Research on the Scatter of Structural Load-time History in a Fleet

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It is necessary to comprehensively consider various factors to determine the safe life of structure. These factors can be mainly divided into two major categories, one is the structural features and another is the difference of load-time history. The scatter of structure features is related to material properties, structural properties, processing techniques, assembly relationships, etc. Research on the scatter of structural features has formed a relatively mature analytical method. On the other hand, the differences of aircraft structural load-time history in a fleet due to climate, weather, runway quality, pilot operating habits, etc. Even the same aircraft and the same task, the structural load-time history will vary.
Recently, more and more researchers and engineers have tried to describe the scatter of load-time history in a fleet. Log-normal and Weibull distribution are the most commonly used statistical models. And there are relatively many researches on the gravity center overload (*N*z) spectrum and large parts load spectrum, for example, the wing root spectrum. But there are few results about the scatter of structural details load-time history. With the development of the flight data recorder and load recognition technology, obtaining the actual load-time history of structural details becomes a reality. Further, the differences in the load-time history on different structural details have been recognized. And there is also a difference in the scatter factor. At present, when assessing the fatigue life of the structure, all the structures of the aircraft are taken with the same scatter factor, which may lead to partial structural risk, while other structures are over-examined. If the scatter factor of the fatigue life is more accurate, and the calculated fatigue life of structure can be more economical and reliable.
In order to analysis the scatter of structural load-time history, 12 aircrafts were picked out from the same fleet as the research object, which has the same aircraft structure, similar flight hours and flight missions. And four typical structural details were selected from the whole aircraft structure. According to the structure form, the representative fatigue testing specimen are designed. And each kind of specimen has finished fatigue tests under three typical load spectrums. The fatigue notch factor (*Kf*) of each structure is calculated based on the fatigue test results. Based on the method of Junyong Wang[1] and Hongna Dui[2], the flight data to structural load equation is established. According to the flight data of each aircraft, every aircraft's four structural load-time history were made. The fatigue damage of every load-time history is evaluated based on the modified local stress-strain method. Finally, making statistical analysis of every structure fatigue damage in a fleet. The research process is shown in the figure 1.

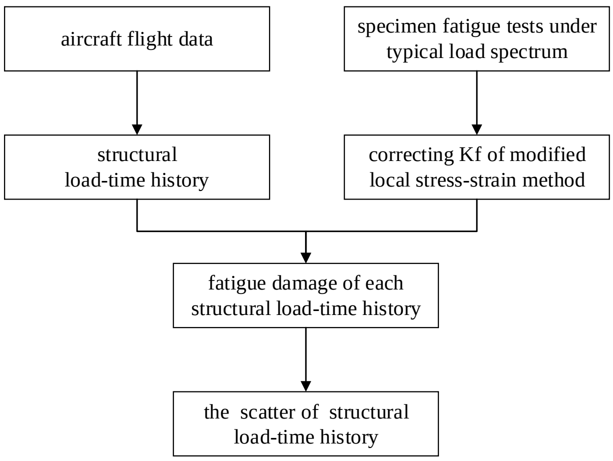

Figure 1. The research process.

Statistical analysis results show that all structural fatigue damage obey the log-normal distribution. The logarithmic standard deviation is a parameter that reflects the dispersion of the sample by a lognormal distribution. The logarithmic standard deviation of the four structures and the center of gravity overload (*N*z) are shown in table 1. At the same time, the fatigue damage dispersion of *N*z spectrum is also calculated, witch reflects the overall use of an aircraft.
Table 1 shows that the actual fatigue damage of different structural load-time history has a significant difference. On the one hand, the scatter of fatigue damage on bulkhead I and bulkhead II are obvious than

the *N*z load spectrum; on the other hand, the scatter of fatigue damage on Beam I and Beam II are smaller. And the Beam I and Beam II are symmetrical, but the scatter parameter also has a little difference.

Table 1. The log-normal standard deviation of typical structures.

Structure	Weak area type	Fatigue notch factor	Lognormal standard deviation
*N*z	\	\	0.084
Bulkhead I	hole	2.07	0.168
Bulkhead II	hole	3.35	0.147
Beam I	chamfer	2.0	0.074
Beam II	chamfer	2.0	0.080

According to the results, the scatter of different structures have obvious differences. And, the scatter factor is essential to evaluate the structural fatigue life. Therefore, when assessing structural fatigue life, it is necessary to consider different scatter factor of load-time history.

Keywords: fatigue life, scatter factor, load recognition technology, log-normal distribution, modified local stress-strain method

References

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