Case Studies of Successful Implementations Of Aqueous Cleaning Systems

Richard D. Pirrotta, PE, Manager, Process Engineering
Concurrent Technologies Corporation

Introduction

Non-halogenated metal parts cleaning systems were tested and evaluated for environmental compliance as well as technical and economic feasibility. Surface cleanliness testing was carried out by Concurrent Technologies Corporation (*CTC*) at Department of Defense (DOD) and commercial facilities to establish a baseline of current cleaning operations and evaluate the feasibility of aqueous cleaning systems for specific applications. Several different aqueous cleaning systems were procured, installed, and validated. These activities provide the knowledge and experience necessary to successfully implement new technologies at DOD and commercial sites.

Technology Implementation

To successfully implement new technologies, questions about technical, schedule, financial, and regulatory risks must first be answered. Examples of these risk-related questions include:

Technical
- Will the system work?
- In our shop?
- With our people?

Schedule
- How long will it take to evaluate the options?
- How much production downtime will occur?

Financial Risk
- How much capital investment is required?
- What is the payback period for this investment?

Regulatory Risk
- Is the process compliant?
- What happens when the regulations change?
- What about proof?

Technology Transition

A six-step approach to technology implementation, was developed to minimize these risks. Examples of work performed in each step include:

1. *Requirements Analysis*
    - Perform an on-site survey
    - Establish a baseline
2. *Identified Alternatives*
    - Perform environmental information analysis

- Identify potential solutions and regulatory requirements
- Perform preliminary assessment

3. *Technology Demonstration*
   - Perform feasibility, optimization, and verification tests
   - Demonstrate alternative technologies
   - Gather system operating data
4. *Technology Justification*
   - Perform cost, schedule, and regulatory analyses
   - Perform risk and life cycle assessment
5. *Technology Implementation*
   - Design, procure, fabricate, install, and startup alternative technologies
   - Design and conduct training
6. *Follow-up*
   - Review the implementation periodically
   - Measure progress
   - Recommend corrective actions to improve implementation

This approach was used at various industrial sites to transition cleaning technologies with minimum risk. Results of installations at a commercial site and a DOD site are described in the following sections.

Cabinet Washer Cleaning System

Spencer Turbine Company (Spencer), located in Windsor, CT, manufactures various blowers, fans, gas boosters, vacuum systems, and fittings, and other accessories for ventilation systems. Before the components of these parts can be assembled, various cutting fluids and light oils must be removed. To eliminate the emission of ozone depleting chemicals, steam clean and cold solvent wipe cleaning methods were used in place of their conventional vapor-degreasing cleaning operation. Both of these alternative processes were very time and labor intensive and resulted in very high operating and maintenance costs. In addition, steam cleaning created a rusting problem not previously encountered with vapor degreasing.

The Spencer plant was surveyed for baseline information regarding part cleanliness and quality requirements, soil types, part size distribution, part substrates, part geometry, current equipment and methods, operating costs, production throughput, process information, and current and future regulatory concerns. Soiled parts representing the common range of part sizes, geometry, and contaminants were obtained from Spencer. *CTC* personnel identified potential alternative cleaning systems after quantifying the existing level of contamination prior to cleaning and examining part geometry.

A study was also done on a one-step, drop-in solvent process as a replacement cleaning technology. The conclusion of this study was that the use of aqueous cleaning is more feasible based on technical, economic, regulatory, environmental, health, and safety factors.

The results of the requirements analysis and a review of the potential alternatives indicated that a high-pressure spray aqueous cleaning system was the most applicable for Spencer’s application. Spray systems are typically used for applications involving parts with simple to medium complex geometry, such as Spencer’s. A demonstration test plan was developed for a high-pressure spray power washer. This system is capable of cleaning parts up to 3’ x 4’ x 4’, which is large enough to handle most of Spencer’s parts. Bench-scale material compatibility testing was performed with Spencer substrates to identify feasible candidate cleaning chemistries for use in the process demonstration testing. Cleanliness levels achieved by the demonstration trials held in *CTC*'s demonstration factory were evaluated qualitatively and quantitatively. The results of the cleaning trials indicated that the power washer was a suitable cleaning technology for Spencer's application.

Connecticut permitting requirements were reviewed by *CTC* to determine whether Spencer needed to obtain any permits prior to installation and operation of an aqueous high pressure spray cabinet system. The results of this study showed that, for this type of system, Spencer would not be required to apply for an air permit, based upon the following conditions: the total capacity of the system would be 1000 gallons or less for ventilated tanks and the system would emit less than 5 tons/year of any one air pollutant.

CTC assisted Spencer with the development of a design specification for an aqueous high pressure spray cabinet system and a request for quotation package. *CTC* also developed a scoring system to evaluate vendor responses on both technical and economic merit. Using this system, a vendor was selected to fabricate the cleaning system which would be installed at Spencer's facility. *CTC* assisted Spencer in placing the order and following the procurement process. Once the system was assembled, *CTC* performed a factory inspection test at the vendor's facility to determine if the features detailed in the equipment specification were included in the system. *CTC* then assisted in the installation of the cleaning system at Spencer's facility and performed acceptance testing and startup. *CTC* completed the proven approach to technology transition by training Spencer personnel in the operation of the system, including chemical maintenance and waste minimization techniques. These actions insured that Spencer was able to operate the equipment in and effective and environmentally friendly manner. As a result of this installation, Spencer saved over $150,000/year, which is equivalent to a less than one year payback on their investment.

