One-Step, Zero-Effluent Organic Phosphating

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A new process has recently become available in the U.S. and Canada for preparing metal surfaces for painting. It has been used in Europe for the past 20 years. There are about 400 installations throughout Europe and, more recently, in Brazil. Plaforization is an organic phosphating process with several advantages over traditional treatment processes when used in the right applications. It both cleans and phosphates the parts in a single step, thus saving space and expense. It operates at room temperature. There are no effluents to dispose of, either waterborne or solid sludges. Oils are absorbed and used in the process, increasing the flexibility and impact resistance of the phosphated surface and eliminating the need to dispose of the oils. Various types of metals and various shapes of parts can be treated simultaneously. It is compatible with virtually all types of powders and liquid paints and is very simple to use, either by spray or dip.

The process is most appropriate for small- to mid-sized operations (less than 4,000 ft^2/hr); mild steel, galvanized steel, and aluminum; but not high-silicon alloys. It is best suited for uses that do not require inordinately high salt-spray resistance such as furniture, electrical appliances, safes, file cabinets, shelving, etc.

Plaforization works by taking process oils into solution into a fluid containing a polymeric resin and phosphating agents. The oil is then encapsulated into the resin. The phosphate layer is laid down on the metal surface and the resin polymerizes with the encapsulated oil to provide further corrosion protection and impact resistance.

METAL PREPARATION

The preparation of metal surfaces for painting has evolved through several stages over the past 25 years, partly due to improvements for particular applications and partly due to increasing environmental regulation. The underlying treatment issue, however, remains essentially the same.

Shaping of metal parts always requires a lubricant to keep the metal die from grabbing and tearing the forming metal part. On the other hand, lubricants are deadly to paint adhesion. Thus, if the part is subsequently painted, the lubricant must be removed.

Another element of metal surface preparation is the deposition of a layer of iron, zinc, or manganese phosphate on the metal surface, because the layer enhances both paint adhesion and corrosion resistance of the coated part. The presence of the phosphate retards the growth of metal corrosion from any break in the paint surface that may occur and/or retards the spread of metal corrosion under the paint film.

In traditional metal preparation processes the two parts of the operation—cleaning and phosphating—are accomplished in separate steps. Moreover, there are often several associated washing and rinsing steps, resulting in an operation having anywhere from 3 to 8 separate steps.

LUBRICANT REMOVAL

As with metal pretreatment in general, processes for lubricant removal have undergone an evolution, largely due to the increasingly stringent environmental regulations put into place over time. Vapor degreasing has been the classic method for eliminating lubricants from metal parts. Vapor degreasing is carried out by placing the cold part in a chamber in which a chlorinated solvent is vaporized by boiling at the bottom of the chamber. Vaporized solvent rises and condenses to a liquid on the cooler part, where it dissolves the grease and carries it off as it drips from the part. Periodically, the solvent must be distilled to purify it for recycling (reuse) and the separated grease must be disposed of.

A variety of chlorinated solvents and aromatic solvents have been used as well, but now many chlorinated and aromatic solvents are being phased out of operations under the relentless pressure of environmental regulation. Consequently, water-based (wash) systems that clean the metal surface of grease and other soil through the use of heated alkaline cleaners generally followed by rinsing have been developed.

PHOSPHATE DEPOSITION

The second part of the metal pretreatment operation is deposition of a layer of iron, zinc, or manganese phosphate on the surface of the cleaned part, with iron phosphate being the most commonly used. In the traditional process, normally the wash cycle (see above) leads directly into the phosphating step with-

