ELSEVIER

Desalination 180 (2005) 163–172

DESALINATION

www.elsevier.com/locate/desal

Development of an ion exchange system for plating wastewater treatment

Tae-Hyoung Eom[a], Chang-Hwan Lee[a], Jun-Ho Kim[b], Choul-Ho Lee[a]*

[a]*Department of Chemical Engineering, Kong ju National University, Kong ju, 314-701 South Korea*
Tel. +82 (41) 8528638; Fax +82 (41) 8582575; e-mail: chlee@kongju.ac.kr
[b]*RRC/NMR, Kong ju National University, Kong ju, 314-701 South Korea*

Received 13 July 2004; accepted 29 November 2004

Abstract

Ion exchange technology was applied to this study to treat nickel ion from plating wastewater which contains heavy metal, bringing environmental problems such as chromium, zinc, copper, and lead. To separate nickel ion from wastewater, the nickel recovery unit (NRU) used a column packed with strongly acidic cation resin. The leak of the ion appeared when rinse water that has a concentration of 1.8 g-Ni/L-distilled water flowed into the NRU as much as 20 times the bed volume. At this time, the capacity of resin packed in the column was 1.7 meq/ml and over 99% nickel ion was removed. Sulfuric acid was employed with a reagent in order to regenerate nickel ion from the resin adsorbed. Nickel ion recovered by sulfuric acid was obtainable up to 120 g-Ni/L. The concentration of sulfuric acid was 2N and space velocity was 2/h. Acid retardation unit (ARU) experiment could be accomplished by deacidification to control the pH of the solution to recycle in the plating process. The composition was 30 g-Ni/L and the pH maintained was over 3.0.

Keywords: Ion exchange technology; Plating waste water; Nickel recovery unit; Acid retardation unit; Ion exchange system

1. Introduction

Wastewater discharged from industries like plating processes contains many heavy metals. They, such as copper, lead, chromium, nickel, iron, and zinc etc., have a fatal effect on the human body as well as causing environmental pollution. Especially, nickel that has been used in plating processes, nickel batteries, alloys, and steels. To be produced from rinse water to electrolyte after plating is a major source that exhausts nickel ion in the middle of them [1–5]. The nickel concentration contained in rinse water is about from 500 ppm to 2000 ppm.

In environmental pollution, plating companies focussed on the removal of toxic materials in the past, but recently researchers have been studying a technology to hold back pollutants at least and recycle them [4].

In order to choose the method to recycle the metals in the plating process, there are some

*Corresponding author

doi:10.1016/j.desal.2004.11.088

points to consider like using the solution concentrated from the process, treatment for by-product sludge, regeneration and recycling of process water and recycling for treated wastewater [3,4].

Technologies to separate ions from wastewater have been physical adsorption using an adsorbent such as silica gel, activated carbon and activated alumina, etc. These physical methods, however, are limited in selective removal of organic materials and other metals containing high concentration in the rinse water from the plating line. To overcome the problem of physical methods and to efficiently separate pollutant ions, many methods have been used such as oxidation/reduction, precipitation, ion exchange, reverse osmosis, adsorption, electrowinning, electrodialysis and so on. Of the above methods, the performance of electro-dialysis and reverse osmosis has some advantages over the others. But even though both methods have an advantage in efficiency, they have some problems such as installation charges and operation costs. Also, there is the need to secondarily treat the recovered solution and there are difficulties in treating large volumes and high concentration due to the pressure drop [4–6,8].

Comparing the technology of ion exchange with others, ion exchange technology has the advantage that it can treat a large volume at once and directly recycle the metals in a plating bath. It can recover over 97% [6,7].

Ion exchange is a phenomenon that is reversibly exchanged between counter ion on bead surface and ion in the solution by the difference of electrostatic force. In the process, cation, such as nickel, copper, sodium etc., is exchanged with hydrogen ion. Also, anion, as sulfates, chromates and chlorides etc., is exchanged with hydroxyl ion [10–13].

This technology has been mainly applied to pharmaceutical purification, water softening processes, separation and purification in the food industry, catalyst and manufacture of ultra-pure water used in semiconductor processes etc. Technology recovering nickel ion-by-ion exchange uses a column that packed beads. At the present, to separate nickel ion, ion exchange resins use cation resins that are able to selectively exchange the nickel ion with hydrogen ion in wastewater. While the solution flows into the column until its capacity is reached to breakthrough point, the resin separates nickel ion from the solution. After adsorbing nickel ion, the resin is regenerated by acid [11–13]. Because the pH of the solution recovered through the column packed with cation is too low to recycle directly in the plating bath, it requires other treatment to be able to use the solution in it. To accomplish this requirement, acid retardation also was used in this study. That is the technology that high concentration acid is adsorbed on the anion resin and metal salts are excluded by passing through the resin. This is a reversible process and acid adsorbed on the resin could be easily regenerated by distilled water [14,15].

This study was carried out to confirm and select operational conditions and ways that need to develop ion exchange system (IXS). It was composed with a nickel recovery unit (NRU) to concentrate the concentration of nickel ion from rinse water as salt and acid retardation unit (ARU) to control the pH of the salt solution to be recycled in the bath. Experiments were conducted on each unit, NRU, ARU, and IXS integrating them in order to build up operational variables as space velocity (SV) of solutions flowing into column, H_2SO_4 concentration and volumes of distilled water used in regeneration of the ARU column.

2. Experiment

Before the experiment was carried out, the resin had to be selected and its characteristic understood. In selecting apt ion exchange resin, although weakly acidic cation and weakly basic anion resins have greater affinity than each strong resin for counter ion, the strong resins were used because they especially have an advantage for pH range.