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APPENDIX

APPENDIX A

EXPERIMENTAL DATA

Table A.1 Cleaning agent concentration in rinsing tank at rinsing time 5 seconds.

Number of rinsing	Cleaning agent concentration (g/l)		
	First tank	Second tank	Third tank
2	0.0603	0.0040	0.0011
4	0.0990	0.0079	0.0028
6	0.1380	0.0093	0.0035
8	0.1730	0.0100	0.0035
10	0.1970	0.0178	0.0045
12	0.2300	0.0209	0.0063
14	0.2640	0.0295	0.0079
16	0.2850	0.0372	0.0100
18	0.3070	0.0417	0.0107
20	0.3260	0.0501	0.0107

Table A.2 Cleaning agent concentration in rinsing tank at rinsing time 10 seconds.

Number of rinsing	Cleaning agent concentration (g/l)		
	First tank	Second tank	Third tank
2	0.0295	0.0025	0.0011
4	0.0910	0.0050	0.0020
6	0.1254	0.0076	0.0025
8	0.1536	0.0112	0.0035
10	0.1881	0.0158	0.0042
12	0.2292	0.0200	0.0050
14	0.2888	0.0240	0.0066
16	0.3242	0.0316	0.0076
18	0.3711	0.0380	0.0095
20	0.4165	0.0447	0.0105

Table A.3 Cleaning agent concentration in rinsing tank at rinsing time 15 seconds.

Number of rinsing	Cleaning agent concentration (g/l)		
	First tank	Second tank	Third tank
2	0.0501	0.0132	0.0040
4	0.1126	0.0251	0.0079
6	0.1586	0.0380	0.0105
8	0.1803	0.0501	0.0132
10	0.2163	0.0589	0.0178
12	0.2623	0.0631	0.0199
14	0.2833	0.0661	0.0199
16	0.3436	0.0708	0.0224
18	0.3738	0.0759	0.0224
20	0.4165	0.0794	0.0251

Table A.4 Cleaning agent concentration in rinsing tank at rinsing time 20 seconds.

Number of rinsing	Cleaning agent concentration (g/l)		
	First tank	Second tank	Third tank
2	0.0479	0.0040	0.0011
4	0.0949	0.0074	0.0025
6	0.1227	0.0100	0.0043
8	0.1552	0.0166	0.0050
10	0.1842	0.0191	0.0063
12	0.2122	0.0224	0.0079
14	0.2428	0.0295	0.0095
16	0.2833	0.0398	0.0095
18	0.3060	0.0427	0.0107
20	0.3242	0.0477	0.0107

Table A.5 Cleaning agent concentration in rinsing tank at rinsing time 25 seconds.

Number of rinsing	Cleaning agent concentration (g/l)		
	First tank	Second tank	Third tank
2	0.0617	0.0105	0.0063
4	0.1189	0.0199	0.0105
6	0.1656	0.0295	0.0126
8	0.1901	0.0339	0.0166
10	0.2291	0.0427	0.0178
12	0.2780	0.0501	0.0199
14	0.3243	0.0537	0.0251
16	0.3639	0.0603	0.0269
18	0.4038	0.0631	0.0269
20	0.4581	0.0692	0.0302

Table A.6 Cleaning agent concentration in rinsing tank at rinsing time 30 seconds.

Number of rinsing	Cleaning agent concentration (g/l)		
	First tank	Second tank	Third tank
2	0.0562	0.0071	0.0032
4	0.1057	0.0112	0.0040
6	0.1366	0.0178	0.0052
8	0.1536	0.0240	0.0074
10	0.2122	0.0302	0.0105
12	0.2674	0.0355	0.0112
14	0.2944	0.0398	0.0112
16	0.3180	0.0479	0.0158
18	0.3435	0.0501	0.0178
20	0.3856	0.0562	0.0209

APPENDIX B

RINSING TECHNIQUE

This section presents alternatives to traditional rinsing techniques. Two strategies for reducing water use are improving the efficiency of the rinsing operation and controlling the flow of water to the rinsing operations. Contact time and agitation influence the effectiveness of the rinsing operations.

1. Improving Rinsing Efficiency

We can use several methods to improve rinsing efficiency. The factors affect to improve efficiency cconsist contact time and agitation.

Contact Time

Contact time refers to the length of time workpieces are in the tank. For a given workpiece and tank size, the efficiency of rinsing varies with contact time however production rate varies inversely with contact time. We should do the experiment to find the contact time that satisfies production requirements while providing the highest rinsing efficiency.

Agitation

Rinsing process that is agitated reduces the required amount of contact time and improve rinsing efficiency. Rinse water can be agitated by pumping either air or water into the rinse tank. Air bubbles create the best turbulence for removing chemical process solution from the workpiece surface. However, misting as the air bubbles break the surface can cause air emissions problems.

