8.5 Additive manufacturing

Name: _____ Class: _____ Date: _____ **Total: 15 marks**

KEY WORDS additive manufacturing • staircase effect • cusp height • anisotropy

Objective

Count layers and build time, find the cusp height on a sloping wall, and decide between printing and machining by break-even.

1 Key knowledge and worked examples

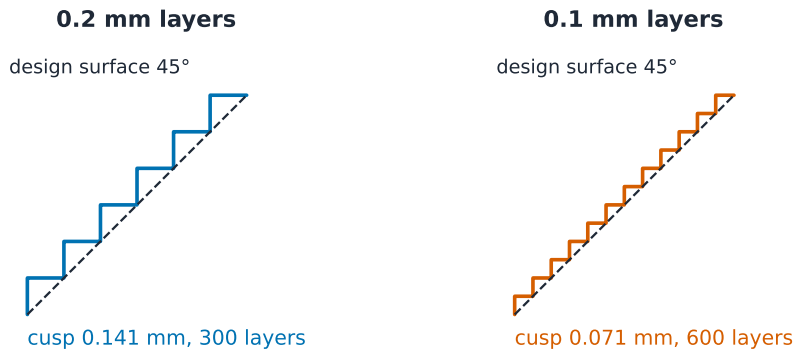
■ **Layers, cusps and cost**

- **Additive manufacturing** builds a part layer by layer: layers = height / layer thickness t.
- **Staircase effect** : on a wall at angle θ to the build plate the **cusp height** is $c = t\cos\theta$; a vertical wall ($\theta = 90°$) has none.
- **Anisotropy** : parts are weakest across the layers.
- Break-even quantity = set-up cost / (unit cost difference).

■ **Worked example. Layer choice for the straightener**

The part is 60 mm tall, with a 45° wall.

- At 0.2 mm: $60/0.2 = \mathbf{300}$ layers and $c = t\cos\theta = 0.2\cos 45° = \mathbf{0.141}$ mm.
- At 0.1 mm: 600 layers and $c = 0.071$ mm: twice the time for half the roughness.
- Turning the wall vertical removes the cusp: orientation is the first lever.



2 Practice

2.1 A part 45 mm tall is printed in 0.15 mm layers at 30 s per layer. Find the number of layers and the build time (min). [3]

2.2 Find the cusp height on a wall at 60° to the build plate with 0.2 mm layers (two decimals, mm), and on a 30° wall (three decimals, mm). Which wall looks rougher? [3]

2.3 Printing costs €55 a part with no set-up; machining costs €300 of set-up plus €15 a part. Up to how many parts is printing cheaper? [3]

3 Exam-style questions

3.1 The machined design of 2.3 is two parts that need an extra €20 assembly step each; the printed part is one piece. Find the new break-even, and which route is cheaper for an order of 20, with both totals. Name one property risk of the printed part. [6]

Solutions

2.1

- Layers $= 45/0.15 =$ **300**.
- Time $= 300 \times 30 = 9000$ s $=$ **150** min.

2.2

- 60°: $c = t\cos\theta = 0.2\cos 60° =$ **0.10** mm.
- 30°: $c = 0.2\cos 30° =$ **0.173** mm, so the shallower wall is rougher.

2.3

- Break-even $= 300/(55 - 15) = 7.5$ parts.
- Printing is cheaper up to **7** parts.

3.1

- Machined unit cost becomes $15 + 20 =$ €35: break-even $= 300/(55 - 35) =$ **15** parts.
- For 20: printing $20 \times 55 =$ €1100; machining $300 + 20 \times 35 =$ €1000. Machining is cheaper by €**100**.
- Anisotropy: the printed part is weaker across its layers, so a load across them needs checking.