THE NEW WORLD of Finishing

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Paint Stripping—New Techniques

In the past, the removal of paint has not presented many challenging problems. Metals, which were not affected by hot alkali solutions (i.e. ferrous materials, magnesium, some copper) were simply immersed in the hot solutions containing sodium hydroxide and a wetting agent. They might also contain a chelating agent such as sodium gluconate or chemicals to prevent etching, such as sodium carbonate, and many contained an oil (such as pine oil) phase usually in emulsion form to hold the removed paint.

If the substrate could not withstand the hot alkali, the cold strippers containing phenols (cresylic acids), methylene chloride, chromates and various solvents, (i.e. orthodichlorobenzene, mineral spirits or methanol) were available. As the more durable polyester, epoxy and polyurethane paint systems came into use the strippers needed to become more acid, so in addition to the phenols and methylene chloride, formic acid or acetic acid or their anhydrides were added. By adding thickeners these could be used as brush-on "in situ" strippers and thus they became the standard chemical stripping media for these hard to remove materials.

Where chemical stripping wasn't practical (or possible) one could always resort to sand blasting as presented by the Steel Structures Painting Council or to burning either with a torch or in burn-off ovens.

Today, many of the older methods of paint removal cannot be used. In many cases they simply won't work, as in the case of removing paint from composites and plastics.

Chemical strippers don't know the difference between the paint resins and composite resins or plastic and sand blasting is far too severe for such substrates. Even the softer media like nut hulls or alfalfa seeds can damage a fiberglass or molded plastic part while not being very effective on the very durable paint systems. In wearing away the paints the substrates first exposed are over exposed while removing stubborn paint.

In other cases, while the cold methods do work, the environmental regulations and toxicity of the materials will not allow them to be used. Methylene chloride, phenols and chromate ion are severely restricted because of toxicity and environmental contamination and "blast" removal of many of the older paints exposes workers to lead, cadmium and chromate containing dusts.

As a consequence of durable paint systems, toxicity awareness, EPA regulations and new substrate materials a number of novel paint stripping procedures have emerged. Among these are carbon dioxide blasting, laser scanning, flash lamp exposure and plastic media blasting (PMB). All of these are relatively environmentally safe and nontoxic with controllable hazardous waste at the end of the line. All are expensive and each has problems which need to be faced if the method is used.

CARBON DIOXIDE BLASTING

This technique involves propeling dry ice pellets in a high pressure air stream. The dry ice machine produces the irregularly shaped pellets which are used like nut hulls to blast off the paint. It works well for heavier paints, no doubt because the low temperatures cause the thicker coatings to become brittle. Substrate damage tends to vary from being reported as having no effect on epoxy-fiberglass to causing lamination of the same substrate. It appears for best results the system must be optimized to the job.

Steel and heavy aluminum parts with heavy coatings can be easily stripped at rates of two or more square feet per minute, depending on the size of the pellet producing machine. When finished, the only thing left to clean up are the paint chips. On a conveyorized system, where the work passes under the blast nozzle and the paint chips are pulled away with an air stream into a collection bay, the operation could become quite efficient. This would also eliminate the effects of the high noise level (100 plus dB have been reported) of the method.

LASER SCANNING

The use of a laser to strip paint is intriguing. The technique has advantages not readily obtained by chemical stripping or any of the blast techniques, i.e. removal of paint in layers. The top coat can be removed and the primers or the resin substrate remain unaffected.

The method works simply by focusing the laser on the painted surface and sweeping it along at a rate fast enough to vaporize the paint. The focusing and sweeping is accomplished so as to remove only a layer at a time of the coating, before moving on. A 3 kW CO_2 laser is capable of removing paint at a rate of 1.5 square feet per minute. With computer control and automatic focusing, the technique can become a valuable, clean stripping tool.

FLASH LAMP STRIPPING

Light from a xenon flash lamp, like a laser, is capable of stripping paint. The light needs to be concentrated into a high flux, with energy densities in range of 5 to 20 J/cm^2. These energies are readily attained with a laser, since the beam of even the small lasers can be focused small enough to attain the energy. These levels are at the upper practical limit of the xenon flash lamp and therefore the lamps have a shortened life and become expensive.

Nevertheless, the flash lamp technique may have several advantages over a laser for some stripping opportunities. To begin with, the xenon lamp system has far less capital costs since beam focusing equipment and control equipment are not necessary. The xenon system is more efficient (35 to 50% vs about 15% for lasers) and can discriminate between paint layers, composite or plastic structure and metal structure with an equal ability.

The technique gained immediate and national recognition when it was used to remove contamination (abrasive kitchen cleanser) applied by vandals from 2,500-year-old cliff paintings in Moab National Park without damage to the paintings.

