A Summary of the EPA Capsule Report On Nickel Plating Emission Issues, Control Technologies, & Management Practices

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This article summarizes the Capsule Report entitled "Nickel Plating Emission Issues/Control Technologies, and Management Practices" that was prepared under the direction of the U.S. Environmental Protection Agency's (EPA) Office of Research and Development to assist the metal finishing community with the management of nickel plating environmental issues. Its purpose is to profile the nickel plating community, to present the compelling nickel plating issues and to provide metal finishing practitioners with technical and management practices that incorporate cost-effective solutions to plating emission problems. The Capsule Report combines a current review of the nickel plating industry with a technical, economic and regulatory analysis by stakeholders who understand the industry's needs. This article emphasizes the integration of best management practices and control technologies in the hopes of encouraging members of the nickel plating community to use the Capsule Report as a resource document for this purpose.

Capsule Report Content & Organization

The Capsule Report begins with a description of its objective and scope. Presented is a profile of the nickel plating industry including an overview of both the nickel electrodeposition process and electroless nickel deposition process. Plating process formulations and additives are described in the overview.

Potential environmental releases are covered. While some of the regulations addressing these releases are location specific, most apply to the nickel plating industry as a whole within the United States. Included are discussions of air emissions, wastewater releases and toxic and hazardous waste issues and worker and environmental impacts. The chapter addressing best management practices and control technology options is the focus of this article. Finally, major environmental issues and recommendations are discussed.

Nuts & Bolts: What This Paper Means to You

This article summarizes the Capsule Report entitled "Nickel Plating Emission Issues/Control Technologies and Management Practices" that was prepared by the U.S. EPA Office of Research and Development. It profiles the nickel plating community, presents the issues and provides practices that are effective solutions to emission problems. This analysis is based on information from stakeholders who understand the industry's needs.

The major environmental issues of the Capsule Report are:

- Economically achievable pollution prevention (P2) and control technology options are needed to meet changing regulations;
- The playing field for environmental compliance between jurisdictions needs to be leveled within the United States and globally;
- Continued research and development is needed to develop and transfer technology to reduce waste generation through process changes, material substitution, water use reduction, metals recovery/recycle and bath life extension;
- Continued establishment of Government-Industrial partnerships is needed with trade and professional organizations to jointly consider regulatory limits and solutions to environmental problems and
- Long-term research and development planning by the industry should attempt to identify what is needed five and ten years from now to enable companies to address environmental issues while remaining competitive within a global economy.

Major Recommendations

The Capsule Report includes five major recommendations. The first is for facilities to continue to conduct environmental audits and pollution prevention opportunity assessments. These tools have been very successful in assisting nickel-plating practitioners to identify where P2 and environmental compliance can be accomplished. These tools help to establish baselines and provide for a systematic approach for environmental decision-making.

The second recommendation is to embrace environmental management techniques and approaches that encourage life-cycle assessment, pollution prevention rather than pollution control, environmental management systems that incorporate ISO 14000 and environmental cost accounting such as activity-based costing.

The third recommendation is to improve production and reduce environmental impacts through enhanced technology transfer by government, industry, academia, and trade and professional associations. Several nickel plater needs

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can be met with technical and management information transfer through case studies, reports, workshops, journal articles, meetings and newsletters.

The fourth recommendation builds on the first three and calls for a continuation and enhancement of the existing EPA-Industry partnership for out-year planning with specific goals to be more competitive on the global market while reducing environmental impacts and improving production.

The fifth recommendation is for government and industry to develop more efficient plating solutions that utilize lower concentrations of nickel and produce lower levels of air emissions and other releases.

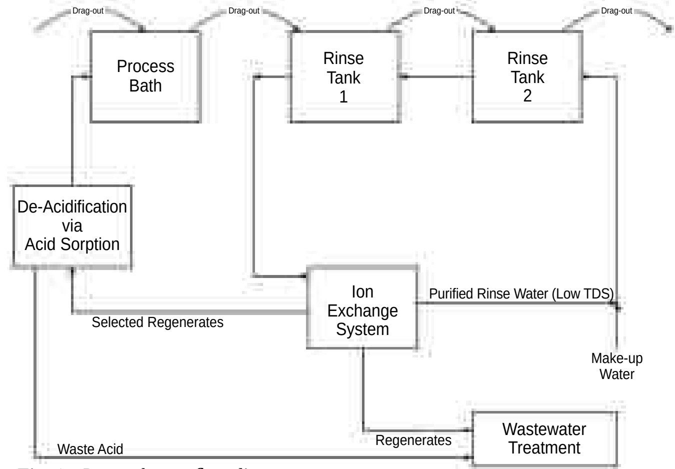

Fig. 1—Ion exchange flow diagram.

