INVESTIGATION ON THE BEHAVIOR OF WASTEWATER FROM INDUSTRIAL COOLING WATER SYSTEMS

AATIQ AFTINI BINTI AB RAHMAN

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I declare that this thesis entitled "*Investigation on the Behavior of Wastewater from Industrial Cooling Water Systems*" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ………………………………

Name : Aatiq Aftini Binti Ab Rahman

Date : ……………………………….

To my beloved family:

En Ab Rahman Bin Che Ahmad

Pn Jamaliah Binti Mohd Salleh

Khairul Ikhwan Bin Ab Rahman

Syukrina Binti Abdullah

Khairul Farihin Bin Ab Rahman

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ABSTRACT

Industrial wastewater is discharged from industries and associated processes utilizing water. Industrial water cooling systems generated large amount wastewater. Industrial water cooling systems produce waste such as silt, heat, biocide and slimes. The problems need to be controlled or eliminated are at interferes with heat, commonly referred to as deposits and deterioration of the water-contacted equipment, referred to as corrosion. Therefore, this research is carried out to overcome this problem by determine the behavior of wastewater from industrial water cooling systems and determine the influence of concentration of Acid Hydrochloric in water cooling systems during Passivation process. The parameters considered based on APHA method in Standard Methods for Examination of Water and Wastewater (2005) are including Chemical Oxygen Demand (COD), Total Organic Carbon (TOC), pH, Turbidity, Heavy Metals (Iron, Lead, Copper, Nitrate and Nickel). The study of behavior of wastewater from industrial water cooling systems will be taken place at behind the block W, Universiti Malaysia Pahang, Campus Gambang, Pahang Darul Makmur. The results show that all parameters except lead are recorded to be over than standard that have been use for comparison purpose such as the highest concentration of iron recorded that 3012 mg/L but the standard is 5 mg/L. As a conclusion, this effluent need proper treatment before been discharge because majority of parameters over than standard propose. According to study of concentration of Acid Hydrochloric (HCl) can affect the efficiency of passivation for Carbon Steel pipe. For concentration HCl 2 %, passivator needs to increase from 0.1% to 1.0% and pH also not exceed to alkali conditions or not in range 10-12 for effective passivation.

ABSTRAK

Air buangan industri adalah daripada industri-industri dan proses-proses tertentu yang menggunakan air. Sistem-sistem pendingin air perindustrian air buangan jumlah besar dijanakan. Sistem-sistem pendingin air perindustrian menghasilkan sisa-sisa seperti kelodak, haba, biosid dan lendir. Masalah-masalah itu hendaklah dikawal atau disingkirkan adalah pada campur tangan dengan haba, biasanya dirujuk sebagai deposit dan kemerosotan air dihubungi peralatan, dirujuk sebagai kakisan. Oleh itu, penyelidikan ini dijalankan bagi mengatasi masalah ini dengan menentukan tingkah laku air buangan itu daripada sistem-sistem pendingin air perindustrian dan menentukan pengaruh tumpuan Acid Hydrochloric dalam sistem-sistem pendingin air semasa proses Pempasifan. Parameter itu mengikut kaedah APHA dalam Standard Methods for Examination of Water and Wastewater (2005) adalah termasuk Keperluan Oksigen Kimia (COD), Jumlah Karbon Organic (TOC), pH, Kejernihan, Logam Berat (Besi, Plumbum, Tembaga, Nitrat dan Nikel). Kajian tingkah laku itu air buangan daripada sistem-sistem pendingin air perindustrian akan menjadi berlaku pada di belakang blok W, Universiti Malaysia Pahang, Campus Gambang, Pahang Darul Makmur. Keputusan-keputusan itu menunjukkan semua parameter kecuali plumbum direkodkan melebihi daripada standard yang telah menggunakan untuk tujuan perbandingan seperti kepekatan tertinggi besi itu direkodkan yang 3012 mg/L tetapi standard adalah 5 mg/L. Seperti satu keputusan, keperluan pengaliran keluar ini rawatan sesuai sebelum pernah melaksanakan kerana majoriti parameter mengenai daripada standard mencadangkan. Mengikut kajian Acid Hydrochloric (HCl) boleh menjejaskan kecekapan pempasifan untuk paip Keluli Karbon. Untuk kepekatan HCl 2 %, pempasif perlu ditingkatkan daripada 0.1% kapada 1.0% dan pH juga tidak mengikuti syarat alkali atau bukan dalam julat 10-12 untuk pempasifan yang berkesan.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

