HW 2 - METE

Q1) increased from 30 cm x 10 cm to 32 cm x 12 cm

Original Area (A_0) = 30 x 10 = 300 cm^2

Final Area (A_f) = 32 x 12 = 384 cm^2

Percent CW ; $CW\% = \frac{A_f - A_0}{A_0} \times 100 = 28\%$

From diagrams, for CW% = 28,

$\boxed{\text{Yield strength} = 760 \text{ MPa},}$

$\boxed{\text{Ductility} = 11\%}$

Q2) Strengthening is the relation between dislocation motion and mechanical behavior. Hardness and strength are related to the ease with which plastic deformation occurs. The aim is to reduce dislocation mobility and hence increase the force necessary to cause dislocation motion since the ability of a metal to plastically deform depends on the ability of dislocations to move.

Main strengthening mechanisms:

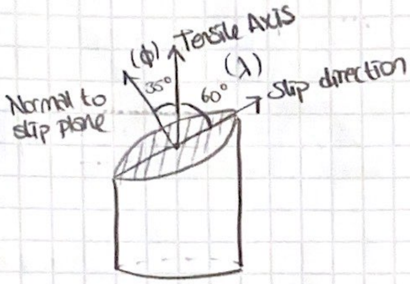
① Grain size reduction: Since atomic disorder at grain boundaries cause a discontinuity in slip planes, grain boundaries are bariers to slip. By reducing grain size, we achieve to increase grain boundary area

② Solid-solution alloying: Adding pinning points that inhibit the motion of dislocation causes the metal to require more stress to continue dislocation motion because of the distortion of lattice and stress generated.

③ Precipitation strenghtening: Hard precipitates are difficult to shear and precipitates act as pinning sites.

(4) <u>Cold Work</u>: while simultaneously deforming the metal, we strain harden the metallic material.

Q3)



$\boxed{\tau_{crss} = 6 \text{ MPa}}$

$\phi = 60°$ $\lambda = 35°$ $\sigma = 11.6$ MPa

$$\tau_R = \sigma . \cos\phi . \cos\lambda$$

$$\tau_R = (11.6) . \underbrace{\cos 60}_{0.5} . \cos 35$$

$$= \boxed{4.75 \text{ MPa}}$$

4.75 MPa $< \tau_{css} = 6.2$ MPa, therefore single crystalline <u>will not yield.</u>

Q4)

Time	Avg diameter
30	$10 . 10^{-6}$
120	$18 . 10^{-6}$

(a)

$d^n - d_0^n = K.t$ $n \sim 2 \rightarrow d^2 - d_0^2 = K.t$

$$(10 \mu m)^2 - d_0^2 = 30K$$

$$(18 \mu m)^2 - d_0^2 = 120K$$

$$224 \mu m^2 = (90 \text{ min})K \rightarrow K = \frac{224}{90} \frac{\mu m^2}{min}$$

$$100 \mu m^2 - d_0^2 = (30 \text{ min}) . \left(\frac{224}{90} \frac{\mu m^2}{min}\right)$$

$$\boxed{d_0 = 5.0332 \mu m}$$

(b) $t = 300$ min

$$d^2 - d_0^2 = K.t$$

$$d = \sqrt{K.t - d_0^2}$$

$$d = \sqrt{746.667 - 25.3331}$$

$$\boxed{d = 26.8577}$$

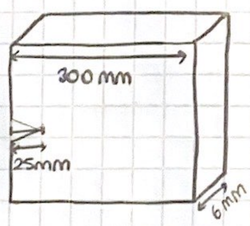
Q5) $K_{IC} = 101$ MPa $\sqrt{m}$, $\sigma_y = 890$ MPa , $S_{design} = 510$ MPa , $y = 1.0$

(a) Critical crack length, $a_{cc} = \frac{1}{\pi}\left(\frac{K_{IC}}{y S_{design}}\right)^2$ (Taken $\pi = 3.14$.)

$$a_{cc} = \frac{1}{3.14} \cdot \left(\frac{101 \text{ MPa} \sqrt{m}}{1.0 \times 510 \text{ MPa}}\right)^2 = 0.01249 \text{ m} = \boxed{12.49 \text{ mm}}$$

(b) $a_{cc} = 12.49$ mm > 2.7 mm , therefore crack can be detected.

Q6) $K_{IC} = 85$ MPa $\sqrt{m}$, $y = 2.1$, $a = 25$ mm



(a) $K_{IC} = y \sigma_c \sqrt{\pi a} \Rightarrow \sigma_c = \frac{K_{IC}}{y\sqrt{\pi a}} = \frac{85 \text{ MPa} \sqrt{m}}{2.1 \sqrt{3.14 . 25 . 10^{-3}}} = 144.4657$ MPa

$$F = \sigma . A = 144.4657 \times 10^6 \times 6 \times 10^{-3} \times 300 \times 10^{-3} = \boxed{260.038 \text{ KN}}$$

(b) $F = \sigma . A = (700 \text{ MPa}) \times (300 \times 10^{-3} \times 6 \times 10^{-3}) = \boxed{1.26 \text{ MN}}$

Q7) (Part a is added in the end.)

