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Masking for Surface Finishing

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ABSTRACT

Masking is employed in most any metal finishing operation where only a specifically defined area of the surface of a part must be exposed to a process. Conversely, masking may be employed on a surface where treatment is either not required or must be avoided. This article covers the many aspects of masking for metal finishing, including applications, methods and the various types of masking employed.

Keywords: masking, stop-off lacquers, tapes, selected area plating

Applications

In some cases, masking may be avoided, as in controlled depth plating where a part is of a geometry that allows only the portion requiring finishing to be immersed in the processing solutions. Masking (also called stop-off application) is employed in most any metal finishing operation where only a specifically defined area of the surface of a part must be exposed to a process. A partial list of the processing operations where masking is commonly employed is provided here.

Masking may be employed in dry and wet processes. An example of a dry process where masking may be employed is a blasting cabinet, where defined areas are to be exposed to the media. Masking is also popular in brush plating, where defined areas are covered with the plating brush. Hard chromium and electroless nickel plating operations often utilize masks.

Masking may also be employed to limit anodic coatings to specific areas or to apply multiple anodic coatings over the same part. For example, an aluminum part may be type II anodized in one area and type III anodized in another.

Masking may also be employed in the application of chem film, black oxide or phosphate coatings.

Chem milling operations on aluminum or titanium typically employ masking to achieve selective dimensional changes and specific shapes.

Aerospace finishing often requires a part be held in place with an in-house custom produced jig or fixture which requires protection from chemical solutions via masking materials. Maskants may also be employed to repair damage to the protective coatings typically found on racks (Plastisol®) temporarily.

Masking methods

Masking methods fall into permanent and temporary categories. Temporary masks include waxes, tapes, paints and any other methods where the maskant is applied, used one time, removed and disposed of or recycled. Permanent masks are designed to conform to a specific geometry and are made of materials that resist chemical attack to the point where they can be used many times without degradation.

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The production of these masking methods is expensive and typically needs to be justified by large production runs or by some other advantage such as higher coating quality. Permanent masks generate a low level of waste over time, while temporary masks, especially tapes, generate a large volume of spent material that typically requires disposal as hazardous waste.

No one method of masking is suitable for all stop-off operations. Each has its own advantages and disadvantages.

In some cases, the masking technique is specific to one type of operation. For example, copper plating is used as stop-off for carburization processes, because copper resists the diffusion of carbon. Also, anodic films do not conduct electricity well, so they can be used as stop-off for selective plating and hardcoat anodizing.

Plastic coated magnetic sheets that can conform and adhere to steel surfaces by magnetic force have been used by some platers. These are easy to remove and use multiple times.

Stop-off lacquers

The most widely used stop-off materials are lacquers. There are a number of formulations commercially available, but the quick drying vinyl lacquers are the most commonly used stop offs for hard chromium plating. These feature application ease, adequate adhesion and ease of removal. Since they do not normally go through cleaning cycles, they are not strong in their resistance to alkaline cycles and cleaners. Depending on the complexity of a part and the drying time of the lacquer, it may take 30 to 40 minutes to apply three to five coats of lacquer, which is the minimum considered adequate for elimination of porosity. After plating, the lacquer is peeled, or chemically removed with a solvent. It is usually best to remove the lacquer at the conclusion of the plating cycle. If allowed to remain for days, the lacquer will become especially hard to remove.

Lacquers especially designed for hot alkaline cycles and acids are also available. These stress adhesion and maximum chemical resistance and consequently, are not easy to remove after plating. Tenacity through the baths and removability after the cycle are polarities which always represent a formulating compromise. Some lacquers feature ease of stripping but these may not exhibit the best adhesion.

Virtually all stop-off lacquers may be air dried. However, the required time will vary with such factors as coating thickness, temperature and humidity. Since they all contain volatiles which must be evaporated before immersion in hot solutions, force drying is recommended when possible, to eliminate some of the variables. This may be accomplished by forced air, hot plates, or even ovens. Failure to completely dry the film may result in blisters, pin-holing and plate-through. Force drying will also usually enhance adhesion for tough cycles.

