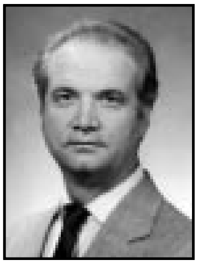

Advice & Counsel

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Keeping It Simple, Part II

Editor's Note: *This month's column continues the answer to a letter from an eighth-grade student who is planning a science project on electroplating. The information contained here is excerpted from a new interactive CD, "Electroplating for Beginners," which may be purchased by contacting AESF Publications Sales at 407/281-6441.*

How the Recifier Works

Let's review some of what we learned last month. You will remember that there are two basic "kinds" of electricity—AC and DC. The electricity that comes from the power companies is called AC, which stands for "alternating current." AC electricity is great for operating toasters, garage door openers, lights, and so on, but AC is terrible electricity for electroplating. That's because AC electricity changes direction 60 times every second. It goes forward, then backward, then forward and so on, all the time. Your house appliances are designed to work with this kind of electricity, but for electroplating, we want the electricity to go only in *one* direction all the time. That is called DC or "direct current" electricity. Because the power company doesn't sell this kind of electricity, we need to convert it from AC to DC. The equipment we use to convert the electricity is called a "rectifier." The rectifier is designed to take the power that is brought to the plant in AC form and change it to DC. It delivers the DC power to the plating tank through either cables or copper/aluminum bars.

A rectifier is a lot like your car battery. In fact, we could use a car battery to plate small parts. But the battery would need frequent recharging, and we would have trouble keeping the current from the battery at a set level, so using a rectifier is most cost effective, provides more uniform current conditions and allows us to plate larger loads.

A rectifier has two terminals, one positive and one negative. The terminals are marked positive (sometimes marked with a red + sign) and negative (sometimes marked with a black + sign), which show the direction that the electricity will flow if hooked up to a motor or other gadget. For our purposes, the direction that electricity flows is from the positive terminal to the negative. How much electricity is flowing through the cables or bus of the rectifier to the plating tank is measured by amperes. Think of amperes like gallons of water—1,000 amperes is a lot of electricity, just like 1,000 gallons of water is a lot of water. What causes the electricity to run through the cables? Electricity flow is caused by voltage. Think of voltage like pressure in a garden hose. If we want 1,000 gallons of water delivered by a garden hose in one minute, we have to apply a lot of pressure. If the 1,000 gallons of water can be delivered in a whole day, we don't need much pressure. The same applies to electricity. If we need to deliver 1,000 amperes in one second, we need a lot of voltage, while we don't need much voltage to deliver 1,000 amperes in a whole day.

The rectifier will have two meters for measuring electricity flow (amperes) and pressure (voltage)—an ampere meter and a voltage meter. We turn the voltage up or down to increase or decrease the delivery rate of amperes to the plating tank. It is the ampere delivery rate that gives us the plating rate (speed). For example, 100 amperes in one hour will plate twice as much metal on our part as 50 amperes in one hour, or 100 amperes in two hours.

Rectifiers generally deliver high amounts of amperes at relatively low voltages. This is the opposite of how electricity is delivered to your home, which is low in amperage and high in voltage. High voltage is very dangerous to humans. You might have 110 or even 220 volts in your home circuits, and your stereo might use maybe 3–5 amperes. In electroplating, plating voltages are usually low—around 4–6 volts—and are relatively safe for humans. Plating voltages are about the same as the batteries in a portable radio. But, unlike the batteries in your radio, rectifiers have the capacity for delivering a lot of amperes at low voltage, which makes the circuit on a plating tank dangerous to touch (short out) with a metal conductor, such as a copper bar or

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cable. **Never** connect a conductor, such as a metal bar or cable, directly between the positive and negative cables or bus coming from the rectifier to the plating tank. Creating such a connection (called a "short") can generate enough heat to cause a fire and burn you.

We need to set the rectifier to a voltage that will deliver the right amount of current (amperes) to our part so that it will be covered with a solid layer of metal. We also need to deliver the current to our part for a certain amount of time, so that our part will be covered with the right thickness of plating. If we deliver too much or too little current to our part while it is in the plating tank, the plated metal will look ugly, or the part will have bare spots.

