

Case Study: Mass Balance and Energy Consumption

Beta Control Systems, Inc.



Assumptions:

- 7.63 M3 Spent pickle acid discharged per day (1.29 s.g. = 9.84 MT/day SPL)
- 5% acid remaining in the SPL
- Zinc is mostly isolated to a strip tank for eventual sale
- 11.43 M3 of rinse water disposed (added) each day
- Cost for quicklime etc. (US\$ 0.073 per liter)
- Electricity costs (US\$ 0.15 per KWh)

Products and Costs:

- An electric boiler will cost US\$ 0.11 per liter of SPL
- 1.71 equivalent tons per day (@30% HCl) will be recovered = US\$427 per day
- \$ 0.11 cost - \$ 0.057 recovered = \$ 0.053 per liter cost of operation
- Current cost of neutralization = \$ 0.073 per liter
- FeCl₂ has commercial value as a fertilizer or chemical (est. \$50/day) *not considered*
- ZnCl₂ has a high value as a micronutrient fertilizer (est.> \$50/day minimum) *not considered*

Benefits of Beta Evaporator:

1. Eliminate operating costs
2. Eliminate hazardous waste
3. Recover acid and rinse water (close the loop)
4. No need to replace or expand existing water treatment plant
5. No future environmental liability

Comments: The current waste treatment system is inadequate to process current or future acid and rinse water wastes. A new capital cost for a traditional "lime/filter press neutralization" system would be similar to the cost of a Beta recovery system. The traditional system would be a capital and ongoing operating expense. The Beta system will pay for itself immediately and be an asset for the next 20 years.

ABC Galvanizing Mass and Energy Balance

System Type: **10MT Hydrochloric Acid Recovery**

The following Inputs are provided by ABC Galvanizing:

Input	Value	Unit
Iron (in sol.)	9	% by Weight
Zinc (in sol.)	1	% by Weight
HCl (in sol.)	5	% by Weight
Spent Acid	7,670	Liters / day
Iron % in	66	% by Weight

The following Outputs were tabulated by the Beta Control Systems Calculator:

Output	Value	Unit	Concentration
Size	10MT		
Flow rate	402.67	kg / hr	
Recovered Acid	2.67	Tons / day	17.8%
FeCl ₂	2.61	Tons / day	
Water	4.38	Tons / day	
Specific Gravity	1.26		

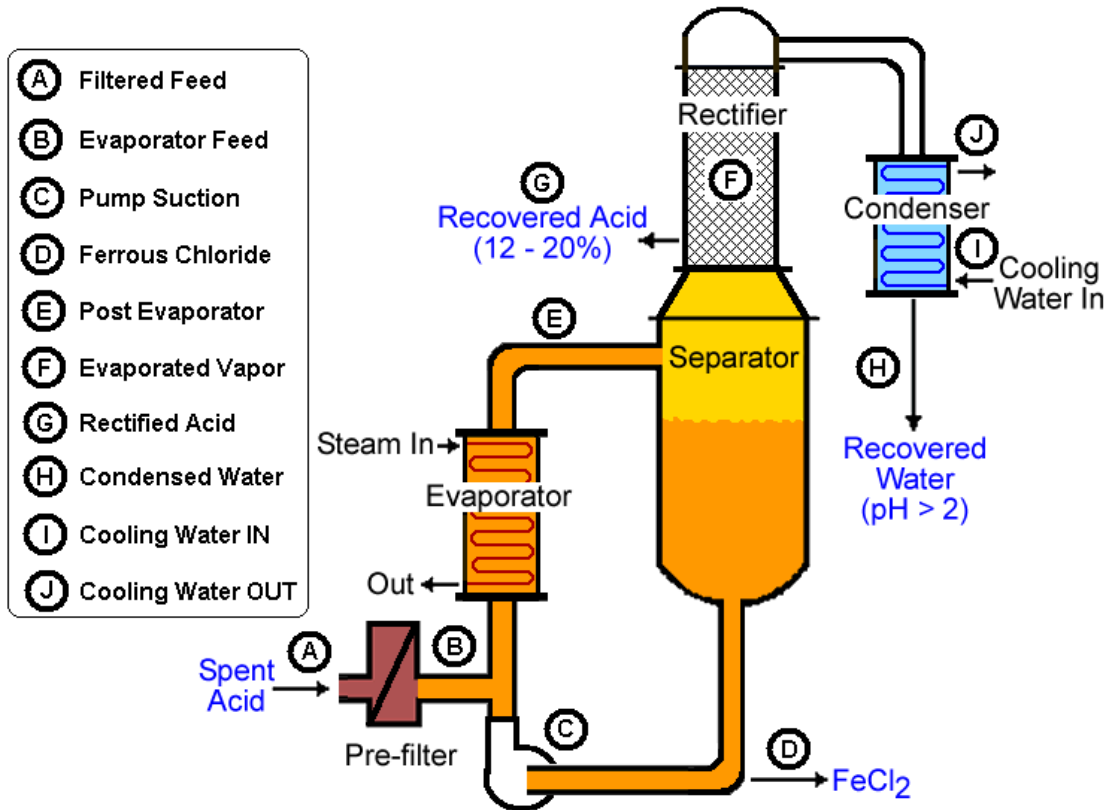
The following Energy Requirements were tabulated by the Beta Control Systems Calculator:

