Evolution in Polymer Technology Journal

Short Communication *Volume 3 Issue 1*

Driving Criteria for the Evaluation of the Safety Factor

Sergio Baragetti*

Department of Management, Information and Production, Univeristy of Bergamo, Italy

***Corresponding author:** Dr. Sergio Baragetti, Department of Management, Information and Production, Univeristy of Bergamo, Viale Marconi 5, 24044 Dalmine (BG), Italy, Email: sergio.baragetti@unibg.it

Received Date: January 28, 2020; **Published Date:** February 18, 2020

Abstract

Companies contact the University only after the incidents have occurred. The causes must be anticipated with appropriate studies and with the preparation given by universities and research centers. Companies often do not consider the potential of some modern tools (companies no longer have alibis) that would increase the reliability of mechanical components and systems. Accidents due to structural failures, which in the past were often unavoidable due to poor technical knowledge, can now find no justification in the light of the technical knowledge achieved in the structural field. It is more likely that today the damage is caused by insufficient preparation of the designer or improper use of the machine. After all, inadequate maintenance can introduce defects as well as aggressive environment and misuse: all these aspects contribute to unpredictable failure during the design phase. Objective of this paper if to give a critical analysis of the state of art definition and utilization of safety factor in engineering applications.

Introduction

Figure 1 shows typical failures due to poor technical knowledge: a) jet airplane Comet fuselage fatigue damage and b) liberty ships complete fracture [1-7].

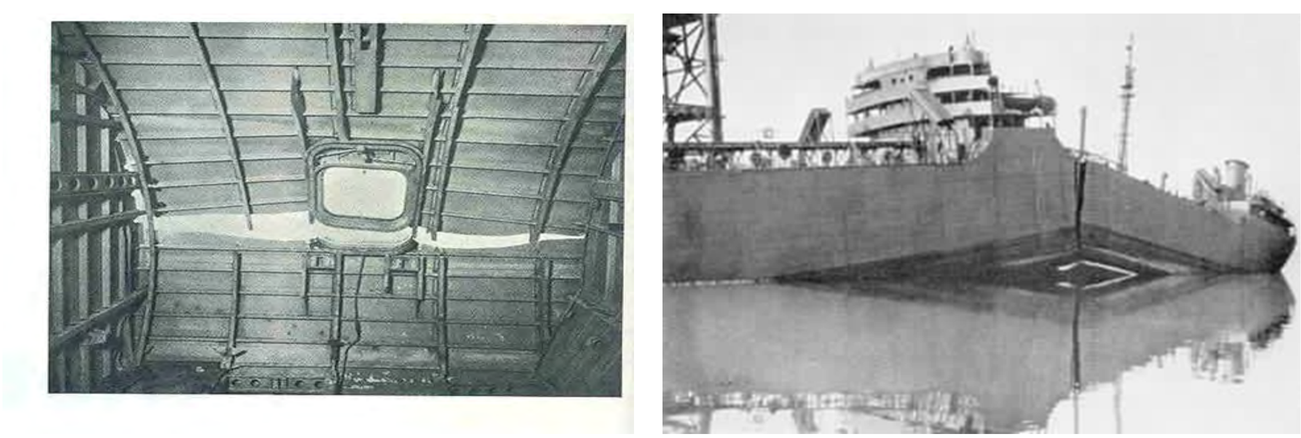

Figure 1: a) jet airplane Comet fuselage fatigue damage and b) liberty ships complete fracture [1-7].

The estimation of deterministic resistance deals with the definition of the safety factor. The safety factor is the ratio of the average value of the component's resistance to the average value of the load (ratio of between the limit and the operating load). In using the safety factor, the designer is aware that there are uncertainties about the loads applied, the dimensions, the calculation methods used the strength of the materials. Usually International Standards, under conditions of static application of operating loads and in the absence of unforeseen accidental or exceptional events, assume a safety coefficient equal to 1,5, i.e. the structure must be able to withstand 50% more load than the nominal (normal operating) load. The safety factor can be reduced if the machine designer uses advance numerical modelling (Figure 2) or probabilistic approaches. Figure 2 shows an example of evaluation of fatigue crack propagation in thin hard coated spur gears by means of FEM numerical models [8-12].

