Use Optimum Size and Capacity for Immersion Heaters
(Arc 2.4323)

(The analysis below was extracted from one of the assessment reports by the Clemson University Industrial Assessment Center (IAC). This is only an example recommendation and hence, not all the background information and sources for numbers are included here.)

Est. Electric Consumption Savings	= ***462,000 kWh/yr***
Est. Electric Consumption Cost Savings	= ***$32,340/yr***
Est. Electric Demand Savings	= ***924 kW***
Est. Electric Demand Cost Savings	= ***$7,937/yr***
Est. Total Cost Savings	= ***$40,277/yr***
Est. Implementation Cost	= ***$14,300***
Simple Payback Period	= ***4.3 months***

Recommended Action:

It is recommended to downsize or remove some of the oversized or unnecessary immersion heaters used for temperature increase in different solution tanks throughout the plant.

Background:

The plant uses a series of immersion heaters (nozzle-mix, tube-firing burner) that are used to heat up the solution tanks use in plating and coating lines. The installed immersion heaters used on this plant are Honeywell Eclipse ImmersoJet tube burner heaters. The reported average efficiency on these heaters is 80%. This company provides a range of different immersion heaters with a variety of capacities (from 2kW and up). To estimate the minimum required energy for temperature increase we started by gathering the information on different heaters, tanks, and solution. A key parameter in determining the required energy is specific heat capacity. The specific heat capacity of a solution, SHC, represents the amount of energy (Btu) required to increase the temperature of the solution in the tank to required level and can be calculated as:

$$SHC = V(gal) \times SH(\ Btu/gal\ ^{\circ}\mathrm{F}) \times \Delta T(^{\circ}\mathrm{F})$$

Where,

V = volumetric capacity of the tank containing the solution (gallon),

SH = specific heat rate of the liquid, the amount of energy required for 1°F increase in the temperature of 1-gallon liquid (Btu/gallon °F)

ΔT = required temperature increase of the solution (°F)

By assuming an 8-hour activation period to reach the favorable temperature level, we can estimate the minimum required energy consumption and compare it with the actual energy consumption using the current immersion heaters. The plant managers provided the details of immersion heaters including capacity, assigned tank for temperature increase, the solution, and related plating line. By estimating the specific heat capacity of each tank, we noticed some of the heaters are oversized and can be replaced by smaller size heaters. Two of the heaters were activated but had no specific use. Having these observations, we made some suggestions the details of which are provided in

Table 1 below. To estimate the *CHS*, we based our calculations on the specific heat rate of the water since the primary liquid in all of tanks were water based (water specific heat rate is 8.36 Btu/gal °F).

Table 1. Immersion heaters, tanks, and temperature increase and proposed downsizing/removal

Equipment Description	Process Line	Soln Volume (gal)	Ave. temperature increase (°F)	Specific Heat Capacity (Btu)	Required energy consumption (kWh)	Actual energy consumptio (kWh)	Current heater capacity (kW)	Proposed heater capacity (kW)
Specialty Gold F.A.O.	Anodize	70	85	49,742	14.58	19.2	3	same
Specialty Bordeaux R	Anodize	70	80	46,816	13.72	19.2	3	same
Specialty Blue A / Green	Anodize	175	85	124,355	36.44	19.2	3	same
Specialty Green / Orange	Anodize	180	75	112,860	33.08	19.2	3	same
Alkaline Etch Cleaner	Anodize	225	22	41,382	12.13	19.2	3	2
Non-Etch Cleaner	Anodize	545	10	45,562	13.35	19.2	3	2
Anodize Tank #1	Anodize	500	10	41,800	12.25	N/A	coal	same
Anodize Tank #2`	Anodize	540	10	45,144	13.23	N/A	coal	same
Anodize Tank #3	Anodize	540	10	45,144	13.23	N/A	coal	same
Black Dye	Anodize	510	10	42,636	12.50	19.2	3	2
Cold Seal	Anodize	495	10	41,382	12.13	19.2	3	2
Hot Rinse	Anodize	500	60	250,800	73.50	19.2	3	same
Alkaline Cleaner	Black Oxide	180	10	15,048	4.41	19.2	3	2
Black Oxide	Black Oxide	520	5	21,736	6.37	N/A	gas	same
Hot Water Rinse	Black Oxide	180		-	-	19.2	3	**Remove**
Non-Etch Cleaner	Chromate conv.	090	25	18,810	5.51	25.6	4	2
Alkaline Etch Cleaner	Chromate Conv.	090	10	7,524	2.21	25.6	4	2
Chromate	Chromate Conv.	150	15	18,810	5.51	19.2	3	2
Hot Rinse	Chromate Conv.	150	62	77,748	22.79	25.6	4	same
Alkaline Cleaner	Electroless Nickel	150	10	12,540	3.68	25.6	4	2
EN Plating Bath - #1 Mid Phos	Electroless Nickel	150	11	13,794	4.04	76.8	12	3
EN Plating Bath - #2 Mid Phos	Electroless Nickel	150	11	13,794	4.04	76.8	12	3
EN Plating Bath - #3 Mid Phos	Electroless Nickel	150	11	13,794	4.04	76.8	12	3
Black EN	Electroless Nickel	090	12	9,029	2.65	25.6	4	2
Hot Rinse	Electroless Nickel	085	75	53,295	15.62	25.6	4	2
Electropolish #1	Electropolish	1280	10	107,008	31.36	51.2	8	4
EP Dragout	Electropolish	315	N/A	N/A	N/A	51.2	8	same
Electropolish #2	Electropolish	315	40	105,336	30.87	25.6	4	same
Hot Rinse	Electropolish	185	56	86,610	25.38	25.6	4	same
Electropolish #3	Electropolish	1130	95	897,446	263.02	51.2	8	same
Alkaline Cleaner	Hard Chrome	205	15	25,707	7.53	25.6	4	2
Hot Rinse	Hard Chrome	160	63	84,269	24.70	25.6	4	same
Hard Chrome	Hard Chrome	800	10	66,880	19.60	76.8	12	3
Hard Chrome	Hard Chrome	92	5	3,846	1.13	25.6	4	2
Decorative Chrome	Hard Chrome	300	15	37,620	11.03	25.6	4	same
Alkaline Soak Cleaner	Nickel	245	30	61,446	18.01	25.6	4	same
Alkaline Electro-Cleaner	Nickel	245	16	32,771	9.60	25.6	4	3
Bright Nickel	Nickel	675	16	90,288	26.46	76.8	12	6
Sulfamate Nickel	Nickel	220	5	9,196	2.70	25.6	4	2
Tri-Chrome (Hexagone)	Nickel	374	20	62,533	18.33	25.6	4	same
Alkaline Cleaner	Passivation	520	70	304,304	89.18	25.6	4	same
Pickle Passivation	Passivation	1900	10	158,840	46.55	51.2	8	same
Nitric Acid/ Sodium Dichromate	Passivation	70	16	9,363	2.74	19.2	3	2
Passivation (Bertha)	Passivation	2500	32	668,800	196.01	76.8	12	same
Hot Rinse	Passivation	230		-	-	25.6	4	**Remove**

