INFLUENCE OF ADDITIVE MANUFACTURING TECHNOLOGY ON MECHNICAL PROPERTIES OF GLASS-FILLED FINE POLYAMIDE PA 3200 GF

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1. Introduction

Additive Manufacturing called as a 3D printing is a very fast developing field of research. Many complicated parts which are very hard to produce by standard ways (injection molding process, castings, milling, turning processing and other) are easy and in low cost manufactured by using printed technology (FDM, SLS, MJP/PolyJet). The main problem in additive manufacturing is that the printed structures have not homogeneous topology and the mechanical properties cannot be treated as isotropic. The porosity of printed parts has a strong influence on mechanical strength and solid density. Moreover, the direction of the printing, thickness of layer and used printing system produce decreasing or increasing structure porosity.

Generally, suppliers give information about the mechanical properties of the material, but the data are very poor and often do not describe the accurate stress/strain characteristics taking into account direction of the printing. For better understanding of mechanical properties of printed glass filled (bubbles) thermoplastic materials, series of tests using special equipment are needed.

2. Selective Laser Sintering for printing parts

Selective Laser Sintering (SLS) is a one of additive manufacturing technique, which is used to produce experimental specimens. SLS allows to create tough and geometrically complex components using a high-powered CO_2 laser to fuse or sinter powdered thermoplastics. Due to this, the technique is used to obtain a strong part, water and air-tight, heat resistant. The polyamide PA 3200 GF is selected to perform experiments and investigate influence of porosity and printing direction on mechanical properties.

3. Catalogue of mechanical properties of PA 3200 GF

PA 3200 GF is a thermoplastic material reinforced with glass fiber which is applied to manufacturing parts using additive manufacturing technology like a laser sintering process for all EOSINT P systems with fine polyamide option. The parts made from this material are characterized by very high mechanical strength, low density, smooth surfaces and high accuracy, cf. Figure 1 and Table 1.

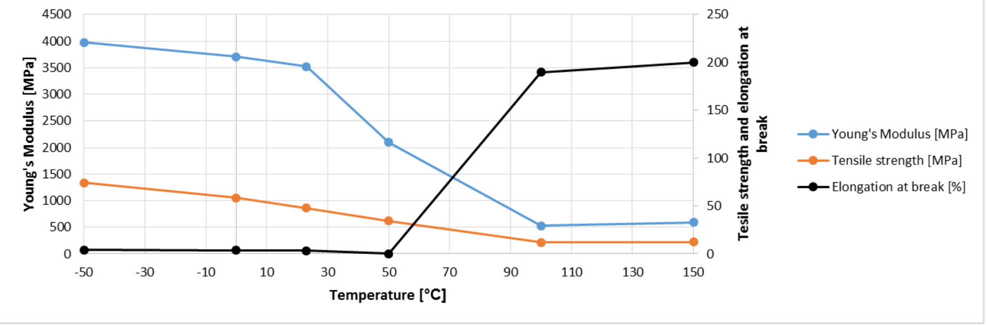


Figure 1. Temperature dependence of mechanical strength.

T [°C]	Young's Modulus [MPa]	tensile strength [MPa]	elongation at break [%]
-50	3980	74,2	4,2
0	3710	58,6	3,7
23	3520	48	3,4
50	2100	34,3	6,9
100	531	12,2	190
150	589	12,5	200

Table 1. Temperature dependence of mechanical strength.

4. Experiments and further investigations

The mechanical properties of the manufactured parts with use of rapid prototyping strongly depend on the process parameters, thickness of a layer, grain size, manufacturing system and direction of printing.

In this purpose, series of specimens are produced and tested using two special machines. The first one is the strength testing machine Instron 3367. It is dual column, tabletop, suitable for tension, compression, peel, flex and other applications with load requirements to 30kN. The second machine DMA 242 E Artemis is the dynamic mechanical analyzer which allows to characterize the dynamic mechanical properties as a function of frequency, temperature and time.

Based on own experiments, the effective Young's modulus is determined in each of the printing directions. Also the influence of porosity on mechanical strength is checked. In further investigations the results of experiments will be the basis to create material model in FE analyses.

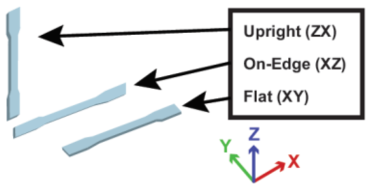
Direction of the 3D printing	Instron 3367	DMA 242 E Artemis
 XZ = X or "on edge" XY = Y or "flat" ZX = or "upright"		

Table 2. Equipment and the idea of experiments.

5. References

[1] I. Gibson, D. Rosen and B. Stucker (2015). *Additive Manufacturing Technology*, 2nd ed. Springer, New York.

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[3] Instron 3367. *http://www.instron.pl/pl-pl/products/testing-systems/universal-testing-systems/electromechanical/3300/3360-dual-column*, (May 2016).

[4] DMA 242 Artemis. *https://www.netzsch-thermal-analysis.com/us/products-solutions/dynamic-mechanical-thermal-analysis/dma-242-e-artemis/*. (May 2016).