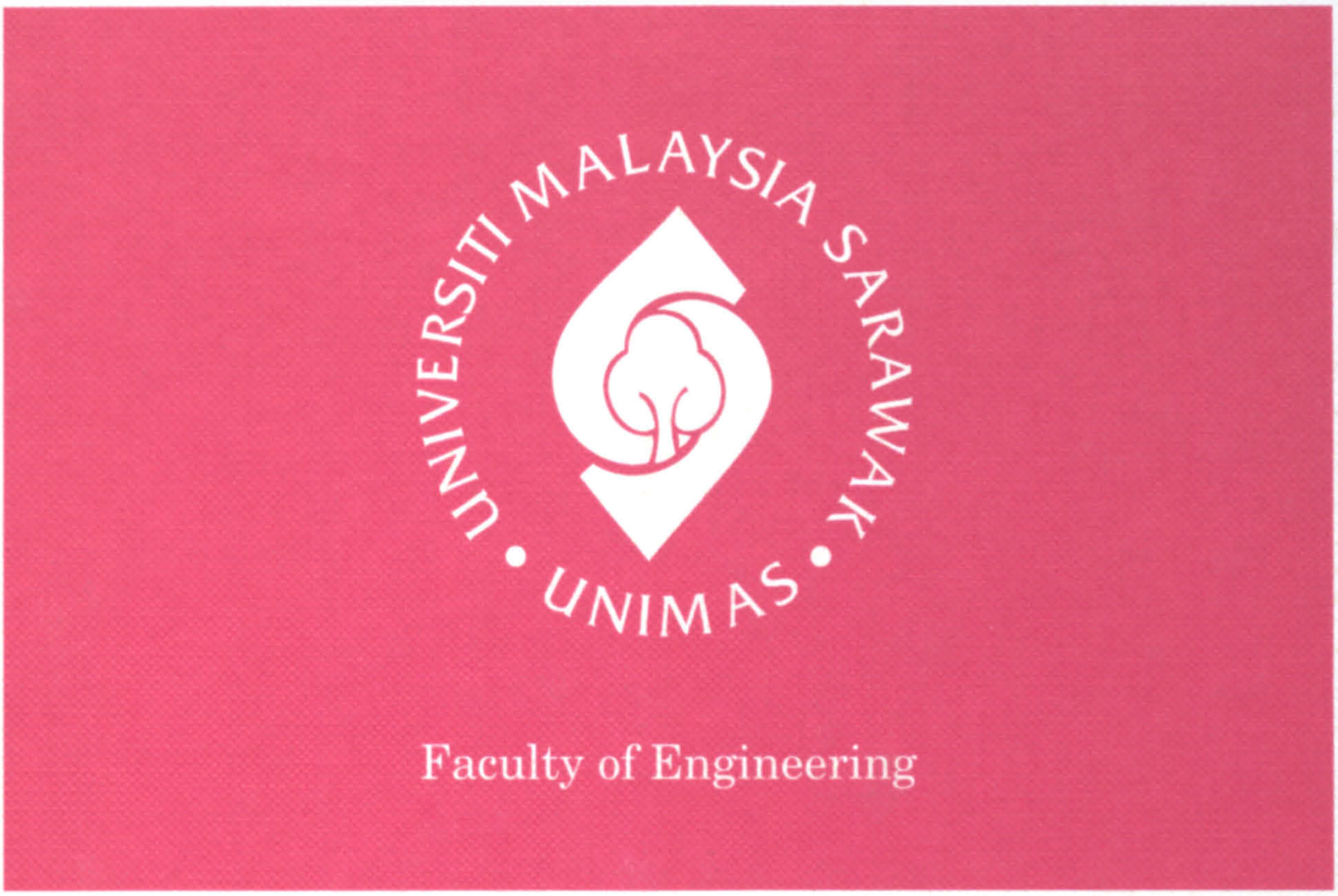

RESOURCE OPTIMISATION AND WASTE REDUCTION

Winsell Anak Juim

Bachelor of Engineering with Honours
(Mechanical Engineering and Manufacturing Systems)
2004

Universiti Malaysia Sarawak

BORANG PENYERAHAN LAPORAN PROJEK TAHUN AKHIR

Judul: RESOURCE OPTIMISATION AND WASTE REDUCTION

SESI PENGAJIAN: 2003/2004

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APPROVAL SHEET

This project entitled "Resource Optimisation and Waste Reduction" was prepared by Winsell anak Juim as partial fulfilment of the requirement for degree of Bachelor of Engineering with Honours in Mechanical Engineering and Manufacturing Systems is hereby read and approved by:

Pn. Shanti Faridah Salleh

(Supervisor)

Date: 14/4/04

RESOURCE OPTIMISATION AND WASTE REDUCTION

WINSELL ANAK JUIM

This project is submitted in partial fulfilment of
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ACKNOWLEDGEMENT

The author would like to thank Pn. Shanti Faridah Salleh for her guidance, patience and support which have helped a lot in making this project to be completed. Many thanks are also given to the staff of 1st Silicon, Kuching especially Mr. Max Lee Jun Ning and Mr. Roland Ulin for their generous assistance and cooperation. Finally, thanks to the author's family and friends for their support.

ABSTRACT

Resource optimisation and waste reduction are among important aspects that ought to be considered to increase productivity and profitability. Optimisation method comes in many different ways causing difficulties for company to choose a suitable approach to be implemented while taking into account the environmental effect of the chosen method. When a company has decided that the resource to be optimised is energy or heat, among the approaches that is found to be practical is Pinch Analysis. Thus, this project applies Pinch Analysis to do a heat optimisation on a local plant, namely 1st Silicon (Malaysia) Sdn. Bhd. Pinch Analysis is done on that system using available data extracted from the system flow sheet of the Utility Department (1st Silicon). Heat can be properly optimised to its maximum level using this method. Thus, giving out result of a suggested Heat Exchanger Network that are supposed to be better than the existing system in term of heat recovery although has not really been proven best in term of economic.

