Intentional Over-Plating

by
Felipe Atti
KraftPowercon Inc, USA
Pensacola, Florida, USA

The evolution of the plating process has been a slow one relative to other manufacturing processes. While plating has seen some strides in the realm of automation, the majority of manufacturing processes are already fully computer controlled or progressing to that end.

In attempts to achieve consistent results from plating processes, there has been a huge push in process parameter control. Platers across the board, as well as the markets they serve, have adopted narrow acceptable ranges for solution temperature and chemical concentrations (as well as low tolerance for contaminants). In addition, there is a rising demand for precise control of electric current. Despite said efforts, there are still many variables in the process that make it difficult to achieve consistent results within a narrow range of plating thickness and/or coverage.

When plating several parts simultaneously, the parts are electrically connected in parallel in a tank. Theoretically, the parts have the same electrical conditions. However, in practice, there will be variance in the resistance between the parts to the rack and/or the anodes to the tank bussing. In a parallel configuration, the voltage is common, but the electrical current is subject to the inconsistencies of the voltage interactions at each contact point and part being plated. Any difference in potential will result in different electric currents across the parts and/or anodes (this can easily be checked with clamp meters). While the rectifier may deliver the desired current, the process may still produce varying plating thicknesses across the parts.

The simplest way to deal with variance in the plating results is to intentionally over plate. By doing this, the least plated part in the batch will still maintain the minimum specified plating thickness, thus meeting quality standards. The drawback is that many of the parts will have more plating thickness than was required. Though effective, over plating is inefficient and calls for additional costs and waste. While practicing this method, platers use more energy, time and chemicals than their customer is paying for, not to mention that parts subject to grinding after processes such as hard chromium plating, will require a longer grinding process to remove all of the undesired excess plating.

Plating is a multifaceted process with many factors to consider. Two significant electrical factors that are known to have influence in plating results are output ripple and the accuracy of current measurements.

Narrow range low ripple

Plating deposition rates (plating speed) are sensitive not only to current density, but also to output ripple. The best output from a SCR rectifier with a ripple filter installed is typically 5% ripple, at the maximum output voltage. SCR rectifiers have their output ripple affected by the output settings - the lower the output voltage, the higher the ripple. This condition is exacerbated when the rated voltage of the rectifier is significantly higher than what the respective plating process requires. The output ripple will also increase as the current is increased.

The efforts put into controlling other variables (keeping the plating solution temperature and chemical concentration within narrow ranges, investing in computer control to keep the current density constant for different process recipes, etc.) are futile if the plater does not consider that slight changes in the voltage to keep constant current can increase output ripple and cause varying plating thickness in spite of other parameter controls.

High quality switch mode rectifiers can deliver ripple below 1% throughout the entire output range.

Accurate control and precise output voltage and current readings

Old fashioned rectifiers typically use huge shunts to provide the electric current flow reading. Shunts are resistors made of special material to keep the electrical properties constant regardless of the temperature. By their nature, resistors will get hot when there is electric current flowing through them, resulting in losses in the circuit.

Some high quality switch mode rectifiers supply DC current split in modules, but also do so accurately with modular electric current measured through Hall Effect sensors (no shunt resistors). Thus, current control is achieved within 1% of the rated output.

Split modular output

There is another feature in high quality switch mode modular rectifiers that can be useful to achieve uniform plating thickness.

Each rack of parts (or a single part) can be connected separately to a negative pole from a power module output (or from a block of power modules), while having a common positive bussing connected to all anodes of a plating tank. Subsequently, each output will compensate the voltage on each part in order to achieve equal electric current. Maintaining equal electric charge (A.hr) will deliver equal plating thickness among the parts being plated at the same time.

Similarly, each anode can be connected separately to a positive pole from a power module output (or from a block of power modules), while having a common negative bussing connected to the part in a plating tank. Here, each output will compensate the voltage on each anode in order to achieve equal electric current and consequently equal electric charge (A.hr) to deliver uniform plating thickness around the part being plated with several anodes at the same time, *e.g.*, hard chromium on rolls and cylinders.

High quality switch mode modular rectifiers significantly reduce over plating (whether it is intentional or consequential). This affords platers potential reductions in (1) plating times, thus plating more batches per day and (2) energy and raw-material consumption (anodes and chemicals).

Below, we can see an example of a typical hard chromium plating batch, with eight parts connected in parallel to a single thyristor controlled rectifier:

In this case, the part receiving the least current (353 A) serves as the indicator for the job being completed to the desired specification. If the goal is to plate 1.5 mils (38 microns), the average plated thickness among the parts will be 15% above the goal. If the thyristor-controlled rectifier was replaced with a high quality switch-mode rectifier with split output, those differences in the resistance of each part would no longer be translated into different electric currents as seen above: but in different voltages to achieve the exact same electric current among all the parts. In this instance, the modular rectifier would save 15% in energy, raw-materials, and plating time.

Amps		Deviation					
		Thickness			Surface Current Density		
total	3257	%	mils	microns	A/ft²	A/in.²	A/dm²
min	353	goal	1.50	38.00	362	2.5160	39.0
average	407	15.3%	1.73	43.83	418	2.9018	45.0
max	458	29.7%	1.94	49.30	470	3.2644	50.6

About the author

Felipe Atti is the Senior Applications Engineer of KraftPowercon, Inc. Before joining KraftPowercon team, he has been in the hard chromium plating business since his Industrial Apprenticeship Training in electronics in 1991. He earned his BSc degree in Mechanical Engineering from Universidade de Caxias do Sul, Brazil and holds a MBA degree from Fundacao Getulio Vargas, Brazil. KraftPowercon has been a world leader in industrial power conversion since 1935 and has designed and manufactured plating rectifiers since the 1950s. Among notable achievements, KraftPowercon pioneered the world of metal finishing with the first switch mode rectifier designed specifically for this application in 1983. 35 years later, this technology has become the industry standard. KraftPowercon's US headquarters that includes sales, service and assembly is located in Fairfield, CT.