Technical Information Compilation

The primary purpose of the Capsule Report is to assist the metal finishing community with the management of nickel plating environmental issues by providing technical information and practical examples of cost-effective, environmentally acceptable practices. The technical description focuses on both electro- and electroless nickel deposition processes.

Nickel platers are constantly making decisions that affect their production and processes, and the decision drivers are diverse. One of the purposes of this report is to provide a viable reference for making informed choices. Decision-makers within the nickel plating community should seek partnerships in solving shared technical problems and coordinating difficult environmental issues. The *National Metal Finishing Resource Center (NMFRC),* http://www.nmfrc.org; *American Electroplaters and Surface Finishers Society, Inc.(AESF*), http://www.aesf.org; and *National Association of Metal Finishers (NAMF),* http://www.namf.org are examples of metal finishing organizations where partnerships are working. The EPA offers a number of hotlines and web sites regarding environmental information. EPA's Small Business Ombudsman Office (SBO), http://www.epa.gov/sbo serves and assists small business by addressing small business issues, problems and needs.

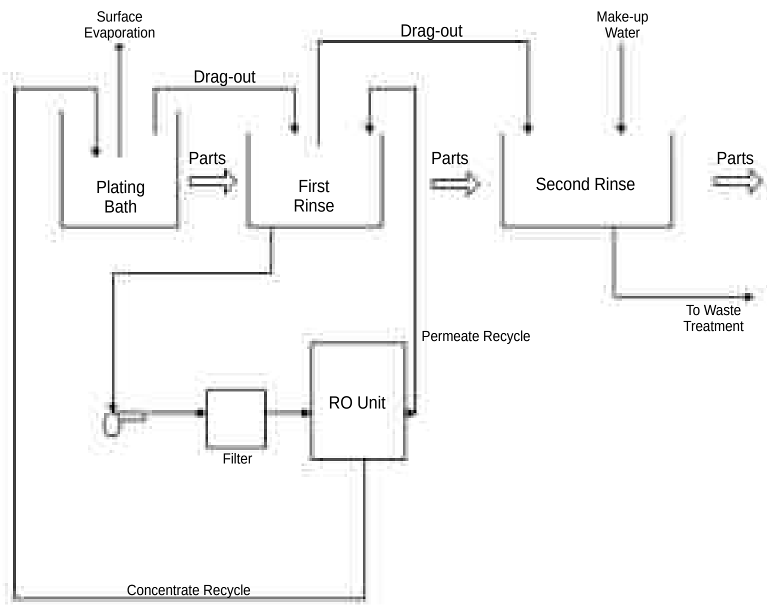

Fig. 2—Typical reverse osmosis system.

Nickel Plating Industry Profile

The nickel plating industry is part of the larger metal finishing community in the United States. It consists of job shops (independently owned plating businesses) and captive shops (metal finishing operations contained in larger manufacturing facilities). There are some 3000 United States job shops that average fewer than 50 employees with annual sales of about $5 million. Some larger shops exist and captive shops that support larger manufacturing facilities vary in size depending on their mission within the company. The metal finishing industry is highly regulated with respect to environmental protection and occupational health and safety because of the nature of the processes and materials required by the companies and their workers to create the products being demanded by industrial and public consumers. Nearly all manufactured products require surface finishing in providing decorative or technical substance value-added qualities. Consumers demand products that have appeal and will not deteriorate. The nickel plating industry provides a service that improves appearance, slows or prevents corrosion and increases strength and resistance to wear for manufactured parts and products.[1] Pollution abatement costs and expenditures for the metal finishing community comprise nearly 20% of the community's budget. Industry representatives are working together with government, trade associations and professional organizations to encourage technological advances that lead to more efficient cleaner production while reducing waste generation and control costs.[1]

