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RESEARCH ARTICLE

‘WASTE MANAGEMENT PROCESS IN ELECTROPLATING’ INDUSTRIES.

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Abstract

Electroplating is a versatile deposition method in which thin films of metals, metallic alloys are coated on a substrate for decorative purpose, rust prevention and wear resistance. A number of wastes that are hazardous to human health and the environment are commonly generated by the electroplating industry. Wastewater, spent solvent, spent process solutions, and sludge are the major waste forms generated in large volumes in electroplating industries. The waste containing heavy metallic ions such as nickel, chromium, zinc, lead, silver, cadmium, mercury, cyanides etc. are more hazardous. The hazardous waste generated in electroplating industry are major problem for environment. It is necessary to control the waste generated in electroplating industry to prevent environmental pollution. In this perspective various techniques have been developed for controlling the waste. The most important process material is water. Water to be used for bath and recovery rinse makeup may have to be treated to high quality. The two most common technologies used for water treatment are ion exchange and reverse osmosis, it may be economically advantageous to use reverse osmosis alone or as a roughing filter. Waste minimizing method is one of the most important technique in which generated waste reduces at source. This can be done through process modification and operational improvement.

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Introduction:-

Electroplating is a process which is used for many purposes in which a fine layer of metal is electrodeposited on other substances for improving properties such as corrosion resistance, hardness and lustre. Metals such as copper, nickel, chromium, zinc and alloy, tin and alloy, copper and alloy are commonly used for electrodeposition.

Electroplating process has been successfully applied in large manufacturing plants such as automobile, cycle, and engineering industries as well as in small units for decorative, high durability and rustproof purposes [1-3]. Electroplating processes is responsible for pollution and to generate large amount of wastes . Wastewater, spent solvent, spent process solutions, and sludge are the major waste forms generated in large volumes in electroplating industries. Chemicals and metal salt used in electroplating solution, rinse water and spray losses causes pollution in environment. Wastewater contains hazardous and toxic chemicals, metal and nonmetals contaminants must be reduced in order to prevent pollution. Waste minimization is a process to reduce pollution by dealing with it during manufacturing process. Wastes comes from electroplating industry can be significantly minimized through process modification and operational improvement [4-7].

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Types of Electroplating Wastes

Electroplating is a major cause of pollution because it generate hazardous wastes in form of toxic materials and heavy metals through wastewater, air emissions and solid wastes in environment [8,9]. According to the Hazardous Waste (Management and Handling) Rules, 2002 following wastes from Electroplating Industries are identified;

1. Acid Residues
2. Alkali Residue
3. Rinse water from pre-treatment and plating operations
4. Spent bath containing cyanide and toxic metals
5. Sludge from bath containing organic solvents
6. Phosphate containing sludge
7. Etching residues
8. Plating metal sludge
9. Chemical Sludge from wastewater treatment.

The waste generated in electroplating process is in liquid form mainly. The pollution caused by them is more dangerous than by solids and gaseous discharge and affected the public health seriously. The waste containing heavy metallic ions such as nickel, chromium, zinc, lead, silver, cadmium, mercury, cyanides etc. are more hazardous. The concentration of waste depends on surface area and shape of article, thickness of solution, speed of removal, drains time etc. The most important parts of these wastes are acids used for cleaning, alkaline cleaners etc. The solid wastes are the bottom sludge containing chromium, ferric, sulphate ions and metallic impurities are hazardous In electroplating process gaseous emission comes due to high temperature of plating bath or excessive agitation. It contains volatile organic compounds, vapors of chlorinated solvent, vapors of metals such as Platinum, Hexavalent Chromium, Rhodium, Cadmium etc., vapors of chemicals used in electroplating, Cyanide vapors from plating bath[10].

Effect of Electroplating Wastes on Environment

Electroplating is a very useful process which is used for anticorrosion, heat resistance, electrical conductivity and in decorative purposes but in spite of these benefits this process is a big challenge for environmental pollution. Electroplating industry generates large amount of wastewater containing heavy metals [11]. Heavy metals are hazardous in nature depending upon their concentration. Toxic pollutants such as cyanide, cadmium, mercury, chromium and arsenic from the electroplating industries are often discharged into lakes and rivers and contaminated the water and seriously affected the human health.

The heavy metal containing water also affected the quality of soil. A large part of metals reaching soil surface get strongly bounded to colloidal components present in soil. In course of time, either due to decomposition of soil organic matter or due to soil, induced through soil internal process or due to acid depositions, appreciable amounts of metals could be mobilized, which could increase the mobile metal concentration. The mobile metal concentration could pose a real danger either to growing organisms in the soil or changes in soil properties such as decrease in pH, change in redox potential, enhanced decomposition of organic matter, losses of fine textured particles from soil, are responsible for the mobilization of metals. The solvents and vapors from hot plating bath results in elevated levels of volatile organic compound, volatile metal compound and hydrogen cyanide gas.

Hazardous wastes generated in electroplating industries are major problem for environment. It is necessary to control the waste generated in electroplating industry to prevent environmental pollution. In this perspective various techniques have been developed for controlling the waste. Waste minimizing method is one of the most important technique in which generated waste reduces at source. This can be done through process modification and operational improvement [12, 13].