Energy Req.	Value	Unit
Steam	416	kg / hr
Electrical	6.71	kWh
Compressed Air	17	m ³ /hr
Tower Output	751,945	Btu / hr
Boiler Size	238	kW

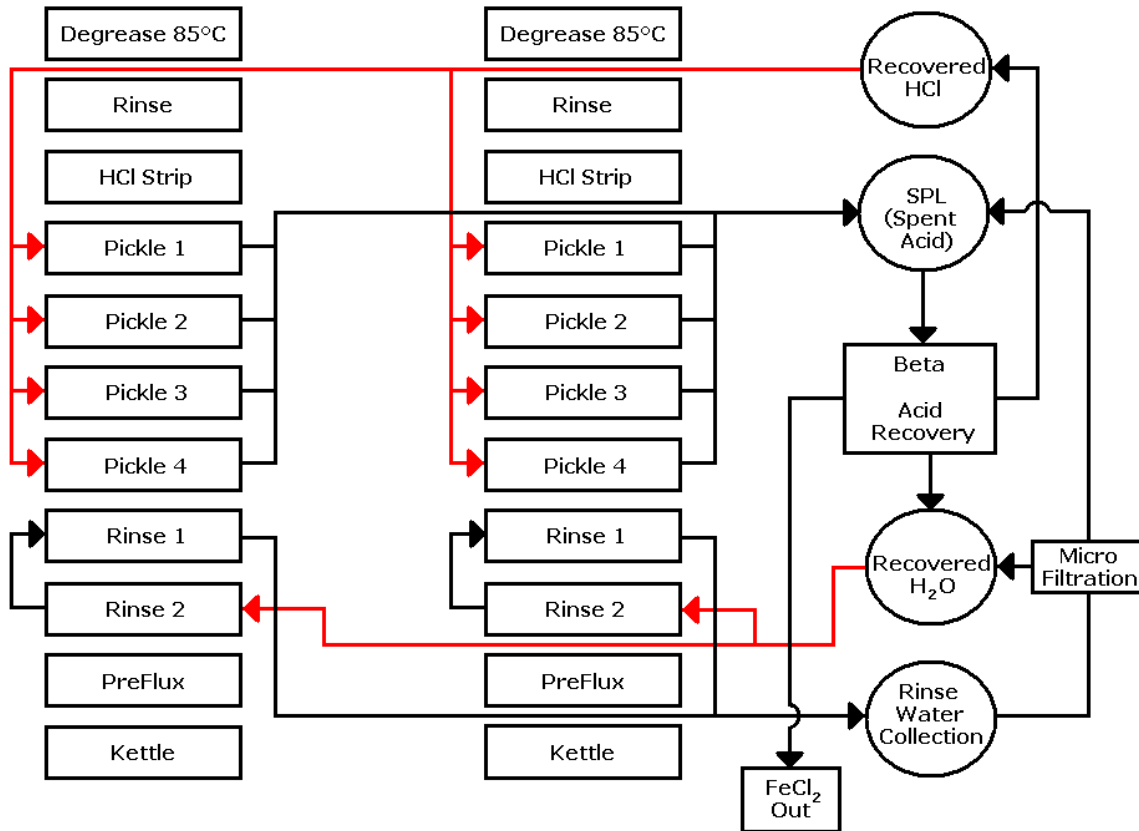
Additional information:

Using waste rinse water instead of fresh water for cooling the acid recovery condenser will result in evaporation of approximately six cubic meters (6.5 M³) of rinse water per day. Beta has a rinse water recovery technology if additional water recovery is necessary.

Diagram and Mass Balance of System



	Units	A	B	C	D	E	F	G	H	I	J
Phase		liquid	liquid	liquid	liquid	liquid	HCl-H ₂ O	HCl	H ₂ O	vapor	liquid
Press.	Bar	3.1	1.38	1.6	2.19	2.2	1.2	0.01	0.01	0.01	0.01
Temp.	°C	23	85	116.8	116.8	124	116	102	99	99	45
Mass	kg/hr	403	403	81000	109	80891	294	111	183	0	0
Water	kg/hr	311	311	27540	37	27503	274	91	182	0	0
HCl	kg/hr	20.13	20.13	259.2	0.35	258.85	19.79	19.78	0.01	0.25	0.25
ZnCl₂	kg/hr	6.65	6.65	4942	6.65	4935	0	0	0.07	0	0.01
FeCl₂	kg/hr	65.26	65.26	12964	65.26	12899	0	0	0.01	0.01	0.01
Metals	kg/hr	0	0	0	0	0	0.01	0.01	0.01	0.01	0.01
Density	S.G.	1.26	1.26	1.65	1.65	1.45	0.05	1.09	0.05	0	1
Vol. Flow	L/min	6.71	5.33	818.2	1.1	818.2	0	1.7	3.04	1.4	1.4
Acidity	%	0.05	0.05	0	0	0	0.07	0.18	0	0	0



Daily Operation of the Pickle Lines:

Each day, 10 cubic meters of SPL will be drained from the pickle tank with the highest iron concentration. The solution proceeds by gravity to the SPL (Spent Acid) tank for processing through the Beta Acid Recovery System. Approximately 4.3 cubic meters of HCl recovered from the previous day will be returned to the pickle tank to make up for volume lost. Approximately 3.4 cubic meters of 30% HCl will then be added to the pickle tank to make up for the disposed acid volume. Then, 2.3 cubic meters of rinse water from Rinse 1 will fill the rest of the volume in the pickle tank.

Water recovered from the Beta Acid Recovery System will flow through Rinse 2 cascading into Rinse 1 to make up for the volume removed from Rinse 1.

Throughout the day, rinse water will continue to flow through the cascading rinse tanks to maintain a clean final rinse before Pre-flux. The overflow from Rinse 1 will flow by gravity to the Rinse water collection tank. This rinse water will be used in a cooling tower to provide condensation for the water vapor coming from the Beta Acid Recovery System.

Since there is 220 KW/hr of energy in the Beta System water vapor, we will be able to evaporate 4.5 liters per minute of rinse water by simply using the waste heat energy. That is about 6.5 cubic meters of rinse water evaporated each day.

Using the current consumption volume of 11.43 cubic meters of rinse water being treated and discharged each day, we can see that $[11.43 - 6.5 - 2.3 = 2.63]$ there will only be about **2.6 cubic meters of water** left to process.

Once the second rinse tank is installed and the pickler is trained in proper cascade rinse methods, we will be able to adjust the rinse volumes for the most effective process.



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