The machines are built to give various pulse times from 5 to 600 microseconds. For most durable paint systems (i.e. epoxy-polyurethane combinations) 6 to 10 pulses of 400 to 600 microsecond duration and 12 to 13 J/cm^2 flux density provide adequate removal and optimum lamp life. Fewer pulses can be used to just remove the topcoat from the primer systems. Since flux density varies with distance from the lamp, the lamps need to be arranged to conform to complex part shapes. Still, there is enough tolerance in the energy required to evaporate the coating that this is not a serious problem.

PLASTIC MEDIA BLASTING

Each of the above techniques will no doubt find special uses for which they alone will be ideally suited and so will find their way into industry. Plastic media blasting appears to be the way of the future of paint stripping, especially in the aerospace industry where in addition to the extensive use of aluminum substrates, composites with graphite reinforcing and both thermoset and thermoplastic resins are becoming commonly used substrates. From the aerospace industry a number of important questions have been raised and as of today only partly answered. These will be discussed as they appear in the following description of the process.

THE PLASTIC MEDIA:

Where steel and titanium are the substrates, the media is of little consequence. Both materials, even in the annealed condition, have sufficient hardness so as not to be affected unless the materials are very thin. Aluminum and resin composites can be seriously affected so the media must be carefully chosen. The media size can vary from 10 through 80 and is available in hardnesses of 3.0, 3.5 and 4.0 on a Moh scale.

There are several chemistries for the media; among these are styrene acrylate, styrene acrylonitrile copolymer and melamine-urea polymers. The harder materials are filled, probably with silica. The purity of the new material is generally good for materials which are ground from virgin sheet, but the material ground from scrap parts such as buttons, auto parts and any number of molded parts may have undesirable elements such as lead, cadmium, etc. (generally from the coloring pigments originally used in making the parts).

These contaminants may or may not be a problem with the substrate, but with aluminum and magnesium the purer media is probably the best choice. Once media has been used to remove paint, it will have become contaminated with the paint chips which it has removed. How much of this contamination needs to be removed also depends on the work. For some substrates, such as aluminum, some operators prefer to use only virgin media while for others this is not so important and the media can be reused many times. When the recovery system can retain 80% of the original media it will have taken out most of the paint chips and broken grit and should prove to be economical.

The device used to propel the grit need not be more than an ordinary blast machine capable of handling fine alumina. Air pressure varies, depending on use, from 30 to 80 psi, usually measured at the "pot" not the nozzle. The higher pressures remove paint faster, but they also destroy media faster and they may cause problems with the substrate such as metal removal, metal fatigue, the hiding and causing of surface cracks, and buckling. These metal problems are the ones causing the controversies in the aerospace industry where materials like aluminum are required to carry dynamic or fatiguing loads and where the new high strength composites are being used.

TESTING:

Fatigue testing of typical aircraft aluminum alloys (i.e 7075-T6) done by Battelle Columbus Division[1] and on Navy contract N00019-83-0049 have shown that fatigue losses did not occur. Conditions for the Battelle tests were a media hardness of 30 Moh, stand off distance of 12″, blast angle of 60° and a nozzle pressure of 60 psi. Navy conditions were the same except the air pressure was 85 psi.

Under these conditions the paint was removed at about half the rate it could be removed with the 3.5 Moh hardness media, but with the softer media it was shown there was no damage to the thin aluminum samples. On the Navy contract[2] roughly the same conclusions concerning removal rate were made. The Navy report also concluded "plastic media of 3.5 and 4.0 Mohs hardness can damage these surfaces even at a stand off distance of 4 feet". The surfaces referred to are clad aluminum and fiberglass.

In the above tests and various other reported testing an almen strip made from the material being tested and designed according to MIL-S-13165 has been used to determine the compressive stress induced by this stripping method in the same way it is used to control shot peening. While this appears to be a control method for grit size, intensity, and dwell time a correlation between this test and fatigue has not been definitely established.

There appears to be a general agreement that the media blasting technique of removing paint is viable even for composites, however, there also is agreement that much work is needed to completely define all of the parameters of this technique. For aerospace, if grit of 3.0 Moh hardness, 30/40 mesh size is used with stand off distances of 12 to 20″, air pressures of 30 to 60 psi and attack angles of 40 to 80° there appears to be little damage to aluminum or fiberglass substrates. With these parameters the stripping speed will be 1.5 to 2.5 ft^2/min which is considerably faster than chemical stripping when the "in-situ" strippers are used. For graphite reinforced plastics and composites, this method has not been proven satisfactory.

CONCLUSIONS

As regulations regarding atmospheric contamination and material toxicities become more strict, a number of new paint stripping tools and techniques will be needed. The ones discussed here have shown promise. **MF**

References

1. "Plastic Bead Blast Materials Characterization Study Follow-on Report, Battelle Columbus Division," dtd 11-13-87; for The Air Force Corrosion Program, Managers Office; Robins Air Force Base, GA.
2. Contract # N 00019-83-G-0049, Grumman Corp. for Naval Air Systems Command; Final Report, June, 1987.