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PLATING RATE ENHANCEMENT THROUGH THE EXPLOITATION OF AIRLESS, EDUCTOR AGITATION

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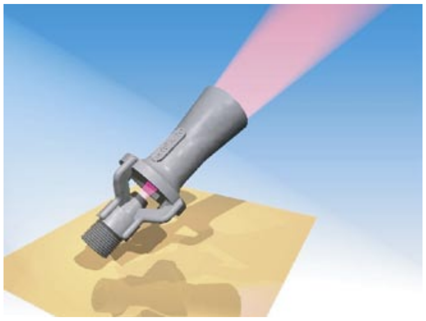


Solution agitation is essential in almost all facets of Metal Treatment Processes.

This article explores the various methods of agitation employed within the industry, focusing on pumped flow Eductor systems, the most recent development is agitation technology.

Following an overview of the technology, several case studies of various applications will be reviewed, reinforcing the benefits that can be achieved by adopting Eductor agitation when compared with other methods of agitation, particularly air.

PLATING RATE – What Is It?

On a technical level, Plating Rate can be defined as the speed at which metal is deposited. However, in commercial terms, although the speed of deposition is a vital issue, the cost of producing output provides a far more relevant and rewarding focus. There are many other issues to consider when studying the overall costs of Metal Finishing. Consumable Chemistry, Heating costs, metal distribution and the costs of maintaining buildings contribute to the production cost when measured in $ per lb, m^2 or unit.

IMPORTANCE OF SOLUTION AGITATION IN METAL FINISHING PROCESSES

- To provide a constant supply of plating ions, brighteners and wetters to substrate. Burning occurs when the solution immediately surrounding work, often called the diffusion layer, becomes depleted of ions. The avoidance of burning in high CD areas usually limits the current at which successful electrolysis can take place. Therefore constant replenishment of fresh solution around the substrate often facilitates plating at higher current.
- To disperse Hydrogen away from work to eliminate gas pitting
- To eliminate temperature stratification, dispersing heat generated by electrolysis away from work
- To prevent settlement of sludge and, with appropriate filter system, provide a particulate free solution
- To encourage dissolution of anode material

COMMON METHODS OF AGITATION

Air	Compressor or blower generated air dispersed via sparge pipes arranged on bottom of tank.
Cathode Rod Movement	Mechanical, lateral movement of Cathode bar within the confines of its overall length, normally on rollers attached to tank flanges.
Ultrasonic	Used mainly in de-greasers and cleaners.
Pumped Flow Eductor	To be discussed in detail, the main topic of this paper.

AIR AGITATION

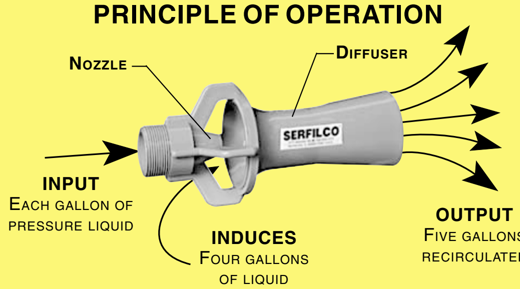
Air agitation has been used for many years, but several inherent problems arise with this method:-

- Holes in sparge pipes are small, which makes them prone to blocking. It is very common to see plating tanks and other process tanks with vigorous surface movement in one corner of the tank and static solution in other areas. This is obviously detrimental to the performance of process.
- Due to the explosion of air bubbles on the surface of solution, foam and noxious chemical fumes are produced which create an unpleasant and potentially dangerous working environment as well as increasing the need for extraction. This also impacts greatly on the fabric of buildings and on the health of operators.
- As the air bubbles rise to the top of the tank latent heat is lost to the atmosphere, which further increases the energy input requirement to sustain operating temperature. This has a huge impact on the operating costs of a plant and is particularly relevant when considering the forthcoming Climate Change Levy. Air cools hot tanks.
- Chemical layering can occur and temperature 'hot-spots' are not eliminated.
- Break down of expensive brightener products is accelerated by air oxidation.
- Foreign bodies and or oil contamination can be introduced to the bath through air source.
- Finally, compressors are inherently inefficient and expensive to run and air blowers are noisy and difficult to control without damage.

CATHODE ROD AGITATION

This type of agitation is limited as the cathode bar needs extra length to allow a backward and forward movement. Obviously, the distance the bar moves is lost cathode space. When ionic replacement and homogenous electrolyte requirements are considered this agitation type has many failings. The work is only moving within the envelope of solution surrounding it, so burning problems are difficult to overcome limiting the current densities which can be used.

PRINCIPLE OF OPERATION



Liquid pumped into the eductor nozzle exits at high velocity, drawing an additional flow of the surrounding solution through the eductor. This additional flow (induced liquid) mixes with the pumped solution and multiplies its volume five-fold. The source of the pumped liquid (input)can be a pump or filter chamber discharge.