Integrating Best Management Practices & Control Technologies

The solutions for the nickel plating industry environmental problems include the reduction and control of wastes generated by the industry. This waste reduction and control approach integrates the concepts of pollution prevention and waste management control technologies. The Pollution Prevention Act of 1990 reinforces the United States EPA's "Environmental Management Options Hierarchy," which assigns the highest priority to preventing pollution through source reduction and reuse, or closed-loop recycling. Pollution prevention focuses on product and process changes that reduce the volume and toxicity of production wastes, and the reduction of end-product wastes during the products life-cycle. When waste cannot be reduced by pollution prevention methods, the preferred alternatives are recovery/reuse/recycle of the process materials during the life-cycle of the product. Where prevention and/or recycling are not feasible, waste stream treatment followed by safe disposal is required to achieve environmental goals. "End-

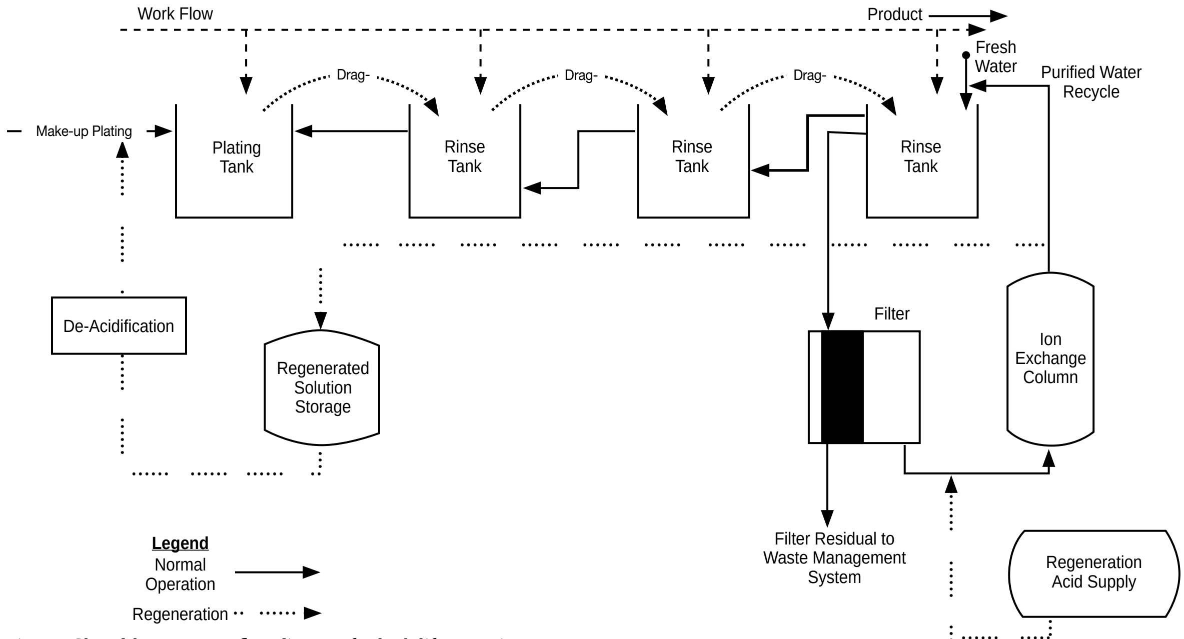

Fig. 3—Closed-loop process flow diagram for bath life extension.

of-Pipe" approaches were the earlier focus for environmental compliance, controlling releases and environmental clean-up. These approaches not only can be expensive and less than fully effective, but sometimes they simply transferred pollution from one media to another. Today's trend is to integrate the best practices and technologies available to meet the goals of industry.

The Capsule Report integrates pollution prevention and end-of-pipe control technology options in addressing the environmental issues of the nickel plating industry. This practical approach allows the nickel plating community to determine the best options for managing pollution. The nickel plating industry uses a myriad of chemical processes. There are technical, cost and regulatory limitations to consider on a process-by-process and facility-by-facility basis. While it is important to recognize the differences and similarities of waste management approaches, the desired outcome for the individual nickel plater is to be competitive and compliant while producing high quality products. In most cases, there will be waste disposal concerns for the producer and consumer. Therefore, all waste management options should be considered in addressing the environmental issues of the nickel plating industry.

