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Evaluation of Pressurized Water Cleaning Systems For Hardware Refurbishment

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Abstract

Historically, refurbishment processes for RSRM motor cases and components have employed environmentally harmful materials. Specifically, vapor degreasing processes consume and emit large amounts of ozone depleting compounds. This program evaluates the use of pressurized water cleaning systems as a replacement for the vapor degreasing process. Tests have been conducted to determine if high pressure water washing, without any form of additive cleaner, is a viable candidate for replacing vapor degreasing processes. This paper discusses the findings thus far of Engineering Test Plan - 1168 (ETP-1168), "Evaluation of Pressurized Water Cleaning Systems for Hardware Refurbishment."

Introduction

Thiokol Corporation is one of the largest users of 1-1-1 Trichloroethane (TCA) in Utah. TCA is an EPA targeted Ozone Depleting Compound that is scheduled to be banned from production in 1995. Thiokol currently uses approximately 400,000 pounds of this material per year in its vapor degreasing operations for RSRM hardware refurbishment. Therefore, Thiokol and NASA/MSFC personnel recognized the immediacy of a necessary change in the refurbishment process. A joint Thiokol and NASA/MSFC ODC Elimination team was formed to investigate alternative cleaning methods for RSRM hardware. The team's approach for the elimination of TCA from all RSRM processing is divided into two phases. Phase I is scheduled to eliminate 90% of TCA usage by January 1, 1996. It is accomplished through two main steps. This paper discusses the Phase I Step I effort. The Phase I Step I task is the replacement of the Refurbishment Center's vapor degreasing system with a high pressure water wash system in conjunction with the implementation of greaseless storage and shipment of RSRM hardware.

Body

Thiokol is investigating several approaches to eliminate the use of TCA in the RSRM hardware refurbishment process. This paper focuses on one of these approaches, pressurized water cleaning systems. The investigation of pressurized water cleaning systems is broken into two phases as outlined in ETP - 1168.

Phase One of the test plan was established as a feasibility phase and completed in July of 1993. Phase One testing demonstrated that all non-bonded contaminates such as grease, proof test oil, and magnetic particle inspection residue could be removed at operating pressures not exceeding 15,000 psi. This portion of the testing was so promising that a quick study of paint removal at 15,000 psi was incorporated into Phase One testing. Although the testing proved that paint could be removed at these pressures, it removed the paint too slowly to fit into Thiokol's scheduling requirements. Phase one testing was completed on 8" x 10" witness panels. Further, preliminary erosion testing was accomplished on 2" x 2" steel or aluminum coupons. On the basis of this early testing, more in-depth investigations of bonded contaminates were undertaken in Phase Two testing.

Phase Two of the testing investigates the critical parameters of the high pressure water wash system, the erosion caused by the high pressure water on both D6AC steel and aluminum substrates, the feasibility of cleaning full scale components, and all bond lines that are affected by the change in processing. To accomplish these tasks, Phase II efforts are divided into seven tables investigating five contaminates on 2 different substrates. The contaminates are grease, proof test oil, magnetic particle testing residue, epoxy paint/primer, epoxy based adhesives and insulator residue. The two substrates are D6AC steel and 7075 aluminum. Of the seven tables, the first three have been completed. A description of the tables follows.

The first table is a design of experiments devised to determine the critical process parameters of the high pressure wash system. The parameters investigated were pressure, flow, nozzle rotational speed, nozzle angle, nozzle standoff, and sweep rate across the part. The contaminates and substrates chosen for this testing were grease on steel and aluminum, epoxy paint/primer on steel, and EA913 adhesive on aluminum. The measures for the tests were level of cleanliness and erosion. Thus, the critical parameters yielded by this test were those that had the most impact on level of cleanliness and the amount of erosion. The results are shown in Table 1 below.

Table 1
Engineering Test Plan – 1168
Statistical Evaluation

Parameter	Test Range	Significant Effect Erosion (D6AC)	Significant Effect Rating (D6AC)	Significant Effect Erosion (AL)	Significant Effect Rating (AL)
Pressure	18 - 36 ksi	No	Yes	Yes	Yes
Flow	6 - 12 gpm	No	No	No	No
Nozzle Speed	400 - 800 rpm	No	No	No	No
Nozzle Angle	60 - 80 deg	No	No	No	No
Standoff	3 - 10 in	Yes	Yes	Yes	No
Sweep Rate	1 - 10 in/sec	No	Yes	Yes	Yes

It should be noted that significant effect in this case represents statistical significance. When the erosion rates of the pressurized water cleaning are compared to the current grit balst process, the erosion due to pressurized water cleaning is an order of magnitude lower than the current grit blast process.

The second table of the test plan establishes maximum removal rates for all contaminate/substrate combinations that are present on RSRM hardware. It sets the critical parameters from the first table to their optimum settings and increases/decreases the sweep rate across the part until a 100% clean surface is achieved. The maximum removal rates established are given in Table 2.

Table 2
Engineering Test Plan - 1168
Established Maximum Removal Rates

Contaminate	Substrate	Maximum Removal Rate, sqin/min/nozzle
EA913NA	D6AC Steel	205
EA946	D6AC Steel	499
Chemlok® 205/233	D6AC Steel	281
Chemlok® 205/236A	D6AC Steel	378
Chemlok® 205/220/Tycement®	D6AC Steel	228
Rust-Oleum® Paint/Primer	D6AC Steel	343
Conoco HD-2 Grease	D6AC Steel	723
Shell Diala Oil	D6AC Steel	1250
Magnetic Particle Rinse Solution	D6AC Steel	1250
EA913NA	7075 Aluminum	185
EA946	7075 Aluminum	449
Alodine, Bostic Finch Paint/Primer	7075 Aluminum	228
Conoco HD-2 Grease	7075 Aluminum	723

The third table addresses the feasibility of cleaning full scale components. To this point in the test plan all testing has focused on 8" x 10" witness panels and 2" x 2" erosion coupons. To ensure that similar removal characteristics could be obtained on full scale RSRM hardware, six components were tested that represent all contaminate/substrate combinations. The six components are RSRM Throat Housing, Nose Inlet Housing, Cowl Housing, Fixed Housing, Forward Dome and Forward End Ring. In all cases the maximum removal rates established in table two were met or exceeded on the full scale hardware.

Tables four through seven investigate the bondline sensitivity of RSRM case and nozzle components when the refurbishment process is changed from vapor degreasing to high pressure water washing. These tables process one set of witness panels and surface analysis coupons through the current process in parallel with another set processed through the proposed process. Each step of each process is included in the test plan. For this testing the bond strength is the measure. After completion, the bond strengths associated with each process will be compared to see if there is any significant difference between the two processes. Further, the bond strengths will be compared to historical RSRM data. This testing will be conducted over the next three months.

Conclusions

Testing to date indicates that pressurized water cleaning systems are a viable alternative to vapor degreasing operations. Thiokol has demonstrated that more than just grease removal can be obtained with the high pressure water systems. In fact, a high pressurized water wash system would most likely not be justified if the only contaminate being removed was grease. However, the pressurized water wash systems are extremely versatile and can be adapted to replace many technologies. In this RSRM application the high pressure water wash system will replace vapor degreasing, some manual grit blasting, some manual glass bead, and some manual low pressure (10,000 to 15000 psi) water blasting operations. Further, Thiokol was able to gain added benefits in the form of a more consistent process yielding higher quality components, removal of operators from injury prone environments, less possibility of damaging RSRM hardware, and greatly reduced processing times.

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