We can use many methods to agitate rinse tanks. In manual operation, we lift and lower the workpiece in the rinse tank, creating turbulence. In other tanks, the most effective form of agitation involves a propeller type of agitator, but this method requires extra room to prevent parts from touching the agitator blades. Good agitation also can be obtained with the use of a low-pressure blower. The following is a list of other effective agitation methods:

- Filtered air pumped into the bottom of the tank through a pipe distributor (air sparger).
- Ultrasonic agitation for complex workpieces.
- Mechanical agitation.
- Recirculation of a sidestream from the rinse tank.
- An in-tank pump (a process known as forced water agitation).

Table B.1 Comparison an advantage between increased contact time and increased agitation.

Advantages	
Increased contact time	**Increased agitation**
▪ Improves rinsing efficiency. ▪ Reduces contamination. ▪ If combined with agitation, can shorten contact time.	▪ Improves rinsing efficiency by removing process chemicals using turbulence (they remain in the tank instead of being dragged out). ▪ Reduces water fees, sewer fees, treatment chemical costs, and sludge generation.

Table B.2 Comparison a disadvantage between increased contact time and increased agitation.

Disadvantages	
Increased contact time	**Increased agitation**
▪ Rinse efficiency varies with contact time ▪ Experimentation is needed to find the optimal rinse efficiency ▪ Can reduce production rate (this factor varies and the production process should be analyzed to see the effect of this technique on production).	▪ Manual system requires operators cooperation. ▪ Compressed air needs to be contaminant- free otherwise contaminants could enter the water supply and affect work quality (oil- free, low-pressure blowers reduce the likelihood of contamination) ▪ Might need an additional tank for water reuse.

2. **Controlling Water Flow to Rinses**

The following sections present rinsing methods that use less water and increase the efficiency of the rinsing operations.

Countercurrent Rinsing

Countercurrent rinsing uses sequential rinse tanks in which the water flows in the opposite direction of the work flow (dirtiest to cleanest). Fresh water is added only to the final rinse station and is conveyed, normally by gravity overflow, to the previous rinse tank. Wastewater exits the system from the first rinse tank. Figure B.1 illustrates a three-stage countercurrent rinse system. In some cases, the water contained in the first rinse can be used as makeup water for the process bath. Many factorys with a rinsing process have used this technique successfully to minimize water consumption. The amount of saving water will depend on the number of tanks installed for countercurrent rinsing. In some cases, countercurrent rinsing can achieve 95 percent reductions in rinse flow if the facility uses three rinse tanks; 90 percent is possible with two tanks.

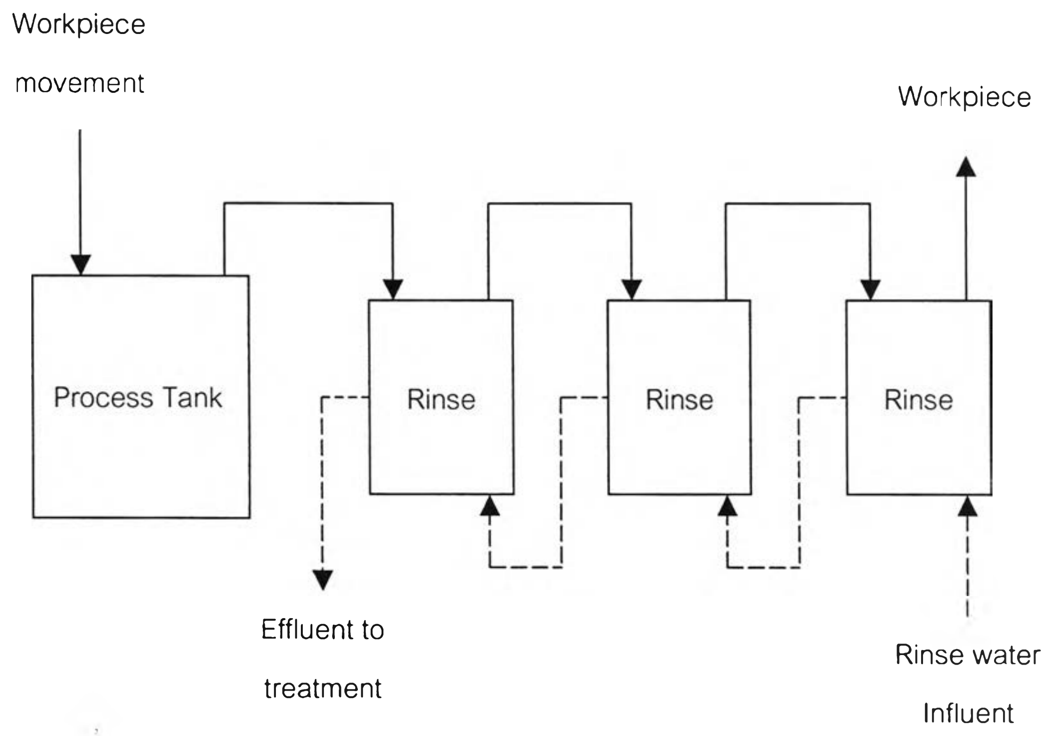

Figure B.1 Three-Stage Countercurrent Rinsing.