Recovery, Recycle, & Extended Bath Life

The most common P2 option for nickel plating being implemented today is reusing the drag-out rinsewater. This involves using the tank water where the parts have been rinsed (before the parts are rinsed in a flowing-water rinse), to replace the process tank water lost through evaporation. This reuse of drag-out rinsewater reduces chemical loss. Other waste rinsewater P2 alternatives include:

- Operation of equipment to reduce drag-out;
- Increasing solution temperature;
- Lowering the concentration of plating bath constituents;
- Using an air knife to reduce drag-out from the process;
- Reducing speed of product withdrawal to provide added drainage time;
- Using surfactants to lower solution surface tension;
- Properly positioning parts on rack for maximum drainage;
- Using multiple rinse tanks in countercurrent series;
- Using fog nozzles and sprays for rinsing simple work pieces;
- When still-rinsing, recycling rinsewater upstream (re-use the water elsewhere upstream in the process line);
- Using automatic flow instrumentation to control flow rate;
- Reusing rinsewater when possible and
- Increasing rinsing efficiency by agitating rinse bath.[2]

P2 alternatives for work cleaning wastes are:

- Reducing cleaning frequency when possible;
- Designing process and equipment to minimize surface area of exposed process liquid;
- Recording cleaning costs as a separate item;
- Converting from a batch process to a continuous process;
- Maximizing dedication of process equipment;
- Avoiding unnecessary clean-ups;
- Operating equipment to inhibit fouling;
- Minimizing residue build-up during operation;
- Minimizing the amount of cleaning solution used;
- Recycling cleaning solution by filtering solids from used solution and
- Substituting cleaning system with a proprietary process that biodegrades the oil, generating almost no oily waste.[2]

P2 alternatives for treating wastes include:

- Installing a sludge dewatering system;
- Improving operating practices;
- Installing a metal recovery system;
- Segregating waste streams to facilitate treatment and recovery of metals;
- Using the most efficient precipitating agents and
- Returning spent process solutions such as strippers and EN plating solutions to the manufacturer for recycling.[2]

There are a variety of technologies that are used within the nickel plating industry to separate plating chemicals from rinsewaters, or to concentrate the chemicals for ease of recycle/reuse. The six most commonly used technologies are:

1. Electrowinning
2. Atmospheric Evaporation
3. Vacuum Evaporation
4. Ion Exchange
5. Reverse Osmosis
6. Electrodialysis

Electrowinning involves placing two electrodes (insoluble anode and cathode) in a solution containing ions, where the ions move toward the charged electrodes. Dissolved metals in the electrolyte are reduced and deposited on the cathode. The deposited metal is removed by mechanical or chemical means and either reused as anode material or sent off-site for processing or disposal. Electrowinning is used to recover expensive common metals for recovery/reuse or to reduce the amount of inexpensive metals for treatment and disposal. This technology is most often applied for gross metal recovery from concentrated solutions. The combination of ion exchange and electrowinning has a much higher potential metal recovery efficiency than electrowinning from a drag-out rinse. Nickel recovery using ion exchange is possible, but it requires de-acidification of the regenerant and close control of pH and is not commonly performed.[3,12]

Electrowinning is best applied to dumped concentrated plating baths. It is not expensive to operate nor is it labor-intensive. Energy costs comprise only a small part of the total operating costs. The system utilizes an inert anode that is very expensive to replace, if damaged. The relative low cost of nickel in today's market compared to the cost of recovery should be considered in evaluating this technology for recovery of nickel.[12]

Atmospheric evaporation is used to concentrate liquid plating wastes prior to treatment/storage/disposal. This technology reduces the amount of waste, and consequently, the costs of transportation, treatment, storage and disposal. Atmospheric evaporation is the most widely used method of chemical recovery in the plating industry. Evaporators are devices that evaporate water to the atmosphere and consist of a pump for moving the solution, a blower to move the air, a heat source, a mixing chamber for mixing the solution and air and a mist eliminator to remove any entrained liquid from the exhaust air stream. The capital and operating costs can be relatively low in some installations in arid climates.[12]

Vacuum evaporation systems are relatively complex and more expensive than the simpler atmospheric evaporation systems. The vacuum evaporator is a distilling device that vaporizes water at low temperature when placed under a vacuum. Vacuum evaporators can be employed for recovering nickel plating solutions, if foaming problems are resolved. At least one supplier of vacuum evaporators has resolved the foaming problem using thin film evaporative methods. Vacuum evaporators are consumers of high quantities of energy making the technology less competitive on an operational cost basis.[12]

