Can We Afford to Ignore Corrosion?

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In a recent editorial in the British Corrosion Journal, they referred to the objection of a councilor on Surrey County Council who objected to the provision of a £20,000 sterling laboratory to be associated with a new sewage disposal plant. He objected because he could not understand why anyone would want to play around with "it" and analyze "it" when all they wanted to do was to get rid of "it". For those who specialize in corrosion, it is difficult to realize that most industries are not as interested in understanding and analyzing their corrosion problems as they are in getting rid of them.

Until recently, the materials engineer relied upon a combination of his experience and the use of economic analysis to make the proper choice of materials. His economic analyses required projection of useful life, probable obsolescence, eventual cost of equipment replacement - all seasoned with future predictions on the costs of money and labor.

The conservationists point out that the end of our natural resources is in sight. But the more optimistic of these people allow that in many cases the supply is virtually inexhaustible if we can afford to pay the additional cost of working leaner and leaner resources. Can the materials engineer today foretell the probable cost of a depleting resource 20 or 40 years hence? There is an immediate need for a conservation dimension to be inserted in our economic decisions on materials selection, both in the interests of industry faced with ultimate replacement of equipment and in the interest of the nation as a whole.

If we assume, as we have done in the past, that the economic yardstick has the best validity, let us examine the probable cost of corrosion. In 1949, the direct cost of corrosion in the USA was estimated to be 5 billion dollars per year. More recent surveys in 1971 undertaken by T. P. Hoar in England on behalf of the Department of Trade and Industry, suggested that direct losses due to corrosion would be 1.25% of the gross national product. A recent estimate of the National Commission on Materials Policy in the USA comes up with the figure 15 billion dollars per year whereas using Hoar's percentage of the GNP, in the USA, the USA losses would approach 30 billion dollars per year. The total annual costs of fires, floods, hurricanes, tornadoes, and earthquakes in North America do not exceed the lowest estimate on the direct costs of corrosion.

Let us examine some of the costly areas to see how such enormous losses can be accumulated. A national Bureau of Standards report in 1966 stated that 40% of US steel production was used to repair or replace items rendered useless due to corrosion. At that time, this amounted to 40 million tons of steel a year. Fifty percent of the world's zinc production is sacrificed to protect steel. Sixteen cents on every barrel of crude oil is spent on corrosion losses.

Corrosion costs the oil and gas industry an estimated $200 per mile of line pipe per year on over one million miles of underground pipelines in the USA.

The importance of reducing some of this wastage transcends the economic considerations because some of this waste results in the dispersion of essential materials in such a manner that they cannot be recovered by recycling. Voluntary restraint does not seem to work well in our society. It will no doubt be necessary for changes to be made in our tax structure such that the national policy on materials (when formulated) will be followed using familiar economic methods of analysis. It is difficult to predict what form these measures will take, but no doubt they would involve different depreciation write-off procedures, tax concessions on increased capital expenditures to decrease maintenance costs, to increase equipment life, or salvage value, etc. It is incongruous that original equipment is often made of less than adequate materials simply because the piece of equipment can be eventually rebuilt of the proper materials under maintenance programs where the maintenance dollars are worth 50% of capital dollars.

Although energy cannot be destroyed, it is only useful when sufficiently concentrated. Concentrated forms of energy are used in the mining and refining of metals, in the preparation and upgrading of chemical feed stocks, and the manufacturing processes of all common engineering materials from Portland cement to house bricks. Take steel making for example; our older steel plants use 35 million BTU's to produce one ton of steel. In new plants, the reduction of some 7 million BTU's per ton is considered a possible goal. If 60 million tons of steel are wasted yearly in the USA, then the energy loss is enormous.

The USA steel industry consumes 66% of the coal used by industry in the USA. Forty percent or even 20% savings in this valuable commodity would be worthwhile, especially since the coal will be relied upon in our eventual transition from an oil-fueled economy to a nuclear fueled economy. Even after nuclear energy replaces oil, coal will be needed to produce chemical fed stocks and fuels for aircraft for as long as we can look into the future.

Professor Ulick Evans of Cambridge wrote that interest in corrosion is not something that can be created at will and that it would be a fallacy to imagine that something that makes no appeal to the interest can safely be neglected. If the metallurgists continue to present us with better and stronger materials and if the design engineer with his computers arrives at more sophisticated designs, then the principal cause of industrial failure will be corrosion. If this pertains, then a design engineer who is not interested in corrosion will be one who is not interested in industrial safety.

Corrosion occurs in an often insidious manner. It attacks the internals of equipment where it cannot be seen. It concentrates in highly stressed areas, producing cracks which lead to catastrophic failure. It can lie dormant and suddenly awaken when some environmental parameters change such as temperature or velocity.

Most catastrophic industrial failures have corrosion among their causes. In many cases, corrosion is found to be the principal factor leading to structural or mechanical breakdown. The US chemical industry estimates that the annual costs due to stress corrosion cracking failures alone to be in the order of 30 million dollars per year. In 1968, the US Air Force determined that 38% of their aircraft accidents, major and minor, were attributable to corrosion. A serious problem presently exists in the US atomic energy program which is causing many delays in the construction schedule. In the boiling water reactors, unstabilized grades of steel were used with their predictable (to everyone but the design group) weld area problem. The BWR's also developed corrosion problems in Inconel 600 tubing due to changes in water chemistry adjacent to the tubes, resulting in both pitting and caustic cracking problems.

After early success in the United Kingdom with the Magnox reactor, a serious corrosion problem occurred in the advanced gas cooled reactor where carbon steel bolts in the core vessel corroded in high temperature carbon dioxide, requiring the rebuilding of the internals of these reactors. Although corrosion was not the principal reason for the scrapping of the UK AGR program, it was a substantial contributing cause.

Most people have heard of the various failures associated with the use of stainless steel where the chloride ion was unexpectedly present. A large electrothermal station at Bath, Ontario, Canada had a boiler tube failure during tests due to chloride induced stress corrosion cracking.

The failure occurred before the unit was ever in service and necessitated a very costly repair. These failures point out the necessity of careful consideration of corrosion factors during all stages of design.

A very well known corrosion scientist, S.C. Britton, in a recent article said that the proper first answer to a question about corrosion seemed to be the one most exasperating to the lost traveler seeking direction. “If I were going there, I would not start from here.” Like the traveler, the corrosion engineer must start from wherever he is. Recognition of the type of corrosion and even prescribing the cure is usually the easiest part of the business. Finding and applying an acceptable economic cure for corrosion becomes the major difficulty. It does little good for a doctor to recommend that his poor patient take a cruise around the world for his health, since “what to do” and “how to do it” must be followed by “insuring that it is done”.

To be effective, the person with the corrosion responsibilities must be intimately involved in all the design stages as well as in the operation of the finished equipment. This generally means that the mechanical, chemical, or metallurgical engineer involved in any process industry must educate himself in corrosion principles such that he can intelligently apply the recommendations of experts and above all, be able to ask the correct questions to lead quickly to the solution to the problem that could involve the safety of his operation.

The answer to our question “Can We Afford to Ignore Corrosion?” is an obvious “no”. The time is fast approaching when every engineer and technician, regardless of his specific discipline or industry, must develop an interest in corrosion and be sufficiently knowledgeable to anticipate corrosion problems before they occur. Management must also be informed of the effects of corrosion on conservation of materials and energy, the economy of our society, and the safety of our industrial processes.