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Agitation for Anodizing: It's All About Surface Area

If you anodize, you agitate. Agitation, temperature, concentration, and current density are the four critical factors affecting process performance. Agitation, in particular, affects coating uniformity and, when engineered properly, assures positive rinsing. Process, rinse, anodize, color, and bright dip must all be agitated in order to achieve consistent results in production.

Well-engineered agitation keeps all bath elements—electrolyte, dissolved aluminum, sulfuric and water—in suspension, and assures that parts have continuous contact with fresh solution. It is the primary tool for maintaining chemical consistency and preventing settling, and for closely maintaining bath temperatures.

The idea behind agitation is to maximize wetted surface area. To this end, companies most recently have experimented with microporous pipe spargers. These devices, which conceptually resemble the air stones used in aquariums, have pores as small as 25 microns in diameter. These air agitation systems can dramatically reduce the size of the bubble, increasing the wetted surface area of the part. The wetting effect is excellent, but time has brought to light a major disadvantage, in that these devices require regular cleaning and present downtime issues.

Other equipment operation can also be adversely affected. For instance, it's easy to inadvertently create agitation that's too violent. We've seen tanks where the solution was lifted six in. from the static liquid level, and cavitation in the pumps prevented proper functioning—too much of a good thing. Selecting pumps for applications involving acids, with excess air in solution, has also become a challenge of its own.

So, the new goalpost has been an agitation method capable of equaling the wetting effect of microporous pipes, without creating maintenance issues. One answer, recently proven in production, has been a micro-PVC sparger design. Among other features, it multiplies many-fold the number of holes typically found in air spargers used for this purpose.

Hole diameters for these micro-PVC spargers are in the range of 1/16 in. They do not present maintenance issues because, unlike microporous pipes, they do not absorb dissolved aluminum. Flow rates, pipe sizing, manifolding and graduating, and other factors are important to any sparger's effectiveness, and these things being equal, tests have shown that electrolyte exposure in tanks fitted with micro-PVC sparger systems is equal to that produced with microporous pipes.

It appears that we who design and build anodizing lines, and companies who operate them, have a proven alternative for this critical system component—and another weapon for use in the ongoing war against

Rinse tank and process tank, PVC sparger agitated. The pipe over the rim is water fill. Pipe over left is air agitation.

Rinse tank, typical agitation.

Blower installation with intake filter, approximately 3500 CFM.

downtime. Air agitation is most effective when it's considered concurrently with other equipment specifications. This is particularly true for anodizing tanks, and only slightly less so for rinse and other process tanks. Our starting point is to calculate the consumptions for all of the process and rinse tanks, followed by ventilation. The reason is that if we need to design push air pipes, this is the time to do it.

Ventilation is either "pull-pull" or "push-pull." Push-pull systems are less costly, because they involve just one vent hood, one drum fitting and a push pipe. The push pipe eliminates one vent hood that would otherwise be required, and reduces total cost to ventilate the tank. Pull-pull systems require one vent hood on each side of the tank, typically a plenum or two drum fittings and one or two stacks. If floor space is an issue, pull-pull systems are more demanding on that account, also. Installations that can only be pull-pull are few and far between, although many people believe they must have it because they're exhausting both sides of the tank; in fact, only when tanks are extraordinarily wide is this type of system truly preferable.

Pipe Sizing & Agitation Factors

PIPE SIZE	AREA SQ. INCH	AIR FLOW IN CFM @ 60 FPS
0.5	0.304	7
0.75	0.533	13
1	0.864	21
1.25	1.496	37
1.5	2.036	50
2	3.356	83
2.5	4.788	119
3	7.393	184
4	12.73	318
6	28.89	722
8	50.027	1250
10	78.854	1971

STANDARD DESIGN FACTORS IN CFM / SQ. FT.	
Process	0.5
Rinse	1.0
Anodize / Hardcoat / Plating	1.5

