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SOME ASPECTS ABOUT AIRCRAFT STRUCTURES RELIABILITY

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Abstract: *Based on the main factors which alter the durability of a structure (the loading range, the mechanical features of the materials, the environmental and technological factors, etc.) the present paper presents a way for assessing the aircraft structure durability. In this respect, there has been endorsed the linear cumulative damage criterion Palmgren-Miner results, used in the assessment of average damage level attained by the end of operating period.*

Keywords: *fatigue life, durability, failure, reliability*

1. INTRODUCTION

Take into consideration the main factors which determine the service lifetime of an item or an aircraft structure (the loading range, she mechanical features of the materials, the environmental and technological factors etc). There has been estimated the structural life - based on a sample group of representative structures of a same kind - according to the romanian current standards.

There has also been considered the influence of fatigue phenomena (reiterated loads) upon the structures regarded.

Prediction of the fatigue performance is a simple process but one beset by several complexities. Load magnitude and sequence are very important features of the process.

The need to increase by 3-4 times the landing gears durability to the fact that the problem of choosing the material brand, the designing solution and the admissible stresses is solved by reasons of fatigue strength and not static strength, as well using fracture mechanics principles.

2. THEORETICAL BACKGROUND

Although many techniques have been devised to satisfy specific conditions, the simplest and the most practical technique is Palmgrcn-Miner.

This method merely proposes that the fraction of fatigue life used up in service is the ratio of the applied number of load cycles at a given level divided by the allowable number of load cycles to failure at the same variable stress level. If several levels of variable stresses arc applied to a detail, then the sum of the respective cycle ratios is the fraction of fatigue life used up.

When the cycle ratio sum equals unity all of the potential service life has been used. It is important to notice that there is just so much potential fatigue life available for operational utilization.

The landing gear's load range can be expressed through working cycles ground-air-ground (GAG) because within the landing gear is used up the biggest part of the structure's durability.

The durability fraction used up through iterated loads (fatigue) by one GAG cycle is called wear cycle (relative damage) (1).

$$N = \frac{1}{D_t} \qquad (1)$$

N - Total number of landings

D_t -damage produced by iterated loads during one GAG cycle: $D_t \in (0,11]$.

For instance, a relative damage of $D^t = 0.5$ means that the landing gear should face a double number of GAG cycles, thus for a resource of 3000 landings, the structure should resist up to 6000 GAG cycles.

$$D = PREDICTED\_LIFE = \sum \left(\frac{n_1}{N_1} + \frac{n_2}{N_2} + ... + \frac{n_K}{N_K} \right) = 1.0 \qquad (2)$$

where:

n_K - number of loading cycles at the K^{th} stress level;

N_K - number of loading cycles to failure for the K^{th} stress level based on constant amplitude $\sigma - N$ for the applicable material and stress concentration factor.

K - number of stress levels considered.

Fatigue crack initiation is assumed to occur when the predicted life is equal to 1.0 (2). There are three parameters which alter the magnitude of the summation of the cycle ratios:

1.First, there is the effect caused by the order of load applications. Consider, for example, two different stress levels, f_1 and f_2 and their cyclic lives. N_2 and N_2. respectively. If f_1 is greater than f_2 and if it is applied first, the life will be shorter than if f_2 is applied first.

2.The second effect on summation of cycle ratios is due to the amount of damage caused by continuous loading at the same level. The summation of cycle ratios for different stress levels is accurate only if the number of continuous cycles at each stress level is small.

For the most aircraft structures, the loading is random and the stress level is constantly changing.

3.The third parameter which affects the summation of the cycle ratios is whether the fatigued part is notched or not.

The fatigue strength evaluation must show by analysis and/or testing that the structure can withstand the typical loading spectrum expected in service.

With respect to fatigue life verification testing of safe-life structures, the aviation regulation (FAR) adheres to the use of the following scatter factors:

Table 1

Number of test specimens	*Scatter factor*
1	3.00
2	2.58
3	2.43
4	2.36

This means that the test should verify the safe-life times the factor without failure, or, if, failure occurs earlier the safe-life is designated as test life divided by the scatter factor.

The above short review of the theoretical notions and of the nowadays settlements in the field of aircraft structures durability has used, for the accomplishment of the testing program, a chosen structure of the landing gear made of D.16 AT aluminium alloy.

The stress (daN/mm^2) spectrum to be applied locally to the part consists of 5 loading sequences arranged as shown in table 2.

Table 2

Mean stress (1)	Varying Stress (2)	Number of Cycles (n) (3)	Max. Stress (4)=(1)+(2)	Min. Stress (5)=(1)-(2)
13.0	8.7	70	21.7	4.3
	12.0	10	25.0	1.0
	13.3	150	26.3	-0.3
	14.1	30	27.1	-1.1
14.5	6.1	50	20.6	7.4
	12.9	140	27.4	1.6
	18.0	150	32.5	-3.5
	18.8	40	32.8	-4.3
7.5	17.5	70	25.0	-10.0
	18.5	60	26.0	-11.0
	20.1	40	27.6	-12.6
	20.8	40	28.3	-13.3
19.0	12.0	150	31.0	7.0
	12.8	70	31.8	6.2
10.0	14.6	180	24.6	-4.6
	15.3	120	25.3	-5.3
	15.9	50	25.9	-5.9
	16.7	30	26.7	-6.7
Total : 1450 cycles				

3. EXPERIMENTAL RESULTS AND CONCLUSIONS

For the tested structure, after 1000 cycles (landings) there has been determined cumulative damage of D = 0.05751.

The calculated life.

$$N_C = \frac{1000}{0.05751} = 17388 cycles \tag{3}$$

The best estimate of predicted fatigue life:

$$N_{cb} = \frac{17388}{3.0} = 5796 cycles \tag{4}$$

The bottom line is that by adopting the Palmgren-Mincr cumulative damage criterion, corrected with the stresses interaction factor, there can be estimated the average damage level reached at the end of the operational period and also, can be established technological means for designing and repair in order to increase the durability of the analyzed structures.

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