Ion exchange is a chemical reaction recovery technology that is especially applicable to dilute rinsewaters. It involves exchange of the ions from a plating solution with similarly charged ions attached to an immobile solid particle such as an ion exchange resin. The resins are typically contained in vessels (columns) and the exchange occurs when the solution is passed through these columns. A simple diagram illustrating the use of the ion exchange method is presented in the next Fig. 1.[12] Ion exchange is not practical for process solutions that are more concentrated than the ion exchange regenerate, therefore this technology does not work well for concentrated drag-out solutions. The capital and operating costs can be relatively high for the benefits received from nickel chemicals.[12]

Reverse osmosis (RO) is a membrane separation technique applicable to the dilute stream. It is primarily used to separate water from a feed stream containing inorganic ions. The purity of the recovered water is relatively high, and the water is generally suitable for recycling. Osmosis occurs when a semi-permeable membrane separates two solutions of different dissolved-solids concentration. Pure water will flow through the membrane into the concentrated solution, while ions (brine) are retained behind the membrane. Reverse osmosis occurs when pressure is applied to the more concentrated solution to reverse the normal osmotic flow, and pure water is forced through the semi-permeable membrane into the less concentrated solution. The purified stream that passes through the membrane is called permeate; the concentrated stream retained by the membrane is called concentrate. Chemical recovery by RO is usually not practical for highly concentrated, oxidative solutions due to fouling. A RO system is relatively inexpensive to construct (cost of the membrane) and operate for the benefits received from nickel recovery. Using a spiral wound cellulose acetate membrane, there are a number of successful RO systems in operation for bright nickel, nickel sulfamate and Watts nickel plating baths. Since boric acid is not rejected, RO may not be suitable for rinses that have a subsequent hexavalent chromium plating bath. A typical RO application is shown in Fig. 2.[12]

After minimizing water use by rinsewater reduction or reuse, and metal recycling, the focus for P2 is for extended bath life. An appropriate method to conserve water and conserve chemicals while maintaining bath life is to use a closed-loop plating bath recycling system. Figure 3 shows how a closed-loop plating bath recycling system can be arranged to extend bath life.[4]

Another method to extend nickel plating baths is to remove the contaminants such as grease, oil or organic breakdown impurities from proprietary additives, and unwanted metals from the nickel baths. The most common practices are electrolytic treatment (dummying), batch metal precipitation, and batch adsorption. Electrolytic treatment is particularly effective for the removal of copper, zinc, and excesses of certain organic impurities. Metal precipitation at high pH is used for the removal of impurities such as aluminum and iron. Carbon adsorption is an effective method for removing some organic contaminants from nickel plating baths. Plating bath contamination occurs most commonly when parts fall into the tank, and from bare areas (areas not designed to be plated such as the inside of tubing) exposed to the solution during the plating process. Therefore it is important to assure the parts are properly attached to the racks while in process.

Water use for evaporation loss can be a major source of contaminants. Therefore, de-ionized water should always be used for solution make-up. Continuous or batch filtration through activated carbon is recommended to eliminate the decomposition products and the minor levels of oils and greases that may be dragged-into the baths. These purification methods can be combined for greater contamination removal. Removing contaminants to extend bath life can reduce costs by reducing process chemicals, energy usage, quantities of wastes for treatment/disposal and the potential for noncompliance. Plating bath solution maintenance has become a greater priority to plating shops for extending bath life and improving the operating efficiency and effectiveness of a plating solution.

Surface Preparation

Surface-finishing involves direct atom-to-atom bonding between a basis material (such as steel, aluminum, brass, or plastics) and a metal or organic surface top coating that provides the desired material performance and/or appearance properties. Multi-step surface preparation processes remove oils, particulate materials, old coatings, corrosion products, residual cutting fluids, brazing residuals, smut, pickling acid residuals, cleaner residuals and the like. The surface preparation process removes contaminants, preserves the cleaned surface and/or modifies the surface for the next coating. It is common for surfaces to undergo more than ten finishing steps that include degreasing and cleaning (for oil removal and descaling), etching, desmuting, pickling, plating and rinsing. These baths are ultimately exhausted because of depletion of active chemical agents or buildup of impurities and constitute a major waste stream.

The volume of hazardous/toxic waste streams produced from metal surface finishing operations is significant. Most of these result from blowdown of the ventilation air scrubber and from tank dumping. Therefore, reducing the number of tanks (surface area) needed for production could significantly reduce the amount of these wastes. Decreasing gas evolution from the baths (*e.g.,* the hydrogen gas formed during acid pickling) also reduces wastes because bath gassing causes mist formation. Lower operational temperatures also reduce discharges by reducing impurities carried into the process with make-up water.