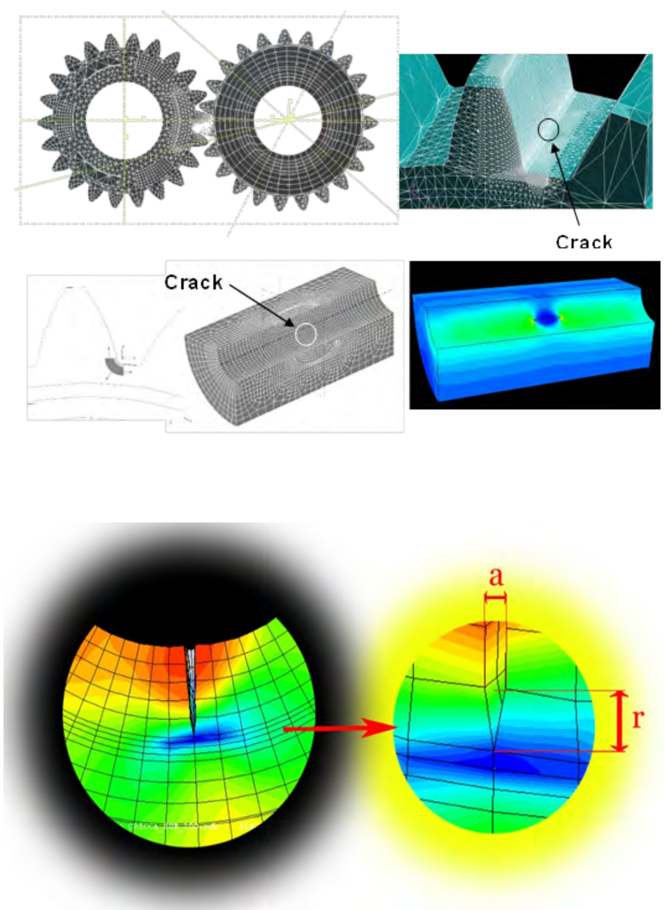

Figure 2: evaluation of the fatigue resistance of damaged PVD thin hard coated components (spur gears here) [8-12].

The safety factor η

This way of dealing with resistance is the "deterministic approach" or with this approach we do not directly consider the variability of the different factors that enter the verification formulas and appropriately amplify the safety factor. Admitting to operating safely on the basis of deterministic assessments can, however, lead us to consider safe situations that are actually very close to failure and this especially when using relatively low safety factors (as is the case in aeronautics, car or motorcycle competitions). Standards in the Aeronautical field admit to lower the safety factor, but only in particular conditions.

Accidents and structural damage in the life cycle of the machine are caused by:

- Lack of technical and scientific knowledge in the design phase (machine designers not properly prepared).
- Use of insufficient safety factors.
- Realization and execution errors.
- Lack of non-destructive controls for important structures from the point of view of reliability and safety.
- Inadequate maintenance.
- Misuse.
- Accidental events not considered at the project stage or unexpected.

$$\eta = \frac{\overline{S}}{\overline{L}}$$

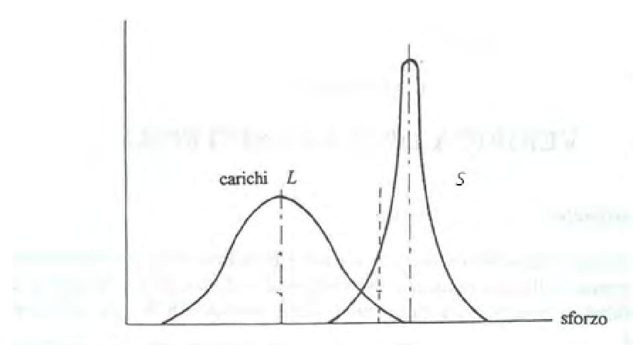

Figure 3: strength S and applied loads L statistical distribution (Gauss curves).

The safety factor η is the ratio between the mean values of loads and strength distributions (formula in Figure 3).

