Successful Cleaning Process Requires Team Effort

Customer and supplier mount intensive effort to develop a new cleaning process.

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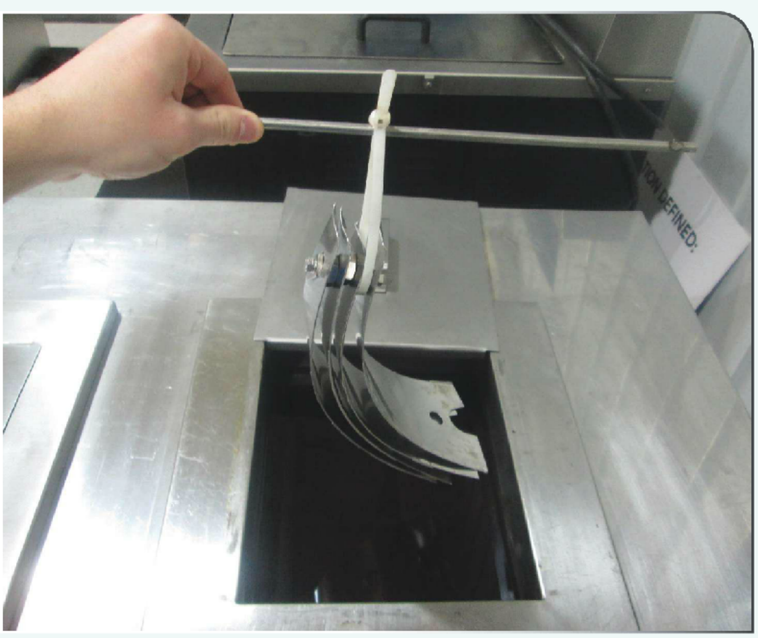
If you have a part with a particular contaminant, there are a number of suppliers out there with a cookbook solution. However, potential applications and variations of existing applications arise on a regular basis. In many cases, these applications challenge existing knowledge and require considerable effort to find a solution. Developing a successful cleaning process requires persistence and the ability to use all available tools to bring a successful cleaning process online.

The temptation when approaching a new application is to look for parallels, or a similar solution that has been used successfully in the past. In many instances, this approach will lead to a solution, but other problems require a fresh start. In the following case study, the path to a solution required several attempts and the manipulation of several cleaning parameters.

Soaking Discs

In this case, the challenge was cleaning centrifuge discs used in an oil field application, separating oil from oil sand in preparation for refining. The discs are truncated cones with an approximate diameter of 24 inches maximum and a smaller diameter hole in the center at the top of the cone. These discs are constructed of thin stainless steel and have radial features that space the discs apart when nested in the centrifuge. These features also contribute to the separation efficiency of the centrifuge by interrupting and redirecting the flow of the material being processed.

Coupons cut from discs were used in bench-scale testing to determine the best cleaning chemistry and other parameters.



The centrifuge discs require periodic cleaning to remove a buildup of oil, wax, tar and small pieces of sand that clog the space between the discs, leading to process inefficiency and possible damage to the centrifuge itself because of imbalance and other issues. The previous cleaning process involved soaking the discs in solvent to soften the contaminant and then manually brushing each disc to remove residual contaminants. A mechanized process was sought to reduce the cost of cleaning the discs.

At first blush, the application appeared straightforward. Similar discs had been successfully cleaned using a mechanized process with ultrasonics, but initial cleaning trials using this process were unsuccessful. In an effort to find a quick solution, increased chemical concentration, increased temperature and longer cleaning times were tried using existing chemistry, though these adjustments did little to improve the cleaning process.

The similarity between the two applications was deceiving. The successful application took place in a different part of the world where the contaminants from the oil and sand were much different from those in this case where the contaminant was rich in wax and heavy tar. So the search for an effective cleaning process continued.

A formal test plan was prepared and reviewed. Based on the customer's need, cleanliness and time test criterion were established. The best process would provide visual cleanliness, with no sign of residue, in a minimum amount of time.