Unless a customer insists otherwise, we engineer push-pull on virtually every system, so there's one hood, one drum, minimal ductwork, and minimum pressure drop. In the design of push air pipes, lance and holes are the same size. Typical push air pipes are 1-in. diameter PVC, with 3/32-in. diameter holes on 4-in. centers through one wall of the pipe. This size hole yields .77 CFM, so the calculation to determine the required CFM is: Tank length in feet X 3 holes/ ft. X .77 CFM/hole = CFM required. For an 8-ft-long tank, this calculation is: 8 X 3 X .77 = 18.48 CFM per lance. 18.48 X number of push air pipe = total push CFM required. 18.48 X 2 = 36.96 total push CFM. This lance should be elevated from the rim of the tank and positioned with the holes at about four o'clock, looking at the end of the pipe. This pipe should be supported at intervals of approximately 48 in. on center. The next step is determining total CFM. There are three factoring numbers used to determine the CFMs required to agitate the tank: 1.0 CFM/ft^2 of surface area for rinses; 0.5 CFM/ft^2 of surface area for the process tanks; 1.5 CFM/ft^2 of surface area for anodize, color and bright dip. If the 8-ft tank is 3-ft wide, surface area will be 24 ft^2, and these factors can be applied depending on the type of tank to be agitated. Examples are: Rinse tank—8 ft X 3 ft X 1.0 = 24 CFM to agitate; process tank—8 ft X 3ft X 0.5 = 12 CFM; anodize, color bright dip 8 ft X 3 ft X 1.5 = 36 CFM.

By determining the total CFM for the agitation, we can obtain a total CFM system requirement. This is added to our push (if required) of 18.48 + 18.48 = 36.96 CFM, added to total agitation CFM = 108.96 total system CFM required. Additional considerations include surface area: length X width X the appropriate agitation factor (1.0 or .5 or 1.5). The diversity factor is a means to reduce total system requirements where needed.

We find that these design calculations more than meet the agitation and push requirements, so a diversity factor of 15-20 percent is possible, particularly if tanks don't always operate simultaneously. Our next step is blower selection, which begins with the determination of blower pressure. That's accomplished by using the solution depth in inches, divided by 27.7 (which gets you back to atmospheric pressure), multiplied by the specific gravity of the solution in the tank. From that point, you factor-in filter and valve losses, orifice losses, and pipe losses. The typical loss values are: filter and valve, .4; orifice, .5; and for pipe, 1.0. The specific gravity of the tank is determined by the solution in the tank. In all rinse tanks, the specific gravity because it's water, is 1.0. Etch solution is typically 1.3, anodize solution is typically 1.2, and the worse scenario is bright dip at 1.7. If your line includes a bright dip tank, you may want to consider a separate blower.

If tank depth is 96 in., using a specific gravity of 1.0 yields 5.4 psi required to agitate the system. If you apply the same tank condition to a bright dip condition, that's about 7.8 psi. So, a typical agitation system for an 8-ft-deep tank could vary from 5.4 to 7.8 psi, depending on processes in the line. Now that we're able to determine how much CFM and what pressure is needed for rinse, process, anodize, and/or bright dip tank, and have the ability to select the blower, the next item is sparger arrangement. You have to get to X CFM in the tank. For small tanks, spargers run diagonally across the bottom. In medium tanks, they don't vary—they're one or two-lance design (the piece of sparger at the bottom of the tank.)

Using the correct factor from the chart here, you can determine the required CFM needed per tank. With this information, you can determine the number of holes in the sparger required to agitate the tank, and/or the number of spargers' lances in the tank. So, if you need 132 CFM of air, you can achieve that by manipulating lances and holes. Fix the sparger for a given CFM of air, or vary the number of holes in the sparge to accommodate the difference in CFM. The range of CFM to deliver to the tank may vary from 74 CFM to 247.5 in one example I'm working on. There's just a wide range in the agitation system from what's needed for a seal or cleaner tank vs. say, an anodize tank.

Opinions on what is best can depend on personal experience, where you got your engineering degree, or even what region of the country you're in! Our west coast office, for example, always made all the spargers identically, and varied the number of lances. We, on the other hand, would look at hole spacing and let that determine the number of lances required to match the tank requirement. If we got the holes closer than 2.5 in. apart, we'd add another lance. On the west coast, they'd add a sparger instead. They would make spargers and put in inventory and just pull out the number of lances required as needed. It was a production-based philosophy.

I'll conclude with a few comments on materials of construction. In many cases, the preferred material for spargers is PVC—which will float! And when you fill them with air, they are even more determined to float! Spargers have to be static at the bottom of the tank and not drift around. Keeping the spargers under the center of the load, so that the load is agitated uniformly is the whole point. Air spargers that wind up in the corners are of no use at all, so you have to either weight them or attach them to the tank.

The proper selection of sparger material is based on tank solution, and tank material. In a mild steel tank, black iron or PVC spargers are best. PVC has a lot of fans: it's inexpensive and easy to assemble. We never recommend PVC, however, for tanks heated above 140°F because plastic pipe performance is limited by temperature and the size of the holes may contort. Heated tanks are best served either by black iron, when solutions are non-aggressive, or by stainless spargers, where solutions are corrosive. *P&SF*