

Atmospheric Evaporators

By Bill Yates

Recovery with atmospheric evaporators shows major benefits-particularly for nickel and chromium plating lines.

tmospheric evaporators are enjoying a new popularity in plating shops for dragout recovery and other applications. They are inexpensive to purchase, install and operate, making them a powerful tool for reductions in the cost of waste treatment and sludge disposal.

An atmospheric evaporator (Fig. 1) is a device that evaporates water from a solution to the atmosphere. Unlike "vacuum evaporators" that boil a solution in a partial vacuum at a reduced temperature, the atmospheric evaporator depends on wet surfaces, forced air, and the available heat taken from the solution for evaporation. The operating principle of the atmospheric evaporator can be compared to the evaporation of water from a plating tank. From either, the evaporation rate (water loss) to the air is related to:

• Solution surface area exposed to the air.

- . Air movement across this surface.
- . Temperature of the air and of the solution.
- . Relative humidity,

In the atmospheric evaporator, solution is sprayed on a large area—sometimes called "mass-pack," "packing material," or "evaporative finned surfaces." Some units contain close to 100 square meters of wet surface area. The runoff from this surface collects at the bottom of the unit and is drained back to the source tank. Blower air is forced past the wet surface to pickup moisture and is then passed through a mist eliminator assembly to remove any airborne droplets. The moisture-laden air should be ducted to the outdoors, directly or through an existing ventilation system.

Relative humidity has a direct effect on the evaporation fate of room-temperature baths but less effect on hotter solutions. This is due to the air being heated when it comes in contact with hot solution, allowing greater moistureholding capacity.

Evaporation rates vary with each model and the operating conditions, ranging from a few liters per hour with cold solutions to 150 or more with hot ones. As we will show, high evaporation rates are not always necessary or desirable.

For drag out recovery, rinsewater containing the dragout is counterflowed through several rinses to the plating tank (Fig. 2). The excess water is removed from the plating solution by the evaporator. Heat for evaporation is taken from the plating bath. A level control in the plating tank can control the supply of water through a solenoid valve into the last rinse,

How Much Rinsewater?

In the context of our discussion of evaporators, it is also

appropriate to ask ourselves this question on an allied subject How much rinsewater is required?

As we know, rinsing is accomplished by diluting the film of plating solution on the work with large volumes of water. The required "rinse ratio" (and flow rate for one rinse) can be estimated by calculating as follows:

Plating bath cone. (g/L or oz/gal) Final rinse cone. (g/L or oz/gal) x dragout (L/hr or gal/hr)

Now for an example:

Chromium bath, 250 g/L Final rinse, 0.015 g/L x 1 L/hr dragout =

16,666 L/hr flow for one rinse



Fig. 1 — Atmospheric evaporator.

The generally acceptable final rinse concentrations are 0.015 g/L (0.002 oz/gal) for hexavalent chromium and 0.0375 g/L (0.005 oz/gal) for other metals and cyanide. All calculations depend on good mixing in each rinse station and on equal volumes of drag-in and dragout.

The advantages of counterflow rinsing are widely known but should be reviewed here because of their general importance in treatment and recovery setups. By counterflowing a single stream of water through two or more rinse tanks, we can use the same water at least twice, multiplying the dilution effect with each rinse. Table 1, which lists liters of water required per volume of dragout, is based on the following estimating formula:

Rinse flow volume = dragout volume $x \sqrt[n]{\frac{bath conc.}{final rinse conc.}}$

where volume in both places is either L/hr or gal/hr, n is the number of counterflowing rinses, and the final rinse concentration is 0.0375 g/L (0.005 oz/gal) or 0.015 g/L (0.002 oz/gal) for chromium. The chromium rinse figures are shown in parentheses.

Table 1Liters of RinsewaterRequired Per Liter of Dragout*										
Ion concentration Number of counterflowing						nses				
g/L	oz/gai	1	2	3	4	5				
25	3.33	666	26	9	5	4				
		(1666)	(41)	(12)	(6)	(4)				
50	6.66	1333	37	11	6	4				
		(3333)	(58)	(15)	(8)	(5)				
75	10	2000	45	13	7	5				
		(5000)	(71)	(17)	(8)	(6)				
100	13.33	2666	52	14	7	5				
		(6666)	(82)	(19)	(9)	(6)				
150	20	4000	63	16	8	5				
		(10,000)	(100)	(22)	(10)	(6)				
200	26.66	5333	73	17	8	6				
		(13,333)	(115)	(24)	(11)	(7)				
*Chromium rinse figures are shown in parentheses.										

Full Recovery?

If all the water needed for good rinsing can be evaporated, the system can be a "closed loop" with no water or dragout going to drain. A recovery figure of 90 to 99 percent is possible with very little evaporation.

