INVESTIGATION OF MINIMUM WATER CONSUMPTION AT PCB MANUFACTURING INDUSTRY USING WATER PINCH METHODOLOGY

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Projek Sarjana Muda II

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DECLARATION

I declare that this project report entitled "Investigation On Structural Vibration Problem At MARS Building UTeM" is the result of my own work except as cited in the references

Signature	:	....
Name	:	....
Date	:	....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Structure & Materials).

Signature :. ....

Name of Supervisor : ....

Date : ....

DEDICATION

To my beloved mother and father.To my beloved brothers and sisters
To my beloved fiancé.

ABSTRACT

The increasing industrial water consumption is one of the main contributors to the global warming phenomena. The purpose of this project is to investigate the minimum water consumption at a printed circuit board plant using the water pinch methodology. This project starts with carrying an inspection on site to identify the important sampling points for data extraction then it continues to implementing the data into three different water pinch methods and then choosing the most feasible option in order to achieve the minimum water requirements for the plant. After applying the water pinch methodology on the PCB plant case study, it was found that the WCA & SDCC methods have managed to achieve a significant reduction in the plant water requirements with 43.42% and 51.77% respectively, while the WSD have only made a 10.98% reduction. After a critical comparison based on the amount of reduction, processing times and accuracy, the WCA was chosen as the best method for the PCB plant case study. The implementation of such methods will ultimately lead to less power consumed on water treatment plants, thus less gas emissions. The water pinch analysis is a viable option to the industry environmentally and economically.

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WPA	Water Pinch Analysis
WCT	Water cascade table
TDS	Total Dissolved Solids
COD	Chemical Oxygen Demand
BOD	Biological Oxygen Demand
WCA	Water Cascade Analysis
WSC	Water Surplus Diagram
PCB	Printed Circuit Board
WPM	Water Pinch Methodology

LIST OF SYMBOL

Fj	=	Water flow rate
Dj	=	Demand
Cj	=	Concentration
ΔP	=	Purity difference
F_D	=	Demand flow rate
N_D	=	Number of demand interval
N_S	=	Number of source interval
F_S	=	Source flow rate
F_C	=	Demand plus source flow rate
F_{ww}	=	Wastewater flow rate
F_{FW}	=	Fresh water flow rate

CHAPTER 1

INTRODUCTION

1.1 Background

There is an enormous increase in water demand globally each year due to the continuous industrial revolution and increase in world population. Water demand for manufacturing processes varies significantly form industry to industry. A rough estimation reported by (Alva-Argaez et al) stated that chemical manufacturing consumes between 4.5-45 liters per kg of product. The wastewater delivered from the chemical production processes contains toxic or hazardous pollutants that must be controlled strictly.

Wastewater is usually treated before discharge into the environment in most of the management scheme in order to reduce contamination to a certain limit that meets the environmental regulations. Since water treatment processes are highly expensive, there is a major economic and environmental value in minimizing wastewater generation as well as fresh water consumption. However, an adequate wastewater management represented by concentrating on processes that produce wastewater in industries, recycling, ensuring proper process- to –process fresh water utilization, regeneration and reuse methodologies, is proved to reduce wastewater generation in a variety types of industry (Khezri, S. M., 2010).

The increasing number of new consumers in housing estates and industry costs billions of dollars to expand the water networks. Since the industrial sector is experiencing a rapid increasing in tariffs, water conservation techniques have become a necessity. Industrial water use in developed countries is reported to be getting less each year as a result of better efficiency in reuse, use and recycling. Wales and England for example have fallen by 900 million m^3 in their use for industrial water since 1998 (Graham, 2001).

Industrial use of water contributes in a big measures to the global warming phenomena. For instance, the entire expensive process of wastewater and drinking water treatment in America requires a huge a mounts of energy from fossil fuels which releases around 116 billion pounds of carbon dioxide annually, which is equivalent to the global warming pollution produced by 10 million cars (EPA, 2008).