Waxes

Two commonly used types of waxes are high temperature chlorinated synthetic waxes and petroleum based microcrystalline, low-temperature waxes. The latter are much more widely used because they are less expensive, and because they present a lower level of toxicity.

A part must lend itself to dipping in order to use a wax. When practical, a wax is the most economical, most efficient method of masking because the wax may be salvaged and re used.

The low temperature waxes melt at about 180°F, and will begin to soften and sag in the neighborhood of 145 to 150°F. For this reason, they should not be used in solutions operating higher than 150°F.

High temperature waxes are liquid at about 300°F. These waxes can take anything in a plating cycle. Some may be made from chlorinated formulations, posing an odor and toxicity problem.

In order to obtain optimum adhesion with wax, the first coat should be only virgin wax and should be applied to a hot part. This can be achieved by preheating the part, in an oven or vapor degreaser, or leaving it in the wax pot until it has achieved temperature. The resultant first coat is very thin, but will be adherent.

One advantageous technique is to maintain two wax pots, one at a higher temperature, to apply the first thin coat and to facilitate removal after plating. Subsequent coats are applied as the part cools, and heavier deposits obtained.

After wax coating, the wax is manually removed from areas to be plated using cutting and scraping. Many operators prefer to trim the wax while it is still warm and easily carved and shaped. The waste trim should be tapered down to the area that is to be plated. This leaves only a thin residue on the areas to be plated, and reduces the tendency of the chromium deposit to build up at the wax border. After the part fully cools, the thin waxy residue, on any areas to be plated, is removed with live steam, solvents, pumice or water-slurry abrasive blasting.

After plating, the wax is removed by immersion in the hot used wax tank or in hot water or in a vapor degreaser. At least one plater has had great success by immersing the waxed part in the used wax tank to remove the bulk of the wax, followed by a hot (260°F) oil immersion followed by an alkaline electrocleaner. This eliminates vapor degreasing.

Wax pots are typically heated with electric heaters or oil jacketed tanks. The heat source should never directly touch the container holding the wax, as excessive temperature can decompose the wax, leading to poor adhesion.

Poor adhesion can also result from using a wax that has been contaminated with too much chromic acid (from re-use of masked wax).

Stop-off tapes

Platers and anodizers utilize stop-off tapes to avoid coating specific areas of parts. Plater's tapes fall into two categories, metallic and non-metallic. Because they conduct current, metallic tapes are utilized in applications and locations where the maskant needs to draw some current away from the area to be plated (current robbers). Non-metallic tapes act as insulators.

Features to look for in all tapes are a high level of tensile strength (resistance to tearing), chemical resistance of both tape and adhesive, service temperature and type of adhesive (and its long term compatibility with the solutions to be employed). Tapes come in various thicknesses. The thicker versions tend to be employed in more abrasive conditions, while the thinner versions are utilized in applications where maximum flexibility is required. Thicker tapes are harder to manipulate into specific shapes, while thinner tapes are easier, but less abrasion resistant.

Metallic tapes

Figure 1 - *Application of a metallic tape.*

Metallized tapes may be used to draw current away from high current density surfaces such as edges and sharp geometric shapes (Fig. 1). Because they are conductive, metal tapes "rob" some of the current, leaving a better defined border, reducing/eliminating the production of "trees" or "nodules" at sharp edges of parts.

Care must be taken to make good electrical contact between the metal of the tape and the part to be plated. Some platers use metal tapes that have no adhesive, utilizing an overlap of plastic tape to provide support and adhesion. A second (and sometimes a third layer) layer of plastic tape is commonly applied over the metal foil tape to hold it snugly in place and make a better seal.

In hard chromium plating, aluminum tape is used wherever possible. Lead is only used if the part is going to be exposed to a caustic (high pH) environment, which would destroy aluminum. In rare cases, lead tape has been used as auxiliary anode material.

