SPT323 - Material Comparison Part 2: Creation and Testing

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Fabrication Process: FDM/FFF
Reason: FDM/FFF 3D printing was the fabrication method of choice. This was required as the metal-composite material I was comparing was only available in a filament. This also allowed fabrication time to be brief and any printing mistakes / broken fasteners could be quickly replaced.

Because of my partially failed testing in previous studies, I decided to print out a solid bolt and then thread the bolt post-printing. In theory, this will result in cleaner, more robust threads while allowing for an overall stronger and easier-made print.

Print Settings:

Nozzle Size: 0.4mm (Stainless Steel)

Layer Height: 0.15mm

Line Width: 0.3mm

Shell Thickness: 1.8mm (6 layers)

Top/Bottom Thickness: 0.9mm (6 layers)

Infill: 100%, Rectilinear

Print Temperatures

Hotend: 235c

Build Plate: 90c

Flowrate: 100% (density: 7.83g/cm³)

Print speed (general): 30-80mm/s

Support used with raft

Test Plan:

Property tested will be torque applied to fastener along longest axis. Nominal Torque Limit for class 8.8 M6 ZC-SS fastener = 9.9Nm/7.3 ft lb.

Variables:

Independent: Fastener material, fastener size, tooling, fastening speed

Dependent: Torque measurement, location of break, details of break

Tools Required:

- M6x1.0 Nuts/Bolts (in both testing materials)
- M6x1.0 Taps/Dies (cleaning/preparing nuts/bolts)
- Wrench (preferably fixed, non-adjustable to remove possible tool slack)
- Vice
- Machine Oil
- Scale Gauge (with upper/lower limits within bolt spec)
- Recording device (paper, computer)

Steps:

1. Prepared bolt will have one (1) SS nut hand-tightened until bottoming out on bolt head. Align bolt and nut faces for vice application

   This will allow for thread joint strength to be tested rather than bolt head joint strength.

2. Bolt with nut will be tightened down into vice until bolt with nut does not move.

   ~5-20Nm pressure.

3. One (1) SS nut will be hand-tightened until bottoming out on existing SS nut.
4. Wrench with scale gauge attached will be placed onto bolt with existing nuts. It will then be rotated in a tightening motion until bolt limit is reached (bolt breaks/strips)
5. Measurements taken, nuts cleaned, repeat process for subsequent bolts.

Minimum Success Criteria:

The end goal for this experiment is to see the practicality for using 3D printed fasteners in the real world. I want to test to see if the 3D printed bolts can even support any load at all before failing. The expectations I have for the 3D printed fasteners are low solely because they are not being properly post-processed. I also am concerned with the test rig as it may be prone to bad results due to inaccuracies of data.

Physical Prototypes:

Below are the prototypes. The far left image is of the 3D model in CAD, the second image shows three bolt prototypes. The left bolt has not been post-processed, the second bolt has threads cut into it, and the third bolt is a zinc-coated stainless-steel bolt.