In our case study on a PCB manufacturing plant. It was found that the plant is consuming a huge amount of water and equally generate a huge volume of wastewater. The company have to pay for the cost of water as a raw resource then again the same cost for its disposal as an effluent. This water is mostly used in rinsing boards in different stages of the process. Furthermore, PCB manufacturers are facing a great pressure from governments to reduce water use and effluent generation by implementing new technologies and regimes.

In this project we are going to use the Water Pinch Analysis (WPA) which is a systematic technique for analyzing water networks and reducing water costs .This technique have helped many companies in minimizing their wastewater and fresh water volumes in a systematic way. Advanced algorithms are used to identify and create the best water regeneration, reuse, and effluent treatment opportunities (Dakwala, M., 2011). Hence the aim of this project is to investigate the minimum fresh water consumption in a PCB plant in order to decrease the air pollution rates and the expenses of water treatment.

Figure 1.1: Printed circuit board washing machines (Sundin et al., 2009)

1.2 Problem Statement

The increase of carbon dioxide emissions to the atmosphere is globally arising environmental issue. Carbon dioxide emissions into the atmosphere are mainly generated by fuel consumption, electricity consumption, water consumption, solid waste generation and waste water generation and. The carbon dioxide emission rate have been increasing dramatically through the past few decades due to the industrial revolution and its resulting the global warming phenomena to emerge and become more evident. The increasing industrial water consumption is one of the main contributors to this phenomena. In this investigation study it is a vital option to optimize the fresh water consumption at the PCB plant in order to limit the rates of carbon dioxide emissions which will help in reducing the effects of the global warming.

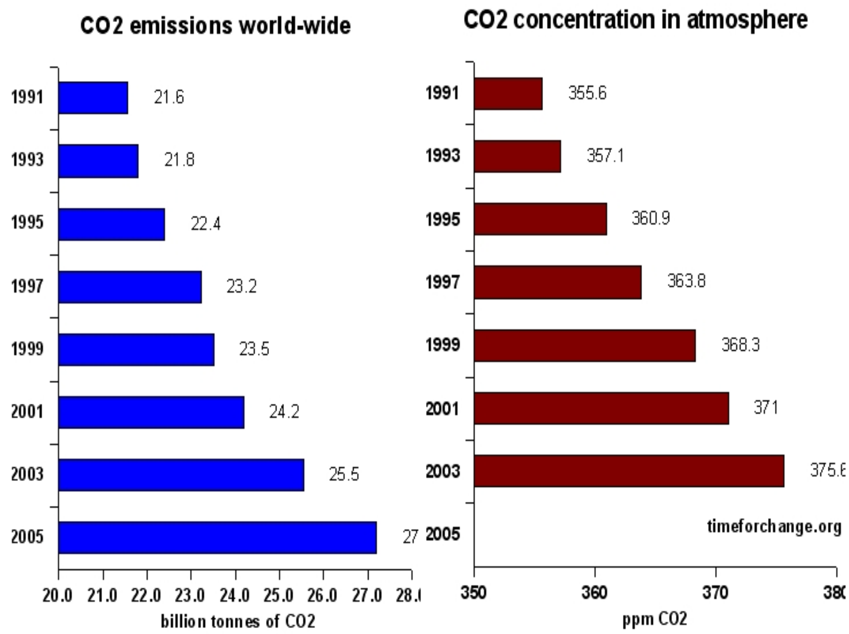

Figure 1.2: CO2 emissions and concentration rates

1.3 Objective

The main aim of this project is to investigate the minimum water consumption at a PCB plant by using Water Pinch Methodology.