Rotary Basket Cleaning System

Examples of the complex parts evaluated for one DOD location include engine, transmission, and powertrain components such as rotor heads, transmissions, and engines. Parts were previously cleaned by vapor degreasing and cold solvent wipe techniques. These processes used outdated equipment, inefficient cleaning methods, and hazardous materials. As a result, the cleaning facility had difficulty meeting production and quality requirements, and was also a contributor to the overall waste streams.

An on-site survey was performed to gather baseline data on the cleaning operations and to recommend appropriate state-of-the-art cleaning technologies, methods, and materials suitable for current and future operations. The baseline data included part cleanliness and quality requirements, soil types, part size distribution, part substrates, current equipment and methods, operating costs, production throughput, process information, and current and future regulatory concerns. The baseline data and subsequent material and energy balances revealed that the degreasing and cleaning area was responsible for the majority of the needs identified for environmental compliance, production throughput, quality, and health and safety. The most critical needs were the elimination of ozone-depleting chemicals and the elimination/reduction of volatile organic chemicals from vapor degrease, solvent spray wash, and cold solvent wash processes.

Baseline information obtained on part geometry, production throughput, cleanliness requirements and soils was then used to evaluate alternative cleaning technologies. The evaluation revealed that cleaning technologies using immersion and parts rotation were the most suitable alternatives because of the complex geometry of the parts. In addition, aqueous cleaning chemistry was determined to be most applicable, based upon technical, economic, environmental, health, and safety criteria. The rotary basket system using immersion and parts rotation, with an aqueous cleaning chemistry, was chosen as the primary candidate for demonstration.

Actual parts from the DOD facility were tested in the rotary basket at *CTC*'s demonstration factory to determine suitable process parameters such as cycle time, temperature, chemistry concentration, and fixturing. Qualitative and quantitative tests were performed to determine the surface cleanliness levels achieved using the rotary basket. Qualitative testing included methods such as visual examination, wipe, and tape lift. These tests were performed to identify visible soils and their location (e.g. seams, threads, cavities). The qualitative tests merely defined the existence of residual soils; they did not indicate if the level of cleanliness was sufficient for that particular application. Quantitative testing, such as surface tension, weight test, and non-volatile residue analysis, assigned a number to the level of cleanliness. When used in conjunction with the baseline data, these tests indicated whether parts were clean enough for a particular application and allowed for direct comparison between cleaning trials under different operating conditions.

The results of the qualitative and quantitative tests performed on the parts cleaned in the rotary basket showed that the cleaning satisfactory. These results, combined with production throughput, cost savings, regulatory analyses, and the results of risk and life cycle assessments, justified the use of the rotary basket as a replacement technology for this application. Regulatory analyses indicated that a closed-loop, aqueous cleaning system, such as the rotary basket system is more environmentally compliant than vapor degreasing or cold solvent wiping. Fewer hazardous and regulated substances are used and less waste is generated.

As part of the technology implementation step, a survey team evaluated the existing facility and space constraints and developed project installation specifications and drawings. After process optimization testing was completed, the system was disassembled and prepared for shipment from *CTC* to the DOD site. The unit was shipped via truck to the site, where *CTC* personnel performed the reassembly and installation.

Startup was conducted by *CTC* personnel to ensure all facets of equipment checkout. All electrical, plumbing, and exhaust connections were checked. Validation was conducted by using a formal acceptance test to check all operational and safety features of the system and confirm that all commands entered through the programmable logic controller resulted in the appropriate process functions.

CTC personnel also trained the operators at the facility. The training consisted of classroom instruction on the theory of aqueous cleaning and the basic features and limitations of the rotary basket system. This was followed by demonstration of the system's capabilities and hands-on operator training. A training manual was written by *CTC* personnel and delivered to the operators. The manual included aqueous cleaning theory, rotary basket system specifications, operational and maintenance procedures, and troubleshooting guidelines.

The DOD site realized a significant reduction in operating costs by implementing the rotary basket. In addition, a significant increase in production throughput resulted from installation of the rotary basket due to the labor intensive nature of cold solvent wiping. By transitioning the actual unit from *CTC*'s demonstration factory, steps such as vendor selection, procurement and fabrication were avoided and the transfer of the system was completed within three months.

Since the installation, startup, and operator training were completed, *CTC* has remained in contact with site personnel to follow up with operations and assist with any technical questions or troubleshooting.

Conclusion

While there are many different types of cleaning applications, the procedure for transitioning replacement technologies remains the same.

- Baseline information on the current process must be gathered.
- This information must be analyzed to identify the appropriate alternatives.
- Process alternatives must be demonstrated and optimized.
- The selected technology must be justified on cost, schedule, and regulatory analyses, as well as risk and life cycle assessments.
- The technology must be installed and started up, and process operators must be trained on its proper use.
- Follow-up must be conducted periodically to aid in troubleshooting and improving the implementation.

CTC has successfully used this six-step approach to transition aqueous cleaning technologies and will continue to assist industry in overcoming the technical, schedule, financial, and regulatory risks inherent in technology transition.