The Probabilistic Safety Margin Z_R

The resistance in probabilistic terms needs the knowledge of the variability of the mechanical characteristics of the real components and the variability of the applied loads (that means mean value and mean square deviation of each parameter). Furthermore it is necessary to accurately assess how loads and resistances can interact in probabilistic terms. The probability safety margin is reported in formula (1). μ_S and μ_L are the standard deviations respectively of the strength and loads distributions [7].

$$Z_R = \frac{\overline{Z}}{\mu_Z} = \frac{\overline{S} - \overline{L}}{\sqrt{\left(\mu_S{}^2 + \mu_L{}^2\right)}} \quad (1)$$

For sufficiently high probabilistic safety margins (i.e. $Z_R > 4$) the deterministic safety coefficient can be reduced (i.e. $\eta <$ 1,5). Reliability R is the probability of non-rupture, which is the probability that the resistance is greater than the stresses generated by loads. The relative importance between the components of a machine or structure in general depends mainly on how the different components are inserted into the plant. There are two design methodologies in particular and the choice is influenced by reasons related to the structural strength of the machine, economic reasons or the safety of the machine itself or the structure. From a probabilistic point of view, the different components of the machine can be connected in series or in parallel. Equations (1) report the two design criteria, series and parallel. If components are put in series reliability Rc is the product of the reliability of the components. The failure probability is Pc. If the components are put in parallel (redundant systems) the probability of failure is the product of the probabilities of failure of the components. Surely higher reliability can be achieved by using parallel systems [7].

Series:

$$R_C = \prod_{i=1}^{n} R_i \qquad P_C = 1 - R_C \quad (2)$$

Parallel:

$$P_C = \prod_{i=1}^{n} P_i \qquad R_C = 1 - P_C$$

References

1. Lo Bao, Phil (1996) The de Havilland Comet (Airlines & Airliners). Middlesex, UK: The Aviation Data Centre Ltd.
2. McNeil Ian (1996) An Encyclopedia of the History of Technology. London: Routledge, 2002 (E-edition), First edition 1990. ISBN 9780415147927.
3. John Motum (Ed), (1991) The Putnam Aeronautical Review, (2) London: Conway Maritime Press, ISBN 1-55750-676-0.
4. Munson, Kenneth (1967) Civil Airliners since 1946. London: Blandford Press.
5. Painter, Martin (2002) An Illustrated History. Tonbridge, Kent, UK: Air Britain (Historians) Ltd, ISBN 0-85130-330-7.
6. Sawyer LA, Mitchell WH (1985) The Liberty Ships: The History of the "Emergency" Type Cargo Ships Constructed in the United States During the Second World War, Second Edition 13: 141-142.
7. Baragetti S, Terranova A (2007) The problems of causality in the engineering sciences: causality and the lack of continuity between technical-scientific culture and application. ISBN: 978-88-13-28082-6.
8. Baragetti S (2013) Corrosion fatigue behaviour of Ti-6Al-4V in methanol environment. Surface and Interface Analysis 45(10).
9. Baragetti S, Gelfi M, La Vecchia GM, Lecis N (2005) Fatigue Resistance of CrN Thin Films Deposited by Arc Evaporation Process on H11 Tool Steel and 2205 Duplex Stainless Steel. Fatigue & Fracture of Engineering Materials & Structures, Blackwell Science Ltd, Oxford, England 28(7): 615-621.
10. Baragetti S, D'Urso G (2014) Aluminum 6060-T6 friction stir welded butt joints: fatigue resistance with different tools and feed rates. Journal of Mechanical Science and Technology 28: 867-877.
11. Baragetti S, Tordini F (2007) Fatigue resistance of PECVD coated steel alloy. International Journal of Fatigue, published by Elsevier Science Ltd. The Boulevard, Langford Lane, Kidlington, Oxford, England 29(9): 1832-1838.
12. Baragetti S (2007) Fatigue resistance of steel and titanium PVD coated spur gears, International Journal of Fatigue, published by Elsevier Science Ltd. The Boulevard, Langford Lane, Kidlington, Oxford, England 29: 1893-1903.