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Literature Review on Pickling Inhibitors and Cadmium Electroplating Processes

The problem of hydrogen-induced delayed brittle failure, or hydrogen-stress cracking, of parts fabricated from high-strength steels has been the subject of a large research effort during the past five years. The primary reason for this problem was that most of these high-strength steels must be protected from corrosion in their service environments. The preferred method of providing this protection was cadmium electroplating. However, the application of electrodeposited coatings to solve corrosion problems, or to provide other desirable surface qualities, could make the part susceptible to failure by hydrogen-stress cracking because, frequently, hydrogen was introduced during the cleaning, pickling, and electroplating operations.

As a result of hydrogen-stress-cracking failures attributed to hydrogen introduced during bright-cadmium electroplating, restrictions were placed on the use of cadmium electroplating on certain steels having tensile strengths greater than 220,000 psi. Thus, it was necessary for manufacturers to resort to other methods of providing corrosion protection that were inferior to bright-cadmium electroplates in the protection provided. Consequently, many studies of electroplating processes, particularly cadmium electroplating, have been conducted to determine whether one or more processes could be used for electroplating ultrahigh-strength steels without the likelihood of encountering hydrogen-stress-cracking failures.

These studies showed that most ultrahigh-strength steels were embrittled to various degrees by virtually all of the common electroplating processes, including cadmium, chromium, zinc, tin, nickel, lead,

copper, and silver. These earlier studies also showed that the amount of hydrogen entering steel specimens during certain electroplating processes might be as great as that introduced during severe cathodic charging and that more hydrogen sometimes was introduced during pickling or cathodic cleaning prior to electroplating than during the actual plating operation. As a result of these findings, some work was expended in evaluating the hydrogen-embrittling tendencies of preplating cleaning and pickling processes, particularly on the effectiveness of inhibitors in minimizing hydrogen absorption during acid pickling. In addition, these studies showed that the sustained-load tensile test employing notched bars was the most sensitive method for evaluating the embrittling tendencies of cleaning and electroplating processes.

Because of numerous confusing and conflicting statements contained in the technical literature concerning the hydrogen-embrittling tendencies of various cleaning, pickling, and electroplating processes and concerning the susceptibilities to hydrogen-stress cracking of various high-strength alloys, a program was undertaken to evaluate various processes and materials. The first survey constituted a review of the literature on the phenomenon of hydrogen-stress cracking and the embrittling tendencies of conventional cleaning, pickling, and electroplating processes. The results of numerous investigations into this problem area were included along with data on the effectiveness of various hydrogen-embrittlement relief treatments. The report on the literature and industrial survey also presented information on reportedly low-hydrogen-embrittling and nonhydrogen-embrittling

(continued overleaf)

cleaning, pickling, and electroplating processes and on hydrogen-embrittlement relief treatments.

This report describes the results of a literature and industrial survey of the available information on the effectiveness of inhibitors for reducing hydrogen absorption by steels during acid pickling and on additional low-hydrogen-embrittling and nonhydrogen-embrittling cadmium-electroplating processes. No attempt was made to repeat the information on pickling inhibitors and cadmium-electroplating processes presented in the previous reports.

Notes:

1. Several organic compounds have been shown to be quite effective in reducing attack on a hydrogen absorption by low-carbon steels during acid pickling. These compounds warrant further study to determine their effectiveness in reducing hydrogen embrittlement in certain ultrahigh-strength steels.
2. This literature review should prove valuable to metallurgists, producers of steel, and to the aircraft and related industries.

3. No further documentation is available. Inquiries may be directed to:

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No patent action is contemplated by NASA.

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