The elimination of surface processing steps is desired by manufactures to reduce processing costs, waste production, and energy consumption. With this objective in mind, a proprietary no-waste surface-finishing agent** has been designed to provide a nearly one-step metal surface preparation operation for metal finishing operations. In a study sponsored by the United States EPA, this process provided metal surface cleaning, pickling, conversion coating and priming using a process simply consisting of degreasing, one dip-step (can also be sprayed), one rinse and then final processing. Because of the large number of surface-finishing operations, the potential for sizable waste and cost reductions by using such a product is significant. The National Risk Management Research Laboratory (NRMRL) of the United States EPA has performed an assessment of its efficacy in major polluting surface-finishing operations.[5]

Process Changes

Changes can be made in the production process through improved operation and maintenance procedures, material substitutions or changes in equipment that will reduce waste generation. Operating the plating line more efficiently can reduce waste generation and is usually inexpensive to implement. Instituting standard operating procedures and optimizing the use of raw materials can increase overall efficiency. An evaluation or review of all current operating practices will provide an opportunity to identify waste generating activities. In many cases, simple operational changes can reduce waste generation. By following the raw material from receiving, through the process and following the product and process materials as they leave the facility through shipping or releases, activities and areas to target for waste reduction may be identified.

A strict maintenance program that stresses corrective and preventative maintenance can reduce waste generation caused by equipment failure. Assuring that all employees are properly trained for operating and maintaining equipment, handling process materials and handling waste materials is the key to increasing efficiency. Well written, practical guidance manuals coupled with hands-on training and frequent updates and interaction between employees and supervisors are necessary for the communication of this ongoing process.

Material substitution is typically a more difficult means of reducing waste generation because it may require product reformulation with a less hazardous or non-hazardous material that may adversely impact quality. In the United States there is more pressure toward producing products that contain less hazardous materials. This pressure is coming from the regulatory agencies with increased regulations on hazardous substances and wastes, and from consumers who are looking for products that are safer, environmentally friendly and create less waste when the product is used. Since so many product formulations are proprietary, specific examples are limited. The use of water-based cleaning systems instead of solvents and replacing chlorinated solvents with non-chlorinated solvents are two examples. Adding more holes to a product or designing product shape for better drainage or easier shipping may also reduce waste and costs. Also, redesigning the racking fixture to allow better escape of gases that are generated on the plating surface may reduce the waste of nickel plating chemicals.

Modifying process equipment can be a very cost-effective method for reducing waste generation within the nickel plating industry. The incorporation of such equipment will reduce waste and improve operational efficiency. Improving parts draining before and after cleaning and improving reactor design are two examples of process modification.

Waste Reduction Through Process Simulation

Process simulation is a general methodology for designing or modifying processes to reduce their environmental signature. In traditional manufacturing process design, attention is focused primarily on minimizing cost while the environmental impact of a process is often overlooked, potentially resulting in large quantities of waste materials. Using process simulation techniques and models, it is possible to modify the process to reduce the generation of wastes and their environmental impact while still reducing cost, resulting in a more "sustainable" process. Most decorative nickel electroplating processes are similar in design and operation. Technologies such as ion exchange, reverse osmosis and electrowinning are similar in design and operation. A model of these technologies with the typical electroplating process can be simulated to determine the "best" technology to use for a specific operation. This is true for determining operating modifications within a specific nickel plating operation without actually expending the capital in a trial and error approach. Software products are available for other industries such as the chemical and pharmaceutical industries to identify inputs and wastes throughout an industry's process. The nickel plating industry should consider the development of a computer-based tool to facilitate user input of desired qualities and determine environmental considerations along with process optimization. The result of process simulation would allow nickel platers to consider optimization and waste reduction options using a model prior to any capital expenditure for modification.

Life Cycle & Sustainability Considerations

Environmental decision-making requires life cycle and sustainability considerations for a holistic approach to address environmental impacts beyond the facility gates. While the major focus of environmental impact assessments is the manufacturing stage for nickel platers, life-cycle assessment (LCA) takes a comprehensive approach by analyzing the entire life cycle which includes four stages: (1) raw materials acquisition, (2) manufacturing, (3) use/reuse /maintenance and (4) recycle/waste management. LCA is a systematic method for identifying, evaluating and minimizing the environmental consequences of resource usage and environmental releases associated with a product, process or package. LCA identifies the mass and energy inputs and outputs for an industrial system in an effort to identify their possible environmental relevance and significance. The life-cycle impact assessment goes beyond the unit operation to encompass a cradle-to-grave perspective. The purpose of using LCA is to avoid shifting pollution from one media to another, or from one life cycle stage to another. It is important for the nickel industry to recognize that no one stakeholder or decision-maker has control over the entire life cycle of a product or process and environmental impacts ultimately affect everyone.