Cleaning Parameters

The following parameters known to affect cleaning were targeted for testing:

Cleaning chemistry. A number of cleaning chemistries were identified to potentially provide a good cleaning result, including both solvent- and water-based cleaners. In addition, an effort to formulate a custom chemistry that would attack the unique contaminants in this application was initiated.

Cleaning temperature. Temperature is a major factor in cleaning. In general, higher temperatures provide better results, though some cleaning chemistries have high temperature limits that must be recognized. In this case, both solvent- and water-based chemistries with different temperature limits were tested.

Ultrasonic frequency. With both 25- and 40-kilohertz options available, some testing to establish the optimum frequency for this application was performed.

Cleaning mechanism. Although ultrasonic cleaning technology was thought to have the best chance of success, some additional action would be required to flush out loose contaminants from between the discs. Agitating the parts during ultrasonic cleaning and turbulation of the cleaning solution, alternated with ultrasonic cleaning, were identified as potential options.

Part fixturing. Nesting the discs close enough to touch was detrimental to any cleaning process tested. Therefore, it was determined that specially designed spacers providing ¾-inch and ⅜-inch spacing would be used for cleaning. Spacers were prepared to determine the amount of spacing needed for the best cleaning result.

The production equipment will be based on the standard equipment used for testing, but with variations, including side-mounted ultrasonic transducers and a tank sized to provide the needed throughput.

Temperature Factor

The first step in testing was identifying the most effective chemistry for this application. Coupons consisting of segments cut from discs were cleaned using a variety of chemistries in a small benchtop ultrasonic cleaner with capabilities similar to that of the equipment that would be later used for production scale cleaning. Using coupons preserved the supply of available full discs for final testing, while also enabling the use of a smaller ultrasonic bath, which reduced the volume of chemistry required.

Several chemistries were tested, including solvents normally used for cleaning in oil field applications and several existing water-based chemistries. Temperature was quickly identified as a major factor in cleaning and increasing temperature provided superior cleaning results with all of the chemistries tested, though none of them produced a truly clean part. Ultimately, specially formulated, water-based chemistry was the best option for this application. A cleaning temperature of 160°F gave optimum results, producing totally clean coupons in 30 minutes or less. The other chemistries were tested for up to 80 minutes without success.

During this process, ultrasonic frequency was closely monitored. Though the difference was minimal, 40 kilohertz produced better results and was chosen for full-scale testing.

Meanwhile, testing was performed to determine the effects of agitation and turbulation on cleaning. Turbulation, provided by pumping cleaning solution in a return loop to the cleaning tank either along with or alternating with ultrasonics, was not as effective as agitation at flushing loose residues from a set of sample discs. Because of its success, agitation was chosen as the mechanism.

Results

With the bench-scale testing completed, testing moved to full scale. An ultrasonic cleaning system with a capacity of 200 gallons and the capability to agitate parts was charged with the experimental cleaning chemistry and heated to 160°F. A stack of five discs with spacers was processed with excellent results. The ¾-inch and ⅜-inch spacers were tested with no perceptible difference. One observation during testing was that the contaminants removed from the discs, including sand and organics, were heavy and collected on the bottom of the cleaning tank. This concern was identified in a cleaning system with ultrasonic transducers mounted on the bottom of the tank.

Specifying Equipment

The final step was to specify the equipment for production cleaning. The size of the cleaning tank is determined by the number of parts that can be fixtured in a given space, the cleaning time and the number of clean parts required in a specified time period. Other considerations were the ability of the proposed system to agitate the parts during cleaning and mounting the ultrasonic transducers on the side walls of the tank instead of on the bottom. A proposal meeting these requirements was forwarded to the potential customer.

This case documents the result of several months of work by a dedicated team of cleaning specialists, and demonstrates the effort required to solve cleaning problems with unique requirements. In this case, although the requirement initially appeared similar to an existing successful application, there was enough difference to require developing a new process and chemical formulation to bring the project to fruition.

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