Update in Practical Cleaning Trends

By Stephen F. Rudy, CEF

The initial treatment or surface conditioning of parts in most process cycles involves cleaning. It's usually the first and most important step. I have always been impressed with how critical this first step is toward developing a successful metal finish, organic finish, or mechanical top coat. The quality we insert at the start truly exemplifies the quality derived at the end.

During the past decade cleaning has consistently exhibited it's importance in finishing cycles. Innovations, new developments, and refinements in cleaning have met some intriguing challenges.

Some aspects of cleaning technology have spent time in the "dry-dock," retrofitting to exceed new and anticipated challenges. The science and art of cleaning provides an interesting perspective and update to this all important first step. A strong driving force has been environmental considerations and the promulgation of related domestic and international regulations.

Properly cleaning parts before they are processed continues to be the first and most important part of providing a quality surface finish.

Aqueous Based Cleaning

Cleaning parts in water continues to be predominant for practical and economic reasons. Concentrated blends of cleaners in liquid or powder form are mixed and prepared according to the optimum operating parameters. The traditional concept of removing non-polar materials (oils, grease, wax, shop dirt, etc.) in the polar water medium is accomplished by the activity of surfactants and other agents. Surfactants are very important in this regard.

Earlier generations of cleaners typically relied on a fixed range of alkalinity in tandem with one and sometimes two surfactant groups. Now, the versatile cleaners may include several surfactant groups, in ratio, responding best to cleaning within a unique alkalinity level. There are many classifications of surfactants available for this cleaning.

Most surfactants have been designed with polar and non-polar sides. This allows the non-polar soils to be emulsified in the polar water solution. Another view relates to the water loving, or hydrophilic portion of the surfactant and the hydrophobic or oil loving side. The surfactants used are predominantly nonionc and anionic types. Better cleaning performance to optimize the removal of soils has led to the development of more dynamic surfactant systems. These new classes of surfactants provide increased non polar attraction sites for oils. Some of these surfactants operate in ratios with other moieties or exhibit additional synergistic effects. Emulsification of oils (percent of loadings in the working cleaner) has increased, extending the service life of a typical soak cleaner.

A trend that continues to grow is cleaning by displacement. In this method, oils, grease, and shop dirt are displaced on the substrate surface by a thin film of the specialty surfactants. The displaced soils are predominantly less dense than water, thus floating to the surface. Mechanical and automatic skimming devices are used to remove the soils. In this way, the cleaner is continually renewed, or purified, providing a practical alternative to emulsification cleaning. Newly developed surfactants and surfactant groups have improved the dynamics of displacement cleaning.

Buffing and polishing compounds, such as animal fats and synthetics, are now quickly attacked, loosened and removed by dynamic blends of low HLB value surfactants (measure of solubility in oil and water). These surfactants are blended into soak and ultrasonic cleaners.

Another improvement to surfactants has increased their stability in highly alkaline working solutions. This greatly reduces the problems associated with oiling out. Formulators can now rely less on relatively expensive hydrotroping agents. This helps to stabilize the costs of cleaner concentrates. Mechanical cleaning, such as spraying and the use of agitating washers, now benefits by the application of unique surfactants. These agents lower foaming characteristics, providing more efficient displacement action. Water hardness has always been a concern with regard to reduced cleaning and the formation of soap films. Chemists have synthesized surfactants that offer reasonable water hardness tolerance. This permits the elimination or inclusion of less traditional additives—such as gluconates, EDTA, NTA and phosphates—that may adversely affect waste treatment of spent solutions.

Biodegradability of surfactants has become an important concern. As such, new classes of surfactants improve the cleaning action with enhanced biodegradability. This means that naturally occurring substances, such as microorganisms, more quickly breakdown residual surfactants into innocuous materials. Specialty surfactants, based on enhanced oil loving characteristics in tandem with coagulant chemistry, have become very helpful in waste treatment. Additions of these additives quickly split emulsified oils simplifying treatment of the spent cleaner.

There has been a great deal of advancement in the science and application of surfactants in cleaning. Industrial surfactants have been working for us since the 1930s. Typical surfactants (alkyl, aryl, sulfonates, nonyl, phenol, ethoxylates, etc), rosinated soaps and dispersants (still very popular today) have been supplemented with many new and varied surface active agents. Among these are natural-based products derived from wood and citrus that enhance the utilization of green chemistry in cleaning.