LCA is of special interest to companies who wish to strategically evaluate their position in reference to the rest of the industry with respect to environmental impacts. The life cycle concept should be employed for any product or process or design activity. LCA can be used as a screening tool to help the user determine if

*** Picklex®, International Chemical Products, Inc. (ICP), Huntsville, AL.*

impacts occur outside the facility when an improvement is made to the product or process. There are several methods, computer programs and models for addressing environmental impacts using LCA principles. These tools encourage more informed environmental decision-making and can be applied to benefit/cost analysis. Considerations for sustainable development cannot be fully appreciated without life cycle thinking.

Integrated Pollution Prevention/Control Success Stories

Pollution prevention success case stories are increasing with the nickel industry's increased environmental awareness and pursuit of improved operational efficiency. Four case studies in the Capsule Report are highlighted as examples of incorporating pollution prevention into nickel plating operations.

The first case study is Poly Coatings of Sarasota, Florida, a family business with 12 employees that specializes in electroless nickel, Teflon-impregnated electroless nickel*** and electrodeposited (sulfamate) nickel plating. The Teflon-impregnated electroless nickel plating is used in plastic molds for dry lubricity. The company plates a variety of items for many industries, including firing devices for Patriot missiles and airbags, molds for injection and blow molding, wear components for sealing devices and other small, high-value components. The company has several established specialized areas of high-quality electroless nickel plating applied in thicknesses from 1.27 to 127 µm (50µ-in. to 5 mils). The bath chemistry used is a high-speed, mid-phosphorus product.**** The company's success in pollution prevention is a result of carefully choosing high quality raw materials and operating the facility at peak efficiency.[6] The plating system is 100% closed loop. Therefore, the only wastes leaving the facility are solids which are disposed of in 55-gallon drums.

The next case study involves Thomas Industries, located in Hopkinsville, Kentucky. They recycle 12,000 gallons of rinsewater per shift while recovering nickel and brass from their plating operation. The company's goals are to exceed all environmental, health and safety regulations as a high-quality producer of a complete line of lighting products. Water reduction occurs through exponential dilution (extra counterflow rinses), so water use can be reduced up to 90% while actually improving the rinsing process.[7]

The third case study is C.J. Saporito Corporation (CJS), located in Cicero, Illinois. They offer a variety of metal finishing processes for electronic, aircraft and commercial applications. Electroless nickel finishes are an integral part of the business in which CJS has specialized. CJS experienced traditional waste generation of electroless nickel plating. They brought new electroless nickel technology on stream which offered extended bath life and process stability by allowing for the precipitation and removal of undesirable orthophosphite by-products.[8]

The last case study is the Fin-Clair Corporation, who plates nearly 40 million seat belt assemblies each year at their facility in Knoxville, Tennessee. They tested four bright nickel plating process solutions and index-based plating baths to provide good leveling and extremely bright deposits at various deposit thicknesses. The process included a total reclaim of the bath solutions with rinses flowing back into the tank. There was no evaporation or ion exchange, and the process had no drag-out. In an effort to correct the problem, Fin-Clair switched to a low chloride, bright nickel plating system.***** The two main reasons for the conversion were the deposit's low stress and excellent ductility. Since there was no build-up, Fin-Clair could "close the loop"and enjoy reuse of rinsewater after treatment through a vacuum distillation unit designed and built by the company. The nickel concentrate was pumped from the bottom of the unit and filtered through heavy carbon before being added, as needed, to the plating tank. The last time Fin-Clair sent anything to the landfill was in 1985. They believe in implementing common-sense strategies for pollution prevention success.[9]

*** Poly-Ond, Poly-Plating, Inc., Chicopee, MA .
**** Nitec 75, Heatbath, Corp., Springfield, MA.
***** Ultralite 2000, Enthone-OMI, New Haven, CT.

