Environmental management for small medium electroplating industry, A Cleaner production approach

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Abstract. Small and medium scale electroplating industry produces a variety of plating products by using hazardous substances as raw materials. The production process at SMI electroplating held manually. Industrial environmental management is conducted by implementing clean production starting from waste prevention, reduction and recycling. Research is conducted in the field through observation and review of actions to reduce process failures and improve them. The success of implementing clean production as an environmental management effort can be extended to other SMIs.

Keywords: environmental management, SMI, electroplating.

1. Introduction
The electroplating industry is growing rapidly as a support for the motor and automotive, furniture, construction, machinery and decorative industries. The use of hazardous and toxic chemicals produces waste that has the potential to pollute the environment. Environmental management of the small and medium scale electroplating industry aims to reduce and minimize negative impacts on the environment.

The pattern of environmental management has evolved from a passive and reactive approach to a proactive approach. Higgins [1] describes proactive environmental management through pollution prevention efforts. Wenston & Stucky [2] and van Berkel [3] emphasize the application of clean production through prevention of direct waste generation from the source followed by reduction and recycling efforts. The environmental management model with cleaner production uses the principle of elimination (rethink), reduction, reuse, recycling, reclaimation or waste recovery [4] [5].

Research and implementation of small and medium scale industrial cleaner production in Indonesia have been conducted by Rahayu et al. [6] and Rahaya et al. [7] in the tofu industry, Wardiyatun and Purwanto [8] in the cracker amplang industry, and Sugiarti et al. [9] in the palm oil mill industry. Furthermore, Wibowo et al. [10] examined environmental management efforts in the fillet fish industry in the aspect of waste management. Hadiwijoyo et al. [11] examined the application of green technology in industrial areas as part of sustainable environmental management.
Field research on the application of clean production to the small and medium scale electroplating industry aims to identify plating product failures, apply the principle of cleaner production and implement cleaner production practices.

2. Research Method

The research was conducted in the small and medium scale electroplating industry located in Semarang City and Pati Regency, Central Java Province, Indonesia. The electroplating industry uses zinc, copper, nickel, brass and chrome plating processes. The equipment used consists of the electroplating bath, rectifier, current conductor, anode and cathode as workpieces, as well as washing and rinsing tubs. The materials used consist of electrolytes containing metal ions for coating, water for the production process, washing and rinsing and chemicals for preparation. The production process is done manually by monitoring the temperature, acidity and density of the solution.

The research procedure includes making a flowchart of the production process by making a block diagram of the process (process mapping), observing the production process, finding opportunities for cleaner production practice, alternative solutions and implementation of the implementation of cleaner production.

3. Result and Discussion

3.1. Observation of process production

The product quality of the electroplating process in small and medium scale industries depend on the operating conditions such as electrolyte concentration, temperature, current density as well as geometry of working object as cathode [12]. The expected qualities include uniform coating and thickness, glossy colour and no stains form on the overlaid workpiece. Operation problems often arise due to the condition of the solution that does not meet the requirements, the presence of contaminants, and it can also be caused by poor electrical connections. Deviations from the composition of the solution under the unsuitable operating conditions cause operation problems which result in low plating quality. Failure of the production process causes the low quality of the coating product and turn into a reject product, characterized by a coating time exceeding the standard, uneven coating, rough deposits, burnt edges of the coating, less shiny deposits and the presence of black spots.

The long plating time duration is due to the low electrolyte concentration, which causes small electrical conductivity and low current delivered to the cathode so that the plating time take longer. It is also due to the loss of current in the conductor from the rectifier to the plating bath.

The uneven metal coating, especially in grooved areas or areas with low current density, is due to poor penetration because the ratio between the components of the electrolyte is not following the standard. Dirty solutions with suspended solids usually settle at the cathode causing the deposit to become rough. Open plating tanks and less pure anodes are a source of impurities.

The part that gets a large current density, especially at the ends of the workpiece, burns because the electrolyte concentration is too high so that the conduct of large currents and currents per unit area in the end area is much larger than the other areas. Hence, the appearance of the coating is less shiny because of the lack of brightener additives. However, the addition of excessive brightener is also the cause of the decrease in plating quality. The black stains on the deposit are due to iron contamination in the electrolyte solution resulting in deposition of the cathode.

3.2. Implementation of cleaner production principles

The application of cleaner production principles [5] to the electroplating process as an environmental management effort starts from preventing and reducing waste generation in the production process, as well as recycling waste to minimize waste.
Replacing toxic compounds with less or non-toxic compounds is to eliminate waste generation from both raw materials and production processes. It was done by replacing cyanide in copper plating using pyrophosphate solutions and replacing cyanide with acid solutions on zinc plating.

Reduce the waste generation of electroplating activities by treating the solution properly and regularly; for example, a contaminated plating solution can be avoided. In the end, it cannot be used so that it becomes waste.

Reuse is an effort to reuse materials in the electroplating process. Immersing dirty filter in washing water and cleaning it can extend the life of the filter. Also, these filters can be used again to filter impurities in the electroplating solution.

Recycle is an effort to recycle materials in the electroplating activity cycle. The rinse water used to wash plating products is collected so that it gets thicker over time. Water with this concentrated concentration is used to increase the volume of the solution in the plating bath when it decreases.