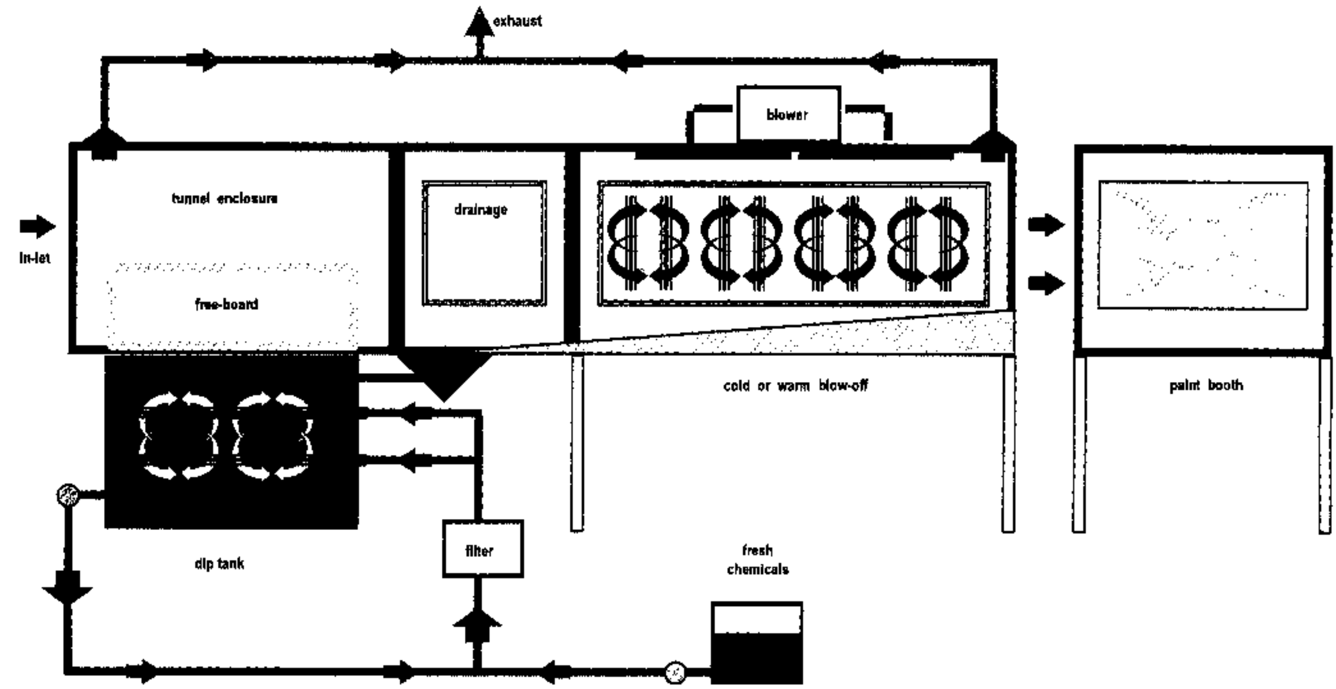

Figure 1. Process schematic of the organic phosphating technology using a one-stage, room-temperature dip for degreasing and phosphating.

out intermediate drying. A combined wash and phosphating line may consist of at least three steps or as many as seven or eight steps, depending upon the perceived need for thorough rinsing before and after the phosphating step and before drying. The complexity of the parts being treated is also a factor in determining design of washing and phosphating systems.

LIMITATIONS OF TRADITIONAL PROCESS

In the degreasing step of traditional processes, whether vapor degreasing or alkaline systems are used, the elimination of the lubricant from the metal surface of necessity involves disposal of the removed oil or grease. In addition the complete processes of cleaning and phosphating generate waste sludge and alkaline water. All of this requires installation and maintenance of treatment and disposal facilities.

Finally, traditional systems all use heated chemicals, which requires energy. This is a particularly important consideration where the liquid to be heated is in a large tank. Such a tank takes significant amounts of time and fuel to heat up and economics require that it be operational for a considerable time to justify that time and energy expenditure.

DEVELOPMENT AND DESCRIPTION

About 20 years ago the chemist-owner of a small Italian paint manufacturer decided to approach the problem of metal preparation in a new way. The goal was to eliminate as many process steps as possible, making the process simple to operate and eliminating waste disposal and environmental issues to the extent possible.