APHA	American Public Health Association
Ni	Nickel
Al	Aluminium
Cu	Copper
Cr	Cromium
mm	Millimeter
mg/L	Milligram per liter
m/s	Meter per second
m	Meter
^{o}C	Degree of celcius
kg	Kilogram
%	Percentage
pH	Alkalinity and acidity
H^+	Hydrogen ion concentration
et al	With friends
‹	Lower than

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Since the Second World War, rapid development has improved the standard of living and quality of life for millions of peoples the world over. This growth has come at the cost of a thirty-fold increase in the use of fossil fuels and a fifty-fold increase in industrial production over the past century. As a result, significant amounts of once freely available natural resources have been consumed by industry, leaving the earth depleted for future generations. Much of the waste produced from these activities is directly discharged into natural water bodies. In developed countries, industry is the biggest consumer of water and accounts for 50% to 80% of total demand. This is far more than the 10% to 30% in developing countries where agriculture is the largest consumer. However, industrial water use is certain to increase over the next decade. In many countries, the high rates of consumption in the last decade have exceeded capacity to replenish dwindling water sources and put excessive pressure on existing resources driving up the cost of raw water for industrial applications (Visvanathan, 2001).

Industrial wastewater is discharged from industries and associated processes utilizing water. Industrial water users in the United States discharge over 285 billion gal of wastewater daily (Corbitt, 1990). Water is used in industrial cooling, product washing and transport, product generation, and other purposes. Although variable between industries and plants within the same industry, about two-thirds of the total wastewater generated from U.S. industries results from cooling operations (Corbitt, 1990).

Industrial water cooling systems produce waste such as silt, heat, biocide and slimes. These chemicals can damage aquatic life as they are carried downstream. Furthermore, the added chemicals can warm the river, which decreases the amount of oxygen that the fish need to live. Water pollution will cause the water shortage and affect the quality of the supplied water. Once the water is polluted, people will face the water shortage problem. When the water is polluted, it will affect the water supply. Reservoir collects the water from rivers, once the river is polluted, the water quality in reservoir will be low. Water Quality Monitoring is an important aspect of water quality management. It helps in identification of the areas in need of restoration, extent of pollution control required, effectiveness of pollution control efforts and water quality trend over a period of time (Prevention and Control of Pollution Act,1974).

Industrialist need to manage wastewater from cooling water systems properly by practice corrosion monitoring, prevention, and control in underground piping and tank bottoms so wastewater from water cooling systems can be recycle and, where cost-effective, treated wastewater. Implementation of pollution prevention measures can yield both economic and environmental benefits. However, a balance on energy usage and environmental impacts may have to be struck. The values relate to the production processes before the addition of pollution control measures.

1.2 Problem statement

Industrial water cooling systems generated large amount wastewater. Industrial water cooling systems produce waste such as silt, heat, biocide and slimes. The problems need to be controlled or eliminated are at interferes with heat transfer (or in cooling towers, heat rejection), commonly referred to as deposits and deterioration of the water-contacted equipment, referred to as corrosion.

Corrosion of metals in cooling and boiler water systems occurs in differing forms depending on the condition of the water, temperature, flow rate, etc. This is a special type of crevice corrosion where the crevice or space is caused by a deposit on the metal surface. Scale, corrosion products or a variety of other debris can cause deposits under which accelerated corrosion occurs. After deposits are formed, it is difficult to stop underdeposit corrosion, because the deposits make it difficult to get corrosion inhibitors to the metal surface suffering the high corrosion rates.Another form of underdeposit corrosion common in open recirculating cooling systems is caused by the attachment of biomasses to metal surfaces. The biomass produces by-products that are corrosive to most metals and are held next to the metal surface by the biomass.

