CHAPTER I

GENERAL INTRODUCTION

Water is a naturally occurring substance existing on the earth as two resources: underground water and surface water. It contains a large quantity and various kinds of essential elements and food which is corresponding to the human particular use, which may involve commercial and industrial uses or recreational pursuits. Water plays an important part in the constitution of living beings; the low percentage of 22 - 34 % for bones and adipose tissue, and 70 - 80 % in the various internal organs, while the highest percentage (82 - 94 %) is reached in nerve tissue. Water constitutes the greater part of foods such that a 78 - 79 % in green vegetables and fruits is water. In case of fish and meat, it contains water around 80 % and 72 %, respectively. Industry uses water as many purposes such as raw material, cleaning agent, solvent, hydraulic and steam production and so on.

Currently, water is in deteriorating conditions. Many industries produce a large volume of wastewater and discharge directly to the environment. Several industries, especially those of metal finishing, plating, inorganic pigment and electronics and so on, discharge waste solution containing heavy metal and toxic substances. The major toxic contaminant found in electroplating wastewater is acid cyanide. Moreover, heavy metals such as chromium (Cr), copper (Cu), nickel (Ni), zinc (Zn) and mercury (Hg), alkaline cleaning agents, degreasing solvents and oil are also found. The wastewater of plating process is discharged from polishing step, degreasing step, acid cleaning step, plating step and rinsing step.

The conventional method for heavy metal removal from wastewater are chemical precipitation, ion - exchange, evaporation, reverse osmosis, adsorption by activated carbon or clay, solvent extraction, cementation, and so on. These methods have either economic or technical limitations regarding to environmental regulations. For example, the most popular process is chemical precipitation. The process is conducted by adding an oxidizing agent such as $NaOCl$ or by adding a reducing agent such as $NaHSO_3$ to reduce the toxicity of substance and then followed by adding a simply lime to form hydroxide precipitation. This process has many drawbacks such as large volume of relatively low density sludge, and chemical contamination in treated water. This sludge has to be disposed of as a controlled waste; however, such performance will be limited in the future. Metal precipitation is limited by its solubility. So, an added chemical substances should be exceed the authorized limits to maintain the high pH condition. This increases the reagent cost and final volume of sludge.

The weaken point of the conventional treatment process is a loss of a few hundred tons of metal per annual and also contributes to environmental problem. The prospect of recovery has attracted an interest among industries for environmental and economic reasons. For example, valuable heavy metals can be recycled and reused while the outlet water is permitted to discharge. During the last 30-50 years, electrolytic removal of heavy metals has been investigated. Unlike the conventional process, the electrochemical process consists of only one step for the direct metal recovery and thus provides great economic benefits. The operating cost of an electrochemical process is cheaper than that of a conventional process due to a power consumption. In addition, no or little volume of sludge is produced during an electrochemical process compared with a conventional process. The strong advantage of electrochemical process is no chemical contamination in a treated water.

All of the above advantages of electrochemical technique strongly attract to apply this technique to recover heavy metals consisted of copper (Cu), chromium (Cr) and nickel (Ni) from electroplating effluent. Firstly, as a fundamental study, this technique is applied to a synthetic solution containing one heavy metal in order to investigate the possibility of metal recovery and to use as a guideline for choosing the suitable method. Then, an optimum condition found from the fundamental study is employed for an industrial electroplating effluent. Objectives of this work are:

- To study the characteristics and mechanisms of heavy metal separation by electrochemical technique including electrodeposition and electroprecipitation methods,
- To determine optimum conditions for copper, chromium and nickel recovery from a synthetic solution and an industrial electroplating effluent, and ;
- To develop a mathematical model and dimensionless number of copper recovery and to develop a pH evolution model for chromium and nickel recovery in a cathodic compartment.

This report is composed of six chapters. The first chapter is general introduction. The second chapter deals with electrochemical theory such as oxidation - reduction process, electrochemical thermodynamic, electrode polarization, overpotential, mass transport in electrochemical system, and conventional processes with their advantages and disadvantages. Moreover, procedures of metal recovery by using an electrochemical technique using classical reactor and modified reactors are described. Material balance of an electrochemical reactor is also mentioned. The status of pollutant activities in Thailand, and previous metal recovery by electrochemical technique performed by other researchers has been discussed as well.

The third chapter presents the experimental set up used to determination of polarization curves in this work. A polarization curve of metals is used to test a possibility of metal removal and to define a working potential range. The description of studied solutions, chemical substances and operating conditions are depicted. The last part shows the results of polarization curve of heavy metals using potentiostat and microbalance techniques.

The results of copper recovery from a synthetic solution by using an electrodeposition technique conducted in both classical reactor and modified reactor are discussed in the fourth chapter. An optimum condition which corresponds to the optimum current density and optimum operating cost of copper recovery is determined. A mathematical model used to predict a mass transfer coefficient in the system is developed in terms of dimensionless number.

The fifth chapter interprets the results of chromium and nickel recovery from a synthetic solution by using an electroprecipitation technique in a classical reactor with membrane. Three models with different assumptions are developed to predict a pH evolution in a cathodic compartment.

The last chapter presents the metal recovery from a mixed metal solution. Experiments with synthetic solutions are firstly performed based on the optimum condition obtained from a synthetic solution containing a single metal. After that, experiments are applied to treat wastewater from a plating industrial plant. The results of metal recovery from this effluent solution differ from that obtained from synthetic solution.