1.4 Scope of Project

The scopes of this project are:

1. Determine the water consumption loading over a period of time.
2. Targeting minimum water requirements using water pinch methodology.
3. Suggest the best option to reduce water consumption at the PCB plant.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction:

The current drive toward environmental sustainability and the rising costs of fresh water and effluent treatment have encouraged the process industry to find new ways to reduce freshwater consumption and wastewater generation. This chapter will be reviewing the previous studies that are related to the minimization of water consumption in the industrial sector using the pinch methodology. However, before going into the details about water pinch methodology we must first clarify and explain the destructive side effect of industrial effluents on the environment and their contribution to the global warming phenomena.

2.2 Industrial Effluents, Water Scarcity & Global Warming:

Industrial fresh water consumption contributes in a great measures to the global warming because of the huge amount of energy required for water treatment before and after use. Furthermore, the new challenges and regulations of water treatment have elevated the reliance on advanced treatment systems which consumes even more energy than the conventional technologies. However, that contributes to a regrettable link between climate change and improved water quality. Potable water systems (kWh/gal) will be increased in their energy intensity due to the increased use of advance water treatment processes. Greenhouse gases caused by fresh water consumption must be assessed to reduce their impact on the global warming which threatens the earth fresh water resources to disappear by time. However, there are many strategies that have been developed including water pinch analysis to reduce the effect of water using industries to the environment (Karl, Thomas R, 2003).

Global warming affects water sources in three general ways (Bates, B.C, 2008):

1. Changes in annual rainfall: the frequency and intensity of rain changes due to the global temperatures rise.

2. Sea levels rise: melting of the polar ice caps, resulting in a rise in sea levels

3. Decreased raw water quality: Higher temperatures can introduce toxins, poor taste, and odour compounds into water sources.

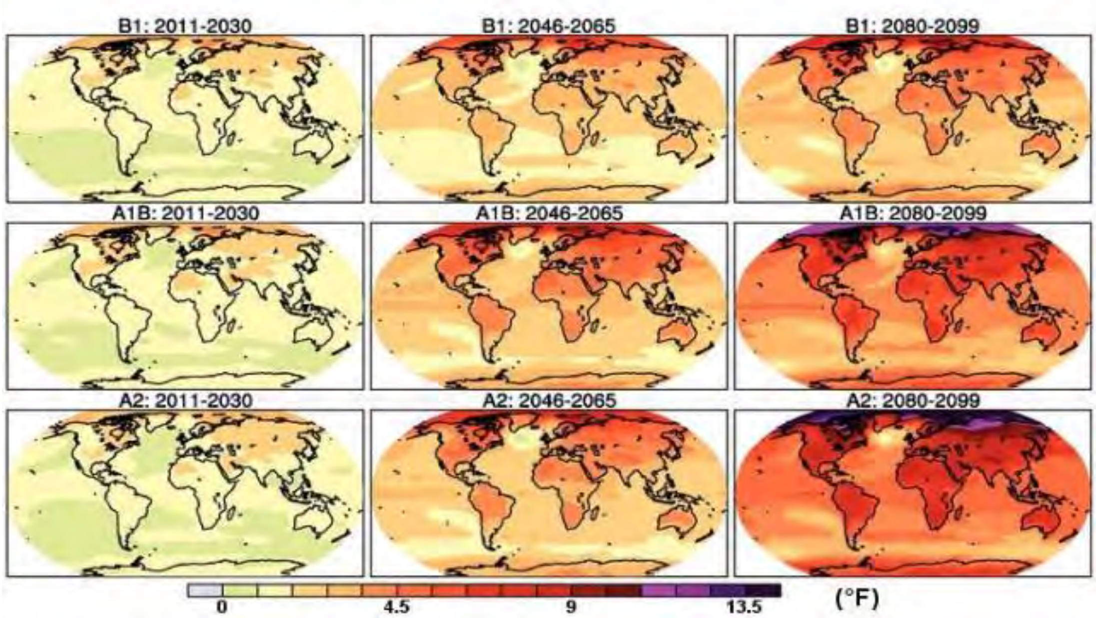

Figure 2.1: The expected increase of temperature until 2099 due to global warming

2.3 Water Pinch Analysis (WPA)

WPA is a systematic technique that is widely used to minimize the generation of wastewater and consumption of fresh water by implementing a certain activities or processes. It was first found by Wang and Smith (Tripathi, Paul, 1996). Since then, it has been globally used as a tool for water conservation in industrial process plants.