Therefore, this research is carried out to overcome this problem by determine the behavior of wastewater from industrial water cooling systems and to determine the influence of concentration of acid hydrochloric in water cooling systems during passivation process.

1.3 Objectives of the Study

The objectives of the study are:

i. To determine the behavior of wastewater from industrial water cooling systems.
ii. To determine the influence of concentration of Acid Hydrochloric in water cooling systems during Passivation process.

1.4 Scope of Study

The scopes of the study to ahieve the objectives are:

i. Samples are taken from Gebeng Industrial.

ii. Parameters that suitable for laboratory analysis are Chemical Oxygen Demand (COD), Total Organic Carbon (TOC), pH, Turbidity, Iron, Lead, Copper, Nitrate and Nickel.

iii. Consist of in-situ measurement during water sampling as well as laboratory testing. The parameter involve in in-situ measurement is pH while the other parameters such as COD, TOC, Turbidity, Iron, Lead, Copper, Nitrate and Nickel will be tested in the lab.

1.5 Significant of Study

The study will serve at the good application of environmental studies which is theories into practical by giving the opportunity for the student to conduct site investigation and to carry out laboratory testing for the analysis of the wastewater of industrial water cooling systems. The student will able to develope knowledge and skill from doing investigation of capability of pipes. Understandings about effectiveness of monitor properly for the life expectancy and/or the operating efficiency of the water cooling systems. Critical thinking of how to solving problem can be develope from this study. The industrialist also can gain unique benefits to manage piping systems in cooling water systems properly with minimum cost and avoid potential of environmental issues.

CHAPTER 2

LITERATURE REVIEW

2.1 Industrial Wastewater

Industrial wastewater is discharged from industries and associated processes utilizing water. Industrial water users in the United States discharge over 285 billion gal of wastewater daily (Corbitt 1990). Water is used in industrial cooling, product washing and transport, product generation, and other purposes. Although variable between industries and plants within the same industry, about two-thirds of the total wastewater generated from U.S. industries results from cooling operations (Corbitt 1990).

2.1.1 Wastewater Characteristics

Wastewater quality can be defined by physical, chemical, and biological characteristics. Physical parameters include color, odor, temperature, solids (residues), turbidity, oil, and grease. Solids can be further classified into suspended and dissolved solids (size and settleability) as well as organic (volatile) and inorganic (fixed) fractions. Chemical parameters associated with the organic content of wastewater include the biochemical oxygen demand (BOD), chemical oxygen demand (COD), total organic carbon (TOC), and total oxygen demand (TOD). BOD is a measure of the organics present in the water, determined by measuring the oxygen necessary to biostabilize the organics (the oxygen equivalent of the biodegradable organics present).

Inorganic chemical parameters include salinity, hardness, pH, acidity, alkalinity, iron, manganese, chlorides, sulfates, sulfides, heavy metals (mercury, lead, chromium, copper, and zinc), nitrogen (organic, ammonia, nitrite, and nitrate), and phosphorus. Bacteriological parameters include coliforms, fecal coliforms, specific pathogens, and viruses (Canter, 1999).

Table 2.1 Parameters Addressed In Discharge Standards for Selected Industrial Wastewaters (Corbitt, 1990)

Industry	Parameter								
	COD	TOC	Heavy Metal	Copper	Nickel	Iron	Lead	Nitrate	Turbidity
Automobile	x				x	x	x	x	
Beverage									x
Canning	x	x							
Fertilizer	x					x		x	
Inorganic Chemical	x					x			
Organic Chemical	x	x	x					x	
Meat Products	x								x
Metal Finishing	x		x						
Plastics & Synthetics	x							x	
Pulp & Paper	x	x	x					x	x
Petroleum Refining	x	x		x		x		x	x
Steel						x	x		
Textiles	x		x						
Dairy	x	x						x	x

