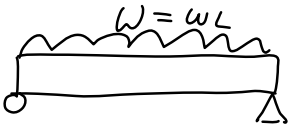
Holiday work (tripos Qs)

13 April 2020 17:41

2019 Q11 (long)



From structures databook

central deflection $= \frac{5WL^3}{384EI}$ (1)

$W = mg$

$= \rho L b d g$ (2)

$I = \frac{bd^3}{12}$ (3)

(3) & (2) → (1)

$\delta = \frac{5\rho bdgL^4}{384E\frac{bd^3}{12}}$

$= \frac{5\rho gL^4}{32Ed^2}$ QED

$\frac{M}{I} = \frac{\sigma}{y}$

$\sigma_{max} = \frac{(My)_{max}}{I}$

from structures databook, $M_{max} = \frac{WL}{8} = \frac{\rho bdL^2 g}{8}$

$I = \frac{bd^3}{12}$

$y_{max} = \frac{d}{2}$

$$\therefore \sigma_{max} = \frac{\frac{\rho b d^2 L^2 g}{16}}{\frac{bd^3}{12}}$$

$$= \frac{3\rho g L^2}{4d} \qquad \text{QED}$$

b) stiffness constraint

$$\delta = \frac{5\rho g L^4}{32 E d^2} \leq 0.20\ m$$

$$\frac{185g}{7} \frac{\rho}{E d^2} \leq 0.20$$

$$\sqrt{\frac{2025g}{32} \frac{\rho}{E}} \leq d_e$$

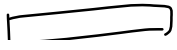
strength constraint

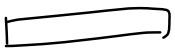
$$\sigma_{max} = \frac{3\rho g L^2}{4d} \leq \frac{\sigma_f}{2}$$

$$\frac{27g}{2} \frac{\rho}{\sigma_f} \leq d_f$$

$0.005 < d < 0.020$

(minimum)	Al foam	Biocomposite	Pine	Poly foam	Fibre board
d_e/m (stiff.)	0.019	0.010	0.0061	0.026 too large	0.011
d_f/m (strength.)	0.037 too large	0.0070	0.0020	0.0071	0.0099

c)  $m = \rho L b d = 6\rho d$

c)  $m = \rho L b d = 6\rho d$

	Biocomp.	Pine	~~Fibreboard~~
min. mass/kg	31.8	21.96	~~49.2~~ too large
Cost/£	25.99	17.57	
embodied energy/MJ	222.6	263.52	

∴ Biocomposite has lowest embodied energy

d)

	Biocomp.	Pine
transport energy/MJ	29.892	20.642
total energy/MJ	252.99	284.16

parking doesn't change

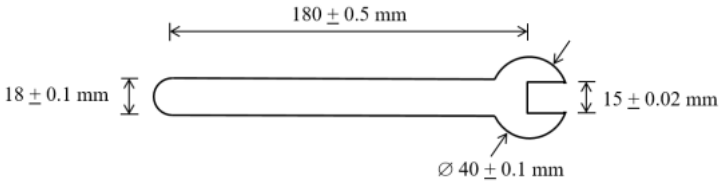
(252.49 < 294.16)

(36 minutes)

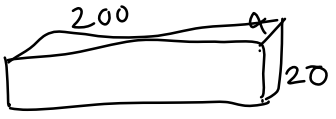
2018 Q9 (short)

9.

a)



$t = 4 \pm 0.1$ mm

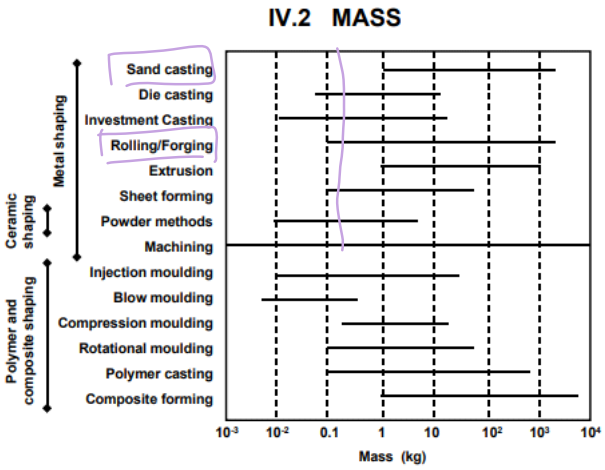
mass ≈ 

$\rho = 7.85\ Mg\,m^{-3}$

$= (200 \times 20 \times 4) \times (10^{-3})^3 \times \rho$

$= 125.6\ g$

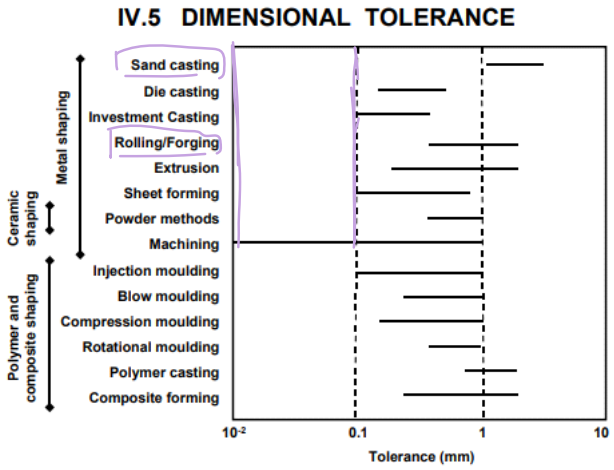
$= 0.1256\ kg$



forging is better for mass

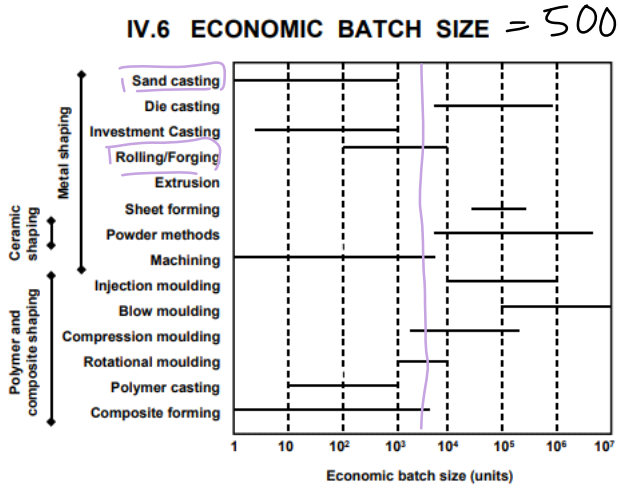
Figure 4.2: Process attribute chart for shaping processes: mass range (kg)

tolerance → ± 0.02mm (limiting)
→ ± 0.1 mm for most



neither sufficient
∴ require machining

Figure 4.5: Process attribute chart for shaping processes: dimensional tolerance (mm)



forging is better than sand casting

Figure 4.6: Process attribute chart for shaping processes: economic batch size

Figure 4.6: Process attribute chart for shaping processes: economic batch size

Process → use forging

b) heat treament → precipitation hardening

this is where particles provide strong obstacles, hindering the movement of dislocations by "pinning" them in place

This increases the shear stress needed to cause plastic deformation in the spanner. Therefore the fracture toughness will increase (harder to fail plastically)

Young's Modulus originates from atomic bond stiffness ∴ will not be affected by heat treatment