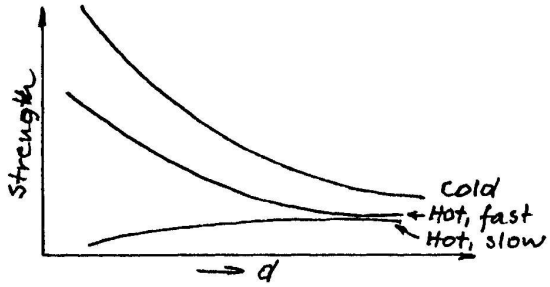
# Solution for ME 355 Homework 7

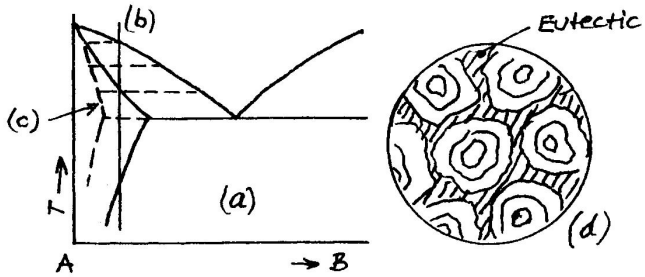
1. 6A-6

Fig. 6-18 (p171)




2. 6A-7

Fig. 6-5 (p150)




3. 7A-5

(a) At a given shear strain rate, viscosity of a pseudoplastic substance decreases with increasing time of exposure.

(b) Rheocast material in which dendrites are broken up to form a globular solid phase in the melt.

4. 7A-7

(a) Isolate from atmosphere
(b) React with impurities
(c) Collect inclusions
(d) React with gases
(e) React with specific alloying elements

5. 7B-23

(a) Use low superheat
(b) Use low mold temperature
(c) Use mold made of a material of high heat conductivity

(d) Increase cooling rates by (b) and (c) above
(e) Inoculate the melt with nuclei to promote heterogeneous nucleation
(f) Break up dendrites by mechanical means (vibration, shearing)
(g) Break up dendrites by applying pressure during solidification

6. 7C-7

The problem can be simplified to calculating strain and stress developed in a 100-mm-long solid bar, fully constrained at both ends.

(a) Strain $e = \alpha\Delta T = (23)(10^{-6})(1100\text{-}900) = 0.0046$

(b) Deformation of "e*l" happened in 10 min (600 sec.),
Shrinkage velocity $v = e*l/t = (0.0046)(100)/600 = 7.67(10^{-4})$ mm/s
From Eq. (4-17), (p102)
Tensile strain rate $\dot{\varepsilon} = v/l = 7.67(10^{-4})/100 = 7.67(10^{-6})\ s^{-1}$

(c) From Table 8-2 (p282), for 1015 steel, at 1000 C, C = 120 MPa; m = 0.1
Therefore: $\sigma_f = C\,\dot{\varepsilon}^{\,m} = 120\ (7.67*10^{-6})^{0.1} = 36.9$ MPa

(d) From Table 5-2 (p130), at room temperature E = 200 GPa
Thus, at 1000 C, E = 0.6*200 = 120 GPa
Elastic stress $\sigma = e\,E = 0.0046(120)\ (10^{9}) = 552$ MPa
Since $\sigma > \sigma_f$, plastic deformation will occur

(e) Critique of the assumptions:

- Mold is unyielding: A sand mold would yield and the stress would be lower. Assumption is reasonable for a ceramic mold but not for a sand mold.
- Mold dimensions are unchanging: They are likely to increase while the mold is heated by the metal, thus the stresses increase too, increasing the danger of hot tearing.
- Friction on mold walls may contribute to disturbing the stresses over the length of the bar, making calculation uncertain.
- The flow stress in Table 8-2 is for large deformations and high strain rates, while the problem falls more into the creep range.

7. 7C-8

According to Chvorinov's rule (p212): $t_s \propto (V/A)^2$

| *Shape* | *Volume* | *Surface area* | $(V/A)^2$ |
|---|---|---|---|
| Sphere | $\pi d^3/6$ | $\pi d^2$ | 0.0278 |
| Cylinder (h/d = 1) | $(\pi d^2/4)d$ | $\pi d^2/2 + \pi d^2$ | 0.0212 |
| Cylinder (h/d = 10) | $(\pi d^2/4)10d$ | $\pi d^2/2 + 10\pi d^2$ | 0.0093 |
| Cube (a = d) | $d^3$ | $6d^2$ | 0.0181 |

Thus, the longest solidification time is secured by a sphere.