Electroforming for Mold Repair

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'These parts are coming out oversized' - words that any tooling manager hates to hear. Often times, they spell a lot of trouble. But if you have a good electroformer among your vendors, things are not as bad as they sound. Adding metal where it's needed does not necessarily entail smoke and fire of welding along with the inevitable splatter, potential for warpage, cracking and annealing of the heat affected zone. In the following paragraphs we will not only take a closer look at the way electroforming can help the molder bring his parts back into tolerance, but also point out situations when welding is a viable alternative.

So, is it 'plating' or 'electroforming' and what is the difference? Technically speaking, these two technologies overlap with a pretty fuzzy boundary lying somewhere in between 0.001" and 0.003" thickness of the deposit. While the former implies coating a surface with a thin layer of another metal, the essence of electroforming is heavy plating with low stress and controlled deposit properties, often with the purpose of creating a self-supporting structure. Thus, when we apply a significant thickness of tightly adherent, stress-free metal with the right hardness, surface finish, machinability and wear resistance to a mold component, we undoubtedly 'electroform'. Although plating thin (under 0.001") layers of chromium, nickel or nickel-PTFE composites is used to improve a mold's corrosion resistance, release properties and reduce wear, since our topic today is mold repair, let's limit the discussion that follows to heavier (>0.001") electroformed deposit thicknesses.

The Basics

All plating is done from water-based solutions of metal salts and other ingredients necessary for the correct functioning of the baths. Metals commonly used for mold component repair are: nickel (soft, hard and electroless), chromium (hard) and nickel-cobalt alloys. A comparison of important properties of these deposits and corresponding processes is found in Table 1. Electroless nickel deposition occurs due to a chemical reaction that takes place on the surface of the metal resulting in the formation of a nickel-phosphorus alloy. Electrodeposition processes (Ni, Cr, Ni-Co) are driven by an electric current that is passed between an anode and the part being plated.

Figure 1 Threads Plated up with 0.002" of NiColoy™

Table 1. Common Metal Deposits used for Mold Repair

Metal	Plating rate, *** 0.001"/h per side**	Hardness R_c	Appearance	Plating Uniformity/ Ability to plate in recesses	Post-Plating Machining Required?
Nickel (soft)	up to 5	$\leq$ 20	Matte grey	Average	Yes
Nickel (hard)	up to 5	up to 45	Semibright	Average	Yes
Electroless Nickel	up to 1	up to 70 (baked)	Semibright to Bright	High	No
Chromium (hard)	up to 2	up to 70	Milky-white, matte	Poor	Yes
Nickel-Cobalt	up to 5	up to 55	Bright to Semibright	Above Average	Sometimes

Deciding which metal and process to use in a particular case requires substantial knowledge and experience and is best determined jointly by the moldmaker and plater. But data in Table 1 can assist in making the right decision. For instance, electroless nickel's ability to plate uniformly into recesses makes it the only option for building up the inside of a narrow (< 1/4" ID) and deep (>½") hole. An external thread (See Fig. 1), on the other hand, can be built up by either electroless nickel or nickel-cobalt electroforming. Both processes will provide a bright deposit with a sufficiently uniform thickness distribution. However, when an appreciable (>.002") thickness of metal needs to be added, the slow-plating electroless process becomes impractical.

Process Outline

Figure 2 Mold Blocks Selectively Plated on two Sides with 0.040" of NiColoy™

Key to mold rebuilding is a strong bond of the plated layer to the substrate assured first and foremost by surface cleanliness and the absence of any burnt-in residue on it. Whenever possible, surfaces to be plated are sandblasted. After that, a preliminary chemical cleaning step is carried out and the part is masked to protect from deposition all areas except the ones that must be plated. Maskants are plastic- or wax-based non-conductive compositions inert to the plating chemistry that are brushed on or applied by dipping. Alternately, plating tape can also be used. In electroplating processes it is often necessary to install plating shields and/or auxiliary anodes which improve deposit thickness uniformity.

