Clear and Hardcoat Anodizing: Selecting and Sizing Equipment for Greatest Efficiency

Clear and hardcoat are the fastest growing among the anodizing processes. For them to be operated most effectively proper equipment and optimum sizing of that equipment is crucial. Here are some ideas to help you select the most appropriate equipment and how to size each for best results.

PROCESS PARAMETERS

Before beginning, the important process parameters should be noted. Sulfuric acid content in the anodize tank is 100 to 200 g/L, which is typical. It is 150 to 300 g/L in the hardcoat process. The practical limits of the aluminum concentration are the same for both processes: 3 to 15 g/L. The temperature, however, is different: 15 to 25°C (or 60–80°F) for clear anodize and 1 to 10°C (30–50°F) for hardcoat.

Current density for the clear anodize process is 1½ A/dm^2 (or 10–15 A/ft^2), compared to hardcoat tanks at 2 to 5 A/dm^2 (24–50 A/ft^2). The time in the anodize process is 20 and 40 minutes; hardcoat ranges between 30 and 43 minutes, and occasionally more. Respective voltages are 1 to 24 V and 0 to 100 V.

The thickness these processes generate is 8 to 25 microns (0.3–1 mil) on clear and 25 to 75 microns (1–3 mils) on hardcoat. The equipment used for either type of processing is essentially identical, although the process tanks differ because of the different operating temperatures. Both require air agitation and ventilation, a chiller for refrigeration, an acid pump, and a pump for chilled water or glycol.

TANK SIZE AND AGITATION

Tank size is dictated by the load or rack package and cathodes. The clearance at the end of the tank is typically 12 in. along the long dimension, unless tilt is required (see Figs. 1 and 2). In that case clearance is more generous on one end to allow the load to tilt before it's removed from the tank.

Typically, the side clearance in terms of direction of travel is 6 to 8 in. (see Fig. 1). Steel tanks with PVC, rubber, or flexible drop-in liners can be used, although the preferred construction is polypropylene for tanks used for clear anodize. Copolymer construction, with insulation to withstand cold process temperatures, is preferable for hardcoat.

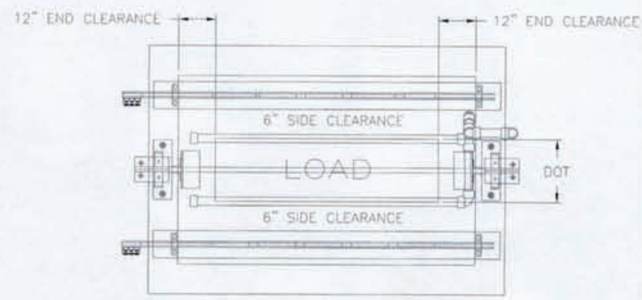

Figure 1. Plan view of a typical single-bay anodizing tank.

To determine the volume of air in cfm required to agitate the anodizing tank properly, we take the surface area of the tank and multiply by a factor of 1.5 cfm/ft^2. So, a 4- × 10-ft tank yielding a 40-ft^2 surface area, times 1.5 cfm/ft^2, requires 60 cfm to adequately agitate the tank. Rinse tanks and other process tanks require a lower factor for agitation.

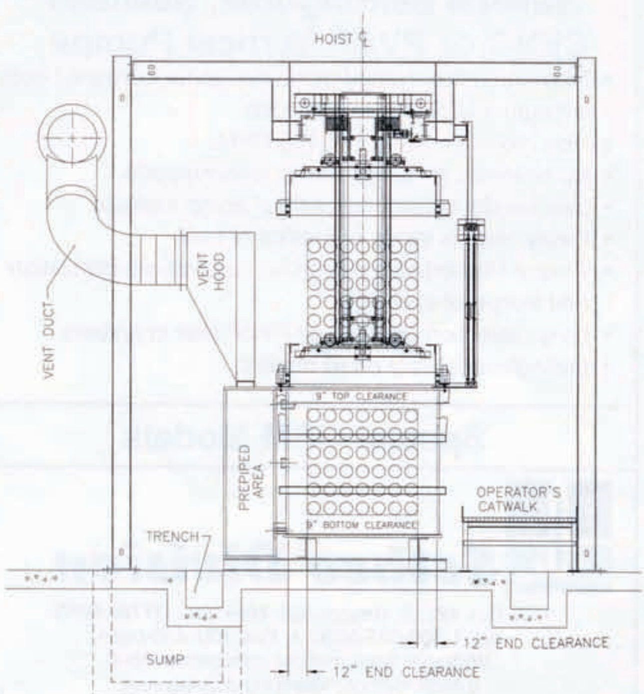

Figure 2. Typical elevation view of an anodizing tank.

