Lubricant Selection— A Seven-Step Process

Too often, stampers settle for using the lubricants currently on their manufacturing floor. However, this may not always be the best solution for a particular die or base material. What follows is a seven-step selection process that will help in understanding and examining lubrication concerns.

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Photos courtesy of Tower Oil & Technology Co., Chicago, IL

There are six basic families of lubricants from which metal stampers can choose:

• Disappearing/vanishing oils
• Straight petroleum oils
• Macro-Emulsions
• Micro-emulsions
• Chemical synthetics, and
• Pastes (invert emulsions).

Numerous choices exist within each lubricant family, making selection complex and confusing. Follow these seven steps to relieve any confusion, and properly document and validate each step along the way to affirm the selection process and provide a history for future projects.

Step 1: Health and Safety Considerations

Before beginning the lubricant-selection process, understand the HMIS (Hazardous Materials Identification System) ratings for health, flammability, reactivity and personal-protection equipment. Developed by the National Paint and Coatings Association in the early 1970s for use as an in-plant labeling system, the HMIS rating is a color-coded, alphanumeric system that gives information about the health, flammability and reactivity of the chemical in question. The system rates a material from a "minimal hazard" to a "serious hazard." It also recommends the appropriate personal-protection equipment needed when handling the chemical. Consult with your safety-program coordinator for a list of acceptable ratings for your manufacturing facility.

The Material Safety Data Sheet (MSDS) should always precede the entry of any chemical into your facility. From the MSDS, review the flash point, flammable limits, threshold limit value (TLV), spill and leak procedures, hazardous ingredients, and proper handling and storage requirements prior to these lubricants entering your facility.

Even though the lubricant may have passed all of the above-listed criteria, in-process considerations should be pre-screened. Some lubricants will have a propensity to smoke or fume when introduced to heat, leading to undesirable situations.

Another in-process consideration is the mist guidelines under discussion at the American Conference of Government Industrial Hygienist and under review by the Occupational Health and Safety Administration. The current guideline is set at 5 mg/m^3 of mineral oil, however there have been discussions on lowering the TLV to 0.2mg/m^3. This guideline pertains only to miner-

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al oil contained in oil-based lubricants. However, guidelines are expected in the future for metalworking-fluid mist in the air regardless of lubricant type. Proper application techniques can reduce mist generation, but not eliminate it.

Step 2: Chemical Content Requirements

The customer will most likely dictate chemical-content requirements, if applicable. Many customers issue specific requirements for the absence of particular additives used in metalforming lubricants. Some examples: no chlorinated paraffins, a widely used extreme-pressure additive; or, no sulfur, to promote rust and oxidation in some extreme applications.

Often, the lubricant must be chlorine-free, as dictated by many electrical component manufacturers. Chlorine in the lubricant could lead to premature oxidation on parts. Ask your customers upfront for a list of prohibited chemicals, rather than wait until you have begun stamping parts. In some cases, the customer may only be concerned with lubricant that remains on the parts, so if you clean the parts prior to shipping, chemical content may not be an issue.

Consult with your lubricant supplier to understand the chemicals present in the lubricant and their possible affects on materials and on secondary processes.

Fig. 1—The Stack-Stain Test determines lubricant staining if parts or material stack flat upon one another, trapping lubricant under a load. This is a good test if shops stamp and stack blanks, then store them for some time before final processing.

Step 3: Clarification, Reconditioning and Waste Treatment

The costs associated with metalforming lubricants do not stop at their purchase. Does part manufacture consume all of the lubricant, or will there be excess available for reuse? Or, must the stamper reclaim excess lubricant and dispose of it? Will the lubricant be consumed by means of carry-off with the part, as with a straight petroleum oil or vanishing-type oil?

If these cases lead to no further costs or waste considerations, then the stamper can quickly narrow its list of possible lubricants. However, if disposal costs are high or if certain equipment is available in the plant, other lubricants may be considered.

The reconditioning possibilities of the lubricant will help prolong its useful life, by adding tank-side additives such as biocides, rust inhibitors and extreme-pressure additives to the lubricant sump. These additives also may prove cost-effective and enable the tooling to perform at a higher level. Under these circumstances, the stamper must properly monitor the setup to determine tank-side additive amounts, and develop a schedule for adding them to the sump.

Certain types of tooling may require a flood-type lubricant system, generating reconditioning concerns such as monitoring ratios, separation of trap oils and proper filtration. Recirculating metal fines and particulate can be detrimental to the performance of the tooling, causing galling and premature tool wear and leading to scrapped parts.

The waste treatment of spent lubricant, no matter the type, can pose monumental challenges. The need to store and ultimately dispose of numerous drums of waste can be expensive. Many disposal companies demand that water-based waste be free of oil, otherwise disposal costs escalate. For water-extendable lubricants, stampers may use an evaporator to remove the water, leaving solid waste behind and creating less material for disposal. If the right equipment is available inhouse, the water-extendable family of lubricants offers a cost-effective choice, provided other considerations listed above have passed review.

