The metallurgical/materials engineer is frequently blamed when a material fails in service. “Two thousand years of metallurgy and the profession remains a black art!” “Why can’t the metallurgist select appropriate materials?” and “Hasn’t the materials industry developed anything that works?” are statements made and questions asked after a failure. Before the failure occurs, the statements and questions are vastly different: “We don’t need a metallurgical review of this project.” “Isn’t there anything cheaper we could use?” and “Could you give us an evaluation of the materials we selected within the next two hours?” It is very difficult to assure that metallurgical and materials evaluations are a regular part of the design process for most systems. My experience suggests that materials considerations are often a backfit that is too little and too late to assure project success.

Materials issues do not receive appropriate attention in many major projects primarily because a strong interface between the design and materials functions is not formally established. Deficiencies in this interface may be reflected in many ways, including premature failures in systems and/or components because of improper materials selection and/or specification. An equally poor alternative to system failure is system over-design to assure against a materials degradation process that does not and should not occur. The lack of an effective interface is so common that when failure analysts evaluate the reasons for failure, six fundamental causes are established: deficiencies in design, improper materials selection, defects in materials, improper materials processing, errors in assembly, and inadequate service.
Clearly, three of the six causes are materials related. A closer inspection shows that materials also play a role in two others. Errors in assembly, for example, include improper welding, and inadequate service includes operation outside the anticipated process or flow sheet windows. Welding is clearly a materials technology, and operation outside flow sheet windows may force a material to perform under inappropriate and/or unanticipated conditions.

The importance of the materials-design interface is further illustrated through a breakdown of the typical causes of corrosion-induced failures. Only 8% of corrosion-induced failures result from a lack of awareness of the corrosion risk, and 10% result from a material not performing as it should. These percentages are lower than the 17% attributed to unforeseen operating conditions, 17% to improper protection of materials (coatings, lubricants, etc.), and 11% to poor process control. Additionally, 19% of corrosion-induced failures result from design faults—faults that presumably would have been corrected by proper attention to the materials-design interface.

The fact that a large fraction of industrial failures involve materials degradation is often ignored for two reasons. First, the team responsible for project design and construction is not the team responsible for operation and maintenance of the facility. Second, national consensus codes and standards rarely include specific provisions for age-related degradation processes other than uniform corrosion and fatigue.

However, if a project is to meet operational goals, serious attention must be given to materials qualification, selection, and validation. In fact, validation processes may be vital to the ultimate success of many projects, because the qualification efforts frequently are in parallel with, rather than prior to, project design. Based on these background observations, a materials-related program will play a key role in the success (or failure) of the long-term operational readiness of most major projects. Unfortunately, the introduction of metallurgical considerations to a project is frequently an afterthought, and the anticipated role for materials is secondary. Additionally, a reduction in materials costs is generally considered a cost savings rather than an increase in the potential for failure.
Most metallurgists are fully aware of the need for increased materials considerations; however, many designers are not aware of the importance that materials play in long-term project success. Perhaps, just perhaps, if the designers could become more aware of the real causes of corrosion-induced (and other) failures, the materials and design functions would become fully integrated early in the design process resulting in fewer failures.

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