Extending the Service Life Of Cleaners—Ultrafiltration

Oil in water emulsions are the result of cleaning action in many aqueous systems. The exhausted bath may have reached its saturation limit for oils and grease. Further additions of the cleaner may not be practical. Filtration technology has developed and refined a specific purification process that will separate these oils, thereby extending the service life of cleaners.

The concept involves the use of semipermeable membranes, in the form of ceramic tubes. A distinct pore size in the membrane permits safe passage of the water phase solution, while barring the oils, grease, and larger particles. The soiled cleaner bath flows in a direction parallel to the membrane surface. Two distinct liquid flows are developed. The water phase (permeate), because of its relatively small size, passes through the membrane. It is recycled back to the process tank. The oily phase (concentrate), because of its larger aggregate size, is membrane impermeable and diverted to a collection tank. In this way, the cleaner bath is continually purified.

The benefits are on-going near optimum cleaning efficiency, decontaminated solution, longer cleaner bath service life, less demand in waste treatment, savings in chemistry, manpower, and less operating line down time. The ceramic membrane tubes are periodically cleaned. With proper care and maintenance these tubes provide a reasonable service life. Some of the wetters and surfactants may be removed during ultrafiltration. Therefore, additional cleaner maintenance additions or the addition of a proprietary additive may be appropriate.

Cleaning applications include alkaline cleaners, parts washers, spray cleaners, and mass finishing. The initial capital expense should be considered versus the type of cleaning installation to be serviced and the potential for total plant volume treatment. State and Federal Government grants for waste reduction may contribute toward making the purchase more feasible.

Replacing Solvents

Specialty water miscible solvents that are Sara Title III exempt and compliant with the Montreal Protocol have found varied applications in hard surface cleaning. The development of these additives has been steadily gaining momentum. Perhaps the widely used trichloroethylene—"cleans everything"—is responsible for this. Trichloroethylene is a fast cleaning solvent, that readily removes virtually all oils and grease, leaving parts dry. It is also non flammable. Then why such a drawback to using trichloroethylene? Quite simply it's very stable in the environment, with a prolonged atmospheric residence. Because of this, scientists have associated it and other solvents (*e.g.* chlorofluorocarbons) with depletion of the upper atmosphere ozone layer.

International studies and collaboration have resulted in issuing the Montreal Protocol. Over 100 of the world's nations have signed this accord. Every two years, a review of alternative cleaning developments may amend the accord resulting in total phase out of targeted solvents. The production of certain solvents, such as CFC-113 and 1,1,1-trichloroethane, have been prohibited now for more than eight years.

Excellent results for replacement candidates have been achieved. These newer classes of cleaning agents are used in aqueous and semi-aqueous cleaning systems. These have been found to be both economic and safe when compared to restricted solvents, which are used at 100 percent active. Comparative cleaning efficiencies are very good, however, the cycle time may be two to six times longer than the targeted solvents. Additionally, cleaned parts are wet. A second drying step is required. Some of the most effective alternative cleaning agents include terpenes, citrus limonenes, soy blends, enzymes, and substituted glycols. These materials have also been found to be successful alternatives to highly volatile solvents (*e.g.* acetone, methyl ethyl ketone, substituted aromatics).

Some of the very critical cleaning requirements for industries such as aerospace, computers, and telecommunications are achieved by using the aforementioned replacement materials. Every substitute additive exhibits much lower volatility, allowing longer soaking times to attack soils. The semi aqueous cleaners are somewhat stabilized mixtures of water and solvents, in the form of emulsions. These solutions are used ultrasonically or by immersion to remove a wide variety of organic soils.

Although many alternative solvents and solvent systems are available, testing and careful evaluation are required to confirm the optimum system for a specific cleaning application. A good selection will also meet significant new alternative policy (SNAP) requirements. A more compliant and safer environment is now becoming more of a reality. This includes the issue of safety in the workplace. Higher OEL (occupational exposure limits) become more evident.

For companies, the longer cleaning times and drying requirements, are offset by much lower VOC emissions and simpler waste treatment and disposal. In fact, some of the alternative cleaning agents are recycled more cheaply and readily than was experienced with trichloroethylene. These factors markedly improve the bottom line in terms of economic payback and realized operating cost savings.

Bioremediation

This is an exciting technology, initially driven by the need for rapid, effective cleanup of fuel spills. Concerted R&D in Europe and the U.S. determined that nature provides us with some rather fascinating cleaning agents. Unique microorganisms, under controlled temperature and pH conditions, convert oils and grease, by breaking them down into simpler, innocuous materials (*e.g.* carbon dioxide and water).

