Rotating fatigue analysis of 3D printed specimens from assorted materials

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ABSTRACT

Fused filament fabrication (FFF), as a form of additive manufacturing (AM), in recent years has become a popular method to manufacture prototypes, as well as functional parts. The most common materials, i.e. the materials that are most widely used, are PLA, ABS and ASA. Although there are a lot of research papers that cover the subject of determination of mechanical properties and characteristics, theoretically and experimentally, as well as fatigue characteristics of aforementioned materials, there is a lack of research and scientific papers dealing with the problematics of S-N curves based on rotating bending fatigue analysis of those materials. Consequently, this poster covers the topic of rotating bending fatigue data for 3D printed specimens of given materials, under different loading values.

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INTRODUCTION

- Rapid prototyping (RP), the additive manufacturing (AM) or layered manufacturing (LM) have become a standard tool for fabricating models, either for visualization, design verification or testing of developing assemblies.
- There are a lot of advantages of AM technologies over traditional manufacturing methods, mainly in terms of speed and cost of manufacturing.
- Nowadays, fused filament fabrication (FFF) is the most widespread AM process or 3D printing technology, available in the market. FFF is basically an extrusion process of melted input material, mostly polymers.
- The basic of FFF process is depositing melted material, layer by layer, thus the term layered manufacturing.
- Although there are a lot of research papers that cover the subject of determination of mechanical properties and characteristics, theoretically and experimentally [1, 2, 3], as well as fatigue characteristics [4, 5] of aforementioned materials, there is a lack of research and scientific papers dealing with the problematics of S-N curves based on rotating bending fatigue analysis of those materials [6].

MATERIALS

- Most popular materials used in AM and FFF manufacturing technologies are thermoplastic polymers:
  - ✓ polylactic acid or polylactide (**PLA**);
  - ✓ acrylonitrile butadiene styrene (**ABS**);
  - ✓ acrylonitrile styrene acrylate (**ASA**).
- Manufacturers of used materials in this work:
  - ✓ *Raise3D Premium* (PLA & ABS);
  - ✓ *Primaselect™* (ASA+).

Table 1. Selected polymer material characteristics.

Material:		Experiment	Manufacturer
PLA	E [GPa]	2923	2636
	σ_m [MPa]	32,13	46,6
ABS	E [GPa]	2182	2174
	σ_m [MPa]	22,81	33,3
ASA+	E [GPa]	1996	2020
	σ_m [MPa]	29,85	48

TESTING

- In order to determine the stress to number of cycles (S/N) curves of proposed polymer materials, 3D printed test specimens, as shown in Fig. 1 - left, have been prepared and used.

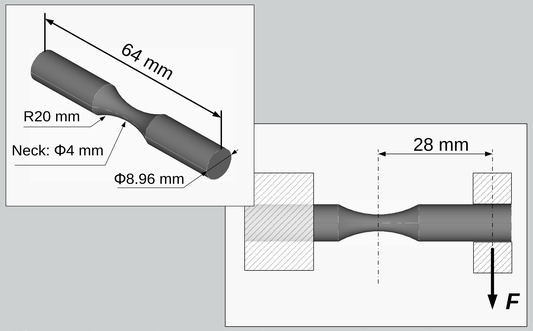

Figure 1. Used test specimens and specimen setup.

- The rotating fatigue machine (Fig. 2) rotates test specimen under constant load, using an adjustable dead weight, thus applying a vertical load on the specimen (Fig. 1 - right).
- Sensor counts the rotations (cycles) of the specimen and a load cell measures the force applied.
- Selected cycle rates for all specimens and materials, are as follows: **10Hz**, **20Hz**, **30Hz**, meaning that every specimen goes through tension and compression stress.

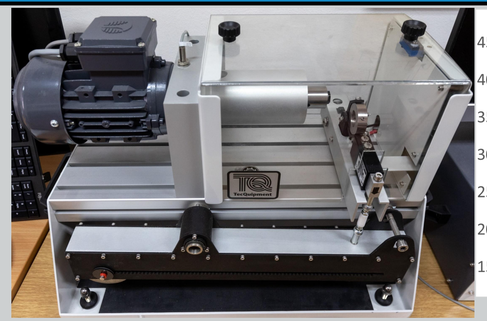

Figure 2. The rotating fatigue machine.

RESULTS

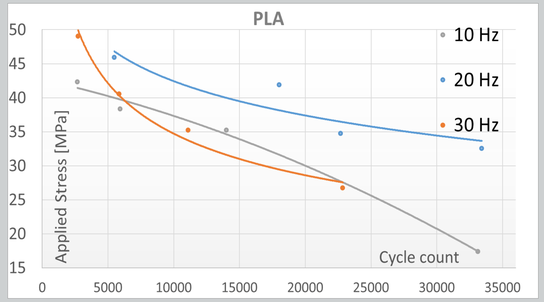

Figure 3. S-N curves for PLA for given cycle rates.

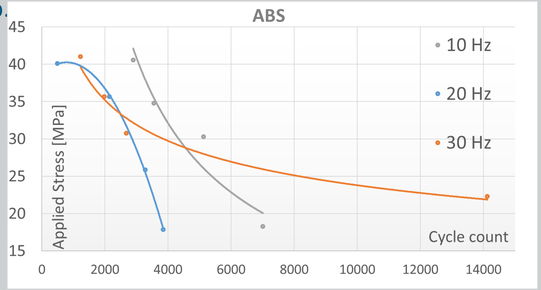

Figure 4. S-N curves for ABS for given cycle rates.

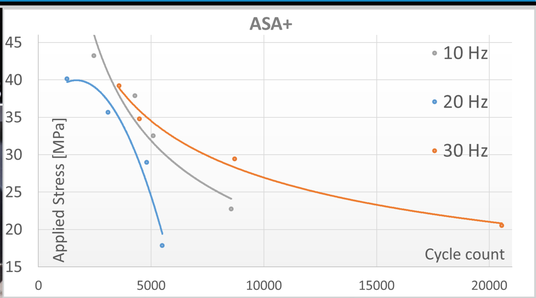

Figure 5. S-N curves for ASA+.

CONCLUSIONS

- Poster at hand gives a preview of rotating fatigue analysis of selected polymer materials.
- Test specimens were printed using Raise3D PRO2 Plus 3D printer, with infill density 100% and *grid* infill pattern.
- Since ASA+ is mechanically similar to ABS (ASA contains saturated weather resistant acrylate rubber, thus much more UV resistant than ABS), a similarity in S-N curves can be observed.

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