen.

5. References

[1] ISO 527-1

[2] Alvaredo-Atienza, A. & Fernández-Blázquez, Juan & Castell, Pere & Guzman de Villoria, Roberto. (2020). Production of graphene nanoplate/polyetheretherketone composites by semi-industrial melt-compounding. Heliyon. 6. e03740. 10.1016/j.heliyon.2020.e03740.