These microorganisms are cultivated to eat hydrocarbons (oils and grease). Quite simply, dirty parts provide the food source.

A water based cleaner additive, usually containing non ionic surfactants, supplements the action of the microorganisms. The cleaner bath temperature is maintained at about 100–110°F (38–43°C) and pH range is 9.0–9.5. Under these ideal conditions for the microorganisms, ferrous and non ferrous parts can be safely immersed in the cleaning solution.

The system itself is a closed loop. The process tank is supported by a treatment tank, allowing for complete breakdown of the oils and grease. Automatic pH adjustment is monitored, along with replenishment and rejuvenation of the various additives. Booster additions of the microorganisms can be made. One gram of the powder may contain up to one trillion of these biologically active agents.

Sufficient work space must be allocated to accommodate the process tank, treatment tank, and replenishment additives. Related equipment includes feed pumps, pH probes, and temperature sensors. Additive test kits determine the levels of the surfactants and microorganisms. The system allows for an essentially no dump cleaner. The resulting, accumulated sludge is nothing more than a small compressed non hazardous, non toxic material that can be disposed of easily.

Advanced Oxidation

This is a new candidate cleaning method. The concept is based on reacting oils and grease (non polar compounds) with oxygen, in a unique cleaning method. An oxidation process, employing electrolysis and ozone, introduces oxygen into the aqueous solution. There, oxygen atoms react with the hydrocarbons forming polar sites rendering the contaminant water soluble. In this way, the oils and grease form wetting agents and surfactants. In a sense, this dynamic procedure forms a reserve quantity of cleaning surfactants in the working solution.

Maintaining the system requires an oxygen generator. The rectifier and electrodes would be present similarly to a traditional electrocleaner. Promising advantages include: optimized cleaning solution for continually cleaning parts, much less waste for disposal and the ability to recycle the solution.

Carbon Dioxide

The use of carbon dioxide in cleaning has found specialized applications. The very low human toxicity and positive environmental impact, make this an interesting cleaning alternative. Carbon dioxide cleaning takes the form of blasting the surface. In one type, carbon dioxide pellets are shot at surfaces, stripping paint and removing oils and grease. The other form employs carbon dioxide in the form of snow flakes for cleaning surfaces. The process generates very little waste. A relatively new development is the addition of polymer compounds to the carbon dioxide system for improving the scrubbing power of liquid carbon dioxide.

Carbon dioxide cleaning is expensive, because it requires generating and maintaining liquid carbon dioxide. Special equipment, techniques and handling procedures make this a rather unique cleaning application. In addition, personnel must be specially trained in all aspects of carbon dioxide cleaning technology. Current industrial use includes aircraft maintenance (stripping paint), medical instruments and clean room applications.

Supercritical Fluids

Fluids meet this category when they are subjected to pressures and temperatures above their critical points. The result is properties that are intermediate between the liquid and gaseous states. Parts exposed to critical fluids are cleaned by the fluid's ability to penetrate and dissolve the soils. Carbon dioxide meets this category of supercritical fluids. Maintenance, storage, handling, and application of the critical fluid make this an expensive cleaning alternative. Specialized training of attending personnel is required.

Media Blasting

This method employs a pressurized transport medium for abrasive media. Soils are blasted off the surface. Oils, grease, paint, and rust, are some of the materials effectively removed off the substrate. Sand and glass beads, once the staple medias, have been replaced with sodium bicarbonate, starch, and plastics. The process is specialized, with the need for containment equipment and a focus on single parts.

New developments in cleaning are on going. Updates continue to be published. There are steady sources of funding to carry on necessary work in government labs, academia and industry. Vendors introduce novel process equipment and products. Technical shows and expositions make us aware of new items and alert us to interesting perspectives.

The opportunity to change an existing cleaning process to a new one, or modify an existing one, can be very challenging. There is a certain amount of risk associated with anything new, or for that matter any change. A can't miss, perfect solution, or universal corrector, quite frankly is rarely found. What is important is understanding the cleaning application, problems and realistic opportunities for change. Any change or new method should be extensively evaluated by trial. Be certain it readily meets the most difficult or critical challenge. Understand what changes must be made to equipment and the plant. Develop a rational and practical cost analysis, to confirm any change is economically feasible. Determine there will be a clear advantage towards improving worker safety, waste treatment, and the general environment. Evaluate how changes will improve marketing the finished parts or products. Focus on customers, consumers, and the general community, based on quality and stewardship to the earth.

Change is necessary. Change is good. Change is on going. With change comes improvement. ***P&SF***

About the Author

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