Use of Failure Analysis in Materials Selection

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Introduction

Materials selection for parts or components usually occurs under two conditions. The first is when a new part or component is designed while the second is when an existing part or component needs to be upgraded. Upgrading may be needed due to a variety of reasons. If the part or component is relatively new, upgrading may be needed if part life is marginal or inadequate. Or, a competitor's newly improved part is performing better and sales of your part are dropping. Or, operating conditions may have changed and your part is no longer performing acceptably. Of course, it is possible that parts have failed and the failure study recommends upgrading the material being used, perhaps also with other suggestions regarding the design and manufacturing processes.

Several failure analysts have categorized the nature of the failures that their organizations have studied over a long period of time [1-4]. In most such summaries, few, if any, failures are attributed to the wrong grade choice. A survey by Davies [4] is the exception as origins and causes of failures are considered separately. A small percentage of failures are attributed to imperfections in the material. This percentage will vary depending upon who is doing the examination and the purpose of the examination. However, classifications by cause are not informative regarding materials selection needs because the classification is based upon failure modes and mechanisms rather than the recommendations for avoiding such failures in other like parts. Dolan [5] described a broad-based failure analysis philosophy aimed at preventing future failures through proper materials selection, the basis of the design and reliance on safety factors, careful fabrication and maintenance with input from failure analysis studies, simulated service tests and prototype evaluations.

Material selection involves more than merely selecting the grade designation of the metal, alloy, polymer, ceramic, etc. For example, suppose that bearings or races used in a certain application are not lasting long enough. The study revealed that failures always initiated at relatively large, hard oxide inclusions. The grade of steel used was found to be quite common for this application, but the pedigree of the material was quite ordinary. In this case, fatigue life could be improved dramatically by purchasing a premium quality level of the same grade. For a few of the more common alloy grades, a manufacturer might produce as many as five to ten different variations within the normal composition range, each designed for a certain balance of