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

FINAL EXAM. , JAN. 2011
SPECIAL COURSE (DESIGN)
FOURTH YEAR

TIME ALLOWED: 3 HOURS

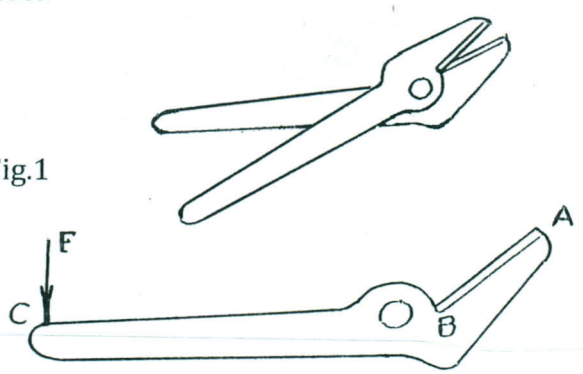
- **SOLVE ALL PROBLEMS.**
- **PROVIDE NEAT SKETCHES WHERE NECESSARY.**
- **ASSUME ANY MISSING DATA.**
- **DESIGN EQUATIONS ARE PROVIDED.**
- **ALL PROBLEMS HAVE SAME MARKS.**

PROBLEM # 1 :

a) State the three modes of crack extension and the type of load associated with each mode.

b) The cutter bar of a hand-operated embosser shown in Fig.1 is operated by pressing at C. The cutting edge is AB. The bar is made of a hardened steel. It is found that the bar broke after about 200 operation cycles. What do you think was the cause of the fracture? Locate the point at which the fracture may have initiated. How could the design of the part be improved? Note that the cutting edge AB was produced by a bevel-edge grinding wheel.

Fig.1



PROBLEM # 2 :

a) The selection of a proper material for a specific application is one of the important tasks of the mechanical designer. List and explain two common methods of material selection.

b) An aircraft windshield is rated according to the following material characteristics.

(b) A straight, uniform rod of length L rotates at uniform angular speed ω about an axis through one end and perpendicular to its length.
The density of the material is γ and Young's modulus is E.
The tensile stress generated in the rod is given by:

$$\sigma = \frac{1}{2}\gamma\omega^2 L^2\left[\left[1 - \frac{r^2}{L^2}\right]\right]$$

Where r is the distance measured from the axis of rotation. See Fig. 2.
The stress intensity factor for a crack of length a located at a point in the middle of the rod is given by:

$$k_{Ic} = 1.12\,\sigma_{max}\sqrt{\pi a_c}$$

If the rod is made of AISI steel with the following properties:

$\sigma = 1980\ MPa$

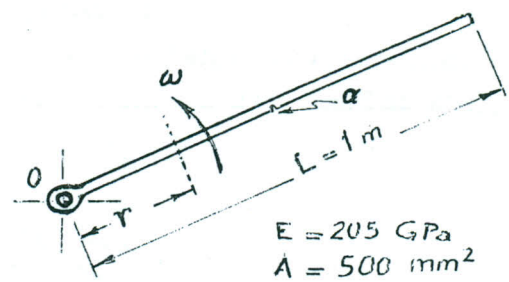
$k_{Ic} = 44\ MPa\sqrt{m}$

$\gamma = 7800\ kg/m^3$

$\omega = 2\pi N/60$, $N = Rpm$

Calculate the critical speed based on conventional design approach and damage-tolerant design approach.

Fig.2



PROBLEM # 5 :

(a) Outline the design process steps and explain the intimate relation between design, material and processing. Support your answer with an example.

(b) There is a **need** for designing a **weight lifting jack**.
Your assignment is to perform full design steps from the start to the end.

Useful Equations

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

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

With my best wishes

Prof. Dr. M. Shabara