MECH9400 – Mechanics of Fracture and Fatigue

Postgraduate Assignment (Semester 2, 2013)

Problem Description

A locking plier made of Aluminium alloy 2014-T6 is shown in Figure 1a. The drawing is in scale so that any dimension may be directly measured from the drawing. A bolt is being clamped between the jaws which require a clamping force (P) of 4 kN applied at the position shown. The components are joined using aluminium pins of 8 mm in length which are under double shear. The lower jaw has a thickness of 5 mm.

Questions

a. What is the magnitude of the clamping force F required to fix the object at the position shown in Figure 1?
b. From literature survey find the pertinent tensile mechanical properties of the material.
c. What is the fracture toughness of the material?
d. Do you consider the parts to be in plane stress/plane strain condition? Why?
e. What is the factor of safety in each pin under the given load?
f. Assuming existing edge cracks at sections a-a to d-d in Figure 2, discuss which crack(s) may propagate under the given load?
g. Find the relevant expression for the stress intensity factor (K_I) for the lower jaw with an existing crack at b-b. In doing so, you may consider the jaw in the failed plane as a plate subjected to simultaneous tensile force and bending moment.
h. Determine the minimum critical crack length (a_{c1}) that could lead to plastic collapse.
i. Determine the minimum critical crack length (a_{c2}) that could lead to elastic fracture.
j. Determine the failure load for the crack-free jaw.
k. For the crack-free jaw, what would be the factor of safety based on stress/load?
l. Which failure occurs first: the crack or the failure in the pins?
m. Why does a crack branch? Explain with the help of appropriate graphs.

Finite Element Modelling

Imagine you are employed in the R&D section of a company that designs tools. Your role is to use ANSYS® to find the stress intensity factor (SIF) distribution in the lower jaw of the plier-wrench in the vicinity of an existing crack (at section b-b) to find critical points that need to be made thicker. You are allowed to make justifiable simplifications to the geometry of the part. Your engineering report should include:

1) Problem description
2) Any assumptions made
3) Modelled geometry
4) Meshed model
5) Stress Intensity plot
6) K_I screen (see the FEM presentation)
7) Your database file (Once you are done, go to File>Save as... and save everything).

General Guidelines

i) Use Distortion Energy failure theory (von Mises yield criterion) where required.
ii) Please explain your assumptions/methods clearly!

Report submission

Please submit your reports through **Moodle** before **Friday 11pm** of the week indicated in the course outline.

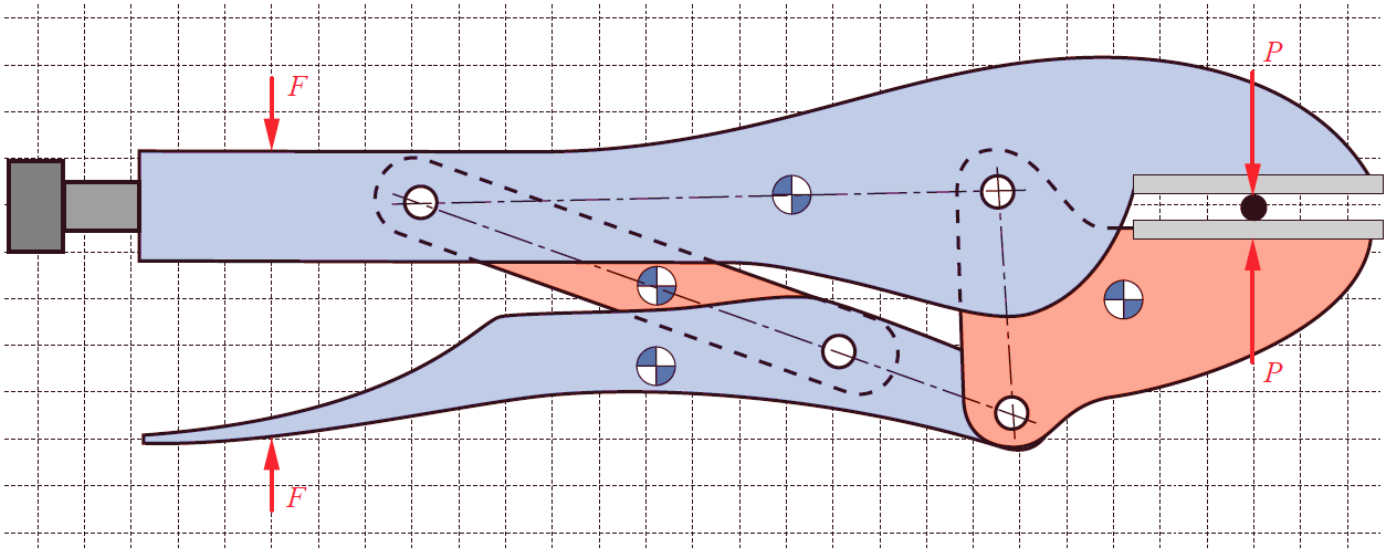

Figure 1 – Drawing of the Locking Plier – 0.5 cm grid

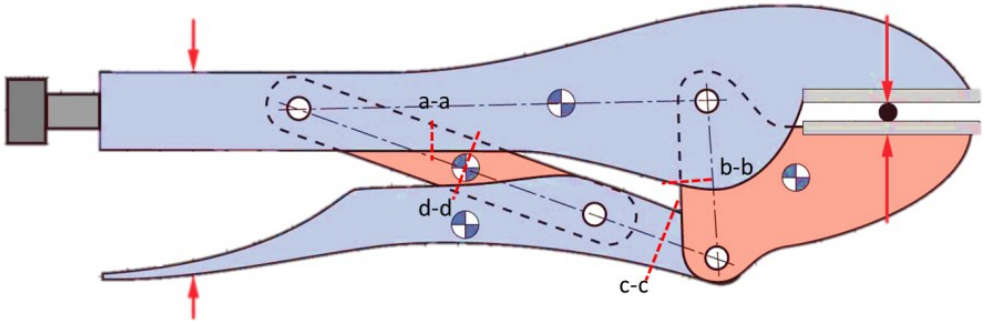

Figure 2 - Location of the edge cracks