Once the part is fully masked and fixtured, a technician will inspect it visually for bare spots, check the surface area to be plated and work with the drawing to verify the desired deposit thickness. A plating calculator or spreadsheet will be used to calculate the necessary plating time and current (electroless processes are controller by time only). Depending on the substrate material (hardened or pre-hardened tool steel, stainless steel, carbon steel, copper alloy, etc.), an appropriate activation/pre-plating cycle will be selected ensuring a strong bond of the deposit to the part. After that, a job ticket will be issued to the plater/electroformer who actually carries out the electroforming cycle.

Now the part will be taken through a series of tanks, some heated (but none hotter than 140 ^{o}F), some at room temperature, where it is successively electrocleaned, acid dipped, activated (with interim rinsing) and, finally, loaded in the plating tank where the process of growing the additional layer of metal on the part takes place. In electroplating, an accurate meter will be used to deliver precisely the desired amount of electricity to obtain the required deposit thickness. The part will remain in the tank from several hours to several days depending on the deposit thickness required and the deposition rate of the process.

Figure 3 Sawtooth Areas Selectively Plated with .0005" of NiColoy™

Once the cycle is over, the part is tanked out and thoroughly rinsed. The maskant is removed and a post-plating inspection is carried out verifying that the deposit is smooth, pit-free, has the required thickness and is applied to the correct area. If a mistake is spotted, the part will be reworked. Deposits applied to the wrong area can be removed chemically or mechanically. A deposit that is too thin can be activated and additionally plated. If everything checks out OK, a 2 hour post-plating bake at 400 - 450 ^{o}F is often carried out for hydrogen embrittlement relief.

When the molder receives the plated parts back, they may require some additional processing before the mold is re-assembled. For thin deposits (<.0.003"), only a touch of stoning may be needed in areas where the maskant edge lifted a bit. Heavier deposits usually require some machining to remove overplate from edges and protrusions that often build up heavier than flat and recessed areas. Grinding, turning, drilling as well as EDM can be used on plated areas.

To Plate or to Weld?

When making this decision, several factors come into consideration.

Affected area. When you have a delicate part with tight tolerances, welding is not a good idea - warpage almost inevitably causes the dimensions to go haywire. Large flat areas on parts with a heavy cross-section, on the other hand, are prime candidates for welding - a fast and inexpensive process compared to plating. Narrow areas and internal surfaces must be plated.

Required additional thickness. When all you need is a few thousands, plating or electroforming may save you additional effort. A correctly masked and plated part can be put into service with minimal, if any clean-up, while welded parts always have to be post-machined, both to restore tolerances and remove splatter. But if you must add 0.020" and more and the part configuration allows it, welding could be a faster and cheaper alternative. In general, welding is a less expensive option than electroforming.

Finish. If your mold component has a smooth surface, plating it up with a bright deposit will leave the surface finish unchanged or even improve it. A welded surface is always rough and must be machined.

What Your Electroformer Needs to Know

When sending your part out for repairs or requesting a quotation, provide your plater with as much information as possible to maximize his chances of fully meeting your requirements. It is absolutely critical that we know what material the part is made of, whether it was hardened or not, the component's history (was it plated or welded before?) and the exact outline of the area that needs to be plated. How thick do you need the plated layer to be? Would you like the deposit to be heavier than required for post-machining or exactly the right thickness? How hard you want the plated layer to be? Does it have to be bright and uniform or will you be post-machining it? Is overplating on sides required so you could restore the sharp edges or not? How soon do you need the component back? What material will you be molding and at what temperature? And, finally, how many identical parts you will be sending for plating.

Conclusion

Heavy plating (electroforming) can help restore for useful service costly mis-machined or worn components that otherwise would have to be scrapped. This method can be implemented in a much broader range of cases and is a more precise but costlier alternative to welding. While deciding what method to use for repairing your defective mold, consult your welder and electroformer. And, finally, don't hurry to throw away a mis-machined component, you may save your company thousands of dollars by rebuilding it through selective electroforming.