NASA TECH BRIEF

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Coatings Decrease Metal Fatigue Failure

The problem:

Metals under cyclic stress have a greater tendency to fail in the atmosphere than in vacuum. This is attributed to reaction of atmospheric oxygen and water vapor, or other reactive gases, with the fresh metal surfaces which are exposed by fatigue cracking. Thus, if contact of the atmosphere with metal in fresh cracks could be limited or prevented, the fatigue properties measured in air should approach those observed in vacuum; testing of metals for spacecraft would be simplified, and service life of parts subject to fatigue failure in reactive environments could be increased by the application of suitable protective coatings.

The solution:

Metal test specimens were coated with suitable materials to limit the rate of attack of fresh metal surfaces by the atmosphere. The fatigue properties of coated metals were superior to those which were uncoated and, in many instances, approached the properties observable in vacuum.

How it's done:

Preliminary experimental work was performed with pure magnesium metal test specimens in flat, localized-stress, cantilever configurations which had been abraded mechanically and then polished chemically. Fatigue tests consisted of cyclic, fully-reversed plane bending (30 cps) under constant load at room temperature. The first tests were performed to establish curves for fatigue life *vs* cyclic loading in air at one atmosphere and in vacuum at 10^{-7} torr. Then, coating materials were selected on the premise that they would be (a) relatively resistant to penetration of reactive gases in the atmosphere over the period of test and (b) sufficiently ductile to withstand without fracture the strains imparted to the metal substrate by bending.

Fatigue tests in the atmosphere were conducted with base metals such as magnesium, magnesium-thorium alloy, magnesium-lithium alloy, and aluminum 1100, 2024, 6061, and 7075 alloys; applied coatings included polymeric material types, such as silicone, polyamide, polyethyleneterephthalate, and epoxy, as well as electro-plated nickel. In every instance, test data indicated that the fatigue life of the coated specimens in air was superior to that of uncoated specimens, and in some instances was equal to that obtainable in vacuum environment. Fatigue strengths of coated specimens in air were increased by 20 to 55%.

Metallic, inorganic, or polymeric coatings selected for special optical, electrical, or mechanical properties may also be used if they can meet the basic impermeability and ductility requirements. They may be applied by established techniques, such as electroplating, solvent or aqueous sprays, dipping, brushing, vapor deposition, or other appropriate means.

Notes:

1. Polymeric materials are usually quite permeable to oxygen. Thus, long-term protection by polymeric coatings must be evaluated prior to consideration of extended applications.
2. Documentation is available from:

   Clearinghouse for Federal Scientific
   and Technical Information
   Springfield, Virginia 22151
   Price $3.00
   Reference: TSP69-10176

Patent status:

No patent action is contemplated by NASA.

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