Fundamental Process of Waste Minimization

The process of reducing waste generated from various kinds of industries at the source itself by following a systematic and continuous approach is called 'waste minimization'. The technique has numerous benefits including reduced manufacturing cost, more efficient processing, reduces costs of both treatment of waste and disposal of the waste which has been generated. By doing this it also helps in minimizing environmental pollution. There are seven rules which are applicable to ensuring pollution control which are as follows:

1. Wherever possible, waste should be eliminated at the source itself.

2. Cost-reduction, in waste generation can be achieved through changing the set points or tightening the control variations of the key variables.
3. As far as possible, recycling of the waste material should be done within the process.
4. If the waste byproducts are formed reversibly within the reaction process, then it should be ensure that they are recycled to extension.
5. The utility with the lowest practical temperature should be used for all heating duties that necessarily require utilities.
6. Minimizing the total number of main equipment items used in the process is essential, especially in areas that handle toxic material. Additionally, minimizing the number of pipe work connection to and from the equipment items is also important.
7. Continuous processes are preferable to batch operations as preventing pollution is generally costlier in the latter case.

The above mentioned rules are helpful to achieve the goals of the waste minimization program in a pragmatic manner, easily and efficiently.

Strategy for Waste Minimization

Due to inefficient processes for electroplating, many industries generate excessive waste and disposal becomes a huge problem. The aim of a waste minimization process is to reduce the formation of byproducts which are discarded as waste and harms the environment and ensure that this formation is minimal. The process of waste minimization assumes far more significance when the waste generate is 'hazardous' in nature, because the treatment of hazardous waste is difficult as well as the huge cost involved. An ideal strategy of waste minimization includes five basic steps:

A. Reduction or Substituting of Raw Materials

It is possible to minimize generation of waste that is hazardous in nature is through substituting less hazardous chemicals. For example, cyanide is one of the most hazardous toxic wastes produced in metal finishing industries. Cyanide is used a solubility enhancing agent because of its chelating properties and cyanide-based baths have a batter 'throwing power'. This will lead to a smoother and brighter finish of the plated part. The disadvantage of using acid-based baths at a macro-level can be compensated by strategically racking the work-piece within the plating bath to achieve even distribution of current. Though, non-cyanide chemicals require more thoroughly cleaned surfaces to ensure high quality finishing, and consequently require high quality degreasing techniques. Substituting cadmium-based plating solutions with materials such as zinc, titanium dioxide and aluminum is also a feasible option. Replacing the highly toxic hexavalent chromium with the less-toxic trivalent chromium that uses considerably lower concentrations of chromium metal and therefore produces air emissions that are less toxic is also an option. The trivalent chromium can be a successful replacement for decorative chrome applications. Though trivalent chromium is not suitable for hard chrome applications.

B. Improving housekeeping and effective operating procedures

To improve housekeeping for reduction in waste volume and strength could be achieved by:

1. altering the washing process, for instance by using counter current washing, reducing the cleaning frequency and recycling the used solvent; and
2. introducing new methods in the production line cleaning; and
3. changing the method used for transporting waste; and
4. By using biological degreasing for cleaning the metal parts. Usage of Water as alternate or soap water solution which can be recycled, for further use for gardening.

C. Process installation for recovery and reuse at Plant

The solutions used in the baths could be recycled or reused. There are three processes that could be of benefit in this context, as follows:

1. Acid solution regeneration: In this process, acid solution is regenerated by using distillation, acid absorption, membrane electrolysis, crystallization, and diffusion dialysis. Diffusion dialysis functions by passing water in a counter current flow to the spent acid stream. The two streams will meet at a membrane where anions and hydrogen will diffuse through the membrane into water. Operators will end with an acid solution at the approximate level which they started with and a diluted acid waste that contains the metal component. The acid can then be reused and the waste will be treated.

2. Spent acid bath reuse: The most common examples of this technique are used alkaline and acid cleaners from the cleaning process. The rinse water from an acid dip process is piped to the alkaline cleaning process for use as rinse water. If the acid dip process and the alkaline cleaning process have the same flow rate, then this technique reduces water use by 50 percent.
3. Spent solution bath reuse: It is a common occurrence that the process baths that have become too contaminated to be used for plating operations, are dumped. However such baths can have important uses in other metal finishing processes including chrome treatment, cyanide treatment and metal precipitation and therefore should not be dumped. This reuse will also reduce the actual waste generated.

D. Innovative technological improvements

Minimization of waste generation can be achieved by technological improvement. It can be implemented through changing process technologies and equipment or machinery. Changing process technology is an important technique for reducing wastes in quantity. Minor changes to the product can greatly increase operational efficiencies leading to lesser generation of wastes.

E. Changing Product

The final step is changing products that can serve the purpose of the original product and also result in lesser waste being generated. This leads to waste minimization. Examples would include, changing non-rechargeable batteries to rechargeable batteries, using spray cans with water soluble formulations instead of volatile chemicals, in case of refrigerators using ammonia or other environmentally safe materials in place of chloro-fluorocarbons.

Conclusion:-

It is clear that there have been many approachable environmental improvements to the metal plating industry. The uses of cyanide, hexavalent chromium, cadmium, leads, and chlorinated solvents are being reduced by the application of waste minimization techniques. Waste minimization process are useful in environment friendly industrial system with minimum pollution load and Adaption of good house keeping measures. Conservation of raw material and energy has been minimized and increases the financial strength of the company. A systematic, disciplined financial management system to keep account records, inventory of raw materials, and processed goods have been developed.

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