Pumped Flow Eductor Agitation of Electroplating and Associated Solutions

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Over the last 8 to 10 years the use of Pumped Flow Eductor Agitation on Plating and associated solutions has increased significantly. There are now many thousands of process tanks operating with this type of agitation having replaced air and mechanical systems on a wide variety of applications – the number increases each week. This technology is accepted as a method of improving the efficiency of processes, reducing energy requirements and significantly improving the working environment within Plating shops by reducing the noxious fumes above tanks.

An overview of Eductor agitation, including details on sizing appropriate systems and a review of various case histories, together with a comparison between this and other methods of agitating solutions will make the case for Pumped Flow Eductor agitation to eventually become the most widely used method of solution agitation in our industry.

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Introduction

Solution agitation has been an ever-present requirement for Metal Finishing Processes for several decades. As electrolytes developed, the need for agitation and good filtration for that matter also became increasingly important to maximise the efficiency and performance of new chemical processes.

The introduction of better, more effective filtration systems really paved the way for solution movement to be considered as a practical way of improving the performance of processes driven by an ever-increasing cost conscious production environment.

This paper explores the various methods of agitation that have been used in our industry. Following an overview of air and mechanical agitation techniques the exploitation of venturi based eductor agitation technology will form the focus of this paper. The benefits of pumped flow eductor agitation over other methods will be identified and considered via a collection of case studies outlining their use on various processes.

Reasons for Agitating Solutions

1. To provide a mass movement of solution around the tank to generate a completely homogenous solution. **Homogenous Solutions lead to Surface quality Enhancement**.

2. To provide a constant supply of plating ions along with other brighteners and wetting agents to the substrate.
   Burning occurs when the solution immediately surrounding work, often called the diffusion layer, becomes depleted of ions. The avoidance of burning in high Current Density areas usually limit the current at which successful electrolysis can take place. Therefore constant replenishment of fresh solution around the substrate often facilitates plating at higher current.

3. To prevent settlement of sludge/particulate and aid filtration. To maintain a crystal clear solution requires good agitation and a filter system with an appropriate flow rate, dirt holding capacity and media selection.

4. To disperse hydrogen away from work interface thus preventing gas pitting.

5. In anodising – to move heat away from work to prevent burning and produce continuity of surface properties.

6. To eliminate temperature stratification – processes will perform at their peak if temperature is constant throughout the tank.

7. To encourage dissolution of Anode Materials.

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Common Methods of Solution Agitation

Air Agitation
Compressor or blower generated air distributed through tank via an arrangement of sparge pipes (see fig.1)

Cathode Rod Agitation
Side to side movement of cathode bar attached to rollers on the tank flange. In Europe it is also common to move the cathode bar with an up and down action.

Pumped Flow Eductor Agitation
The focus of this paper

Ultrasonic Agitation
Used mainly in cleaners and degreasers.

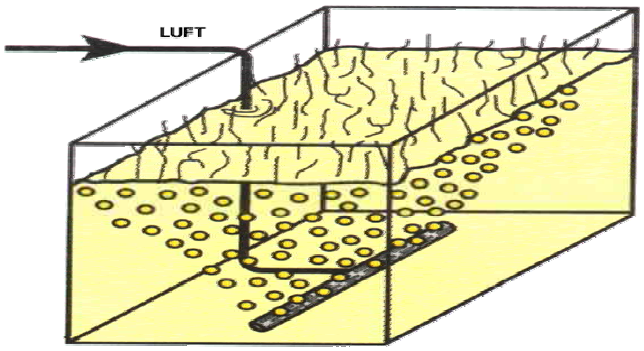

Fig 1 – Typical arrangement of an air agitated tank

Problems with Air Agitation

Air agitation is often very uneven as the sparge pipes block. It is very common to see plating tanks that are highly turbulent in one corner yet static in other areas.

Accelerated heat and chemical losses to air. As the air bubbles explode latent heat leaves the tank thereby increasing the energy requirements to maintain operating temperature This has a huge impact on the cost of operating costs of a plant and is particularly relevant when considering the climate change levy. **Air Cools Hot Tanks**

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Due to the explosion of air bubbles on the surface of the 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 and safety of tank side personnel.

Air is inherently non-conductive thereby reducing the efficiency of the electrolyte.

Brightener usage is increased through oxidation.

Problems with air agitation continued

May carry oil and/or foreign bodies to plating tank.

Poor mixing.

Accelerated Carbonate build up in Cyanide solutions

Limitations of Cathode Rod Agitation

This type of agitation has several limitations; the speed at which the work can move is slow and the distance the cathode moves requires extra length, which then results in lost cathode space. The work is only moving within the envelope of solution surrounding it, so very little mixing occurs and therefore temperature stratification can result and the overall performance of the process diminishes.

