

# Fatigue of Structures - Assignment 5

## Problem 1

Two 10 mm wall thickness steel pipes are joined by welding from one side. Inspection revealed that the welding process did not fully succeed and that there is a large root side lack of penetration defect and a weld toe undercut as shown in Fig. 1. Crack growth properties for the weld metal are found to be  $\gamma = 0.4$ ,  $m = 3$  and  $C = 3 \times 10^{-13}$  (units:  $\text{N mm}^{-1.5}$ ,  $\text{mm / cycle}$ ). For the material, yield strength  $f_y = 580 \text{ MPa}$  and critical stress intensity factor  $K_{Ic} = 5000 \text{ N mm}^{-1.5}$ . The initial crack size  $a$  is 1.00 mm for root side and 0.2 mm for weld toe side. The pipe is subjected cyclic loading with load ratio is  $R = 0$ .

- If the residual stresses are neglected, how many load cycles are needed to grow the crack to failure? Calculate the both weld toe and root side.
- If the residual stresses are considered, how many load cycles are needed to grow the crack to failure? Calculate the both weld toe and root side.

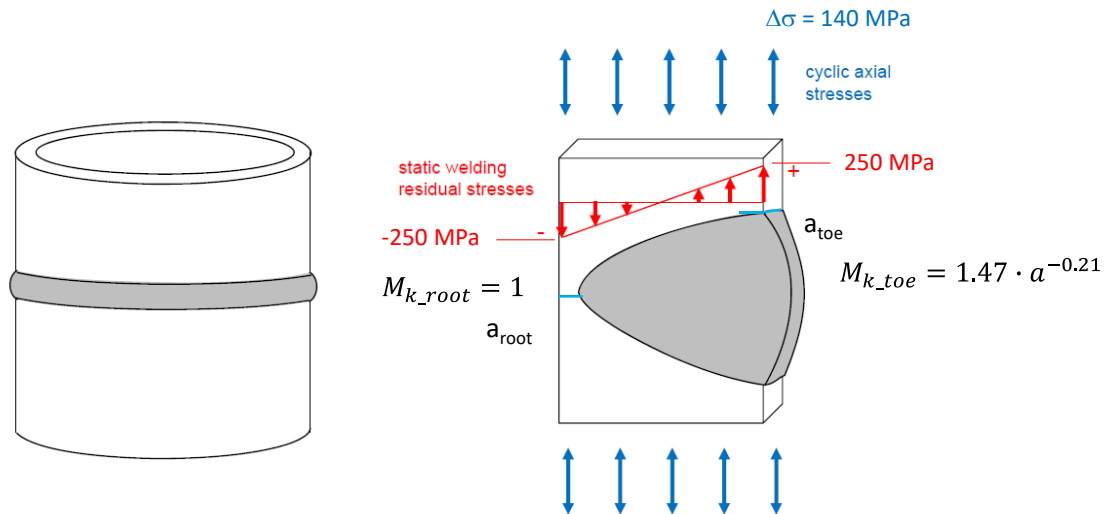


Figure 1 Butt welded pipe connection with 10 mm wall thickness

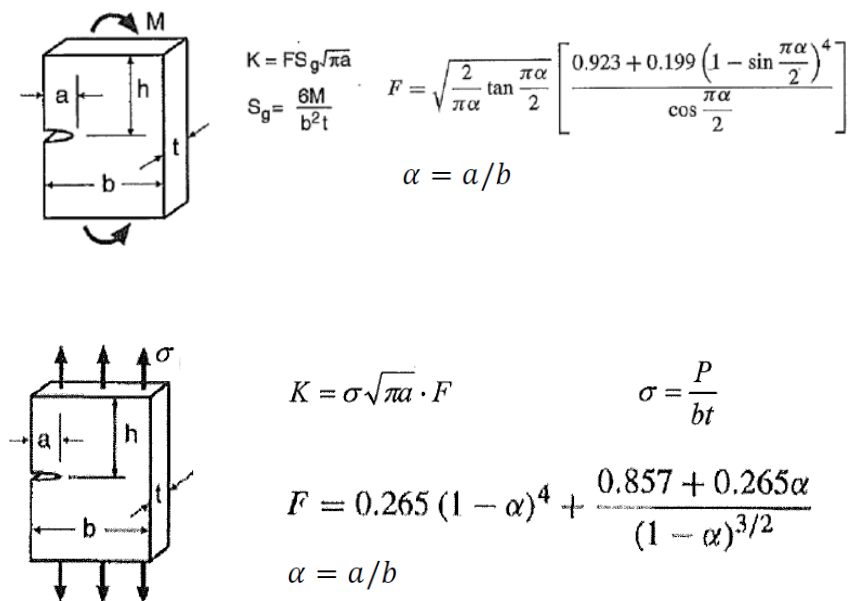


Figure 2 A plate with edge crack

## Problem 2

Consider the fillet welded cruciform joint shown in Figure 3. This joint has the following dimensions:  $t_1 = 16$  mm,  $t_2 = 12$  mm, and  $a = g = 9$  mm. According to Radaj and Zhang, the notch stress concentration factor for the cruciform joint, is

$$K_t = 1.192 * \left( \frac{a}{t_1} \right)^{-0.311} * \left( \frac{t_2}{t_1} \right)^{-0.004} * \left( \frac{g}{t_1} \right)^{0.130} * \left( \frac{\rho}{t_1} \right)^{-0.392}$$

- Use the effective notch method to estimate the fatigue life of this component, when the joint is loaded by nominal stress range  $\Delta S = 110$  MPa.
- The cost of the weld can be reduced by reducing the throat thickness  $a$ . What throat thickness should be used if the required fatigue life is 800 000 cycles?
- If the throat thickness  $a = g = t_1$ , what thickness  $t_1$  should be used if the required fatigue life is 800 000 cycles? Please, considered that the axial load ( $\Delta F = \Delta S \cdot t_1 \cdot b$ ) is constant. Breadth  $b$  is 100 mm.

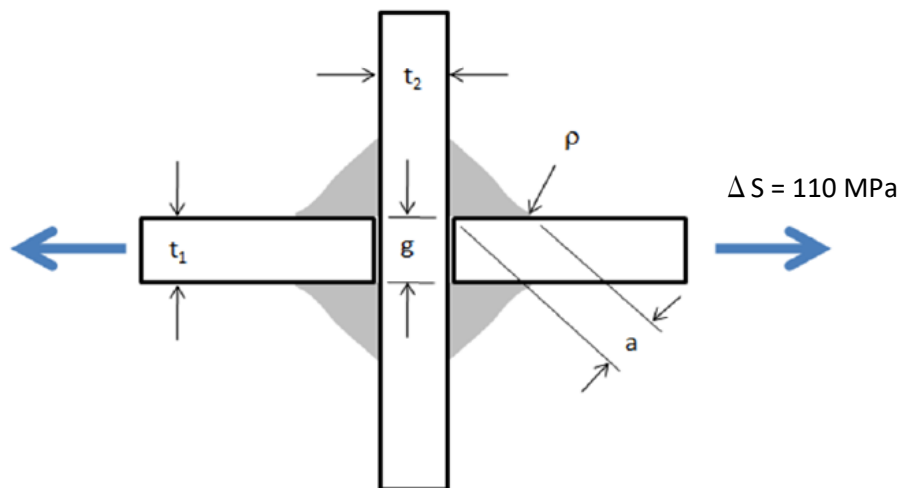


Figure 3 Fillet welded cruciform joint