Biological, Self-regenerating Cleaners for Hot Dip Galvanizing

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Biological cleaning integrates two proven technologies: emulsion cleaning and bioremediation. This process has the advantage that removed oils and greases are digested by microbial action rejuvenating the cleaner and extending its life – often indefinitely. In addition, the overall quality of the cleaning is improved, as is the consistency of cleaning over time. This process limits the formation of costly waste by-products, thereby improving environmental "friendliness." Other benefits include compatibility with acid pickling solutions that eliminates the need for rinsing after degreasing and the ability to operate at lower temperatures enabling cost reduction via lowered fuel consumption versus standard caustic (sodium hydroxide) based solutions. Last, the process overcomes the inability of caustic soda degreasers to consistently and reliably remove paints, lacquers, etc., thereby streamlining the aqueous cleaning stage without this "hit-or-miss" step. Biological cleaners have been used effectively in many metal finishing and metal working applications during the last twenty years. This technology has now been in use for hot dip galvanizing for a number of years in the U.S. and Europe. This paper will review the background and experience of biological cleaning for use in hot dip galvanizing process lines.

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INTRODUCTION

Biological cleaning is based on the simultaneous use of **surface cleaning** and **bioremediation**. The cleaning actually takes place in two steps. When parts come in contact with the solution, the oil and impurities are emulsified into micro-particulates. The particulates are then consumed by microorganisms, which are present in the bath or spray. The microbes consume the oil present in the bath, as their food source producing carbon dioxide as a byproduct. This process has the advantage that the removed oils and greases are digested by the microbial action rejuvenating the cleaner and extending its life.

While microorganisms have been used for many years to digest oil from wastes and spills, the integration of biodegradation with aqueous cleaning for industrial cleaning applications is a relatively recent process. Most of the conventional cleaners will not allow the survival of oil consuming microbes due to high operating pH and temperatures. By formulating a mild alkaline emulsifying cleaner that operates at relatively low temperatures it is possible to integrate the removal of oil and particulates with the biological digestion of the residues. The system is essentially self-regulating, since the microbial activity will adjust itself to the amount of oil present in the system.

The present biological cleaning process employs an alkaline cleaning solution that operates at relatively low temperatures (104ºF - 131ºF) (40ºC - 55ºC) and a pH range of 8.8 - 9.2, which is a viable habitat for these microorganisms. The cleaning solutions from the cleaning baths are pumped continuously into a separator/control module then pumped back into the processing tank. This operation is run in a continuous mode without interruptions for solution dumping and new solution make-up. As a result of the dynamics of the process and the re-circulation of the bath solution, the consumption of oil by the microbes occurs throughout the biological degreasing system. For an efficient operation the oil must be emulsified and oil must be present at all times to keep an active population of microorganisms. In the case of a longer interruption that may be conducive to the total depletion of the oil present in the system, to keep the microbes alive it is necessary to render them dormant by increasing the pH to 10.5 or alternatively, to feed them with small amounts of oil during the down time.

The principles and major industrial applications of biological cleaning can be found in the paper presented at SUR/FIN 2002 (J.Hajdu, Advances in Biological Cleaning**,** *AESF SUR/FIN 2002*, Chicago). Also a comprehensive description of biological cleaning is available at the Environmental Protection Agency's website, under the Environmental Technology Verification Reports ("Evaluation of BioClean USA, LLC

Biological Degreasing System for the Recycling of Alkaline Cleaners”). This investigation was originally presented at the *22nd Annual AESF/EPA Conference on Pollution Prevention and Control for the Surface Finishing Industry, January 29-31, 2001*, in Orlando, Florida.

Recently an in-depth study of the biodegradation process has been completed by Prof. Thomas K. Wood and Sachiyo Iwashita of the Department of Chemical Engineering & Molecular & Cell Biology of the University of Connecticut. Observing the biodegradation of a widely used commercial lubricant containing naphthenic petroleum oil and extreme pressure additives, they found that a naturally occurring microbial consortium was responsible for the degradation of the lubricant and that the process was conducive to the complete mineralization of the lubricant. The active bacteria for the degradation process were identified as ***Bacillus licheniformis,*** responsible for the degradation when high concentrations of lubricant are present. At lower concentrations, ***Bacillus cereus***, ***Pseudomonas aeruginosa***, ***Rhizobiaceae*** **str. M100**, and ***Achromobacter*** **sp. LMG 5431** were also found active. In addition, Wood and Iwashita found that at pH 9 the rate of heterotropic biodegradation of the lubricant was significantly higher than the degradation rate of the surfactants present in the biological cleaner while at lower pH values (pH 7) the rate of surfactant degradation increases. These results confirm the empirical observation that biological cleaners should be operated between pH 8.8 and pH 9.2. The methodology and quantitative results of this work were published in the Journal of Applied Microbiology and Biotechnology.