Setting the Rectifier

The rectifier has a "control" that increases or decreases the voltage going to the plating tank. By increasing the voltage, we deliver more current; by decreasing the voltage, we deliver less current. Some rectifiers have dials, others have switches (called tap switches) and still others have remote control boxes with dials. The dials are turned up or down, or the tap switches are flipped up or down, to increase or decrease the voltage to the plating tank. The "right amount of current" at the tank differs from one kind of plating solution to another. It's not just amperes that matter, but also the surface area of our parts. "Area" is a math term. Area can be used to determine how much land a farmer owns. A farmer with one acre of land, for example, has a very small farm. Some farms in Texas are thousands of acres in size. So an acre is a measurement of how much land there is. We could also measure how much land there is by measuring the boundaries of the land with a ruler. If the land is shaped like a rectangle, we could measure with a ruler along the long side, and then also measure the short side. The area of the farm would be the long side multiplied by the short side. Let's say the long side is 500 feet and the short side is 90 feet. 500 feet x 90 feet is 45,000 square feet, which is just a little more than one acre. The symbol for square feet is shortened to ft^2, which means "feet times feet." Just as we measured the area of a farm by putting a ruler to it, we can put a ruler to our parts to be plated and measure the surface area of the part. Calculating area is easy for parts that are shaped like squares and rectangles, but most parts are shaped in all kinds of unusual ways. That's when we need to leave area calculations to the experts.

Some simple parts are easy to calculate, however. Take a solid steel rectangular rod, for example. Each end is a square, so the area of each end is one side times the other. The rod has four sides, each side is exactly the same size as the other, and each side is a rectangle, whose area is the length times the width. The total area of this rectangular rod is the area of the two square ends added to the area of the four rectangular sides.

Our rectifier needs to be adjusted until it delivers a number of amperes that, when divided by the area of the parts we are plating, gives us a number that is the correct current dosage. Just like we need the right dose of medicine when we are sick, our parts need the right dose of electricity. If we are plating chromium, for example, our parts are going to need a dose of electricity of around 150 amperes for every square foot of parts. If we are plating nickel onto our parts, we might be applying around 50 amperes of electricity to every square foot of parts. What if we have 10 ft^2 of parts? We would then need 10 x 150 amperes per square foot, which equals 1,500 amperes for chromium plating, and 10 square feet x 50 amperes per square foot, which equals 500 amperes for nickel plating. Those are our rectifier settings! We turn up the voltage until the ampere meter reads the right number of amperes for our square footage of parts, and then the rectifier is set correctly.

Calculating Plating Time

To find out how long to leave a part in the plating solution, so that it has the right thickness of plate, requires some calculations. While the principles behind calculating plating time may be hard to understand, the math isn't too hard if we use a formula that looks like this:

$$\frac{\text{Amperes x 0.001 in. x Minutes x Efficiency}}{\text{Thickness in in. x Area of part in ft}^2\text{ x 6,000}} = \text{F}$$

To calculate how long to plate a part to get the right thickness requires you to know the current density that will provide the best-quality plating. Current density is the amount of amperes divided by the area of the part or parts to be plated. In the U.S., the current density is typically amperes per square foot of surface area (amperes/ft^2, or sometimes given as ASF). Outside the U.S., the current density is in amperes per square decimeter (amperes/dm^2) or amperes per square meter (amperes/m^2). The correct current density for each plating solution can be obtained from books on plating, trial and error, or by asking someone who knows.

Once we know the current density, the only other things we need to know to make a calculation is the "F" for the equation, and the efficiency of the plating solution. F is a special factor that changes for each kind of plating solution. It has been calculated using a "law" first stated by Michael Faraday. The efficiency of a plating solution depends on the main ingredients, and the additives and conditions, such as current density, level of agitation and temperature. There are ways to measure the efficiency, or it can be obtained from books or chemical suppliers. The Faraday constant is available from almost any reference book on plating.

Next month, "Keeping It Simple, Part III" will conclude this abbreviated discussion on the basics of electroplating. **P&SF**

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