Table 2.2 Physical and Chemical Characteristics of Wastewater and Their Sources (Metcalf and Eddy, Inc., 1991)

Characteristic	***Sources***
Physical Properties	
• Color	• Domestic and industrial wastes and natural decay of organic materials
• Odor	• Decomposing wastewater and industrial wastes
• Solids	• Domestic water supply, domestic and industrial wastes, soil erosion, and inflow/infiltration
• Temperature	• Domestic and industrial wastes
Chemical Constituents	
ORGANIC	
• Carbohydrates	• Domestic, commercial, and industrial wastes
• Fats, oils, and grease	• Domestic, commercial, and industrial wastes
• Pesticides	• Agricultural wastes
• Phenols	• Industrial wastes
• Proteins	• Domestic, commercial, and industrial wastes
• Priority pollutants	• Domestic, commercial, and industrial wastes
• Surfactants	• Domestic, commercial, and industrial wastes
• VOCs	• Domestic, commercial, and industrial wastes
• Other	• Natural decay of organic materials
INORGANIC	
• Alkalinity	• Domestic wastes, domestic water supply, and groundwater infiltration
• Chlorides	• Domestic wastes, domestic water supply, and groundwater infiltration
• Heavy metals	• Industrial wastes
• Nitrogen	• Domestic and agricultural wastes
• pH	• Domestic, commercial, and industrial wastes
• Phosphorus	• Domestic, commercial, and industrial wastes and natural runoff
• Priority pollutants	• Domestic, commercial, and industrial wastes
• Sulfur	• Domestic water supply and domestic, commercial, and industrial wastes

2.1.2 Water Quality

Water quality is the physical, chemical and biological characteristics of water in relationship to a set of standards. In the United States, Water Quality Standards are created by state agencies for different types of water bodies and water body locations per desired uses (Clean Water Act, 1987). United States Environmental Protection Agency stated that in the setting of standards, agencies make political and technical or scientific decisions about how the water will be used.

2.1.2.1 Measurement of Water Quality

The complexity of water quality as a subject is reflected in the many types of measurements of water quality indicators. Some of the simple measurements can be made on-site (temperature, pH, dissolved oxygen, conductivity) or in direct contact with the water source in question. More complex measurements that must be made in a lab setting require a water sample to be collected, preserved the water sample, and analyzed the water sample at another location such as laboratory.

2.2 Piping Systems

A piping system is a set of components including pipe, pipe fittings, flanges, bolting, gaskets, relief devices, and the pressure-retaining parts included in any stress analysis. It also includes the hangers, supports, and other equipment necessary to prevent overstressing of the pressure-retaining parts. It does not include the structure and equipment and foundations, except as they may affect the stress analysis (Ellenberger, 2005)

2.2.1 Piping Materials

There are many factors to consider in choosing piping materials. They are including such things as availability, type of service, and fluid (Ellenberger 2005).There is an extremely wide range of pipeline materials available. These are selected on various criteria the two most important of which are suitability for service and cost. The suitability for service is determined primarily on the materials resistance to attack by the fluid being transferred and the external environment. The internal corrosion resistance is more important than the external resistance. It is easier to protect and monitor and repair the external surfaces. Also the environment generally provides a less arduous regime. A typical range of fluids with suitable pipeline materials is listed in Table 2.3 below (Roymech, 2008).

Table 2.3: Typical range of fluids with suitable pipeline materials (Roymech, 2008)

Fluid	Pipe line material
Process Air	Carbon Steel, Copper, Plastic
Potable Water	Carbon Steel, Copper, Plastic
Low Pressure Sat.Steam	Carbon Steel, Copper
High Pressure Dry Steam	Carbon Steel,
Demineralised Water	304 Stainless Steel,
Seawater	304 or 316 St.steels, Aluminium Bronzes, Copper nickel alloys, Nickel alloys, Superduplex, 6% or 7% Mo St. steels, Duplex steels, Titanium
Nitric Acid	304 Stainless Steel
Nitrogen,	Carbon Steel,
Argon	Carbon Steel,
Instrument Air	Carbon Steel,