EDUCTOR AGITATION

- Eductor nozzles use the Venturi principle to amplify and direct solution flow from the pump to the required area of the tank.
- The nozzle converts a high pressure, high velocity, low volume flow to a low pressure, low velocity, high volume flow, creating a closed loop agitation
- In simple terms a very high tank turnover rate of solution movement can be achieved from a relatively small pump. Solution can be directed easily within the tank with strategic positioning of the nozzles.

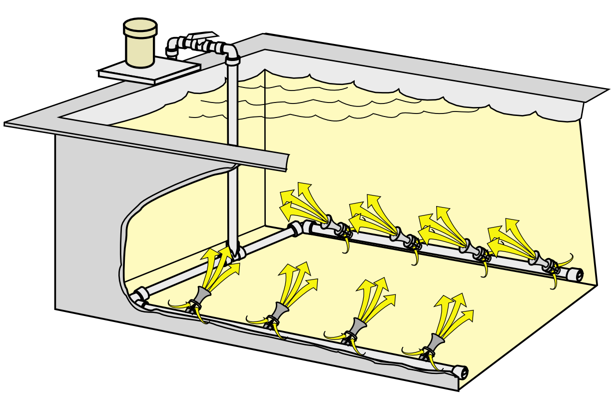
DESIGNING AN EDUCTOR AGITATION SYSTEM

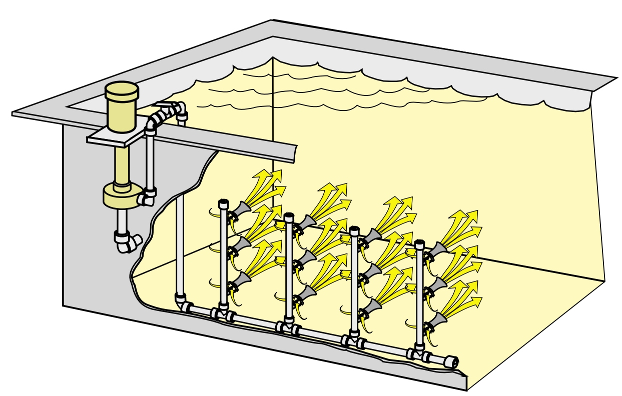
To maximise the effectiveness of an eductor system it is essential to consider the application thoroughly so the correct system can be specified. To this end agitation types can be defined in 3 categories:

1. The vast majority of plating processes benefit from vigorous turbulence ensuring a constant movement throughout the tank, coupled with a directional focus towards the substrate.
2. There are 3 plating processes, Electroless Nickel, Electroless Copper and Alkaline Non-Cyanide Zinc where direct impingement of solution on work must be avoided. In these cases general agitation is very effective, creating a homogenous electrolyte and an even temperature to preventing chemical layering.
3. On high sludge producing processes (eg: Phosphating & Cleaners) a rolling agitation motion focusing on the tank bottom, preventing sludge settlement and allowing the filter to remove it. Indeed on many of these processes just installing a filter is ineffective unless a good agitation system is present. Conversely, agitating an unfiltered bath is not usually recommended.

In some cases, processes will benefit from any combination of 1, 2 and 3.

The agitation type then needs to be considered alongside the tank configuration (ie: dimensions, anode/cathode arrangement). The size, number and position of the nozzles can then be established. This information in turn dictates the size of the pump required to power the system. For deep tanks, plume length can be increased by selecting a pump with greater pressure.

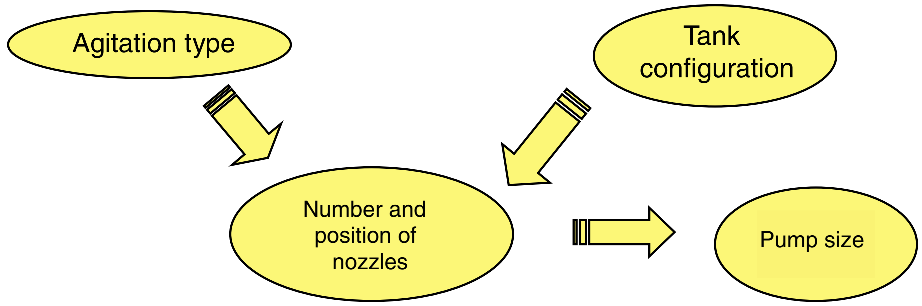




SIZING APPROPRIATE SYSTEM

When installing a system it is good practice to include a valve between pump and eductor manifold so the amount of agitation can be controlled easily and safely.

Also, it is important to use pipework sizes at least as large as pump discharge to avoid excessive pressure drop.



CASE HISTORY – CLEANERS

Process – Ardrox 188 (Caustic Cleaner)

Temp – 90°C

A large Aerospace organization had used Ardrox 188 with air agitation for many years to clean highly oxidized components. Parts were cleaned with up to 4-5 cycle operations to achieve a satisfactory result. The introduction of a vigorous eductor system directing chemical at the work improved several aspects of performance.

- **Complete removal of oxides in 2 cycles**
  The scrubbing action provided by the direct impingement of solution on the work improves the cleaning performance. Also, air pipes notoriously block up on this process, so agitation is normally uneven. With eductors there is no issue with blocking.
- **74% reduction in consumable chemicals**
  Solution analysis results show that the chemical is held in solution far more effectively and the rate of decay through oxidation (with air) is greatly reduced. A reduction in evaporation rate also reduces consumable usage.

