4.5 Processing and property links

Name: _____ Class: _____ Date: _____ **Total: 14 marks**

KEY WORDS heat treatment • solidification

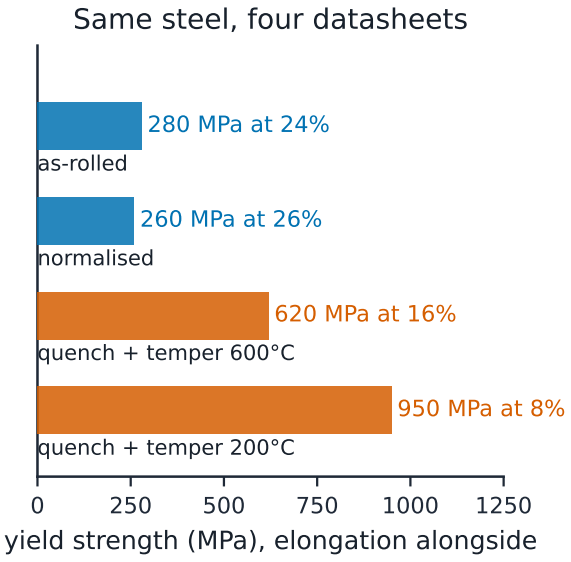
Objective

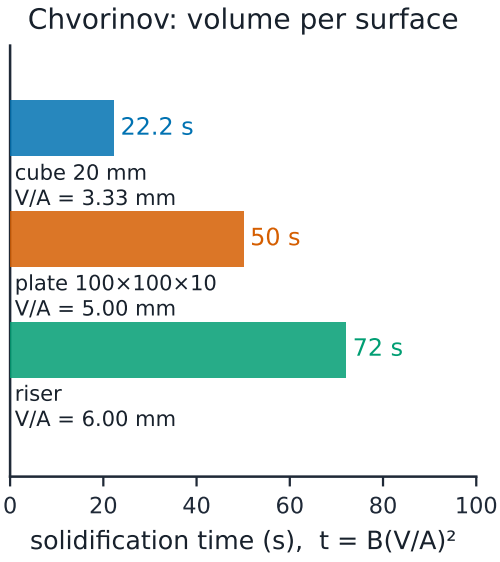
Predict property changes from processing: the heat-treatment menu, Chvorinov's freezing clock, and riser sizing by V/A.

1 Key knowledge and worked examples

■ The process map

Routes (MPa / %): 280/24, 260/26, 620/16, 950/8. Chvorinov $t = B(V/A)^2$ - volume over cooling surface, squared.





*The furnace writes the datasheet

■ Worked example. The clock

$B = 2.0 \times 10^6$: 20 mm cube 22.2 s; 100×100×10 plate 50.0 s - the $(V/A)^2$ ratio 2.25 exactly ✓; a $V/A = 6$ mm riser holds 72.0 s ✓.

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2 Practice

A foundry runs $B = 1.8 \times 10^6$ s/m^2.

2.1 A cylinder 30 mm diameter × 60 mm long: V/A (mm, one decimal) and freezing time (one decimal, s). [4]

2.2 A bar 40×40×160 mm: V/A (three decimals, mm) and freezing time (one decimal, s). [4]

2.3 Which solidifies last, and what does that imply for placing the riser? [2]

2.4 For the impact-loaded mount bracket, choose as-rolled (280 MPa / 24%) or quenched + tempered 600°C (620 / 16%) with one sentence of reasoning. [4]

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Solutions

2.1

- $V = \pi(0.015)^2(0.06) = 4.24\times10^{-5}$ m^3; $A = 2\pi(0.015)^2+2\pi(0.015)(0.06) = 7.07\times10^{-3}$ m^2.
- $V/A = 6.0$ mm, $t = 1.8 \times 10^6 \times (6.0 \times 10^{-3})^2 = 64.8$ s.

2.2

- $V = 2.56 \times 10^{-4}$ m^3; $A = 2(0.04)^2 + 4(0.04)(0.16) = 0.0288$ m^2.
- $V/A = 8.889$ mm, $t = 1.8 \times 10^6 \times (8.889 \times 10^{-3})^2 = 142.2$ s.

2.3

- The bar (larger V/A, 142.2 s): the riser must attach there, with an even larger V/A.

2.4

- Quenched + tempered 600°C.
- Impact energy is absorbed by plastic area: 16% elongation buys toughness the 950/8 route cannot, and 620 MPa clears the specification with margin.

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