ECEN 425
Mechanical Principles 1 Submission

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1. loss of function uncert : $\pm$ 10%, max allow uncert : $\pm$ 30%

$$
\begin{aligned}
n_d &= \frac{\text{loss of function param}}{\text{max allow param :}} \\
&= \frac{1/0.9}{1/1.3} = 1.4\bar{4} \\
\text{Max. allowable load} &= \frac{500}{1.44} = 346.26 \rightarrow 346N\ (3.sf)
\end{aligned}
$$

2. $n_d = 2.0,$ Nominal Failure $= 100N$

$$\text{Max. allowable load} = \frac{100}{2.0} = 50N$$

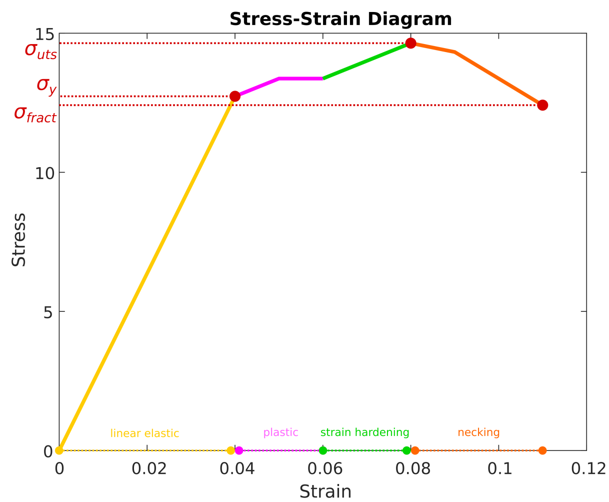
3. $P = 8896.4N,\ S = 165.5MPa,\ n_d = 3.0$

$$
\begin{aligned}
\sigma &= \frac{S}{n_d} = \frac{165.5}{3.0} = 55.1\bar{6} \\
A &= \frac{P}{\sigma} = \frac{8896.4}{55.1\bar{6}} = 161.26mm^2 \\
d &= 2\sqrt{A/\pi} = 2\sqrt{161.26/\pi} = 14.329083 = 14.33mm
\end{aligned}
$$

4. $P = 100N,\ r = 5mm$

$$
\begin{aligned}
A &= \pi r^2 = \pi 5^2 = 78.539816 \\
\sigma &= \frac{P}{A} \\
&= \frac{100}{78.54} = 100/78.54 = 1.273237 \\
&= 1.27N/mm^2\ or\ 1.27MPa
\end{aligned}
$$

5. Used MATLAB for plotting:




```
%% 5
clear;clc;
load("q5.mat"); % has Force/Strain table and diameter values
%%
A = pi*(d/2)^2;
Stress = Force./A;
%%
figure();
plot(Strain,Stress);
xlabel("Strain");
ylabel("Stress");
title("Stress-Strain Diagram");
```

6. (a)

$$E = \frac{\Delta\sigma}{\Delta\epsilon} = \frac{12.7324}{0.04} = 318.31MPa = 0.31831GPa$$

(b) From the given examples (lecture notes), a Young's modulus of 0.31GPa puts this material more in line with the **thermoplastic** HDPE (0.8GPa) than say steel (200GPa)

(c) Due to the assumption of **constant** diameter, this diagram (q5) has flat and decreasing slope regions where a true stress-strain diagrams would show an always upward but still slightly varying slope until fracture, i.e. because the decreasing diameter is taken into account.

7. $\sigma_y = 500MPa, \ \epsilon_y = 0.02$

$$U_r = \frac{\sigma_y \epsilon_y}{2} = \frac{500 \cdot 0.02}{2} = 5N/mm^2$$

8. $P = 3000kgf,\ D = 10mm,\ d = 5mm$

   (a)

$$\begin{aligned} BHN &= \frac{2P}{\pi D\left[D - \sqrt{D^2 - d^2}\right]} \\ &= \frac{6000}{\pi \cdot 10\left[10 - \sqrt{10^2 - 5^2}\right]} \\ &= 142.55 \end{aligned}$$

   (b) The Brinell Hardness test as larger indenter than Rockwell so can give a better measure of average hardness across the sample.

9. (a) No, because it did not undergo any plastic deformation and is thus a brittle alloy.

   (b) No, Sea-ice collision could be characterised as a sharp impact and thus a brittle material could not sufficiently enough energy to prevent fracture.
   "Regardless of the strength, the steel used in the hull structures of an icebreaker must be capable of resisting brittle fracture in low ambient temperatures and high loading conditions, both of which are typical for operations in ice-filled waters[1]"

   [1] Chapter 5 Ship Design and Construction for Ice Operations. Canadian Coast Guard. Retrieved 2013-08-20.

10. $d_0 = 14.0mm,\ E = 111.0GPa,\ \nu = 0.349,\ P = 20kN$

$$\begin{aligned} \sigma &= \frac{P}{\frac{\pi}{4}d_0^2} = \frac{20kN}{\frac{\pi}{4}14^2} = 0.12992\frac{kN}{mm^2}\ (GPa) \\ \sigma = E\epsilon,\ \epsilon_{long} &= \frac{\sigma}{E} = 0.12992/111.0 = 0.00117 \\ \epsilon_{lat} &= -\nu \cdot \epsilon_{long} = (-0.349)(0.00117) = -0.000408 \\ \Delta d &= \epsilon_{lat} \cdot d_0 = 14(-0.000408) = -0.005712 \\ d_f &= \Delta d + d_0 = 14 - 0.005712 = 13.994288mm \end{aligned}$$

11. $l_0 = 100mm,\ l_f = 100.559mm,\ d_0 = 10mm,\ d_f = 9.980mm,\ P = 50kN,\ E = 114.0GPa$

$$\begin{aligned} \epsilon_{lat} &= -\frac{\Delta d}{d_0} = -\frac{10 - 9.980}{10} = -0.002 \\ \epsilon_{long} &= \frac{\Delta l}{l_0} = \frac{100.559 - 100}{100} = 0.00559 \\ \nu &= -\frac{\epsilon_{lat}}{\epsilon_{long}} = -\frac{-0.002}{0.00559} = 0.35778 \end{aligned}$$

    Closest to Magnesium (0.350) but also not far from Phosphor Bronze (0.349).

12. $P = 2kN,\ A = (12mm \times 16mm) = 192mm^2$

$$\tau_{avg} = \frac{V}{A} = \frac{2kN}{192mm^2} = 0.010417GPa = 10417KPa$$

13. $\tau_{max} = 500KPa,\ n_d = 2.0,\ V = 20kN$

$$\begin{aligned} \text{max. load} &= 500/2 = 250KPa \\ A &= \frac{V}{\tau_{max}} = \frac{20kN}{0.000250GPa} = 80000mm^2 \end{aligned}$$