Pumped Flow Eductor Agitation

The Nozzle

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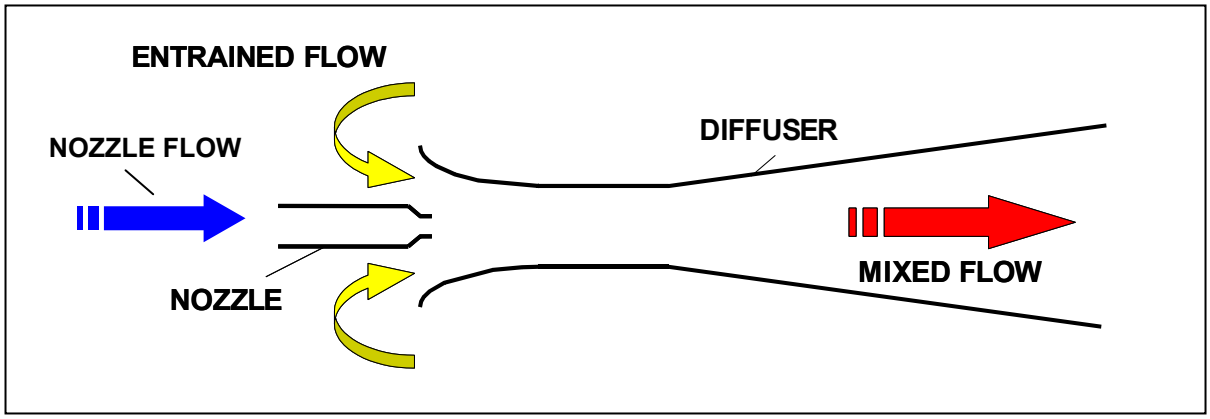
Principal of Operation

Eductor nozzles use the venturi principle to amplify and direct solution flow from the pump to the required area of the tank.

For one litre of solution pumped through the eductor at the required pressure, the discharge flow from the nozzle will be five litres.

In simple terms a very high tank turnover rate of solution can be achieved from a relatively small pump. Solution can be directed easily within the tank with strategic positioning of the nozzles.

Principal of Operation continued



Examples of possible Eductor arrangements

Application 1

Here the eductors are fitted to a manifold along the middle of the tank floor and will generate a rolling agitation as the flow deflects from the tank wall and circulate around the work. This arrangement would often be used where direct impingement needs to be avoided (eg Electroless Nickel and Alkaline Non Cyanide Zinc)

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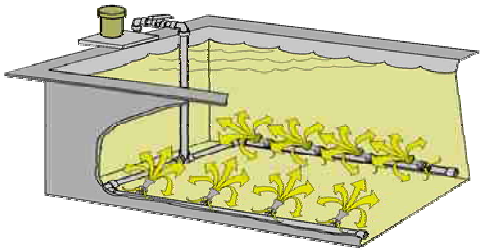
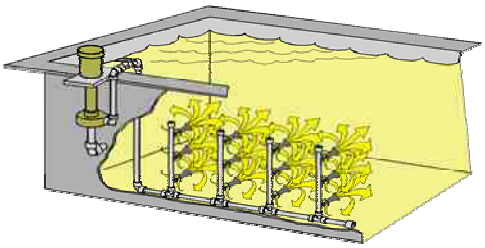
Application 2



For most processes this arrangement is standard. The positioning of the nozzles generates a highly turbulent tank with a directional focus towards the work interface.
(See photograph (fig.2) of installation of this type of system).

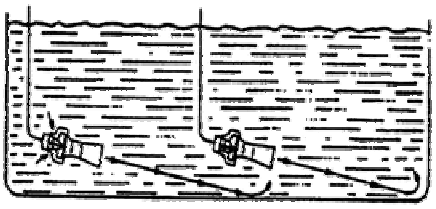
Examples of possible Eductor arrangements continued

Application 3



This arrangement could be used where direct impingement on work is required. Successfully used on PCB plating/pre-treatment and electroforming.

Application 4



For high sludge building processes (e.g. Phosphates and Cleaners) this technique is used to prevent settlement and offer particulate to an appropriate filter unit.

Generally, systems are considered on a case-by-case basis and any arrangement of eductors can be used to generate the best results.

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Another example for instance would be a tank plating stacked wheel rims. Here the positioning of the eductors would need to be specific to ensure fresh solution can pass between the gaps between the rims and also generate a circular motion around the outside. Here eductors placed on vertical manifolds in the tank corners would be used.