(b) Maximum impact energy = 80J

Minimum impact energy = 5J

Average = 42.5 J

Ductile-to-brittle transition temperature is approximately $\boxed{-9.75°C}$

(c) Since $-35°C < -9.75°C$, material acts brittle; therefore, it is not suitable for this application. If it would be used, there will be a brittle fracture which would occur without any warnings.

Q8) (Part a is added in the end.)

(b) Fatigue life N_f for stress amplitude 410 MPa?

Fatigue life 4.95

$\log(N) = 4.95$

$\boxed{N = 89125 \text{ cycles.}}$

(c) There is no data for 300 MPa; however it is safe to check the material after 5×10^7 cycles.

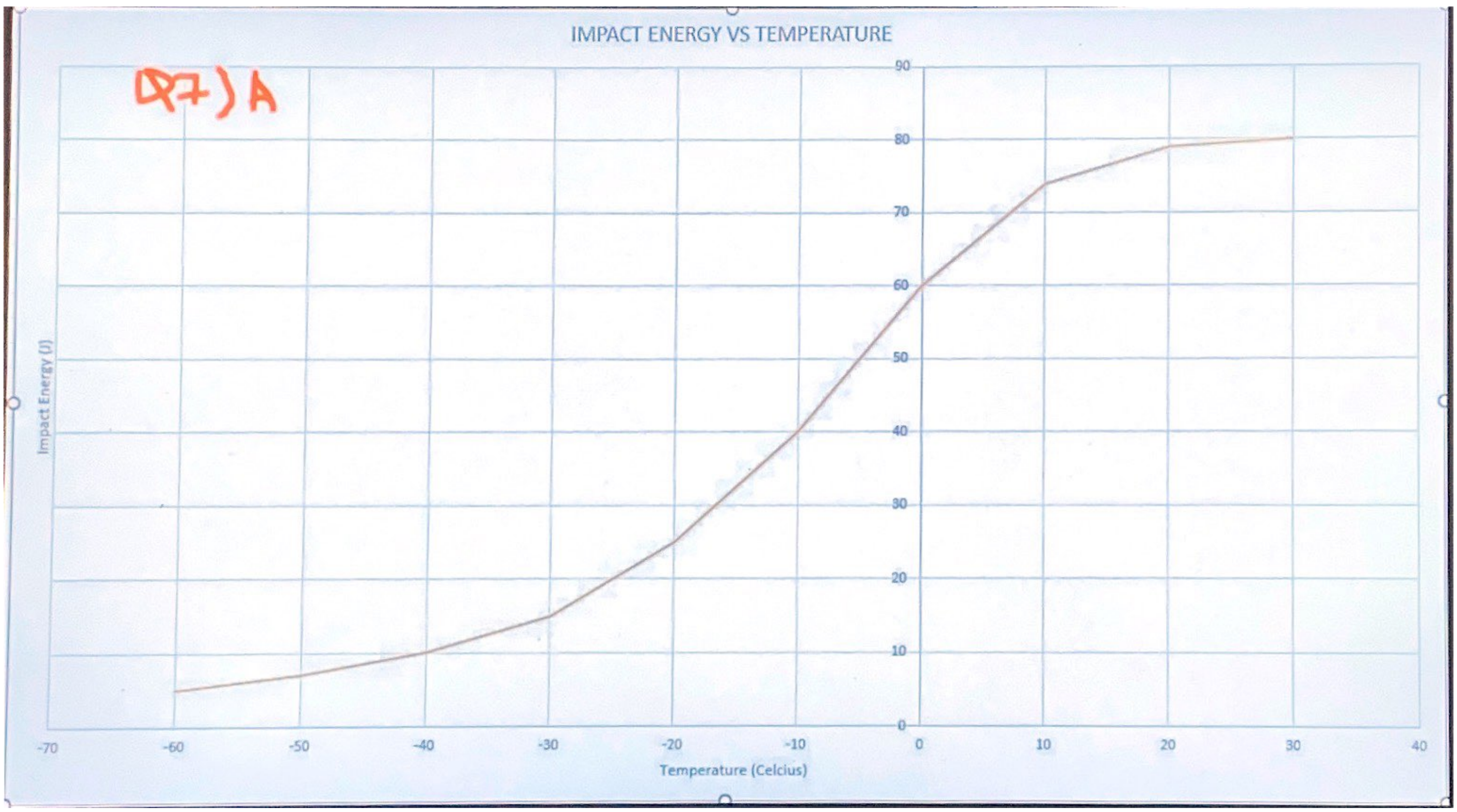
Q9) $\epsilon_s = B \cdot \sigma^n \cdot e^{-\left(\frac{Q_c}{RT}\right)}$ $T = 540°C = 813\ K$, $R = 8.315$