Limitations governing the use of countercurrent rinsing include:

- Factory floor space and/or line space
- Increased cycle time
- General resistance to change

Limited factory floor space can present a significant problem for the improvment. However, careful review of the factory often can reveal opportunities for added rinse stations. The following list presents some of the ways a shop can make room for countercurrent rinsing:

- Reduce the number of process tanks by one or two in order to increase space for rinse tanks.

- Eliminate obsolete processes.

- Evaluate rinse station sizing. Single station rinses often are sized arbitrarily to match plating tanks. In many cases, platers can install baffles in oversized rinse tanks to create multiple rinse stations.

- Review factory floor layout and seek opportunities to combine processes.

- Extend the line and add rinse stations.

Static Rinsing (Recovery Rinsing)

If direct countercurrent rinsewater overflow to the process tank is not possible, the first rinse tank after a process bath can be a static rinse that builds up a concentration of dragin. Static rinse tanks with low-temperature processes can be used as pre-dip or post-dip rinses to recover dragout (as much as 80 percent). Periodically, the accumulation in this bath should be concentrated enough for reuse/recycling into the process bath.

Multistage Static Rinsing

Multistage static rinsing uses multiple dead tanks rather than a system where the water flows from one rinse tank to the other. This process often is used in cadmium plating to keep the metal from entering the waste treatment system. Solution from the first rinse tank can be used to replenish the process bath. However, the solution might need treatment prior to reuse such as filtration to remove contaminants.

Table B.3 Advantage and disadvantage of multistage static rinsing.

Advantages	Disadvantages
▪ Increases contact time between the workpiece and rinsewater; improves rinse efficiency. ▪ Reduces water use.	▪ Needs more process steps. ▪ Needs additional tanks. ▪ Needs more work space. ▪ Should use deionized water to reuse rinsewater.

Spray or Fog Rinsing

Installation of fixed or movable rinse spray nozzles over the process tank can replace separate rinse tanks. Overspray is returned to the process tank, resulting in reduced dragout. This spray or fog rinsing can be used for either rack or barrel plating.

Spray rinsing uses between 10 to 25 percent less water than dip rinsing. However, this method is not always applicable to metal finishing because the spray rinse might not reach all of the parts of the workpiece. The effectiveness of spray rinsing depends upon part geometry and complexity. Spray rinsing compares favorably with single-dip rinses, but is not as effective as countercurrent rinsing. To address this problem, spray rinsing can be combined with immersion rinsing. In this technique, the workpiece is spray rinsed over the process tank as soon as the part is removed from the process solution. The part then is submerged in an immersion tank. As a result, the spray rinse removes much of the dragout, returning it to the process bath before the workpiece is placed in the dip rinse tank. This allows facilities to use lower water flow rates and reduce dragout.

We also can use spray or fog rinse systems above heated baths to recover dragout solutions. Spray rinsing washes processsolutions through impact and diffusion forces and can reduce water use by 75 percent. If we can adjust the spray rinse flow rate to equal the evaporation loss rate, the spray rinse solution can be used to replenish the process bath. Purified water should be used for the spray systems to reduce the possibility of contamination entering the bath. Fog rinsing uses water and air pressure to reduce concentration of dragout films. This method is most useful in simple workpieces.

Table B.4 Advantage and disadvantage of spay/fog rinsing.

Advantages	Disadvantages
■ Reduces dragout by as much as 75 percent. ■ Reduces waste management costs (i.e., lower sewer bills and less sludge generation). ■ Greater quality control (i.e., less chemical use and cleaner rinses).	■ Might not be effective in rinsing certain workpieces and might not work in all plating operations.

VITA

Mr. Sathit Niamsuwan was born in Bangkok on September 9, 1977. He graduated high school from Ratchawinit Bangkeaw School, Samutprakarn province, Thailand. In 2000, He received the Bachelor's degree of engineering with first class in Environmental engineering from Kasetsart University. From June 2000 to the end of 2003, He joined to Thailand Environment Institute (TEI) as asssistance research. He entered the Graduate School of Chulalongkorn University to pursue the Master of engineering in Chemical engineering in 2004.