Reclaim is an effort to take materials that still have a high economic value from a mixture or waste. The silver content in the washing solution or plating waste can be recovered by chemical or electroplating deposition to obtain a pure silver or silver metal compound.

3.3. Cleaner production practices

Cleaner production measures taken in the electroplating industry include good housekeeping, improvement of work procedures, the substitution of raw materials, good process control, modification of equipment, modification of processes and products and replacement of technology. The first step in implementing clean production started from some activities that do not require costs. These are good housekeeping practices, application of operating standards, followed by activities that require low costs such as utilizing rinsing solutions by adding two wash basins.

The replacement of hazardous materials with less hazardous materials generally costs much money. For example, replacing copper cyanide plating solutions with pyrophosphate solutions requires investment in equipment modifications and the cost of purchasing chemicals. If this is not possible, it can be overcome by controlling the solution and operating conditions properly so that material losses can be minimized and waste can be reduced.

Good housekeeping in the electroplating industry. Non-technical factors in implementing clean production are related to employee behaviour and work culture. Excessive use of water, not closing the tap after using water are examples of wasteful work behaviour and attitudes. Other examples relate to the addition of chemicals to electrolytes that are not properly measured, disposal of items that should still be reused, the number of liquid spills in the workplace, good goods mixed with defective goods.

Standard Operating Procedures. Different behaviours and ways of working can be minimized by creating standard operating procedures so that employees have the same handle in doing work. With the existence of operating standards, defects and varying quality result can be minimized. Defective plating products are caused by poor quality control and procedures, starting from poor scale cleaning, less clean workpieces and not completely free zinc plating work. The plating results obtained are defective products and continue to be stained. The final product stored or placed on a damp floor causes corrosion, resulting in a total defect of 25 per cent. Repairs carried out with the preparation of the workpiece and complete rust removal, followed by zinc plating and staining, and storage not carried out in a humid place can reduce the rate of product failure to around 5 per cent.

Selection of Raw Materials. Raw materials should be chosen which have high purity with little impurity. Materials which have high toxicity properties should be replaced with less toxic materials wherever possible. Likewise, the use of flammable hydrocarbon solvents can be replaced with solvents dissolved in water. Selection of good raw materials improves product quality and reduces the quantity of waste. The preparation of the new electrolyte solution is carefully done, and all solids can be dissolved completely, avoiding sparks and spills. The workpiece that will be plating is
appropriately cleaned, the dirt sticks to it and can result in solution contamination has completely disappeared. Good control ensures product quality and minimizes defective plating products.

Control of solutions and operating conditions. The composition of the electrolyte solution is maintained following established standards by regular solution analysis. Deviation in the concentration of electrolyte chemical compounds results in brittle deposits, non-sticking and very long plating times. Many chemicals are lost during processing, and production costs increase. The system of mixing raw materials and good solution control results in the efficiency of chemicals uses by 15-20 per cent.

Minimized drag-out. Drag-out is the amount of liquid that sticks and involved in the workpiece when it is lifted from the plating tank. Workers do not pay attention to the amount of drag-out because it is considered very small, only a few drops. If the number of sticks is multiplied by the number of workpieces during the operating time of one year, the amount of solution involved is enormous and cannot be ignored in terms of cost. By leaving the workpiece on the plating bath for a few seconds, the electrolyte liquid will drip back into the plating bath, and the drag-out can be suppressed, thereby saving the number of chemical additions.

Technology Repair and Equipment Modification. Technological improvements include the layout carried out in the rectifier layout coating industry and the distance to the plating tub. The result obtained is a decrease in the use of electrical energy in one of the electroplating processes by 40 per cent.

Contaminant prevention. Black spots on product plating effect are decreasing the quality of the results, due to the use of anode hanger using iron and immersion in the solution. Observations show that iron is also dissolved in the solution so that it contaminates the solution and causes black spots. Improvements are made by reducing the length of the iron hanger to the surface of the solution so that it does not dissolve, replacing it with a copper hanger, and the best effort is to replace it with a titanium hanger. The results show the loss of black spots on the plating product.

Reuse the rinse fluid. Reusing the rinse fluid to increase the volume in the lining bath or for the manufacture of new solutions reduces the use of pure water and electrolyte chemicals. In the electroplating industry that still uses one rinse tank, it can be modified by using three rinse tanks. The first bath near the coating bath for the first rinsing will get a more concentrated solution so that it can be used as an additional electrolyte in the coating bath, while the second and third tanks the concentration of the solution becomes increasingly dilute. The addition of pure water is carried out in the third tub.

Utilization of plating waste. Coating waste can be reused as raw material or other materials in electroplating. Dissolved metals such as copper, nickel, silver can be recovered by chemicals or electroplating. This heavy metal can be used as an industrial dye. Liquid waste containing copper or chromium can be used as a dye for workpieces with zinc plating. It will give an object a red colour, while chromium will give an object a neutral colour. The combination of the two will be able to provide a rainbow colour.

4. Conclusion

Environmental management in the small and medium scale electroplating industry uses cleaner production principles and practices to increase efficiency and prevent the generation of the waste directly from the source. The successful implementation of cleaner production in the electroplating industry can be applied to other small and medium scale industries.

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