Fatigue Failure of Aircraft Components

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EXTENDED ABSTRACT

Failures can be broadly classified into two categories, those involving fracture and those without fracture. Each of these categories can be classified depending upon whether they are caused by thermal, mechanical or chemical influences. Mechanical failures are further studied considering the nature of forces, whether they are by monotonic or repetitive loads.

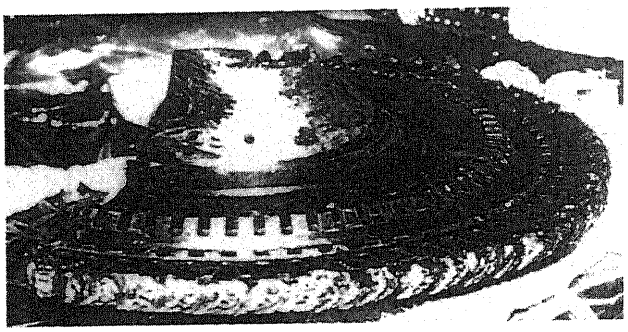
Aircraft components are inevitably subjected to fluctuating stresses and hence, irrespective of the mechanism of defect/crack initiation, most of these components ultimately fail by fatigue fracture. Despite the fact that most engineers and designers are aware of fatigue, and that a vast amount of experimental data has been generated on the fatigue properties of various metallic and non-metallic materials, fatigue failures of engineering components are still common. Study showed that majority of service failures in aircraft components occur by fatigue and it amounts to about 60% of the total failures (Table 1). A number of factors influence the fatigue life of a component in service, viz., (i) complex stress cycles, (ii) engineering design, (iii) manufacturing and inspection, (iv) service conditions and environment and (v) material of construction (Fig.1). Analysis shows that premature fatigue crack initiation in the components can be attributed to defects of various types introduced mostly inadvertently in various stages of component manufacture, maintenance, inspection, operation etc.

Table 1 Frequency of failure modes in aircraft components [1]

Failure mode	Percent of failures	
	Engineering components	Aircraft components
Corrosion	29	16
Fatigue	25	55
Brittle fracture	16	-
Overload (ductile)	11	14
High temperature corrosion	07	02
SCC/corrosion fatigue/HE	06	07
Creep	03	-
Wear/abrasion/erosion	03	06

Investigation of service failures/accidents in aviation industries is a formidable, complex, and challenging task. It is only by a systematic analysis of failures that factors responsible for an incident/accident can be determined and thereby preventive actions can be initiated. The lessons learned from failure analysis are vital for the

engineering profession and the industries that aim at design and manufacture of products with the probability of service failure at the absolute minimum. A large number of failures of aircraft components have been investigated in the authors' laboratory over the past many years wherein fatigue crack initiation was related to one or more of the errors mentioned earlier. A few of these investigations will be discussed in this talk.



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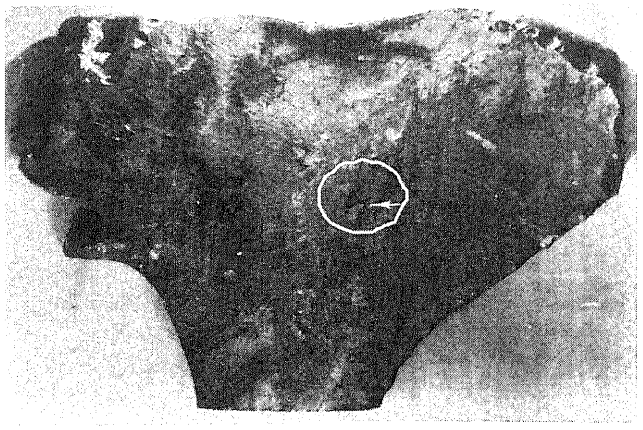

(b

Figure 1 Accident to Airbus 320 at Calcutta in 1998 due fatigue failure of high pressure turbine rotor disc: (a) one half of the fractured disc retrieved from the wreckage, and (b) fatigue crack initiation inside the hub of the disc at an inclusion (encircled)

Reference

[1] S.J. Findlay and N.D. Harrison, Why aircraft fail? Materials today 2002;November: 18-25

Dr. S.K. Bhaumik

- B.E. (Met), Calcutta University, 1984
- M.Tech (Met), IIT Kanpur, 1986
- Ph.D (Met), IIT Kanpur, 1992
- Expertise:
  - o Processing & Development of Nickel-Titanium Shape Memory Alloys
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Dr. S.K. Bhaumik is at present heading the Metallurgical Sciences Activities at the Materials Science Division of National Aerospace Laboratories, Bangalore. His research areas include NiTi-base shape memory alloys (SMA) for smart structural applications, and failure analysis and accident investigation. He has developed technologies for the processing of NiTi based SMA products such as wire and strip for actuator applications. The SMA wire products were developed for the first time in the country by Dr. Bhaumik and these are being extensively used for the development of smart devices.

Dr. Bhaumik has been working in the area of failure analysis and accident investigation for the past thirteen years and has investigated more than 750 service failure cases. About 75% of these investigations are from high technology areas such as aircraft engines/systems/structures. He and his team have been rendering yeomen service to the aeronautical and engineering community in the country using the expertise built over decades of dedicated work, to analyse and identify causes of failures of engineering structures and of aircraft accidents. This has led to better understanding of the behaviour of the system under operational environment, and in design improvement, enhancement of reliability, residual life assessment etc.

Dr. Bhaumik has published about 50 technical papers in National and International Journals and is a recipient of MRSI Medal 2009. He also co-authored a book on "Failure Analysis of Engineering Structures: Methodologies and Case Histories" published by ASM International, USA in 2005.

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