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The Fracture Surface Does Not Confess: 10 Ways to Get Failure Analysis Wrong

Marco Boniardi

Politecnico di Milano, Italy

Abstract

Failure Analysis is often approached as a sequence of laboratory examinations aimed at finding something unusual in a failed component. Chemical analysis, mechanical tests, metallography, fractography and increasingly sophisticated characterization techniques are frequently performed before the actual questions behind the failure have been clearly defined. This approach may generate a large amount of accurate experimental data while still leading to the wrong explanation of the failure.

A fracture surface provides evidence about the physical processes that occurred during failure, but it does not "confess" its cause. One of the most important tasks in Failure Analysis is therefore to distinguish between observations, failure modes, damage mechanisms and causes. Identifying fatigue, brittle fracture, stress-corrosion cracking or hydrogen embrittlement may explain how damage developed, but it does not necessarily explain why the conditions required for that mechanism arose.

This lecture discusses ten common ways in which Failure Analysis can go wrong. These include starting with laboratory testing rather than with the reconstruction of the event, altering or destroying evidence prematurely, confusing failure mechanisms with root causes, treating any detected non-conformity as causally relevant, focusing excessively on material properties while neglecting service conditions, using sophisticated analytical techniques without a specific hypothesis, accepting the first plausible explanation, and drawing conclusions with a degree of certainty greater than that supported by the available evidence.

Particular emphasis is placed on the role of fracture mechanics and materials characterization within the investigative process. These are powerful tools for testing the quantitative plausibility of a proposed failure scenario, but they cannot compensate for an incorrect reconstruction of the component history, loading conditions or sequence of events.

A sound Failure Analysis should therefore be hypothesis-driven rather than test-driven. Its objective is not simply to identify a fracture mechanism or an abnormal feature, but to establish a coherent causal chain linking the available evidence to the physical mechanism, the conditions that produced it and, ultimately, the corrective actions required to prevent recurrence.