

CHAPTER 1

Introduction

An engineering system is designed, developed, and manufactured to fulfill certain human requirements over a total technical life. In addition, the system is also expected to be reliable and cost effective. The realization of the end product goes through the following stages: conceptualizing the system for a given function, designing and development of the prototype, user trials, manufacture, and assembly. An engineering system consists of various components. The designer is required to finalize the geometry and dimension of each and every part, select suitable materials based on availability, draw a fabrication methodology, stipulate the qualitative check and acceptance norms, state the assembling technique, and finally list out the maintenance procedure and schedule. Whenever a system fails to perform a required function, any of the above stage could be the culprit. Human error caused during application and utilization of the system could be another important source responsible for failure. A failure analysis carried out scientifically and systematically alone can pinpoint the cause of such a failure. The suitable remedial measures suggested by the failure analyst can go a long way in minimizing the recurrence of such failures.

Failure of an engineering component is a condition when it no longer is able to perform the desired function due to a breakage, fracture, crack, wear, corrosion, and inaccuracies as regards dimensional or other parameters. In a large number of engineering failures, it has been noticed that unsuccessful or nonperformance of an engineering system is due to failure of one or more component of the assembly. During preliminary examination the system's manager is generally able to locate the component that is suspected to have caused the failure. Whenever there is a crack or fracture telltale evidence is left on the failed component. In certain cases, when there is a rubbing action by the mating fracture surfaces or rubbing of the fracture surfaces by some other component it amounts to loss of useful evidences for an analyst. In such a situation, a failure analyst has to resort to the available data and circumstantial evidences to draw a conclusion about the failure. A good failure analysis can be highly useful in understanding the cause of failure and also the methods to prevent occurrence of such failures in future.

Failure analysis is a combination of an art and a science. All material scientists or engineers cannot handle failure analysis as it needs certain amount of experience and skill to handle a case study. Since every failure is reported as a crisis it is also expected to get an investigation carried out within a very short time. However, it should be borne in mind that a failure analysis cannot be performed with a magical wand. The analyst requires a certain amount of time to understand the background, collect suitable samples, make a variety of specimens for a large number of tests, interpret the test results, and then come to a conclusion in order to pronounce the cause. Failure analysis is based on sound metallurgical principles and authentic scientific evidences gathered through standard tests. The time frame demanded by the analyst should be considered to be genuine and must be provided for a job to be well handled. After all everyone involved in the case looks forward to the cause of failure and a suitable remedial measure in order to avoid future recurrence of the same.

Abuse of metallurgy has been the primary reason for a large number of failures of metallic components in our country. Most of the small- and medium-scale industries appoint mechanical engineers in all such fields of shop floor where a metallurgist should actually be taking care of the job, for example, a heat treatment shop. During the design and development of a system, for example, a weapon, ordinance, or an aerospace vehicle; metallurgist or materials experts are seldom part of the team. When some component of the system fails, which is bound to happen, the development team appoints an inquiry committee to look into the matter. Even at this stage a metallurgist is not appointed as one of the members in the inquiry committee. The engineers of the development team arrive at a cause of failure based on the operational error or breakage of some part of the system. Now they approach a metallurgical laboratory with a request for chemical analysis of the failed component. Sometimes the chemical analysis is also accompanied with a request for hardness check. The inquiry committee thinks that it knows the cause of failure and what more they want is a confirmation by a chemical analysis or hardness check. Even at this stage the committee does not realize that what they require is a failure analysis by an expert. What they do not realize is that they need to approach a materials consultant for a thorough failure analysis and appointment of a metallurgist for all future endeavors. This nonrealization leads to failure after failure but fails to wake them up to understand their basic fault- ‘abuse of metallurgy’. The day this realization comes and metallurgists get the right place in engineering industries and engineering system development team, the problem of premature failure would minimize to a large extent. Whenever an engineering component fails it is advisable to approach a failure analyst for a detailed failure investigation and apply the remedial measures suggested by him, which will help in avoidance of failures in future.