The percentage of recovery depends only on volume of dragout and rinsewater flow rate—not concentration. With 1 L/hr dragout and 10 L/hr rinsewater flow, recovery from one rinse is 91 percent. From two counterflowing rinses it is 99 percent. A separate, final rinse should overflow to drain to complete the rinsing operation (Fig. 3).

Table 2 shows the percentage of recovery for 1 L/hr dragout and is based on:

$$\left(1-\frac{D/O}{D/O+RW}\right) \times 100 = \%$$
 recovery from one rinse

$$\left(1-\frac{\frac{RW}{D/O}}{\left(\frac{RW}{D/O}\right)^{n+1}}=1\right) \times 100 =$$

% recovery from multiple counterflowing rinses

where D/O = dragout and RW = rinse flow or evaporation in L/hr.

It should be mentioned that high evaporation rates can be realized by heating a separate off-line tank that receives all the counterflowing rinsewater. The evaporator can concentrate the dragout in this new tank prior to transfer to the plating tank.

Table 2Recovery PercentageFor Dragout of 1 L/hr

Evaporation	Number of counterflowing rinses					
rate, L/hr	1	2	3	4		
5	83%	97%	99%	99.9%		
10	91	99	99.9	99.9		
20	95	99.8	99.9	99.9		



Fig. 2-Full dragout recovery (no rinsewater to drain).

Operating Costs

 \bar{Two} good reasons for using partial recovery with lower evaporation rates are the reduced heat energy cost and slower accumulation of rinsewater impurities in the plating tank. (Although we are acquainted with more than 70 installations over the past 1 1/2 years, we are not aware of any impurity buildup problems.) If necessary, rinsewater impurities can be avoided using water that is deionized or treated by reverse osmosis.

Operating costs include the electrical power for the blower and recirculation pump (up to 2 hp combined), as well as the heat for evaporation. Any solution above room temperature that is pumped to the evaporator will be returned at a lower temperature. The temperature difference is due primarily to the heat that goes into evaporation. This heat requirement is:

• 540 calories/g of water evaporated, or

• 2137 Btu/L (8090 Btu/gal), or

•626 watts/L (2371 watts/gal), or

• 0.02137 "gas company" therms/L (0.08090 thermal gal), or

Ž 0.0637 boiler hp/L (0.2413 boiler hp/gal)

In many plating shops, gas is used for solution heating. Using 0.50/therm, the heating cost of evaporation is about 0.01/L (0.04/gal).

Two Cases

We have found that most atmospheric evaporators are used to recover dragout from nickel and hexavalent chromium operations. Fewer are used on cyanide copper, cyanide cadmium, acid and alkaline zinc, and trivalent chromium.

The following pair of brief case histories illustrate some of the benefits of atmospheric evaporative recovery

1. Bumper Recycler: A large bumper recycler in the Los Angeles area installed two atmospheric evaporators to recover bright nickel and hexavalent chromium dragout. These have been in use for 12 months, and evaporate enough water from the plating tanks to make room for all the rinsewater.

The four-bay bright nickel tank is followed by four counterflowing rinses flowing at about 30 gal/hr, Because of the recovery processes, additions of nickel sulfate dropped from 7500 to 500 lb/year. Brightener consumption was reduced by 50 percent.

The chromium tank is followed by five counterflowing rinses flowing at about 18 gal/hr. Rinse #5 is heated to speed parts drying. Chromic acid additions have dropped from 400 to 35 lb/month.

2. Cart Maker: A large Southern California manufacturer of shopping carts (wire and tubular steel) has used a small atmospheric evaporator on its hexavalent chromium plating tank for the past 20 months. It is a two-station chromium tank on an elevator-type plating machine, and is followed by seven counterflowing rinses. All the rinsewater is counterflowed to the chromium tank, with no water going to drain.

The machine is in operation 24 hr/day, five or six days a week. Chromic acid additions have decreased from 200 to 8 lb/week. The consumption of sodium metabisulfite for waste treatment was 400 lb/week; that has been eliminated.

What other applications exist for plating and associated operations? First, atmospheric evaporators can be used to remove water from cold plating solutions to make room for liquid additions. Second, some solutions require cooling due to high rectifier current flow, and a single evaporator can be used for both cooling and dragout recovery. Third, the concentration of electrowinning solutions can be increased to improve conductivity by removing water with an evaporator. Finally, an evaporator can be used to reduce the volume of solutions prior to hauling for disposal.

Little wonder that atmospheric evaporators are finding new popularity in plating shops. •

Reference Source

1. A. Kenneth Graham, *Electroplating Engineering Handbook,* Van Nostrand Reinhold, New York, NY, 1971; Chap. 34.

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Fig. 3—Partial dragout recovery from one or more rinses.