Materials of construction for the air agitation spargers are stainless steel, PVC, and CPVC (chlorinated PVC). Microporous air agitation has also been used. This is a porous stonelike pipe that reduces the bubble size and increases the wetted surface on the part. This facilitates a more uniform coating.

Eductors, which educt the acid from the tank, can be used as well. For every gallon pumped through, the eductor picks up 4 gallons of fluid through the tank and pushes it on with the gallon being pumped. This is highly effective as a method of agitating the tank and eliminating bubbling to achieve a totally wetted surface. The downside is eductor size; if they're not designed-in prior to tank construction, a retrofit is difficult unless the tanks have been sized large relative to the loads being processed.

Regarding ventilation, the most common type is push-pull, at a capture rate of 150 cfm for every ft^2 of surface area. Using the same 4- × 10-ft example yielding 40 ft^2 of surface area, × a factor of 150 cfm/ft^2, the ventilation capacity required is 6,000 cfm.

RECTIFICATION AND COOLING

In calculations for the anodize rectifier apply the area of the load in ft^2 times the current density expressed in A/ft^2. As an example: a 100-ft^2 load × current density of 15 A/ft^2, which calls for a 1,500-A rectifier. In clear anodize the normal maximum voltage is 24 V, except for larger architectural extrusion lines where voltage can be 30 V or above.

Calculations for the hardcoat rectifier are similar. We use the area per load times the given current density to yield the current required. As an example: use 100 ft^2 again as the load × 30 A/ft^2 current density, requiring a 3,000-A rectifier. The norm is 100 V.

In the chiller calculation for the clear anodize use the amperage from the rectifier × rectifier voltage × a factor of 3.413, to yield the "Q" in BTUs per hour. The BTUs per hour are then divided by a factor of 12,000 to yield the tonnage chiller required for a standard 44°F leaving water chiller.

Calculations for the hardcoat are similar in that you use the current and voltage from the rectifier × the 3.413 to yield the Q and BTUs per hour, once again divided by 12,000 to convert that into tons for a standard 44°F leaving water chiller. The challenge here is that for every degree you move below 44°F, you have to derate by 2%. Thus, if the goal is a 24°F leaving water temperature from the chiller, you must subtract 20°F and derate 48%.

In the example of a 3,000-A rectifier and 100 V,

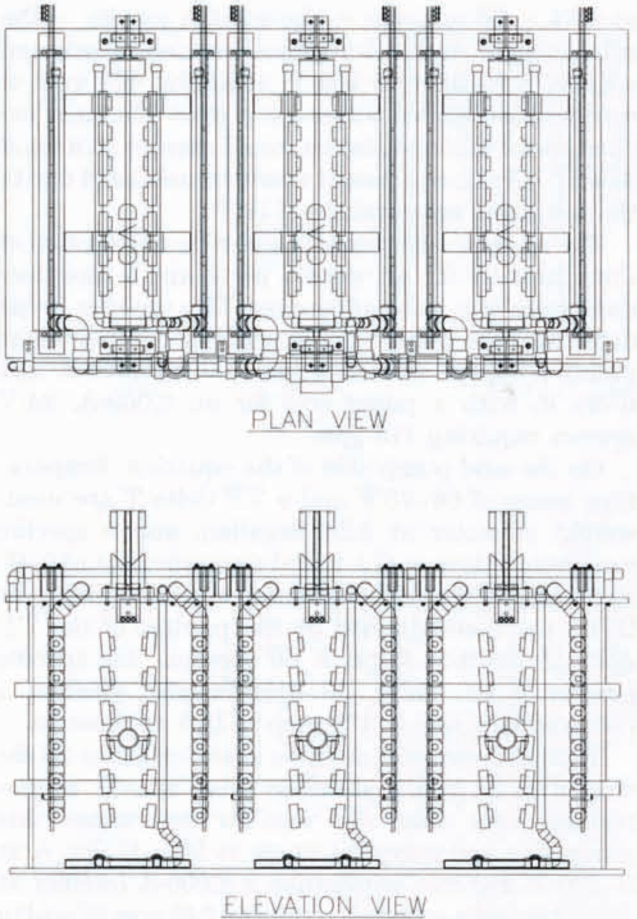

Figure 3. Typical multibay hardcoat tank.

yielding 1,023,900 BTUs per hour, divide by 12,000. That yields an 85-ton nominal rectifier requirement. Multiply that by 1.48 to determine that the chiller capacity needed would be 126 tons.

