RAK-33060 Fracture mechanics and fatigue

7. Exercise, Failure Assesment Diagram (FAD)

Here the reference to Anderson is to the 3rd edition.

1. Anderson, problem 9.6.
   A flat plate 1.0 m wide and 50 mm thick which contains a through-thickness crack is loaded in uniaxial tenson to $0.75\sigma_{YS}$. Plot K_r and S_r values on a strip-yield failure assesment diagram, use for various flaw sizes. Estimate the critical flaw size for failure. For the limit lad solution, use the P_0 expression in Table below (Table A9.11 in Anderson). Set σ_0 equal to the average of yield and tensile strength. Use the following values $\sigma_{YS} = 345$ MPa, $\sigma_{TS} = 448$ MPa, $E = 207$ GPa, $K_\mathrm{mat} = 110$ MPam$^{1/2}$.

a/W:		n = 1	n = 2	n = 3	n = 5	n = 7	n = 10	n = 13	n = 16	n = 20
	h_1	2.80	3.57	4.01	4.47	4.65	4.62	4.41	4.13	3.72
0.125	h_2	3.53	4.09	4.43	4.74	4.79	4.63	4.33	4.00	3.55
	h_3	0.350	0.661	0.997	1.55	2.05	2.56	2.83	2.95	2.92
	h_1	2.54	2.97	3.14	3.20	3.11	2.86	2.65	2.47	2.20
0.250	h_2	3.10	3.29	3.30	3.15	2.93	2.56	2.29	2.08	1.81
	h_3	0.619	1.01	1.35	1.83	2.08	2.19	2.12	2.01	1.79
	h_1	2.34	2.53	2.52	2.35	2.17	1.95	1.77	1.61	1.43
0.375	h_2	2.71	2.62	2.41	2.03	1.75	1.47	1.28	1.13	0.988
	h_3	0.807	1.20	1.43	1.59	1.57	1.43	1.27	1.13	0.994
	h_1	2.21	2.20	2.06	1.81	1.63	1.43	1.30	1.17	1.00
0.500	h_2	2.34	2.01	1.70	1.30	1.07	0.871	0.757	0.666	0.557
	h_3	0.927	1.19	1.26	1.18	1.04	0.867	0.758	0.668	0.560
	h_1	2.12	1.91	1.69	1.41	1.22	1.01	0.853	0.712	0.573
0.625	h_2	1.97	1.46	1.13	0.785	0.617	0.474	0.383	0.313	0.256
	h_3	0.975	1.05	0.970	0.763	0.620	0.478	0.386	0.318	0.273
	h_1	2.07	1.71	1.46	1.21	1.08	0.867	0.745	0.646	0.532
0.750	h_2	1.55	0.970	0.685	0.452	0.361	0.262	0.216	0.183	0.148
	h_3	0.929	0.802	0.642	0.450	0.361	0.263	0.216	0.183	0.149
	h_1	2.08	1.57	1.31	1.08	0.972	0.862	0.778	0.715	0.630
0.875	h_2	1.03	0.485	0.310	0.196	0.157	0.127	0.109	0.0971	0.0842
	h_3	0.730	0.452	0.313	0.198	0.157	0.127	0.109	0.0973	0.0842

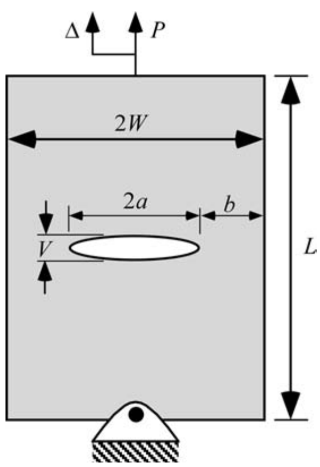
$$J_{pl} = \alpha\varepsilon_o\sigma_o \frac{ba}{W} h_1(a/W, n)\left(\frac{P}{P_o}\right)^{n+1}$$

$$V_p = \alpha\varepsilon_o a h_2(a/W, n)\left(\frac{P}{P_o}\right)^{n}$$

$$\Delta_{p(c)} = \alpha\varepsilon_o a h_3(a/W, n)\left(\frac{P}{P_o}\right)^{n}$$

$$P_o = 2Bb\sigma_o$$

$$\Delta_{p(nc)} = \alpha\varepsilon_o L\left(\frac{P}{2BW\sigma_o}\right)^{n}$$



2. Anderson, problem 9.7.
   Consider a single edge-notched tensile panel with $W = 1$ m, $B = 25$ mm, and $a = 125$ mm. Plot the J results in terms of a failure assesment diagram.

