

Cathodic Protection Against Cavitation Damage

AN INVESTIGATION WITH PLATINUM-CLAD ANODES

The vapour cavities that form in very rapidly flowing or vibrating liquids may collapse on metal or other surfaces in the liquid and cause localised deterioration, known as cavitation damage. This type of damage may occur on marine propellers, and it is common to find all forms of corrosion or erosion damage on propellers referred to as "cavitation". This unfortunately loose application of the term is partly responsible for the wide discrepancy in results that have been reported for the effectiveness of cathodic protection in preventing cavitation damage.

The principle underlying the use of cathodic protection to prevent corrosion is to apply a cathodic current to the metal concerned sufficient to depress its potential below the minimum at which it is thermodynamically possible for the metal to pass into solution in the medium in which it is situated. The forces developed by collapse of vapour cavities in experiments using magnetostriction apparatus and at the blade roots and certain other areas on propellers of some design are, however, sufficient to cause direct mechanical removal of metal and one would not expect this type of attack to be affected by normal cathodic protection. Much of the damage that occurs on propeller blades in service — particularly near the tips — is probably due to impingement attack rather than cavitation and this, being largely an electrochemical corrosion process, can be prevented by cathodic protection.

A recent paper by H. S. Preiser and B. H. Tytell (1) provides an excellent discussion of the types of cavitation damage that can occur and describes experiments on the application of cathodic protection, using a platinum-clad tantalum anode, to mild steel and manganese

bronze specimens fixed to a propeller boss and rotated at 1,250 r.p.m. 10 ft. below the surface in open sea water. In most of these experiments the specimens were rods, $1\frac{1}{2}$ in. diameter $\times 6\frac{1}{4}$ in. long, screwed into the propeller boss. Cavitation damage was severe on the trailing half of each specimen when no cathodic protection was applied, but became progressively less with increasing applied cathodic current densities between 150 and 500 ma/ft².

Preiser and Tytell distinguish three types of cavitation damage: (a) *cavitation deformation or fracture* in which the forces developed by the collapsing cavities are sufficient to remove particles of the material from the surface on which cavitation is taking place, (b) *cavitation fatigue* in which the stresses due to cavity collapse are below the proof stress of the material but sufficient to cause fatigue cracking as well as removing protective surface films and exposing the metal to the corrosive action of the surrounding medium, and (c) *cavitation corrosion* in which the forces are sufficient only to damage the protective film and the actual removal of the metal is entirely electrochemical. This differs from impingement attack only in the nature of the forces causing breakdown of the protective film.

The type of cavitation that is occurring is indicated by the cathodic current density that is necessary to prevent it. The relatively small currents that were found sufficient to prevent damage in Preiser and Tytell's experiments show that the type of cavitation concerned was cavitation corrosion. Similarly, in cases where cathodic protection at low current densities has been found effective in preventing cavitation damage to propellers in service

this damage may also be considered to have been due to cavitation corrosion. Impingement attack would equally be suppressed by cathodic protection and Preiser and Tytell do not discuss how cavitation corrosion in service can be distinguished from impingement attack. They do differentiate between the two and note that since the attack on their rotated rod specimens occurred on the trailing half rather than the leading half the damage to the film was caused by cavitation rather than impingement forces in these experiments.

Cathodic protection at low current densities has practically no effect on cavitation deformation or fracture since the damage is almost entirely due to mechanical forces. The damage can be reduced or prevented, however, if very high currents are used. Current densities of the order of 250 amps/ft² have been found by other workers to be necessary to prevent damage by cavitation in experiments using magnetostriction apparatus. The hydrogen that is freely evolved from the protected metal at these current densities is believed to act as a resilient gas cushion between the collapsing vapour cavities and

the metal surface. Entrained air has a similar effect in reducing cavitation damage and is sometimes introduced into hydraulic systems to prevent cavitation.

In cavitation fatigue metal is not removed directly by mechanical forces and electrochemical corrosion consequently plays an important part. In this case cathodic protection at low current densities greatly reduces the severity of attack since it prevents removal of metal by corrosion, but it does not prevent damage completely since the repeated collapse of cavities on the same part of the metal surface can still cause fatigue cracking. To prevent this requires, as in the case of cavitation deformation or fracture, a current density sufficient to give hydrogen evolution.

To provide a controlled range of current densities in their experiments Preiser and Tytell used impressed current cathodic protection with a platinum-clad tantalum anode. The advantages of platinum-clad tantalum over other anode materials for cathodic protection in sea water have been discussed in a previous paper by the same authors (2).

H. S. C.

References

- 1 H. S. Preiser and B. H. Tytell .. The Electrochemical Approach to Cavitation Damage and Its Prevention, *Corrosion*, 1961, **17** (11), 535T
- 2 H. S. Preiser and B. H. Tytell .. Some Platinum Anode Designs for Cathodic Protection of Active Ships, *Corrosion*, 1959, **15** (11), 596T

High-Temperature Properties of Platinum Metals

STRENGTH AND DEFORMATION CHARACTERISTICS

Some two years ago the Battelle Memorial Institute submitted to the U.S. Office of Naval Research a report on "High-Temperature Properties and Alloying Behaviour of the Refractory Platinum-Group Metals", designed to survey the literature and thence to reveal areas in which investigation is needed. A further report, by R. W. Douglass, C. A. Krier and R. I. Jaffee, has now been issued, under the same title, describing the results of three years of study. The experimental work now reported was based largely on the results of the earlier literature survey.

Much of the report, running to 170 pages, is concerned with the strength properties of the more refractory platinum metals at high temperatures, and includes studies of strength-temperature relationships, deformation characteristics, strain and structure sensitivity and fracture initiation and propagation characteristics. At high temperatures the mechanical strengths of rhodium and iridium are shown to be superior to those of tungsten, molybdenum, tantalum and niobium.

Other sections of this report deal with fabrication, alloying behaviour and oxidation.