To reduce the number of steps he reasoned that if iron or zinc phosphate could be incorporated into what was traditionally the cleaning "stage" of the process he would have a one-step process. He also concluded that if the lubricant could be captured in place, and its antiadhesion properties nullified, then it would not be necessary to remove the lubricant at all during the process and there would be no need for a disposal mechanism. And if he could dispense with the washing and rinsing steps he would be eliminating water treatment and disposal problems.

To accomplish the reduction of the number of steps and the elimination of oil disposal he developed a special solution in which phosphating agents and a small amount of resin are included. The resin and phosphates are dissolved in a mixture of high-solvency oxygenated organic fluids, which are blended to ensure that, in the cleaning/phosphating process, they bring the manufacturing lubricating

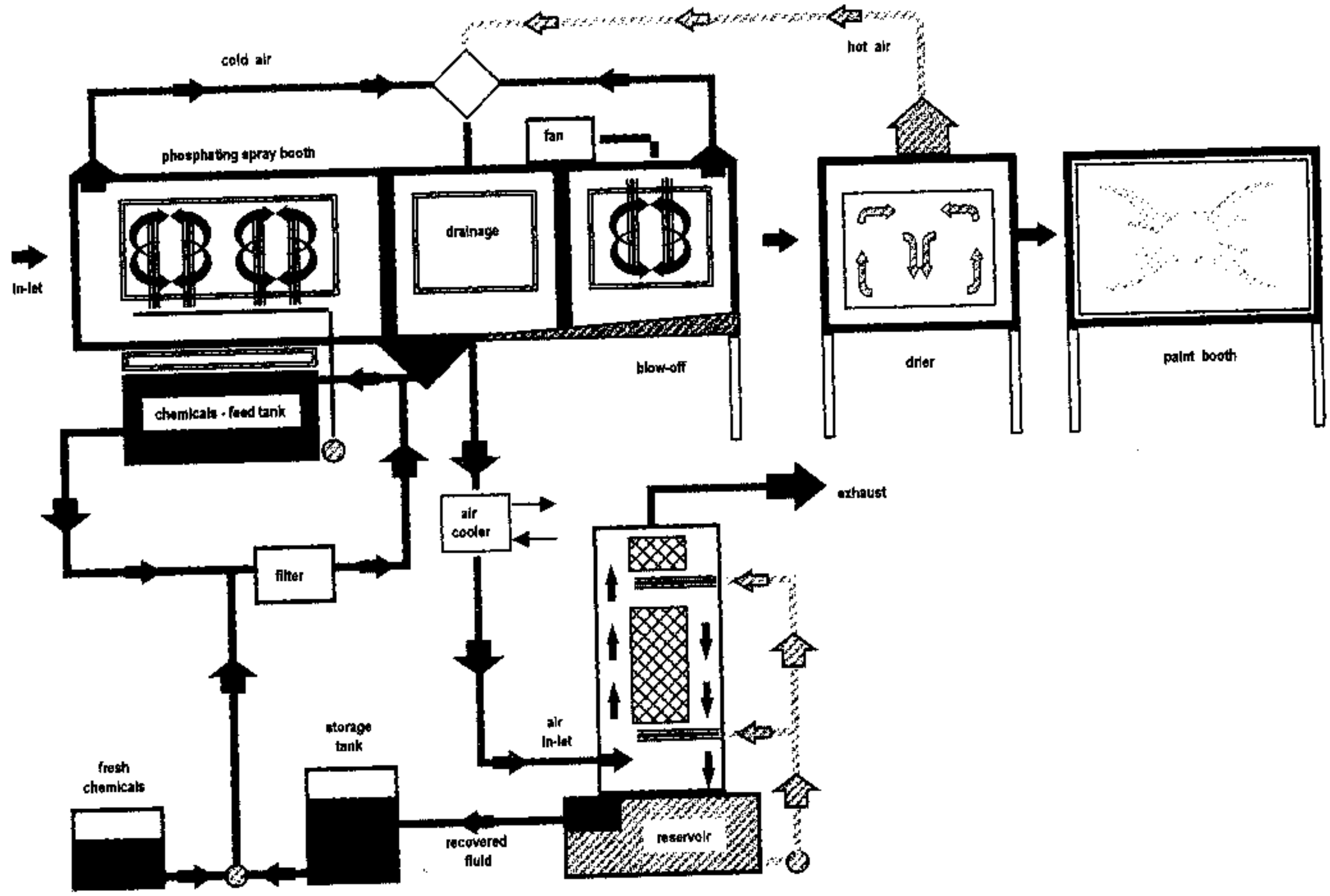

Figure 2. Equipment schematic for the organic phosphating process using spray application.

oils into solution in the fluids. In this way the solution cleans the oils from the surface of the part.

