Engineering Failure Analysis 18 (2011) 394–402

Contents lists available at ScienceDirect

Engineering Failure Analysis

journal homepage: www.elsevier.com/locate/engfailanal

The fleet life reliability analysis under the 90% severe load spectrum

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ARTICLE INFO

Article history:
Received 23 June 2010
Received in revised form 19 September 2010
Accepted 20 September 2010
Available online 25 September 2010

Keywords:
Fatigue life
Load spectrum
Reliability

ABSTRACT

The fatigue life scatter of an aircraft fleet includes the variabilities of the material, structural property and the load spectrum. With more and more knowledge on the load variation, the 90% severe durability load spectrum has been proposed in JSSG-2006 of USA and used in the service life assessment program for several aircraft types. However, what is the life reliability of a fleet under this 90% severe spectrum and how severe the load spectrum should be are still perplexing. This paper would discuss the fleet life reliability under the severe load spectrum. Assuming both the fatigue life under a specified load spectrum and the load spectrum damage of a fleet follow the log-normal distribution and the standard deviations are σ_S and σ_L respectively, the fleet life was deduced to follow a log-normal distribution, the log mean life is unchanged and the variation is the sum of σ_S^2 and σ_L^2. The expression of the fleet life reliability P was also deduced and it is influenced by the σ_S and σ_L. The typical values of P were calculated for the cited σ_S and σ_L. To ensure the fleet service safety under the 90% load spectrum, the requirement on the severity degree, P_L, which is also the load reliability, was discussed. It showed that the severity of the severe spectrum is not a constant. If the 90% damage spectrum was used, the standard deviation of load spectrum damage should be controlled less than 0.14 at least.

1. Introduction

Due to the influences of various internal and external random factors, the fatigue lives of an aircraft fleet have obvious variability [1–3]. Generally, those factors could be divided into two types: one is the variation of the material properties and the built-up quality and the other is the load variation which reflects the variability of the load in a fleet [4,5]. To ensure the service safety, the life reliability analysis method accounting for those variable factors has been founded and introduced in [6,7]. As usual, the above variable factors were depicted by the random variable and the safe-life method has been adopted in the service life assessment program (SLAP) for aircraft structures. With this method, the tested life based on the full scale fatigue test (FSFT) and the corresponding scatter factor are used to assess the safe-life [8,9].

Up to now, a lot of researches have been conducted on the fatigue scatter factor and the load spectrum development method for fatigue analysis and test [8–12]. To ensure the safety, the average load spectrum which represents the average operational history of a fleet was proposed and a large fatigue scatter factor accounting for all variations, such as 4 in [13], 5.7, 7.2 in Australia [7] and 5.0 for unmonitored structures in DEF 00-970 [14] have been adopted. Though the structural variation is clear, the interpretation of the scatter factor seems unclear for the deficient knowledge on the load variation.

With the comprehensive usage of individual aircraft tracking (IAT), a large number of individual aircraft load–time historical parameters were measured and the knowledge on the variation of the load spectrum is clearer [5,15,16]. Therefore, a severe load spectrum was developed for durability analysis and test in USA and it accounts for the load variability and

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doi:10.1016/j.engfailanal.2010.09.020