In action, the analysis starts by considering the water requirements, in terms of quantity and quality in every process done in the system, also these have to be established in advance. Quality means the concentration of critical contaminants, and the impact of each process on the water it utilizes is defined by the amount of contaminant that is transferred to the water when it passes through it. After defining the water requirements pinch technology determines the pinch point that decides the minimum water flow rate needed for the plant and by that it sets the target for minimizing water consumption (Wan & Smith. 1994). The simple strategy to minimize water consumption is to employ the outlet water from one process to satisfy the water demand of another, or even the same process (Wan & Smith. 1994). Pinch technology introduce better understanding of process requirements and thus helps building the internal recycles (Xiao Feng, Jie Bai. 1994). Internal recycles may need some treatment or no treatment at all, to make them good for reuse (Castro, Matos. 1999).

2.4 WPA Techniques

In this section we are going to make an overview to introduce two different WPA techniques which are going to be used in this project. These techniques have been developed by different researchers aiming to create useful and easy tools for minimizing wastewater discharge in the industries. The following is a brief review about each technique:

2.4.1 Water Cascade Analysis (WCA) – (Yin Lin Tan, 2002):

This technique is based on the water cascade table and it is utilized for continuous processes. Water cascade table (WCT) is developed first from the data collected. In this technique, contaminants transfer has no limitations, also there is no trail & error solutions required in estimating minimum targets for fresh water. Water losses operations with several outlets and inlets can be considered with this technique. Water surplus represents the source ($F_{S,f}$) with positive sign while water demand ($F_{D,f}$) represent the deficit with a negative sign and (F_C) is the net of both . The letter C_n represents the total dissolved solids in ppm unit.

In case that Pinch point was not achieved by a direct WCT, we first construct WCA in order to find the minimum fresh water requirement by following these steps (Z.A. Manan et al.2006):

a- Construct a water cascade diagram and assume a 0 kg/s fresh water flow rate.
b- Start a pure cascade analysis to examine the feasibility of the water cascade
c- Start an interval fresh water demand to find out the amount of fresh water required at each purity level

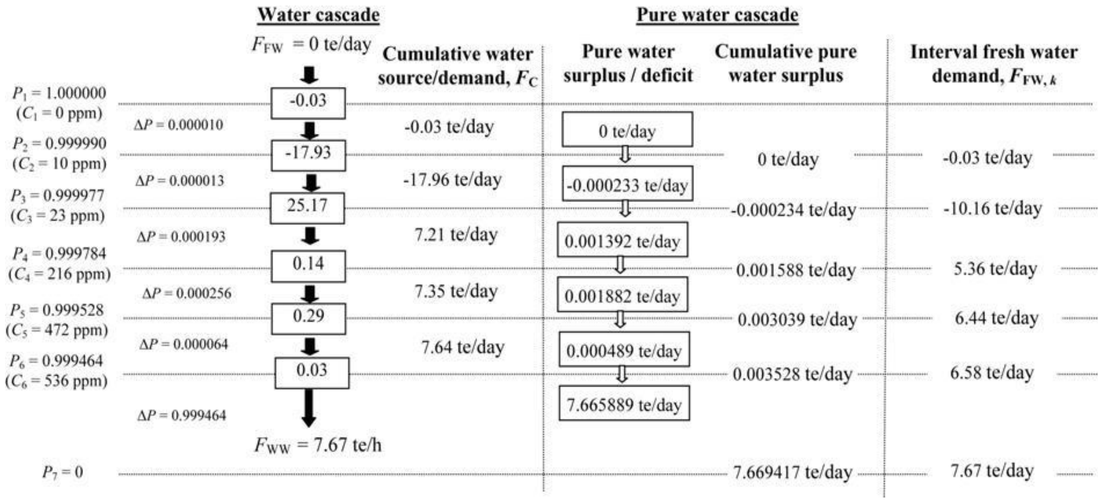

Figure 2.2: Example of a typical WCA including (a,b,c)

After constructing the WCA minimum fresh water demand (-). It is added to the first constructed WCT as a starting point. By doing that the pinch point will be created at a certain column represented by zero which is the most strained point of the network that holds maximum possible recovery.

