EL-MANSOURA UNIVERSITY
FACULTY OF ENGINEERING
DEPT. OF PROD. & MECH. DESIGN

FINAL EXAM., JAN. 2013
ELECTIVE COURSE (3) (DESIGN)
BSC. STUDENTS

TIME ALLOWED : 3 HOURS

- SOLVE ALL PROBLEMS.
- PROVIDE NEAT SKETCHES WHERE NECESSARY.
- ASSUME ANY MISSING DATA.
- DESIGN EQUATIONS ARE PROVIDED.
- ALL PROBLEMS HAVE SAME MARKS. (TOTAL MARKS ARE 100)
- YOUR ANSWER SHOULD REFLECT DEEP UNDERSTANDING OF SUBJECTS.

## PROBLEM # 1 :

The design process can be outlined in several steps starting from "Need" to "Product Retirement", and it is related to a large number of considerations.

a) Give list of these steps with a short explanation of each step.
b) Apply these steps to a need from your own experience.
c) Make a list of at least 10 design considerations and write scientific notes on only **THREE** of these considerations.

## PROBLEM # 2 :

A rotating disc which is spinning at high speed is to be made of AISI alloy steel; the properties of which are:

$\sigma_u$ = 1800 MPa ; $K_{IC}$ = 60 MPa$(m)^{1/2}$ ; $\nu$= 0.3; $\rho$ =7800 Kg/$m^3$

If the maximum hoop stress in the disc occurs at the inner surface and is given by:

$$\sigma_{max} = \frac{3+\nu}{4}\rho\omega^2 c^2\left[1+\frac{1-\nu}{3+\nu}\left(\frac{b}{c}\right)^2\right]$$

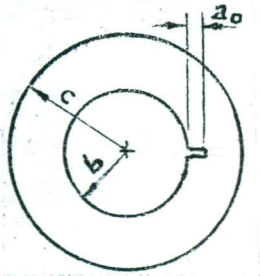


Figure 1

Where $\rho$= mass density
$\nu$= Poisson's ratio
$\omega$= 2πN/60 , the angular velocity
and $c$ & $b$ are as defined in Figure 1.

Calculate the maximum speed of rotation, N(RPM) using conventional design technique (infinite-life design approach which is based on factor of safety).

If internal cracks of length "a" can develop on the inner surface of the disc, use damage-tolerant design approach to calculate the maximum value of N. Compare the two values and give comments.

The stress intensity factor is given by:

$$K_1 = 1.12\,\sigma\,(\pi a)^{1/2}$$

Take $b/a_o$ = 10 ; $c/b$= 2 ; $a_o$ = 2.50 mm

## PROBLEM # 3 :

A cylindrical storage tank for liquified gas having an internal pressure p=10 MPa. The material of the tank should have a yield strength ≥ 500 MPa and a fracture toughness ≥ 60 MPa $\sqrt{m}$ .

It is required to perform the following design steps:

a) Make a full analysis of material selection using the data of table 1. Use any selection method.
b) Using the material selected in step (a) above, calculate the mean diameter and the thickness of the tank based on Leak-before-break design criterion.
c) Suggest a manufacturing method stating reasons for your suggestion.
d) Prepare necessary engineering drawings.

**TABLE 1**

| Material | Densities ($Mg/m^3$) | Price (£/ton) | Thermal Conductivity (%) | Corrosion Resistance (%) | Yield Strength (MPa) | Stiffness E, (GPa) | Fracture toughness ($MPa(m)^{1/2}$) |
|---|---|---|---|---|---|---|---|
| Galvanized Steel | 7.86 | 8000 | 25 | 20 | 480 | 205 | 65 |
| Medium Carbon Steel | 7.75 | 10000 | 28 | 15 | 620 | 207 | 60 |
| Low Alloy Steel | 7.80 | 20000 | 26 | 18 | 500 | 202 | 63 |
| Stainless Steel | 7.95 | 42000 | 30 | 50 | 400 | 201 | 60 |
| Nickel Steel | 7.85 | 36000 | 35 | 35 | 460 | 200 | 50 |
| Aluminum (pure) | 2.70 | 45000 | 82 | 80 | 200 | 70 | 82 |
| Aluminum Alloy | 3.20 | 48000 | 85 | 78 | 600 | 75 | 65 |
| Copper | 8.95 | 60000 | 100 | 65 | 280 | 80 | 85 |
| Brass | 8.80 | 56000 | 70 | 70 | 350 | 78 | 50 |
| ABS (composite) | 2.10 | 560000 | 20 | 95 | 1200 | 160 | 40 |
| Carbon Fiber Composite | 1.95 | 480000 | 12 | 100 | 800 | 140 | 62 |

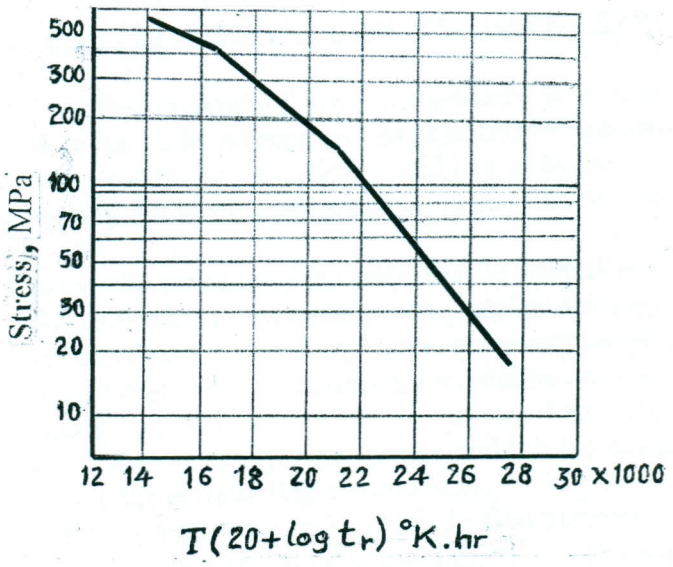
## PROBLEM # 4 :

a) Explain what is meant by "Design charts". Give **FOUR** examples and show how it can be of help to the designer.

b) Figure 2 represents creep design curve for components made of 18-8 Mo stainless steel subjected to tensile loads under high temperatures. It is required to:

i) Give a technical analysis of the curve and its importance to the design engineer.
ii) If a circular rod made of 18-8 Mo S.S is exposed to a tensile load of 100 Kn at a temperature of 527°C, calculate the required diameter for a rupture life-time, $t_r$, of 5 years.

Figure 2




iii) If, for the component with the calculated diameter, it is required to increase its life to 10 years under the same temperature;
What is the design parameter which should be changed?
What should be its magnitude?

**Useful Equations**

$\sigma = F/A$ ; $\sigma = MY/I$ ; $\tau = Tr/J$ ; $K = Y\ \sigma\sqrt{\pi a}$ ; $(da/dN) = A(\Delta K)^m$ ; $F_{cr} = \pi^2 EI/CL^2$,

$N_f = [\ a_f^{((-m/2)+1)} - a_0^{((-m/2)+1)}] / [((-m/2)+1)\ A\ (\Delta\sigma)^m\ \pi^{m/2}\ Y^m]$ ; $\sigma = \frac{pr}{t}$

*Best Wishes , Prof. Dr. M. Shabara*