BIOLOGICAL CLEANING FOR HOT DIP GALVANIZING

The main markets for biological cleaning are in the metalworking, painting and metal finishing industries. Case histories of these applications were presented during 22nd Annual AESF/EPA Conference, January 29-31, 2001, Orlando, Florida under the title ***"Field Experience with an Integrated Biological Degreasing System"*** and during the SurFin Conference, June 27-30, 2004, Chicago, Illinois under the title ***"Biological Cleaning for Organic Coatings"***. The technology is also successfully employed by the hot dip galvanizing industry in Europe and the United States to replace traditional alkaline and acid cleaners.

Traditional cleaners used in the galvanizing industry are typically either highly alkaline or strongly acid and operate at high temperatures. These products must be periodically dumped because the soils and oils build up in the baths until their cleaning efficacy and product quality are reduced to unacceptable levels. The dumped baths must be waste treated or hauled away for treatment, both of which are expensive and time consuming. The re-building of the baths with new chemistry is time consuming and costly. The high operating temperature and aggressive chemical composition produce a hazardous work environment for employees.

Southern Galvanizing in Baltimore, Maryland, converted from a traditional alkaline cleaning to a biological cleaning process in 2001. Prior to this the traditional alkaline cleaner was dumped, waste treated and re-built every 18 months in order to maintain the quality of the galvanized parts at an acceptable level. Since the installation of the biological cleaning system in 2001, the bath has not been dumped thus eliminating the waste treatment problems and costs. More importantly the quality of the galvanized parts is maintained at a consistently high level.

The biological cleaning system operates at 90^{o}F to 100^{o}F whereas the traditional high alkalinity cleaner previously used operated at 180^{o}F. This lower operating temperature saves substantial energy and reduced the energy consumption to heat the 14,200 gallon cleaner tank at Southern Galvanizing by approximately $58,000/year. More importantly, employees are no longer exposed to the scalding temperature and highly corrosive cleaners as the biological cleaner operates at a near neutral pH of 8.8 to 9.2. The lower operating temperature generates almost no steam or other vapors providing a greatly improved work environment for employees.

The biological cleaning system used at Southern Galvanizing has substantially reduced the maintenance costs of operating this process as compared to the high alkalinity cleaner we used in the past. The automatic controls employed by the process maintain the optimum conditions to consistently clean the wide variety of oils used by our customers. Another advantage in the maintenance of the biological cleaning system is that the product does not generate sludge as did the traditional alkaline cleaner used previously. With the traditional product, the generation of sludge was so substantial that every 18-24 months we, production was temporarily halted, and an outside firm was contracted to come in to pump the sludge from the bottom of the alkaline cleaner tank. Even after nearly three years of operation of the biological cleaner, we have no sludge in the tank and have saved both the cost as well as the lost production time from de-sludging the tank.

With the high alkaline cleaner previously used, a rinse was required after the cleaner and prior to entering the acid pickle station. The biological cleaner we now use is compatible with the acid pickle and the rinse after the cleaner was eliminated. The parts now move directly from the biological cleaner to the acid pickle without rinsing. This eliminated one tank and one step in our process shortening the process time. The number of crane lifts was reduced as a result as well.

The zinc from hooks, fixtures and jigs used in the racking process routinely pass through a galvanizing line. With highly alkaline cleaners, this contributes to the sludging problem discussed above as well as increases chemical consumption. With acid cleaners, the zinc introduced in this manner consumes the acid requiring more frequent replenishment and shortening the life of the bath. The biological cleaning system is compatible with zinc so it does not consume additional replenisher, produce sludge, nor shorten the life of the bath.

In conclusion, the use of a biological cleaning bath in Southern Galvanizing's process has reduced our operating costs, improved the consistency and quality of the end products, and improved the overall quality of the work atmosphere.