# How to print a gear that lasts

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**Abstract.** A numbered gear recipe (material, teeth, perimeters, infill, orientation) plus the 2022 Polymers wear test where PETG gears outlasted PLA by 22.3 percent and ABS by 37.

**Keywords:** replacement-parts, part-strength, petg, nylon

## 1 How do you print a gear that lasts?

Print it flat in a tough material, with at least five perimeters, dense infill and teeth big enough for the nozzle. In a 2022 wear test published in Polymers, PETG gears printed at 100 percent infill outlasted PLA by 22.3 percent and ABS by 37 percent at 1.5 Nm and 900 rpm.

### 1.1 The recipe

1. **Pick the material by temperature.** PETG (glycol-modified PET) is the tested choice for a gear that stays below its 69 °C glass transition. Nylon (PA) is what Prusa's Knowledge Base shows for gears. It lists a low coefficient of friction and abrasion resistance, and recommends it for parts needing heat, chemical and mechanical resistance. PLA is stiff but, per Prusa, softens above 60 °C and breaks along layers or into shards on impact.
2. **Give it enough teeth.** EngineerDog's guide sets 13 teeth as the minimum at a 20 degree pressure angle and 9 at 25 degrees, and calls 25 degrees a good balance for a palm-sized gear. The same guide found teeth untrustworthy below about half an inch of gear diameter on a 0.4 mm nozzle.
3. **Use a larger module.** How To Mechatronics' strength tests found gears of module 2.0 to 2.5 stronger than module 1.0 to 1.25. The module is the pitch diameter divided by the tooth count, so bigger teeth on the same gear means fewer of them.
4. **Set five or more perimeters.** How To Mechatronics calls the wall line count the more important setting and recommends 5 or more, with infill of at least 35 percent and up to 100 percent. The Polymers test gears were printed at 100 percent rectilinear infill, 0.2 mm layers, through a 0.4 mm nozzle.
5. **Lay it flat.** The Polymers test printed its gears at 0 degrees, flat on the bed. Each layer then draws every tooth as a closed perimeter, and the bending load on a tooth runs along the layers rather than across the weld between them. The XY-versus-Z figures behind that rule are on the replacement-parts guide.
6. **Prefer herringbone.** How To Mechatronics advises avoiding spur gears in favor of herringbone where possible, and pairing helical gears with bearings that take axial load.
7. **Correct for the extra width.** How To Mechatronics used a horizontal expansion of -0.15 mm and a 0.1 mm first-layer offset against elephant's foot; EngineerDog oversizes holes by about 0.005 inch across the diameter.
8. **Make it thick enough.** EngineerDog: gear thickness at least three to five times the circular pitch.
9. **Grease it.** EngineerDog recommends heavy grease: white lithium, PTFE or silicone.

### 1.2 Why PETG outlasted PLA and ABS in the test

The test used module 6 gears: a 17-tooth pinion driving a 22-tooth gear, both 10 mm wide. Each plastic gear ran against a steel driven gear at 1.5 Nm and 900 rpm. After 100,000 rotations the PETG gears had worn 30 percent less than ABS and 40 percent less than PLA. Run to failure, the ABS gears showed damage first.

The authors' explanation is ductility: PETG's elongation at break was 4 to 5 times that of PLA and ABS, so PETG teeth deformed and recovered where the harder, more brittle materials chipped. Bambu Lab's PETG Basic sheet gives the same picture on impact, 34.2 kJ/m² in XY against 10.5 kJ/m² in Z, which is why the flat orientation in step 5 matters.

### 1.3 When nylon wins

The Polymers test did not include nylon. EngineerDog ranks it first, nylon above PLA above ABS above PETG, while warning it is the hardest to print. How To Mechatronics' own nylon result was inconclusive because of filament quality.

Prusa's material page covers the trade: polyamide is highly hygroscopic and can absorb water up to 10 percent of its weight, warps, and needs a 285 °C nozzle and a 110 °C bed. A nylon gear that has sat out for a week is a wet gear. Dry it before printing and store the part dry.

### 1.4 What the test does not tell you

The gears were module 6 and printed solid. A module 1 appliance gear from a 0.4 mm nozzle has teeth that are only

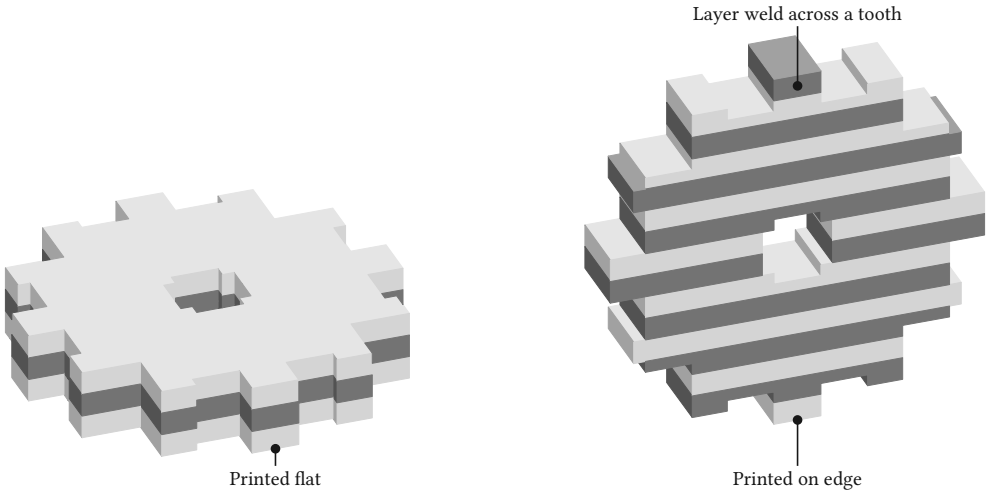



**Figure 1.** Printed flat, each layer draws every tooth whole; printed on edge, the teeth at the top and bottom are split by the welds between layers.

a few extrusion widths wide, so the perimeter count in step 4 sets the whole tooth and the infill setting never applies. The wear percentages are relative, and the paper gives no cycle count at failure, so treat the ranking as evidence and the numbers as test-rig figures.

The two guides disagree on PLA. EngineerDog rates PLA second for rigidity and wear when the gear stays cool; the Polymers test wore PLA fastest at 900 rpm, where friction heat is part of the load. A slow hand-cranked gear and a motor-driven one are different jobs.

### 1.5 How to check it on your own print

1. Print one gear at the settings above and one at your slicer defaults, in the same material.
2. Run the pair on the real shaft at working load for an hour, then look at the tooth flanks under a loupe for whitening or flattening.
3. Measure the tooth width with calipers before and after. Any change means a bigger module, more perimeters or a tougher material.

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