Table2.1: Example of a typical WCT with pinch point

Interval n	Conc. C_n (ppm)	Purity, P_n	$\sum F_D$ (te/d)	$\sum F_S$ (te/d)	$\sum F_{D+S}$ (te/d)	F_C, (te/d)	Pure water surplus (te/d)	Cumulative pure water surplus (te/d)
						F_{FW} =10.16		
	0	1.000000	-0.03		-0.03			
1						10.13	0.000101	
	10	0.999990	-29.07	11.14	-17.93			0.000101
2						-7.80	-0.000101	
	23	0.999977		25.17	25.17			**0 (pinch)**
3						17.37	0.003353	
	216	0.999784		0.14	0.14			0.003353
4						17.51	0.004484	
	472	0.999528		0.29	0.29			0.007837
5						17.80	0.001139	
	536	0.999464		0.03	0.03			0.008976
6						**F_{WW} =17.83**	17.824789	
	1,000,000	0						17.833765

2.4.2 Water Surplus Diagram (WSD) – (Hallale *et al*, 2002):

In this technique a composite curve for water sources and demands is drawn based on the data collected from the site. In this curve water surplus and deficit are shown at different purity levels. Water surplus represents the source with positive sign while water demand represent the deficit with a negative sign.

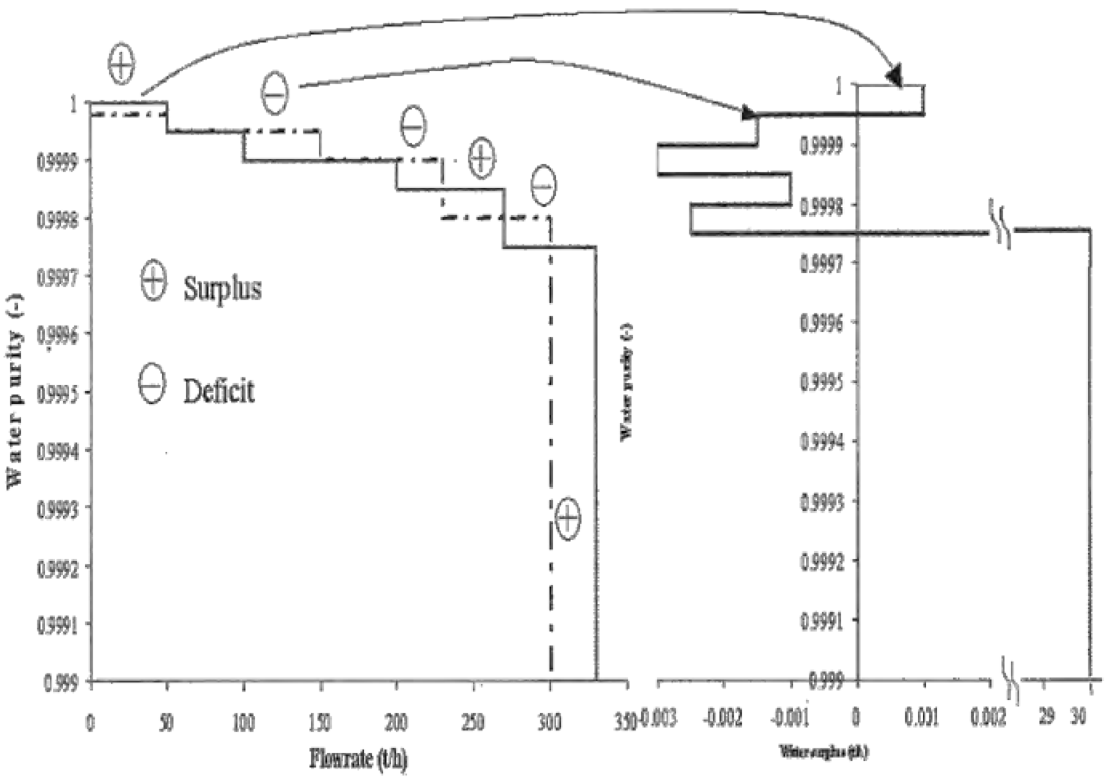