Lead tapes are compatible with anodizing processes but (with the exception of hexavalent chromium solutions) they cannot be used in most any electroplating solutions, as lead is a contaminant in such solutions at very low (few ppm) concentrations.

Lead foil tapes do not have the same degree of conformability as vinyl tape. They have very good thermal properties and will perform over a wide variety of temperature conditions (-65°F to 225°F; -54°C to 106°C). Lead is not as conductive as aluminum. The adhesive for lead tapes is typically a rubber or acrylic based formulation. Adhesive free lead tape is also available.

Aluminum foil tapes are compatible with many electroplating operations, and can also be used to mask parts for paint stripping and in select (non-caustic) etching applications up to 125°C.

The tape is typically obtained in a "dead soft" condition which allows the aluminum to better replicate geometric surfaces. Aluminum is less expensive than lead and has better flexibility. The adhesive for aluminum tapes is typically an acrylic compound, but adhesive-free tape may also be employed.

Glass tapes

Glass tapes are the most commonly employed masking devices in HVOF spray and some blasting operations, due to their high temperature resistance and the toughness of these tapes. These tapes can withstand temperatures ranging from -54° to 232°C (-65° to 450°F).

These tapes have a low level of flexibility (8% elongation), so they cannot easily be applied to complex geometric surfaces.

Plastic tapes

Non-metallic tapes come in numerous polymer types, thicknesses and widths. Tapes may be manufactured with no adhesive (self-adhering) or with any one of a number of adhesives, which must be matched with the chemistries of the processes employed. For example, hycar-nitrile adhesive is very resistant to chemical attack by chromic acid.

Some tapes are thin and flexible enough to provide optimum wrapping characteristics for sealing and draining without adhesives. The ends may be sealed with an adhesive by melting with a heat gun, or by applying a solvent to the tape.

On flat surfaces, or where wrapping cannot be performed, pressure sensitive adhesive tapes must be used.

The higher thickness tapes (5 to 6 mils) and abrasion-resistant glass tapes are typically employed as effective stop-offs for abrasive blasting operations or for HVOF spray stop-off.

Most non-pressure-sensitive tapes are supplied with a sealing adhesive to cement the ends after the wrap. As tension is employed in the wrapping operation, in order to achieve maximum grip, this tension should be relaxed prior to sealing the cemented end of the tape. Otherwise, the tape will begin to retract before the seal is produced. A seal can also be achieved with non-adhesive tapes, by heating the leading edge of the tape to the melting point.

Plastic tapes are the most commonly employed masking devices in plating and anodizing facilities. A broad range of plastic types, thicknesses, strengths and flexibilities are available, as are a variety of colors.

Using tape may appear to be a simple task, but a significant amount of skill needs to be employed to avoid breeches resulting in solution getting into places it should not or nodules plated over surfaces that should be plate-free.

When taping parts where wrapping is feasible, non-pressure sensitive tape with no adhesive may be employed. The tape needs to overlap as each winding is applied and often as many as three layers are used to assure full coverage and sealing of the masked surfaces.

During wrapping, just the right pressure stretches the tape enough to produce the required pressure for the adhesive to function properly. Most non-pressure-sensitive tapes are supplied with a sealing adhesive to cement the ends after the wrap. As tension is employed in the wrapping operation, in order to achieve maximum grip, this tension should be relaxed prior to sealing the cemented end of the tape. Otherwise, the tape will begin to retract before the seal is completed. A seal can also be achieved with non-adhesive tapes, by heating the leading edge of the tape to the melting point.

On flat surfaces, or where wrapping cannot be performed, pressure-sensitive tapes with acrylic or hycar-nitrile adhesives must be used.

Frequently two or more conventional stop-off materials are used in conjunction with each other, to take advantage of the benefits of each.

Hot melts and proprietary products

Hot melts operate in a similar fashion to waxes. They are predominantly of the butyrate family. They can be efficiently applied, trimmed and re-used. They do not provide the optimum in adhesion, are fairly expensive, and possess an odor which is often considered objectionable.