Wastewater Control Technology

Wastewater is generated in the nickel plating industry as byproducts of:

- Process tank rinses,
- Servicing filters and
- Clean-up of equipment and floor spills.

These sources of wastewater are also the primary targets for source reduction, recovery, recycle and reuse. Most of the emphasis on recovery technology has focused on rinsewater since it constitutes the majority of the flow leaving an operation and necessitates expensive treatment. Bath dumps are generally of low volume and occur infrequently. Often bath dumps are collected and transported by a waste service provider for final treatment and disposal, and more baths are being treated on-site for regeneration and reuse of the bath chemicals. Floor spills include both accidental and purposeful incidental waste sources such as tank overflows, drips from workpieces, leaking tanks or pipes, chemical spills, salt encrustations, wash down water for equipment and floors and oil drips or spills from equipment during the operation, transport and/or handling. Floor spills are managed by the application of good housekeeping, maintenance and operating practices combined with appropriate operator training.

Wastewater treatment after P2 and recovery/recycle/reuse options can be accomplished using one of three general approaches:

- On-site treatment system, possibly mobile;
- Pretreatment followed by discharge to publicly-owned treatment works (POTW) and
- Off-site treatment by an off-site treatment/disposal facility.

Maintaining and operating an on-site treatment facility can be labor intensive and expensive and usually not a good option for small nickel plating companies. A mobile system can be expensive for a small plater. Mobile systems are generally used for infrequent site clean-up requirements. Pretreatment followed by discharge to a POTW is a wastewater control option for many platers who are also active in recovery/recycle programs. Off-site treatment by a centralized waste treatment facility works when several platers are located in the same vicinity, usually in large metropolitan industrial areas. A typical option for most small waste generators is simply storing the hazardous waste in accordance with RCRA requirements until it is economically sound to have the waste transported to an off-site treatment and disposal facility.[10]

EPA has proposed Metal Products & Machinery (MP&M) regulations that are intended to replace the existing wastewater treatment standards for metal finishers. The proposed nickel discharge limits are significantly lower than the limits imposed over the last 20 years (1.5 mg/L daily maximum and 0.64 mg/L-30 day average vs. 3.98 mg/L and 2.38 mg/L currently enforced). If finalized as proposed, the industry will need to install additional pollution control and prevention equipment and modify their existing waste treatment systems at an average cost of over $200,000 per facility.

Air Emissions Control Technology

Air emissions are created when hydrogen gas produced in the plating process and air bubbles from air agitation systems in these processes escape and carry some of the nickel plating solution within the release. Emissions escape from the blind holes of parts being plated, and during the chemical process of nickel deposition at the surface of the part. Capturing these emissions with hoods or a general ventilation system and routing them to a wet scrubber is the most common control technology for nickel plating air emissions. If the rest of the United States follows the lead of California and its regulation declaring all soluble nickel compounds to be carcinogenic, it will be necessary for all nickel platers to install High Efficiency Particulate Air (HEPA) filters to control emissions from small, medium and large plating tanks. Since most new tanks are not designed with ventilation systems, and the HEPA filters work best in combination with a scrubber or mist eliminator, the estimated cost for achieving compliance could range from about $20,000 to $140,000 per tank, depending on the size of the tank and design of the facility.[11]

Summary

This summary of the EPA Capsule Report provides an overview of the nickel plating emission and waste release issues within the nickel plating industry, and pollution prevention and control technology options available. It is the objective of this report to assist the metal finishing community and specifically, those involved with nickel plating operations with the management of environmental issues that result from wastes that could potentially be generated by nickel plating. Both the electrodeposition and electroless deposition processes for nickel plating have been profiled to examine waste streams and potential releases.

It is recognized that nickel platers are faced with making a high-quality product that meets the needs of the consumer while being competitive within the market. These same nickel plating practitioners face the environmental, regulatory, technical and business influences required to protect the environment and human health while producing high-quality products. This summary article and the EPA Capsule Report is an attempt to assist the nickel platers by providing technical information to reduce environmental concerns and lower the liabilities associated with preventing and controlling environmental releases. The Capsule Report is an United States EPA publication and can be ordered by telephone (800/490-9198) or via Internet (http://wwww.epa.gov/ncepihom/).

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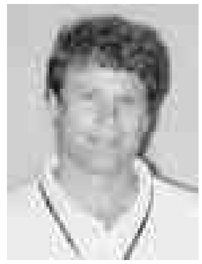
About the Authors



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