Istanbul Technical University

Graduate School of Science Engineering and Technology

MKC517E
Special Topics in Solid Mechanics

Homework 2

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a

Center crack in a finite width plate (TC01 crack scenario, Figure 1) with 1000 mm width and 5 mm thickness is considered using the load spectrum for the space transportation system (STS) given in Nasgro manual on p.61 (Table 1). Assuming that loads are in the fundamental frequency range of 50 to 100 Hz (multiplication factor of 2 for both tensile and bending stresses) and 1000 load blocks in the schedule, cycle at which panel fails for ten different initial length is to be determined. Material is 2024-T3 (Nasgro data).

Table 1: Launch and Landing Spectrum for STS Payloads.

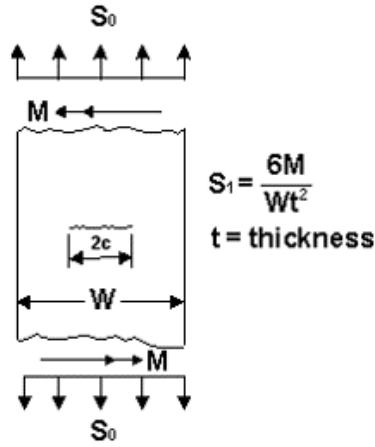| Load Step	Cycles/flight			Cyclic Stress (% limit value)	
Number	Launch	Landing	Total	Minimum	Maximum
1	1	1	2	-100	100
2	3	1	4	-90	90
3	5	3	8	-80	80
4	12	3	15	-70	70
5	46	3	49	-60	60
6	78	3	81	-50	50
7	165	13	178	-40	40
8	493	148	641	-30	30
9	2229	891	3120	-20	20
10	2132	1273	3405	-10	10
11	2920	2099	5019	-7	7
12	22272	6581	28853	-5	5
13	82954	8701	91655	-3	3

Figure 1: Finite width plate with a through crack at the center of plate (TC01).

No retardation (Non-interaction) crack growth model is selected for the growth model. Forman crack growth rate equation is used for growth-rate calculation.

Total number of cycles without failure and critical crack lengths are given in Table 2. Probabilities of crack detection for X-Ray and Ultrasonic methods are taken from USAF Damage Tolerant Design Handbook and plotted with number of cycles at rapture (Figure 1). From the figure, we can see that X-Ray method has very low chance of detecting small cracks when compared with ultrasonic method. Yet, X-Ray method has low cost and easier to implement in comparison with ultrasonic method.

Table 2: Critical crack size, block and cycle at rapture results for ten different initial crack lengths along with detection probabilities of detection for X-Ray and ultrasonic methods.

| Crack Length (2c) [in.]	Crack Length (c) [mm]	Critical Crack Size	Block at rapture	Cycle at Rapture	X-Ray	Ultrasonic
0.05	0.635	15.67330	57	7.45E+06	0.0	35.9
0.10	1.273	13.84030	29	3.72E+06	2.9	56.0
0.15	1.907	12.48780	19	2.39E+06	3.7	59.3
0.20	2.540	12.50300	14	1.73E+06	4.7	59.2
0.25	3.179	12.90320	11	1.33E+06	6.2	91.7
0.30	3.801	13.30850	9	1.06E+06	8.3	99.9
0.35	4.444	16.52140	8	9.31E+05	12.1	100.0
0.40	5.082	12.49910	6	6.65E+05	18.9	100.0
0.45	5.719	12.53200	5	5.32E+05	44.3	100.0
0.50	6.350	15.67340	5	5.32E+05	100.0	100.0