   (a) Compare the FAD curve determined by normalizing the x axis with P/P_0 to the FAD curve that is normalized by $\sigma_{\text{ref}}/\sigma_{YS}$ where the reference stress is defined in Section 9.4.4. Neglect the Irwin plastic zone correction.

   (b) Repeat part (a), but include the Irwin plastic zone estimate in the first term of the J estimation.

a/W:		n = 1	n = 2	n = 3	n = 5	n = 7	n = 10	n = 13	n = 16	n = 20
	h_1	3.58	4.55	5.06	5.30	4.96	4.14	3.29	2.60	1.92
0.125	h_2	5.15	5.43	6.05	6.01	5.47	4.46	3.48	2.74	2.02
	h_3	26.1	21.6	18.0	12.7	9.24	5.98	3.94	2.72	2.0
	h_1	3.14	3.26	2.92	2.12	1.53	0.960	0.615	0.400	0.230
0.250	h_2	4.67	4.30	3.70	2.53	1.76	1.05	0.656	0.419	0.237
	h_3	10.1	6.49	4.36	2.19	1.24	0.630	0.362	0.224	0.123
	h_1	2.88	2.37	1.94	1.37	1.01	0.677	0.474	0.342	0.226
0.375	h_2	4.47	3.43	2.63	1.69	1.18	0.762	0.524	0.372	0.244
	h_3	5.05	2.65	1.60	0.812	0.525	0.328	0.223	0.157	0.102
	h_1	2.46	1.67	1.25	0.776	0.510	0.286	0.164	0.0956	0.0469
0.500	h_2	4.37	2.73	1.91	1.09	0.694	0.380	0.216	0.124	0.0607
	h_3	3.10	1.43	0.871	0.461	0.286	0.155	0.088	0.0506	0.0247
	h_1	2.07	1.41	1.105	0.755	0.551	0.363	0.248	0.172	0.107
0.625	h_2	4.30	2.55	1.84	1.16	0.816	0.523	0.353	2.42	0.150
	h_3	2.27	1.13	0.771	0.478	0.336	0.215	0.146	0.100	0.0616
	h_1	1.70	1.14	0.910	0.624	0.447	0.280	0.181	0.118	0.0670
0.750	h_2	4.24	2.47	1.81	1.15	0.798	0.490	0.314	0.203	0.115
	h_3	1.98	1.09	0.784	0.494	0.344	0.211	0.136	0.0581	0.0496
	h_1	1.38	1.11	0.962	0.792	0.677	0.574			
0.875	h_2	4.22	2.68	2.08	1.54	1.27	1.04			
	h_3	1.97	1.25	0.969	0.716	0.591	0.483			

$$J_{pl} = \alpha \varepsilon_o \sigma_o \frac{ba}{W} h_1(a/W,n)\left(\frac{P}{P_o}\right)^{n+1}$$

$$\Delta_{p(nc)} = \alpha \varepsilon_o L\left(\frac{P}{2BW\sigma_o}\right)^{n}$$

$$V_p = \alpha \varepsilon_o a h_2(a/W,n)\left(\frac{P}{P_o}\right)^{n}$$

$$\Delta_{p(c)} = \alpha \varepsilon_o a h_3(a/W,n)\left(\frac{P}{P_o}\right)^{n}$$

$$P_o = 1.072\,\eta B b \sigma_o$$

where

$$\eta = \sqrt{1+\left(\frac{a}{b}\right)^2} - \frac{a}{b}$$