Engineering Failure Analysis 41 (2014) 30–38

Contents lists available at ScienceDirect

Engineering Failure Analysis

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

Design of a motor glider landing gear strut – The role of failure analysis in structural integrity

D.J. Erasmus [a], D.G. Hattingh [a], A.B. Young [a], A. Els-Botes [a], M.N. James [a,b,*]

[a] Department of Mechanical Engineering, Nelson Mandela Metropolitan University, Port Elizabeth 6031, South Africa
[b] School of Marine Science & Engineering, University of Plymouth, Drake Circus, Plymouth PL4 8AA, United Kingdom

ARTICLE INFO

Article history:
Available online 17 August 2013

Keywords:
Role of failure in design
Light aircraft landing gear
Materials selection
Fatigue cracking

ABSTRACT

The structural integrity performance of light aircraft homebuilt from kits supplied by the designer is unlikely to be as statistically reliable as is the case for commercially produced aircraft. The homebuilt nature of the aircraft means that the culpability of the designer of the kits for the consequences of any structural accident is limited, provided that the design is structurally sound. However, in the case of phenomena such as fatigue where materials, manufacturing and performance are intricately linked the design may be far from sound, and problems can arise early in the operation of the aircraft. This paper presents a case study involving failure of a landing gear strut on a homebuilt motor glider design. The failure analysis established the importance of fatigue crack initiation and growth in the failure and identified contributory manufacturing procedures that were subsequently improved.

1. Introduction

The structural integrity performance of light aircraft homebuilt from kits supplied by the designer is unlikely to be as statistically reliable as is the case for commercially produced aircraft. There are a number of contributory factors to potential problems with structural reliability, including:

- A limited budget for structural design, testing and certification.
- Limited specialist knowledge of complex materials–processing–performance interactions, e.g. fatigue and stress corrosion cracking.
- Limited understanding of damage-tolerant design and the importance of appropriate and reliable inspection.
- Potential consequences of variability in quality of bespoke manufacturing.
- Unknown and variable stresses associated with, for example, the use of unpaved runways.

The homebuilt nature of the aircraft means that the culpability of the designer of the kits for the consequences of any structural accident is limited, provided that the design is structurally sound. In the case of phenomena such as fatigue where materials, manufacturing and performance are intricately linked (illustrated schematically in Fig. 1) this may not be the case and problems can arise early in the operation of the aircraft.

However, sophisticated and widely available strain gauging, finite element and fatigue analysis techniques can easily be linked together and brought to bear on critical aircraft components, such as the undercarriage struts. This could be done at the design or prototype stages of the production cycle, but commercial and expert knowledge constraints render this more

* Corresponding author at: School of Marine Science & Engineering, University of Plymouth, Drake Circus, Plymouth PL4 8AA, United Kingdom.
E-mail address: mjames@plymouth.ac.uk (M.N. James).

1350-6307/$ - see front matter
http://dx.doi.org/10.1016/j.engfailanal.2013.07.030

Nomenclature

C_E	environment factor
C_L	surface factor
C_M	material factor
C_O	surface roughness factor
C_R	mean stress factor
C_S	size factor
D	damage number
k	slope of the S–N curve
k^*	slope of the modified Liu–Zenner curve
K_t	stress concentration factor
m	slope of constant amplitude crack growth curve
N	number of cycles
n	number of applied cycles
n_b	bending support effect
N_e	number of cycles at the endurance limit
N_i	life at *i*th load
n_i	number of applied cycles at *i*th load
n_n	notch supporting effect
R	stress ratio ($\sigma_{\min}/\sigma_{\max}$)
R_z	surface roughness
$S_{a,\max}$	maximum stress amplitude in the applied stress spectrum
UTS	ultimate tensile strength
Σ	sum of the specified ranges
σ	stress
σ_a	stress amplitude
σ_e	stress at endurance limit
σ_u	ultimate tensile strength

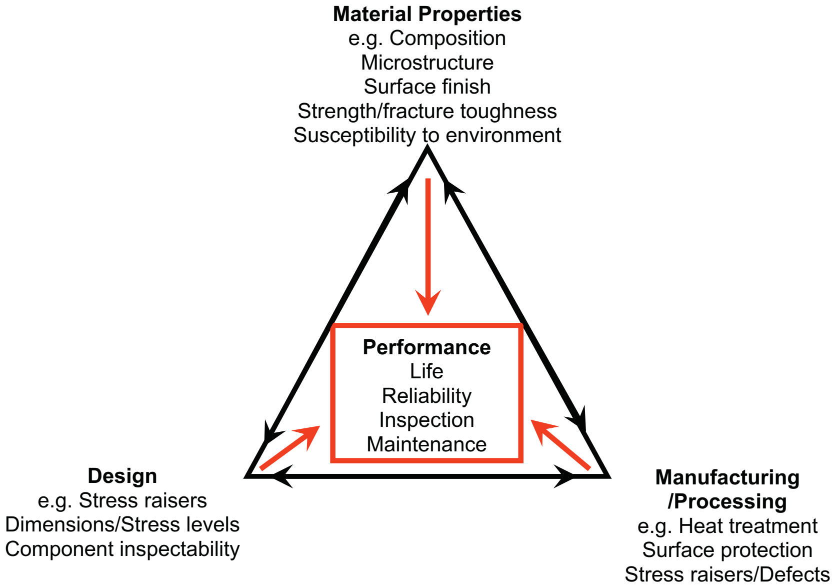

Fig. 1. Illustration of the complexity of the design–properties–processing–performance interaction for safety–critical components.

likely to occur subsequent to structural failure. The process then demonstrates the utility of failure analysis input into designing for structural integrity and into verifying the reliability and performance of key components.