How to design snap-fit clips for replacement parts

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Abstract. Cantilever clip rules from Bayer's snap-fit guide: taper the arm to half its root thickness, fillet the root, keep strain under 2.5 to 4 percent, print the arm flat.

Keywords: snap-fits, replacement-parts, part-strength

1 How do you design a snap-fit clip that survives?

Make it a tapered cantilever. Bayer's design guide reduces the arm thickness to half its root value at the hook, which raises the permissible deflection by more than 60 percent over a constant arm. Add a root fillet of at least half the base thickness, keep the bending strain within the material's limit, and print the arm lying flat.

1.1 The dimensions

Table 1. The dimensions

Feature	Rule	Source
Arm taper	Thickness at the hook = half the thickness at the root (or width at the hook = a quarter of the root width)	Bayer guide, Table 1 designs 2 and 3
Root fillet	A radius-to-thickness ratio of 0.6 gives most of the stress relief; never below 0.015 in (0.38 mm)	Bayer guide, Fig. 9
Root fillet, printed	At least 0.5 times the base thickness	Protolabs Network
Arm width	5 mm minimum	Protolabs Network
Permissible short-term strain, one snap	Polycarbonate 4 percent; PC/ABS 2.5 percent; 10 percent glass-filled PC 2.2 percent; 20 percent glass-filled PC 2.0 percent	Bayer guide, Table 2
Repeated snapping	About 60 percent of the one-snap value	Bayer guide, Table 2
Material with no yield point	About half the elongation at break	Bayer guide, Fig. 13
Clearance around the clip	0.5 mm for FDM (0.3 mm for SLS, SLA, MJF)	Protolabs Network
Print orientation	Avoid cantilevers built vertically in Z	Protolabs Network

Bayer's strain table covers its own molded polycarbonate grades, not printed PLA or PETG. No cited source gives a strain limit for printed filament, so the half-of-elongation rule is the fallback. Bambu Lab's data sheets give elongation at break of 12.2 percent for PLA Basic in XY and 7.5 percent in Z, and 9.5 percent and 5.2 percent for PETG Basic. Halving the Z figure is the conservative start for a clip whose arm you cannot lay flat.

1.2 Why the taper and the fillet

The deflection during assembly equals the undercut, so the undercut sets the strain. In a constant-section arm the strain piles up at the root. Bayer's polarized-light photos show a constant arm using 17 percent more material and carrying 46 percent higher strain than a tapered arm whose thickness falls to 30 percent of the root cross-section. The taper spreads the strain along the length, which is why the arm can bend further before it whitens.

The root is where every clip breaks. Bayer's Fig. 9 shows stress concentration falling steeply with radius until the radius-to-thickness ratio reaches about 0.6, after which the gain is marginal. A bigger radius makes a thick corner, which in molding means sinks. In printing the cost is smaller, so lean toward the 0.5 times thickness Protolabs Network recommends.

1.3 The design procedure

1. Measure the undercut on the original clip: how far the hook must deflect to pass its catch. That deflection is the strain budget. The measuring guide covers the caliper work.
2. Pick the strain limit. For a one-time snap in a stiff material use Bayer's 2 to 4 percent range. For a clip that will be opened repeatedly, take 60 percent of that limit.
3. Make the arm long and thin rather than short and thick. A longer arm reaches the same undercut at lower strain. Protolabs Network's width floor is 5 mm.
4. Taper the thickness from the root to half at the hook. Fillet the root at half the base thickness or more.
5. Orient the part so the arm bends within a layer, never so the hinge line runs across layers. If the part cannot lie flat, tilt the whole part. The Z elongation of PLA Basic is 61 percent of its XY value, and an arm built upright snaps at the root instead of flexing.

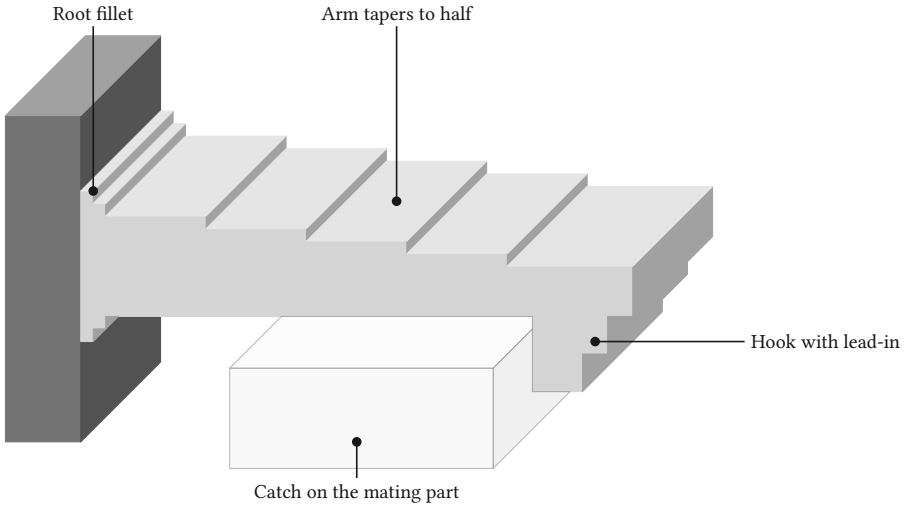


Figure 1. The arm thins from the root to half its thickness at the hook, and the root corner is rounded where the strain would otherwise collect.

6. Give the hook a lead-in and leave 0.5 mm of clearance around the moving arm. Print one, snap it ten times, and look at the root for whitening before you print the rest.

1.4 Material

Stiff, brittle materials fail snap fits at the root. Bambu Lab's PLA Basic breaks at 12.2 percent elongation in XY and PETG Basic at 9.5 percent. Both lose roughly 40 to 45 percent of that across layers. Design to the reduced figure. The replacement parts guide covers the heat and load limits that decide between the two.

References

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