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Research and Development

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Project Summary

Demonstration of a Liquid Carbon Dioxide Process for Cleaning Metal Parts

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The report discuses the demonstration of liquid carbon dioxide (LCO_2) as an alternative to chlorinated solvents for cleaning metal parts. It describes the LCO_2 process, the parts tested, the contaminants removed, and results from preliminary laboratory testing and the onsite demonstration at the Air Logistics Center at Robins Air Force Base, GA.

The objective of the project was to find and demonstrate innovative parts cleaning technologies to replace environmentally damaging chemicals with more benign processes. The process chosen to be replaced was vapor degreasing in 1,1,1-trichloroethane (TCA), a solvent that is ozone-depleting, a hazardous air pollutant, and one of the 17 chemicals on the U.S. Environmental Protection Agency (EPA) 33/50 list of priority pollutants. Carbon dioxide degreasing was chosen for demonstration as a potential alternative to TCA because it is noncombustible, nontoxic, on the EPA Significant New Alternatives Program list of approved cleaning alternatives, and not ozone-depleting.

This Project Summary was developed by EPA's National Risk Management Research Laboratory's Air Pollution Prevention and Control Division, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The objective of the project was to conduct a preliminary feasibility demonstration of the application of liquid carbon dioxide (LCO_2) for general surface degreasing and cleaning. The demonstration was a joint effort conducted through the cooperation of the U.S. Air Force (USAF) and the U.S. Environmental Protection Agency (EPA). A goal of the study was to demonstrate the LCO_2 technology as an alternative to the use of 1,1,1-trichloroethane (TCA) for surface cleaning in manufacturing and maintenance processes. TCA vapor degreasing is still widely used in many commercial operations, Department of Defense (DOD) facilities, and defense related industries for cleaning metal parts, although its use has decreased significantly in recent years. Surface cleaning with LCO_2 has seen limited use for small parts cleaning but has not been demonstrated for large parts and general cleaning applications. It has been used for cleaning such devices as electronic components, medical devices and tubing, optics, ceramics, and natural fibers. The work presented in this report was conducted at Warner Robins Air Logistics Center (WR-ALC) at Robins Air Force Base (RAFB), GA. This DOD Air Logistics Depot provides worldwide engineering and management for various USAF fighter, transport, and helicopter aircraft, and ground support equipment. The report gives the results of the feasibility study on the application of LCO_2 for surface cleaning and degreasing applications.

LCO_2 Cleaning

LCO_2 is distinctively different from the more commonly known supercritical carbon dioxide (CO_2). LCO_2 is formed at lower pressures and temperatures than the supercritical fluid. However, it retains much of the solvency of supercritical CO_2 and provides the added benefits associated with a liquid solvent system. LCO_2 can permeate into natural or machined holes on the surface like a gas to remove many oils, greases, and other soluble contaminants. As opposed to aqueous systems, once the pressure is released, LCO_2 rapidly returns to a gas without leaving a liquid within the surface porosity. LCO_2 has been identified and placed on the EPA Significant New Alternatives Program list as an approved alternative cleaning agent. An LCO_2 degreasing system performs much the same as TCA vapor degreasing, and neither is intended to remove imbedded solid contaminants from the surface. However, similar to TCA systems, the surface cleaning can be enhanced by the addition of complementary processes such as ultrasonics or megasonics.

Program Approach

An LCO_2 system was acquired and installed at WR-ALC, RAFB, GA. Sample parts for cleaning were provided by various organizations at the facility. The cleaning criteria were established by the organizations supplying and inspecting the parts for acceptance after cleaning. The decision of acceptability was made by the respective organizations based on their cleaning requirements and criteria. The parts tested during the study included fuel system tubing, brass filters, machined metal parts, bearings, bolts, brackets, and oily rags. Some parts were given a preliminary soaking in a high-boiling, nonflammable mixture of hydrocarbon oil and surfactants to dislodge difficult contaminants from the surface. The oil mixture and the suspended contaminants were removed from the parts by the LCO_2 process. The oil was recycled back to the hot oil cleaning process. The CO_2 also was recovered and recycled to the process.

Results

Results of the demonstration were determined by the cleanliness criteria defined by the organizations supplying the parts. The acceptability of the cleaning process was determined by evaluating the cleanliness of parts cleaned by the LCO_2 process and equivalent parts cleaned by the current process. The results showed that the LCO_2 process can remove drawing compound from aluminum and titanium tubes used in fuel systems, hydraulic fluid from brass filters, and general shop dirt from aluminum, brass, and stainless steel parts. Breathing oxygen system parts and aluminum honeycomb core also were cleaned. Further testing will be required, however, to complete validation of the LCO_2 process for these applications.

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The complete report, entitled "Demonstration of a Liquid Carbon Dioxide Process for Cleaning Metal Parts," (Order No. PB97-121149; Cost: $25.00, subject to change) will be available only from

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