Figure 2 - Eductor agitation installation on Hard Chromium Tank with 2 x Cathode Stations

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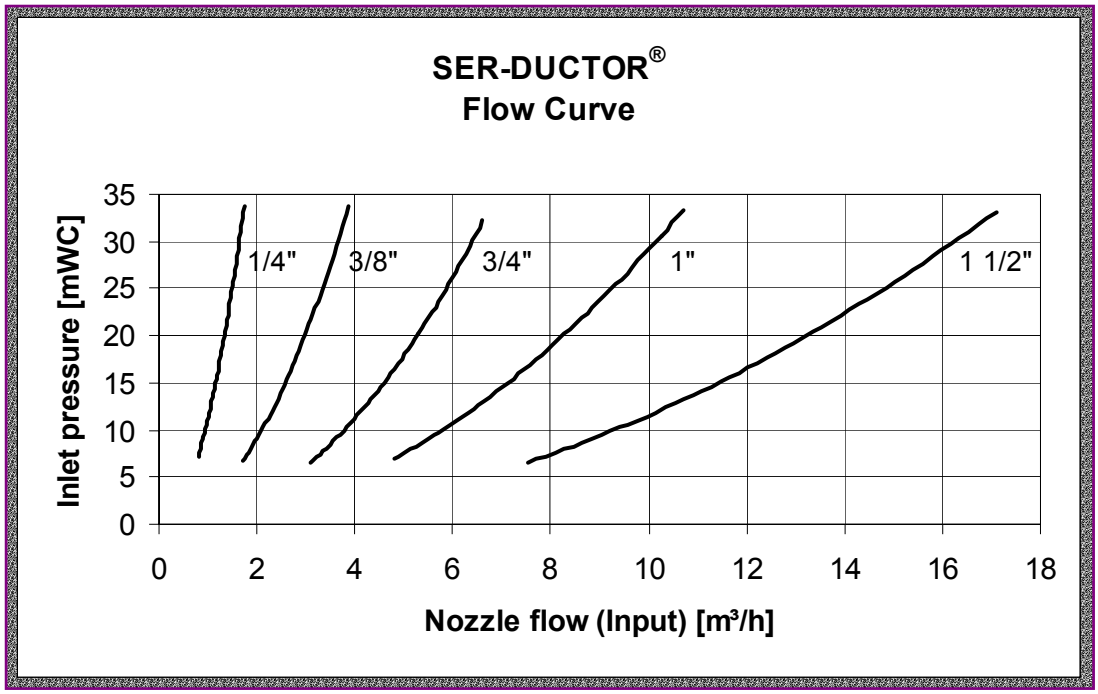
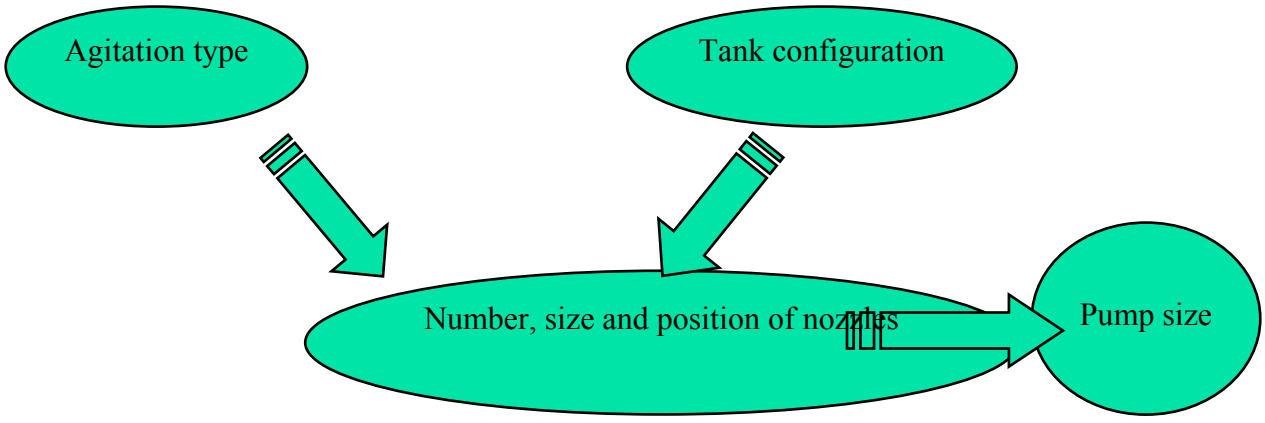
Flow Characteristics of Eductors



The above graph shows the flow and pressure requirement of the different sizes of eductor. The minimum flow and pressure is the point at which the Venturi principal works, generating the extended net flow from the nozzle. You can see that to apply the multiple of five for the relationship between flow in and out of the eductor the pressure increases in line with the flow.