  To clarify the very large reduction in consumables, it is important to consider the ease at which the eductor system is controlled. With eductors the agitation is switched off when not processing – with air, the agitation was running continuously.
- **11% reduction in running costs**
  Here, the costs of producing the air were compared to the cost of running the eductor pump. Unfortunately the cost of sustaining the temperature at 90°C was not studied, but would undoubtedly have resulted in a significant saving, compared with air agitated bath.

CASE HISTORY – BRIGHT NICKEL

Process - Manual, rack, Bright Nickel - plating kettles

Agitation - Turbulent pumped eductor agitation (vertical) directed at work

Pump - Seal-less, Magnetic Drive

Unfortunately, as with many case studies, some reported benefits are not recorded specifically but acknowledged based on personal experience of past and present performance. All of these reported improvements contribute to a decrease in the cost of producing output. Therefore pay back on capital investment is over a relatively short period.

Historically, throw and distribution inside kettles were, not surprisingly, difficult. There was a significant process improvement regarding this when eductors were installed.

Results vs. Air Agitation (previously used)

Reduced Emissions	Yes
Faster Plating (higher CD)	Yes
Improved Distribution	Yes
Heat Requirement	-30%
Reduced Rejects	Yes
Brightener Consumption	-30%
Better Throwing Power	Yes

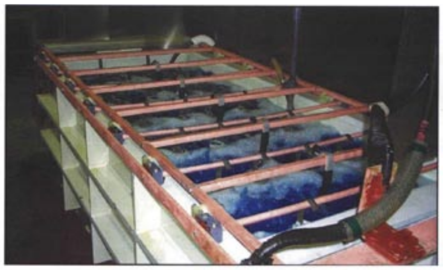
CASE HISTORY – ACID COPPER – PCB APPLICATION

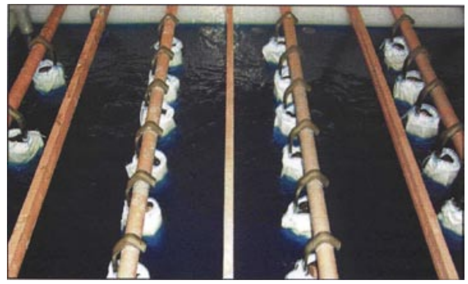
The air agitated solution produced foam, and the turbulence is most visible on the surface. However, it is uneven compared to the eductor agitated solution. The eductor tank displays a very even solution movement, both on the surface and beneath.

The motivation for investing in the equipment in this case was to improve productivity without implementing an extra shift. All of the manufacturers objectives were achieved and pay back on capital was realized very quickly.

Results vs. Air (previously used)

	WITH AIR	WITH EDUCTORS
Current Density	13 ASF	up to 40 ASF
In Hole Thickness	.001” - .0015”	.001” - .0012”
Plating Time	90 mins	30 mins
Emissions		Reduced
Brightener Usage		Reduced





PROCESSES SUCCESSFULLY USING SER-DUCTOR AGITATION

The following are some of the processes using eductor agitation successfully, exhibiting performance improvements when compared with other methods of agitation.

Cleaning & Rinses	Acid Copper (GMF &PCB)	Alkaline & Acid Zinc
Phosphating	Gold, Rhodium & Silver	Electroforming
Nickel & Chrome	Cyanide Copper	Anodising
Electroless Nickel & Copper	Cadmium	Tin

Performance improvements reported on some or all of the above processes

- Airborne noxious fume emissions reduced by over 90%
- Heat savings to 25%
- Savings in Brightener consumption
- More uniform brightness and thickness – metal savings
- Ability to increase CD – especially when replacing Rod agitation
- Improvement in thickness and throw to blind areas
- Reduction in gas pitting
- Reduction in rate of carbonate production on cyanide solutions
- Constant agitation – homogenous chemistry
- Eliminates temperature stratification
- Improves filtration – reducing de-sludging requirements

CONCLUSION

Today's Metal Finishing industry is more competitive than ever before. In many sectors there is a continuous drive to reduce costs, often impacting on the market value of plated components and products. Consequently, any process improvements that can reduce operating costs of surface treatments and improve quality must be considered very carefully.

EDUCTOR TECHNOLOGY MAKES SENSE

- When its principles are reviewed against the criteria for agitating solutions, all of the objectives are more than satisfied. A relatively small capital investment is required to install a system and pay back can be achieved over a very short period.The environmental, process and cost benefits over air and other methods of agitation are indisputable when eductor systems are designed correctly and pump selection is appropriate. Already, there are currently over 2000 tanks on various processes operating with eductor systems in the UK, this number is increasing week by week.As our industry becomes increasingly competitive and environmentally aware, this system of agitation will inevitably be adopted in all facets of the Metal Finishing Industry.

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References:-

i) Exploitation of Eductor Agitation in Copper Electroplating

ii) Process Developments for the PWB Industry

iii) Agitation of Anodising Solutions by Pumped Flow Eductors

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