(a) X-Ray method

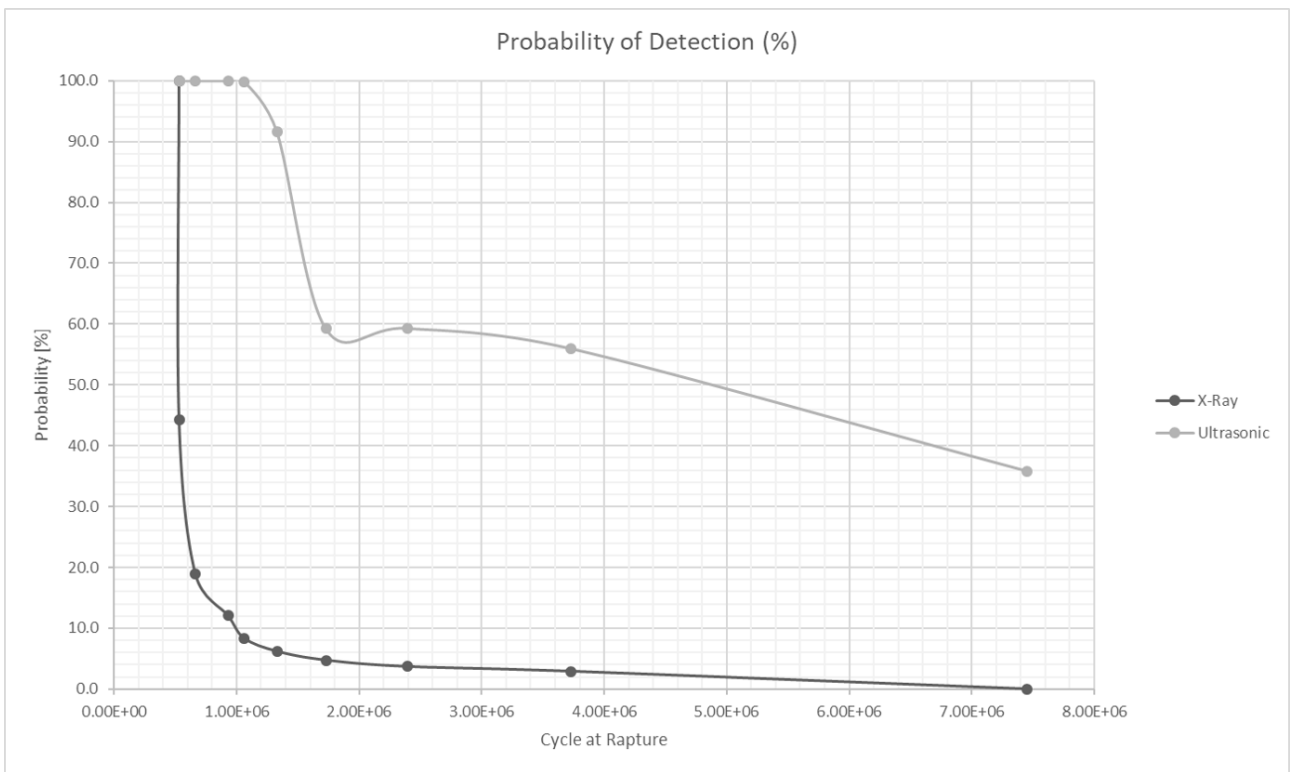(b) Ultrasonic method
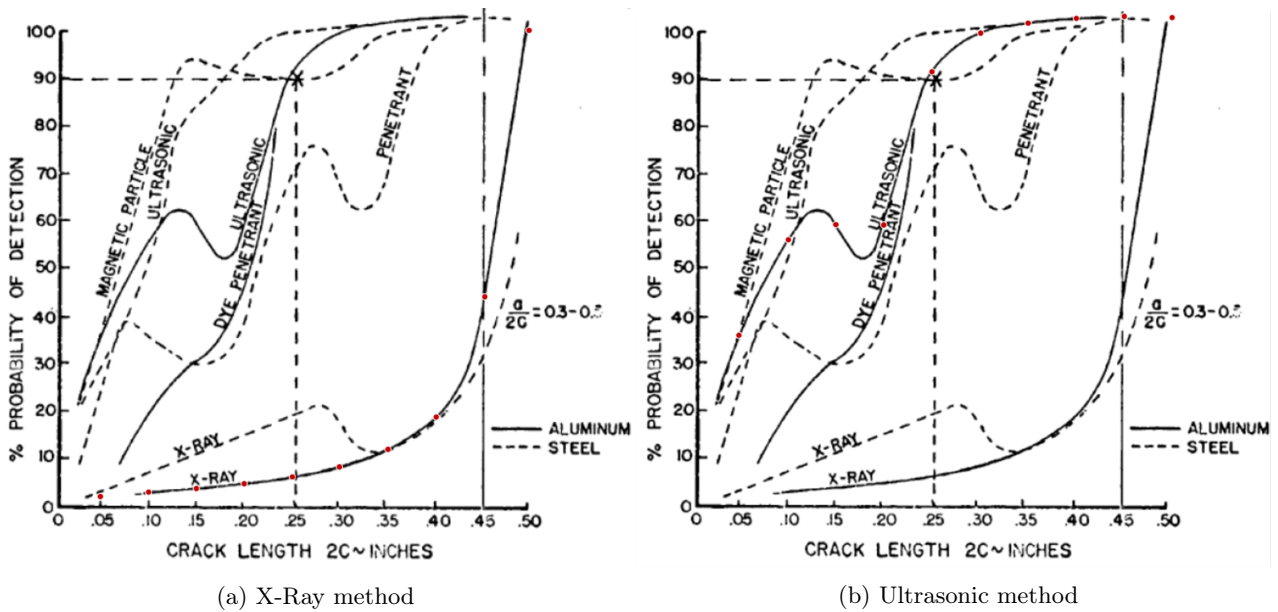
Figure 2: Selected crack sizes (red dots).

Figure 3: Probability of detection for both models.