The next step is to combine the oils physically with the phosphate polymer by absorbing it roughly in the same manner as a plasticizer mixes with a linear polymer. At the same time the process deposits a layer of phosphates on the metal surface. Polymerization of the mixture containing the oil occurs as the part dries. This process is accomplished in a single step, either by dip (see Fig. 1) or spray (see Fig. 2), and at room temperature. Figures 1 and 2 are schematics of typical plant designs.

The encapsulation of the oil, in addition to dispensing with the need for disposal, has another advantage. The oil imparts flexibility to the polymer on the surface of the part, which increases impact resistance.

The process demonstrates several other advantages as well. The fact that it is a single-step process means that the size and complexity of the plant are very much reduced. The fact that it is not water-based and that there is no rinsing means that there is no expense or environmental limitation to consider for water treatment or disposal. The process creates no sludge so no solid waste is created either.

Plant operation is very simple. Parts are dipped or sprayed, hung to drip or blown off, and either air dried or forced-air dried or, for faster processing, oven dried at a low temperature. Nor is any significant training required for maintenance, since the process necessitates no daily analysis of the treating solution. Analysis is carried out every other month by the manufacturer of the process, and—absent serious failure to follow simple guidelines regarding, more than anything else, permissible amounts of oils on the parts—bath conditions will not change significantly from one test to another. Under proper conditions the bath never requires changing, only the addition of fluids as they are used up.

The highest long-term permissible quantity of oils in the solution translates to about 3 times the level normally found on parts; therefore, even if quite oily parts are sometimes part of the mix being treated, the solution will continue to be well within the contained oil limits. The maximum amount of oils removed from the parts on a continuous basis is 14 grams per 100 ft^2 versus the normal on sheet steel of 3 to 4 grams per 100 ft^2. It is important to pay attention to parts having pockets where oil could pool, and to assure either that they do not contain excessive quantities of oil or that they are mixed in with other types of parts to hold the average below the 14 grams per 100 ft^2. Since the process can be used to treat various types of metals simultaneously, mixing of parts is easy.

The process operates at room temperature, obviating the need to heat the solution. This is advantageous both in terms of energy consumption in general and in the case of occasional or intermittent production, where heating would be very inefficient.

There is no rinsing stage and, therefore, there is no water to treat or dispose of. This is an advantage, in general, in environmental terms, but it is particularly useful in areas in which water is in short supply or is expensive, or where wastewater disposal is a problem.

Various types of metal parts can be treated simultaneously. It is compatible with virtually all types of powders and liquid paints and is very simple to use, either by spray or dip. It is compatible with most organic coatings such as varnishes, lacquers, and paints (water-based, solvent-based, and powders).

As for air quality, the product line is free of CFCs, HHCs, aromatics, and ozone-depleting substances.

LIMITATIONS OF THE PROCESS

If anticipated production is very high (over approximately 4,000 ft^2/hr) the economic savings of the system become less attractive.

Finally, if very high salt spray resistance is required (exterior auto parts, for example) traditional systems will be more economical.

CONCLUSION

Overall, there would seem to be a valid range of applications for medium-sized production of parts, which are not going to be exposed to a severely corrosive environment. For these applications the process can provide an economical, environmentally friendly, and space-saving opportunity.

BIOGRAPHY

Scott Carpenter is a graduate of MIT in chemical engineering. He was Vice President of Cabot Corp. before taking early retirement and founding Carpenter & Carpenter LC. **MF**