Reciprocal temperature $\left(\frac{1}{T}\right) = 1.23 \times 10^{-3}\ (K^{-1})$

$\sigma = 40 MPa$

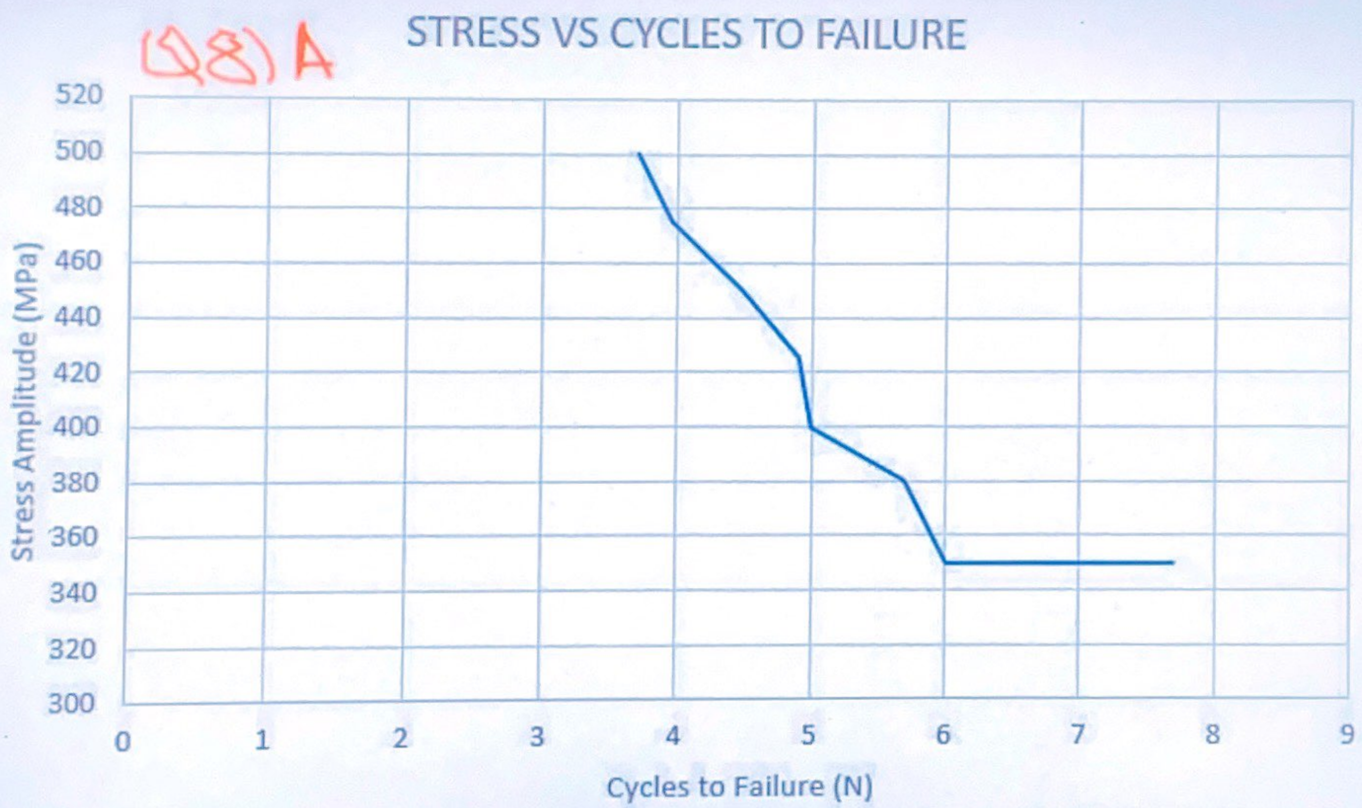
$\dot{\epsilon}_s = 5 \times 10^{-5}\ (hr^{-1})$

$\frac{5 \times 10^{-5}}{3600}\ (1/s) = 1.39 \times 10^{-8}\ (1/s)$



IMPACT ENERGY VS TEMPERATURE
Q7) A
Impact Energy (J)
Temperature (Celcius)
90
80
70
60
50
40
30
20
10
0
-70
-60
-50
-40
-30
-20
-10
0
10
20
30
40

(Q8) A



STRESS VS CYCLES TO FAILURE
Stress Amplitude (MPa)
520
500
480
460
440
420
400
380
360
340
320
300
0
1
2
3
4
5
6
7
8
9
Cycles to Failure (N)