Sizing an appropriate Eductor System



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Successful Uses of Eductors

General Metal Finishing – Zinc and Zinc Alloys, Nickel, Chromium, Copper

Precious Metal Plating – Gold, Silver, Palladium,

Anodising - Chromic, Sulphuric

Electroless Plating – Nickel, Gold, Copper

PWB Plating – Copper, Tin, Tin Lead

Degreasing and Cleaning

All Wet Treating Processes and especially rinse tanks

Case History 1 - 10,000 litre Cyanide Copper Tank @ 70ºC

- Air agitation system replaced with eductors in 2001.
- Tank dimensions 558cm(18 ft) x 122cm(4 ft) x 152cm(5 ft) with 2 x cathode stations
- Window and door furniture plated on jigs
- 64 eductors fitted on 4 manifolds either side of cathode stations
- Powered by a 3" vertical pump with 15 HP motor.

Results of measured improvements

	With Air	With Eductors
Solution life	One year due to carbonate build up	Still using after three years with slow carbonate build up.
Usage of Free Potassium Cyanide	60 – 70 kg/wk	3 – 5 kg/wk

Clearly the evaporation and loss of chemical is accelerated greatly by using air and reduces dramatically when air is removed. The motivation for investment was to prolong life of solution and reduce cyanide additions.

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Case History 2 - Cleaner

- Acid cleaning tank
- Size 700cm(22.9ft) x 140cm(4.6ft) x 250cm(8.2ft)
- Faster and better cleaning due to direct impingement
- Cleaner life time doubled
- Lower temperature
- Investment – 3500 Euros
- Savings after 8 months 5600 Euros
- High Quality Improvement

Case History 3 - Bright Nickel

Air agitation was replaced with an eductor system on the nickel tanks at a Kettle Manufacturer. Results vs. air are as follows:

Reduced Emissions	Yes
Faster Plating (higher CD)	Yes
Improved Distribution	Yes
Heating requirement	-35%
Brightener Consumption	-30%
Better Throwing Power	Yes
Reduced Rejects	Yes

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.

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Case History 4 Acid Copper (PWB)

Tank with Air

Tank with Eductors

The air agitated solution produces 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 movement both on the surface and beneath the solution.

Results vs. air

	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

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

Performance improvements reported in processes using Eductor Technology

- Reduced heating costs
- Reduced noxious fumes above the tank which consequently improves the conditions for tank side personnel. The life of auxiliary equipment around the tank is also extended as the equipment is far less prone to corrosion.
- Reduced evaporation of chemicals.
- Improved solution conductivity generating power savings of up to 25%
- Reduced Brightener consumption.
- Reduced rate of Carbonate build up in Cyanide.

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- Improved distribution leading to metal savings.
- Improved temperature distribution (+/- 0.5ºC), which leads to better temperature control and enhanced heat transfer. This is particularly important for anodisers: - (see Fig 3 – which shows the relationship between the velocity of solution movement and the temperature at the boundary layer. It is clear that good solution movement at the interface minimises the temperature and prevents burning).
- Cleaners operating at lower temperatures.
- Reduction in gas pitting.
- Improves filtration, as particulates do not settle.
- Improved Throwing Power.
- Better/Faster cleaning with direct impingement
- FASTER PLATING AT LOWER COST

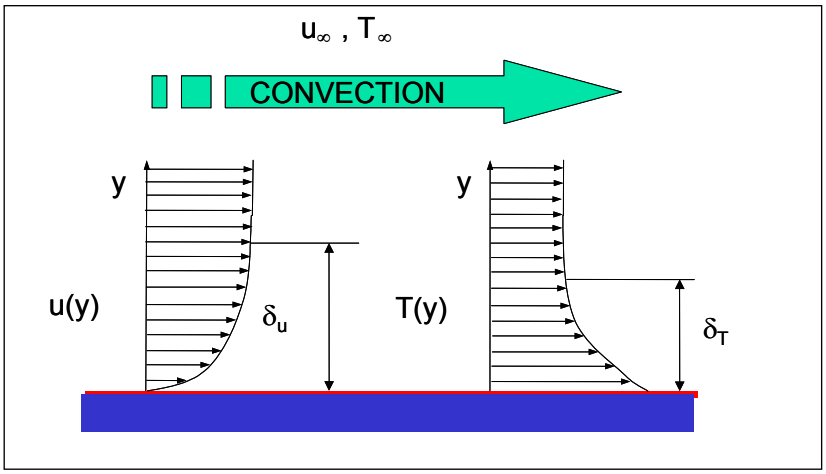

Figure 3 U = Velocity T = Temperature

European Legislation and Eductors

In recent years European Legislators have accepted that the use of eductor agitation has a positive impact on Environmental issues. Reduced emissions above plating tanks, increased efficiency of processing and energy savings from reduced demands for heating have led to eductor agitation technology being nominated as a Best Available Technique Not at Excessive Cost (BATNEC).

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Extracts from *IPPC *Guidance document S2.07***

To minimise emissions to air, recommends incorporating current technology as follows: -

- Generation of turbulence by hydraulic power and eductors

Conclusions

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 3000 tanks on various processes operating with eductor systems in Europe; 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 Metal Finishing Processes.

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