Regardless of the clarification, reconditioning and waste-treatment methods, the composition of the selected lubricant must be compatible with the production processes employed in your facility. The introduction of a lubricant incompatible to these processes, even if initially cost-effective, can cause great expense further in the manufacturing process.

By the conclusion of this step, the stamper should have narrowed its selection to one or two families of lubricants. If not, reverse steps 4 and 5 to help narrow the field.

Step 4: Adverse Affects on Material, Dies or Equipment

Prior testing is essential to determine the compatibility of the lubri-

Fig. 2—The Stability Test finds use when using a water-based lubricant. While many water-based lubricants will initially mix readily with water, the long-term stability of the water-based mixture is of great importance. Should the lubricant separate or split, the lubricant that reaches the workpiece could be severely diluted.

cants to the material. Perform the following four tests when working with new lubricants or materials.

The Dip-Stain Test determines the staining factor of the lubricant on the material. Coat a clean coupon, free of any mill oil, rust inhibitor or other foreign material, with the test lubricant, immerse in a sample jar so that the coupon is half below the lubricant surface. Check the coupon daily for results without disturbing. Results: one day—Pass, three days—Good, five days—Excellent.

In different situations, the staining will occur below, above, both or only at the lubricant level. Evaluate the results closely to determine the severity and acceptance level of the staining. In a variation of the test, for prefinished materials, scribe the material with a razor blade in an X pattern to create a more severe condition.

The Stack-Stain Test (Fig. 1) determines the staining factor if parts or material stack flat upon one another, trapping lubricant under a load. This is a good test if shops stamp and stack blanks, then store them for some time before final processing. Clean three metal coupons to remove mill oil, rust inhibitor or other foreign matter. Coat the entire coupon with the trial lubricant and stack the coupons, clamping with four binder clips. Place the clamped coupons into a 90- to 100-percent-relative-humidity chamber. Inspect the coupons every two to three days, being careful not to disrupt lubricant film. Results: 7 days—Pass, 14 days—Good.

The Residue Test, used for water-based lubricants and disappearing compounds, indicates the amount of residue that might remain on the part after stamping. Often, stampers address excess residue problems only after the customer complains. Document the results of the various dilutions, and compare the relative residues to similar product ratios, as well as other types of lubricants. It may be determined that one type of residue is more acceptable, such as dry-to-touch versus oily residue.

Cover the bottom of a petri dish with the test lubricant at its working ratio, whether in concentrate or diluted form, with a film thickness similar to stamping-process requirements. Heat the dish to 150 to 180 F, until the water in the lubricant has evaporated. When testing disappearing compounds, allow the petri dish to remain in the open air and dry out so that the residue becomes visible. Observe the type of residue that the lubricant leaves behind—hard crystalline, firm wax, soft grease, oily or dry-to-touch.

Stampers also can conduct this test on sample coupons to understand further the nature of the residue left due to the porosity of some materials. You should test several dilution ratios for the residue, as you may have to vary the working ratio once the tooling enters production.

The residue also will help determine methods of tooling maintenance and whether or not you can use synthetic lubricants. Evaluate the properties of the soapy or waxy residue common with many synthetic lubricants in order to ensure that the tooling will perform as expected. A residue buildup on tooling, equipment and parts may cause slides, cams, feeders, etc. to become inoperable or sporadic in their action, requiring routine cleaning and maintenance. One method to avoid these problems is to guard these areas, or use grease compatible with the lubricant that will prevent the lubricant from washing away.

The Stability Test (Fig. 2) finds use when using a water-based lubricant. While many water-based lubricants will initially mix readily with water, the long-term stability of the water-based mixture is of great importance. The hardness of the source water affects lubricant stability—hard water tends to create unstable emulsions due to high mineral content and the inability of the lubricant to emulsify with the source water. Soft water, however, can lead to foaming issues.

Once in production, the lubricant will be mixed in larger quantities and

Fig. 3—The Twist Compression Test measures friction and evaluates adhesion in metalforming. It uses contact pressures set to match the process. This test measures the transmitted torque between a rotating annular cylinder and a lubricated flat-sheet specimen. Tooling and stock material can be mirrored to the exact application to find the best-suited materials.

Fig. 4—The Reichert Test determines the load-carrying capacity of a lubricant. The test uses a weighted lever arm, with a wear pin, on a rotating race in a lubricant sump. The stamper then analyzes the pin and race for wear patterns and comparisons.

placed in sumps or in application equipment. Should the lubricant separate or split, the lubricant that reaches the workpiece could be severely diluted.

To run the stability test, take a graduated cylinder or similar container, select the desired starting ratio, and mix the lubricant properly by adding the oil or synthetic concentrate to the water with agitation. Use the principle of "OIL"—Oil In Last. Allow the mixture to rest undisturbed, checking daily for one week. The results should be similar to that of the center cylinder shown in Fig. 2: a stable emulsion with no separation or splitting of the lubricant.