If you have an anodize tank with multiple bays (see Fig. 3), you add current and voltage, multiply by a factor of 3.413 × the number of bays of rectifiers in order to determine BTUs per hour. You'd then divide by 12,000 to calculate the nominal tonnage. Whether or not derating would be required would depend on whether the process was clear or hardcoat.

For the refrigeration system you need a chiller with a standard leaving water temperature of 44°F. This calls for a chilled water pump with a temperature range of 45–55°F using a 10°F delta T, the weight of water at 8.34, specific gravity of 1.0, and specific heat of 1.0.

Again, refer to the rectifier heat build-up of Q in BTUs per hour and divide by the product of the 10°F delta T × the weight of water × the 60 minutes × the specific gravity × the specific heat to yield the

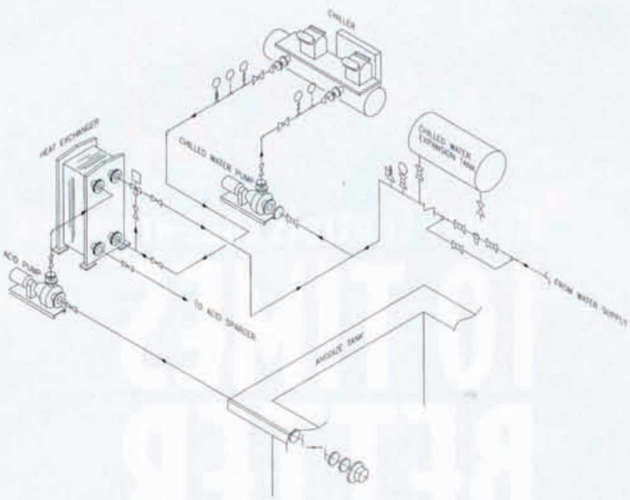

Figure 4. Refrigeration system for hardcoat anodizing.

flow rate in gpm needed to deliver chilled water to the heat exchanger sufficient to dissipate the heat.

In a typical application, use 8,000 A, rectified at 24 V, requiring 131 gpm of chilled water. The typical heat exchanger required for this application would be 172 ft^2 in area and insulation would not be required due to an operating temperature of 70°F. A typical refrigeration schematic is shown in Figure 4.

Refrigeration for the hardcoat system is much the same. The chiller needs to be derated for a 20°F leaving water temperature, based on an operating temperature of 30°F and derated by the 2% per degree below the 44°F threshold.

So a chilled water pump, or more likely a glycol water pump, is needed. Again using a 10°F delta T for a water temperature range of 20–30° and water at 8.34 lb/gal, specific gravity is 1.0, and a specific heat is 1.0 as well.

Again returning to the chiller calculations to obtain BTUs per hour, and that number is divided by the product of the 10°F delta T × the weight of water at 8.34 × 60 minutes × the specific gravity × the specific heat. And in our typical size, we've selected a 6,000-A rectifier at 100 V, requiring 471 gpm of refrigeration-chilled water (or glycol). The heat exchanger for this application would require an area of 539 ft^2. All this equipment would be insulated due to the operating temperature of 30°F.

The anodize acid pump is typically constructed of Carpenter 20 for all wetted parts and a stainless steel base is a solid advantage. The rectifier helps determine the pump size, as with the chilled water pump; a typical size range is 1,000–15,000 A and 0–24 V, with a pump size for an 8,000-A, 24-V system requiring 175 gpm.

On the acid pump side of the equation, temperature range of 66–73°F and a 7°F delta T are used, weight of water at 8.34 lb/gallon, and a specific gravity in this case of 1.1, and a specific heat of 0.97. Returning to the chiller selection and using the Q (or BTUs per hour) divided by the product of the 7°F delta T and 8.34 lb/gal × 60 minutes, the specific gravity of 1.1 ×0.97, the specific heat, yielding a required flow rate of 175 gpm in this application.

The hardcoat acid pump is also Carpenter 20 for wetted parts and a stainless steel base is recommended here also. The rectifier determines this pump size and a typical range is 500–12,000 A at 0–100 V. For this application a 6,000-A rectifier at 100 V has been selected, requiring 548 gpm of acid to be delivered to the heat exchanger. The temperature range is 26–33°, with a 7°F delta T, and the weight of a water at 8.34, the specific gravity at 1.1, and specific heat at 0.97.

Again using the BTU developed for the chiller selection, divided by the product of 7°F delta T × the weight of water × the 60 minutes × the specific gravity of 1.1 × the specific heat of 0.97, yields a flow rate of 548 gpm to be delivered to the heat exchanger. **MF**