The heaters are active throughout the year. We assume a total of 6000 operational hours for the plating lines. The plant is charged \$0.07/kWh for electric consumption and \$8.59/kW for electric demand.

Anticipated Savings:

Total capacity reduction due to replacement (downsizing) of 22 and removal of 2 immersion heaters adds to 77kW of reduction. Therefore, annual *estimated demand saving, EDS*, associated with downsizing and removing some of the immersion heaters can be calculated as:

$$\text{EDS} = \text{Total capacity reduction (kW)} \times 12 \text{ months/yr}$$

$$\boldsymbol{EDS = 77\ kW \times 12 = 924\ kW}$$

Accordingly, we can find the *estimated demand cost savings*, *EDCS*, by using the electricity demand charge provided as

$$\text{EDCS} = \text{EDS} \times \$8.59 \text{ kW}$$

$$\boldsymbol{EDCS = 924\ kW \times \$8.59/kW = \$7{,}937}$$

The total annual operational hour that these heaters are activated is around 6000. Using this information, we can estimate the amount of *energy consumption saving*, *ECS,* as

$$\text{ECS} = \text{Total capacity reduction (kW)} \times \text{Annual OH}$$

$$\boldsymbol{ECS = 77\ kW \times 6000\ h = 462{,}000\ kWh}$$

Using the electricity consumption charge rate, we then can estimate the annual *energy consumption cost saving, ECCS*, as follows

$$\text{ECCS} = \text{ECS} \times \$0.07 \text{ kWh}$$

$$\boldsymbol{ECCS = 462{,}000\ kWh \times \$0.07/kWh = \$32{,}340}$$

Finally, the *total cost savings, TCS*, associated with downsizing and removing some of the immersion heaters can be calculated as:

$$\text{TCS} = (\text{ECCS} + \text{EDCS})$$

$$\boldsymbol{TCS = (\$32{,}340 + \$7{,}937) = \$40{,}277}$$

Implementation Cost:

To estimate the implementation costs associated with downsizing of some immersion heaters, we consider that the provider company might be interested to replace the heaters assuming the older ones are still functional. After some peripheral information gathering we estimate that each replacement would cost around \$400. We also assume a labor cost of \$250 for every installment.

The assessment team has suggested a total of 22 replacements for immersion heaters. Therefore, the estimated *implementation cost, IC*, can be calculated as:

IC = # of replacements × Cost of each replacement × Labor cost

IC = 22 × $400 × $250 = $14,300

Simple Payback Period:

The *simple payback period*, *SPP*, associated with downsizing and removing some of the immersion heaters can be calculated as

$$SPP = \frac{IC}{TCS} \times 12\, months/year$$

$$SPP = \frac{\$14{,}300}{\$40{,}277/yr.} \times 12\, months/year$$

SPP = 4.3 months