Use of butyrate based hot melts in solutions containing wetting agents may result in extraction of plasticizers from the maskant and organic contamination of some plating solutions.

Lacquers and tapes are prone to leaching from strong chemical solutions, at times resulting in cracked, leached maskant and contaminated processing solutions. A number of polymer/resin based masking products are commercially available from several suppliers. One such product is shown in Fig. 2.

Figure 2 - *Example of a polymer/resin-based mask material.*

These maskants provide excellent flow properties, bubble resistance and adhesion values. They are popular in anodizing, chemical milling, electroless plating applications, and many electroplating processes, including hard chromium.

For full protection, numerous coats may be required. Curing these coatings can be accomplished by air drying for periods of three or more hours. The maskant can also be oven-dried at 70°C (160°F) for 30 minutes.

Recommended film thicknesses vary depending upon the actual product and processes employed. Typically they are 0.2 to 0.5 mm for hard chromium and 0.5 to 1.0 mm for other electroplating solutions.

These products typically contain one or more solvents. Some of these pose fire/explosion hazards. Typical solvents include toluene, xylene, VM&P naphtha, perchloroethylene and others.

Permanent masks

Permanent masks typically are either off the shelf basic shapes such as tubing and stoppers which may be molded from polyethylene, polypropylene, rubber or PVC. Stoppers and tubing may be employed to cover holes and protrusions respectively as shown in Fig. 3.

Figure 3 - *Masking of holes and protrusions with stoppers and tubing.*

Rubber masks are superior in retaining their elasticity and affecting the snap-tight fit usually required, as opposed to the cold-flow properties of vinyl. Rubber masks, however, have some inherent chemical limitations, such as attack in chromic acid.

Plastisol® masks, usually molded from approved rack coating material, are ideal chemically and can be fabricated more quickly and less expensively. Shown in Fig. 4 are three simple plating masks molded from a regular plating rack coating Plastisol® for use in the electroplating of aircraft engine parts. For some complicated masking operations, the molded-mask principle can be incorporated in the plating rack, making the latter a precision tool.

More sophisticated permanent masks are also commercially produced. One of the most unusual of these is a proprietary rubber film with an interior consisting of strontium ferrite flexible magnets. This film can be bent, twisted and flexed without loss of magnetic energy. The films can be purchased with or without pressure-sensitive adhesive. As with most permanent magnets, the masks can be used many times over.

For extremely arduous masking requirements, an actual Plastisol® rack coating system may be used. This involves application of a primer-adhesive, then the Plastisol® coating followed by curing. These coatings cannot easily be stripped off.

Figure 4 - *Examples of Plastisol masks.*

About the author

Frank Altmayer, MSF, AESF Fellow, is Technical Education Director of the AESF Foundation and NASF. He holds a B.S. in Chemical Engineering B.S. in Chemical Engineering (1974, Honors Graduate) and an M.S. in Metallurgy from the Illinois Institute of Technology. Mr. Altmayer was President and owner of Scientific Control Laboratories, Inc., from 1986 to February 2007. He is an AESF instructor, Certified Master Electroplater/Finisher (MSF), and has forty-five years of experience in metal finishing, thirty-seven years of experience in the design and trouble-shooting of metal finishing processes/shops and waste treatment systems, and twenty five years of experience teaching metal finishing technology at both the college and industry levels. Since the sale of his business in 2007, Mr. Altmayer has been worked as an outside contractor for Scientific Control Labs., Inc. (2007 to present) and as an independent consultant in metal finishing. Mr. Altmayer is the recipient of the AESF Past Presidents Award (1987), the NAMF Award of Special Recognition (1991), the AESF Leadership award (1991), the Best AESF Branch Presentation Award (1997), the AESF Fellowship Award (1999), the Chicago Branch AESF Geldzahler Service Award (2004) and the NASF award of special recognition (2008). The title of “Master Surface Finisher” (MSF) was accorded to Mr. Altmayer in 2001 by the AESF Board of Directors.