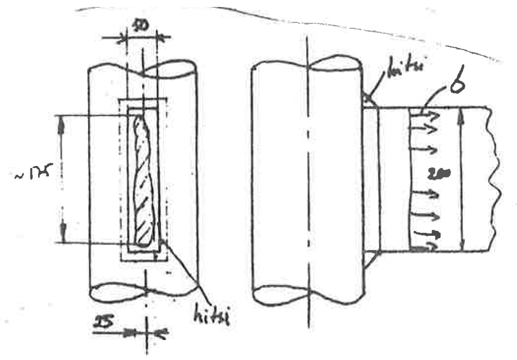
RAK-33060 Fracture mechanics and fatigue

9. Exercise, fatigue

1. A welded structure is loaded with a fully reversed load $\sigma_{\mathrm{a}} = 50$ MPa. Calculate the life-time when $K_{\mathrm{Ic}} = 100\,\mathrm{MPam}^{1/2}$ and the coefficients of the Paris equation are $C_6 = 10^{-6}\,\mathrm{m/cycles}, K_6 = 52.5\,\mathrm{MPam}^{1/2}$ and $n = 3$. With available inspection methods cracks larger than 5 mm can be detected. For the stress intensity factor you can use the formula for a surface crack of a semi-infinite plate. The Paris equation for crack growth is
$$\frac{\mathrm{d}a}{\mathrm{d}N} = C_6 \left(\frac{\Delta K}{K_6} \right)^n .$$
The required life time is twice the calculated one. Estimate how this could be obtained by changing the material ductility, loading or inspection method.

2. In a fillet weld of a radio mast tension chord (50x200 mm^2) connection is a an incomplete penetration of the weld material. Using an ultrasound inspection the area of incomplete penetration has been estimated to be 25 mm x 170 mm. In the worst loading case the tensile force in the chord is 700 kN. The fracture ductility is $K_{\mathrm{Ic}} = 40\,\mathrm{MPam}^{1/2}$. Estimate the maximum force the chord can sustain analysing the tensile bar as a plate strip with a central through-the-thickness crack $K_{\mathrm{I}} = \sigma_{\infty}\sqrt{\pi a} f(a/W)$. Calculate the safety factor for the static load. How many worst case cycles the structure can sustain. Use the same coeficients of the Paris equation as in the previous exercise and assume a constant factor $f(a/W)$.



3. A structural component is loaded first 10^5 cycles such with a zero mean stress and the amplitude is 25 % of the fatigue strength coefficient, i.e. $\sigma_{\mathrm{a}} = 0.25\sigma'_{\mathrm{f}}$. In the second loading phase the amplitude is raised to the value $\sigma_{\mathrm{a}} = 0.35\sigma'_{\mathrm{f}}$. Calculate the total life time of the component when the fatigue strength exponent is $b = 0.1$.