Figure 2.3: example- water composite curve by (Hallale *et al*, 2002)

After the fresh water flow-rate suggested is examined by making a feasibility test, the water surplus diagram is drawn. From Figure 2.4-a , fresh water should be added to reach the pinch point since there is a part of the diagram placed at the negative region based on the suggested fresh water flow rate.

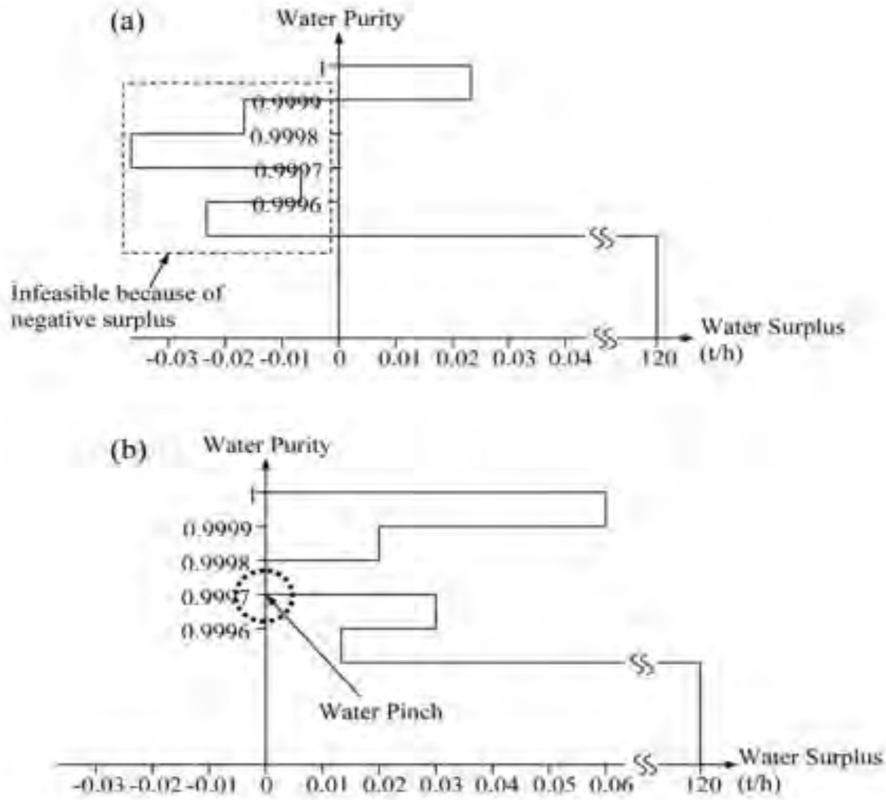

Figure 2.4: Example- (a) WSD shows insufficient pure water in the network.(b) Fresh water flow rate is increased until the pinch point.

2.4.3 Source and Demand Composite Curve (El-Halwagi, 2006).

This method is used to locate the minimum water flow rate targets. For water network with two contaminants, the source/sink composite curves are created by superimposing the arrows in ascending order by connecting to the lower concentration of contaminant. The arrangement of sources and sinks in the composite curves depends on the information obtained from the first step.

It must be pointed out that this method is based on a contaminant concentration curve versus mass load.