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(NASA-CR-158361) OPERATIONAL LOOPWHEEL SUSPENSION SYSTEMS FOR MARS ROVER DEMONSTRATION MODEL: LOOPWHEEL FAILURE REPORT (Lockheed Missiles and Space Co.) 6 p HC A02/MF A01 CSCL 14B G3/14 N79-20163 Unclas 16689

Operational Loopwheel Suspension Systems for Mars Rover Demonstration Model – Loopwheel Failure Report

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INTRODUCTION AND SUMMARY

In late November, 1978, Lockheed-Huntsville delivered four traction elements using Lockheed's Loopwheel concept to the Jet Propulsion Laboratory (JPL) for use on their Mars Rover demonstration model. Two Lockheed employees were in attendance for three days of acceptance tests. These tests were successful and the Loopwheel systems were accepted by JPL.

Several days later, however, a JPL employee detected a transverse crack in the inner fibers of one of the fiberglass loops. (Note that the loops were made of fiberglass, as opposed to titanium alloy specified for flight units, for reasons of economy. Fiberglass has been successfully used in several test and evaluation loops made for military customers. The traction element loops delivered to JPL were designed for a 7.5 mile fatigue life when loaded to 160 pounds per loop.) Nevertheless, the crack did form sometime before, during or immediately following the acceptance tests.

Lockheed was notified of this failure and the unit was shipped to Huntsville for repair and a thorough analysis of the failure. Results from this analysis are presented in this report, including probable causes and recommendations for modifying the remaining three units to minimize chances of such a failure again occurring.

PROBLEM STATEMENT

At some point during testing the fiberglass loop that failed developed a transverse crack in the inner fibers. The crack extends from the center of the loop, adjacent to one of the tread lugs, in both directions to within two inches of each edge. The crack appears to start at the center and then grow in both directions. Upon closer inspection of the loop the outer fibers were found to be bulging at two locations, at the crack and also adjacent to a tread lug. This indicates possible compressive failure in the loop.

The JPL loop is designed for a low profile which requires a large radius of curvature in the transverse direction. As a consequence the loop is susceptible to buckling.

ANALYSIS AND RESULTS

The loop was analyzed using the Nonlinear Elastic Plastic Structural Analysis Program (NEPSAP). The NEPSAP model includes one-fourth of the loop, 180 degrees circumferentially and one-half the width. Symmetric and antisymmetric boundary conditions were used to get a complete representation of the loop. The model consists of 205 nodes and 160 isoparametric plate elements. The load is introduced at the bottom of the loop and is reacted at the load roller.

When inspecting the failed loop in the loaded condition it was found that only three or four tread lugs were in contact with the hard flat ground at any one time. It was also observed that the outside ends of the tread lugs were not in ground contact, resulting in the load being introduced only at the center of the loop.

To simulate the above load conditions, a point load was applied at the center of the loop model. This resulted in high compressive stress (-70 to -80 ksi) in the outer fiber of the loop at the point of load application.

The same load was also introduced as a distributed load across the width of the loop resulting in stresses being reduced by 50 percent. A load condition with a triangular load distribution, peaking at the outer edge of the loop, was also checked and the stresses were reduced to approximately 40 percent of the point load case.

The high compressive stresses encountered with a point load applied at the center of the loop (which go even higher during the buckling process) are very near the material allowables for the S-glass/epoxy loop.

CONCLUSIONS AND RECOMMENDATIONS

The loop failed in compression in the outer fibers forming a hinge which, through cycling, caused the inner fibers to break. The probable cause of this failure is the load being introduced as point loads at the center of the loop causing high compressive stresses and early buckling. To decrease the stress level and delay buckling, the tread lugs should be reshaped so that the entire lug contacts the ground or better yet only the outer portion of the lug contacts the ground when the loop is loaded. This can be accomplished through removal of lug material, starting with zero removal at the outer edge and linearly increasing to one-half of the lug thickness at the center.