Step 5: Secondary-Operation Compatibility

Metalformers often must select a stamping lubricant compatible with secondary operations, such as cleaning, painting, powder coating, e-coating, assembly, welding and brazing. Incompatibility issues in these subsequent operations could result from use of the wrong lubricant or improper ratio of a water-extendable lubricant.

As a test, take clean coupons of the material and apply a light film of the lubricant in question, then perform the secondary operations that the parts will undergo downstream. Evaluate several ratios for water-extendable lubricants to determine the line of pass/fail on parameters such as weld strength, cosmetic issues and cleanability.

In the past, the use of vapor degreasers and solvent-type cleaners proved to be excellent for cleaning and subsequent operations. However, costs, along with safety and health issues, have substantially reduced their use, leading stampers to substitute alkaline cleaners and lubricants that require no cleaning prior to secondary operations. Consult with your lubricant supplier for these types of lubricants, which can greatly reduce the need for secondary cleaning operations and enhance the post-processing of parts.

Step 6: Tool Life and Part Quality Part

With proper due diligence, Step 6—evaluating lubricants in the tooling—is relatively simple. At this point, the stamper should evaluate only a few specific lubricants, selected with the assistance of the lubricant supplier. Too often, stampers use a particular lubricant only because it is currently stocked. It may meet some of the criteria listed above, but not all, thereby creating a sub-par selection.

The overall goal in tool life is producing the greatest number of parts and keeping the tooling running shift after shift without sharpening or polishing. Keep tooling-maintenance records for all tools, indicating the sharpening history, downtime and operating issues. This is the only way to determine if tools are producing as expected.

Stampers can perform several additional tests at this step, but two that will provide a good indication of the lubricant's performance, without damaging tooling or taking precious production time, are the Twist Compression Test and the Reichert Test.

The Twist Compression Test (TCT) (Fig. 3) measures friction and evaluates adhesion in metalforming. The TCT uses contact pressures set to match the process. Flat contact is ensured through self-aligning tooling, and depletion of lubricant without replenishment ensures boundary contact with liquid lubricants. This test measures the transmitted torque between a rotating annular cylinder and a lubricated flat-sheet specimen. The 1-in.-dia. annular cylinder is driven by a hydraulic motor for smooth delivery of the applied torque at speeds to 30 rpm. Pressure may be increased to 35,000 psi to best duplicate the tribological conditions of the metalforming process being studied. The tooling and stock material can be mirrored to the exact application to find the best-suited materials. Data are collected electronically and the coefficient of friction calculated from the ratio of transmitted torque to applied pressure.

The TCT is best used as a comparative rather than an absolute test. Its simplicity and good laboratory practice minimize variation. However, include a reference for each series of evaluations.

The Reichert Test (Fig. 4) will

determine the load-carrying capacity of a lubricant. The test uses a weighted lever arm, with a wear pin, on a rotating race in a lubricant sump. The stamper then analyzes the pin and race for wear patterns and comparisons.

Part quality will depend somewhat on the tooling, but a good portion of part quality results from the selected lubricant. Can the part be stamped and packed to the satisfaction of the customer? Are the parts consistently within tolerance specifications? Can the parts be welded/assembled without the additional cost of cleaning? Is the residue acceptable to the customer? Do the parts rust in storage or in transit? Does the part meet or exceed the customer's expectations?

Step 7: Cost Effectiveness

Too often, stampers consider cost effectiveness as the first step in selecting a lubricant. However, the upfront, visible costs of the lubricant are often minimal compared to the overall costs associated with stamping. Parameters to help evaluate lubricant cost effectiveness include tooling life, polishings, wear, disposal costs and coating life. Data gathering consists of recording the number of parts produced between sharpenings, polishings and other downtime causes. The challenge comes in analyzing the data to determine cost effectiveness. By proper documentation, stampers can compare differences and variations and then can make educated decisions.

Comparing a low-quality, straight blanking oil, with minimal to no extreme-pressure additives, to a highly compounded, high-performance oil is not a fair comparison. If price were the only metric used, we would all be using inexpensive blanking oil. However, when considering the length of tooling runs without polishing forms, the number of parts produced between sharpenings and other intangibles, a heavily compounded high-performance oil may be the clear choice.

Stampers should consider several other cost-justification factors. Can the parts be stamped and sent to the customer without cleaning? Will a water-soluble lubricant work for the application, creating an even greater savings running at a 4:1 ratio, versus straight oil? Take a step back and create a flow chart of the entire process. Too often, once the part leaves the pressroom, what happens downstream is forgotten. Many times the preceding operation can lead to a cost savings in the next operation.

Conclusion

The seven-step lubricant-selection process requires some discipline, to work through all of the steps, but the end results will justify the effort. Do not fall victim to doing things the way you always have. Continually evaluate new technologies and methods. If you have been doing the same thing for the past few years, you had better find out what is new. If not, someone will steal your business. **MF**