ABSTRAK

Optimisasi bahan dan pengurangan buangan adalah antara aspek-aspek penting yang dipertimbangkan untuk meningkatkan produktiviti dan keuntungan. Kaedah optimisasi wujud dalam pelbagai cara yang menyebabkan kesukaran bagi industri untuk memilih pendekatan yang sesuai dengan mengambil kira kesan kaedah itu terhadap alam sekitar. Apabila sesebuah industri telah menetapkan bahawa sumber yang hendak dioptimumkan adalah tenaga atau haba, antara pendekatan yang didapati praktikal ialah Analisa "Pinch". Oleh itu, projek ini menggunakan Analisa "Pinch" untuk mengoptimumkan haba di kilang tempatan, iaitu 1st Silicon (Malaysia) Sdn. Bhd.. Analisa "Pinch" dijalankan terhadap sistem tersebut dengan menggunakan data yang diambil dari rajah aliran sistem Bahagian Utiliti (1st Silicon). Haba dapat dioptimumkan ke tahap maksima dengan menggunakan kaedah ini. Dengan itu, projek ini telah menghasilkan cadangan bagi Rangkaian Penukar Haba yang sepatutnya adalah lebih baik daripada sistem yang sedia ada dari segi perolehan balik haba walaupun belum terbukti terbaik dari segi ekonomi.

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NOMENCLATURES

C_p : specific heat capacity (kJ/kg °C)

dTmin : minimum allowable temperature difference (°C)

FC_p : heat capacity flow rate (kW/°C)

m : mass flow rate (kg/s)

P : pressure in the stream (Pa)

Q : heat load (kW)

$Q_{C\,min}$: minimum external cooling duty (kW)

$Q_{H\,min}$: minimum external heating duty (kW)

R : gas constant (J/kg K)

T : temperature in stream (K)

T_C : cold Temperature (°C)

T_H : hot Temperature (°C)

T_s : supply temperature (°C)

T_t : target temperature (°C)

V : volume flow rate (m^3/h or m^3/s)

ρ : density of fluid (kg/m^3)

ABBREVIATIONS

APO	Asian Productivity Organisation
BOD	Biological Oxygen Demand
c	cold stream
C&D	Construction and Demolition
CFC	Chlorofluorocarbon
CH_4	Methane
CHP`	Combined Heat and Power
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CWS	Cooling Water System
FEHD	Food, Environmental and Hygiene Department
GSTIM	Global Shifted Temperature Interval Method
h	hot stream
HEN	Heat Exchanger Network
MAU	Makeup Air Handling Unit
MAUS	Makeup Air Handling Unit System
MER	Minimum Energy Requirement
PDM	Pinch Design Method
UNEP	United Nations Environmental Programme
UV	Ultra Violet

CHAPTER 1

INTRODUCTION OF PROJECT

Many technological and management approaches have been taken by manufacturing and production companies to increase the productivity and profitability of the company. Proper choice of such methods is increasingly vital for the success of the production line of that particular company.

For a newly set up company, detailed analysis of the technological and management approaches must be done to avoid any major losses from happening. The choices of approaches are very important for these companies. However, for an existing company a study on the effect of switches of the approaches should also be made. This is because a decision to switch or not to switch can either make the existing production system more efficient or much less efficient.

However, all these approaches should be made with the consideration of its effect on the environment. This is an issue that is increasingly getting the concern of many countries in the world especially developed countries. Specific aspects in the production industries which are closely related to this issue are resource usage and waste reduction.

1.1 Objective of Project

Based on this concern, this project will be emphasising on the resource optimisation and waste reduction. Therefore, this project is carried out basically to do a research on the optimisation of resources and reduction of waste specifically in the local industries. Among the local industry that this project might cover would be the chemical industry, household production, energy production, computer hardware, metal processing and food processing. Two aspects, the resource optimisation and waste minimisation are closely related. Therefore, the two will be studied accordingly. However, the main stress is more on resource optimisation.

The main purpose of the project is to find a practical approach to balance the usage of resources in the manufacturing plant for example and looking briefly at the waste the plant produces during the production process. This approach will utilize the optimisation of resource in the overall system of a plant chosen later in this project. A detailed analysis about the method of resource optimisation will be conducted to gain data from a chosen plant.

Besides resource optimisation, this project will focus on the waste reduction methods that can be applied for the chosen plant. Basically, by optimising the resources while reducing the wastes produced, the plant will theoretically reduce cost for raw material and waste treatment. With the waste reduction methods, the effect of the production for the plant towards the environment will also be reduced. Therefore, the waste reduction section will only be covered in the literature review only.

There are two separate sections in this report discussing about the source optimisation and the waste minimisation. The first part, the resource optimisation section, will basically discuss about technological aspect of this topic. In the first section, type of resources used in industries will be discussed first and in the later part of the project, type and amount of resources used by the chosen plant. The determination of specific technology used will be discussed in this project. The technology that will be discussed for this project is Pinch Technology. Pinch technology itself can be classified into few types, namely Water Pinch, Heat Pinch, and Electric Pinch.

In the second section, waste reduction or waste minimisation topic will be discussed but only in the literature review section only. The first thing to be discussed in this section is the type of waste produced. Besides that, the effect of wastes towards environment or human will also be studied. The main emphasis of the project will be on waste reduction methods or technology that can be implemented on the chosen plant. An increasingly popular method practised for waste minimisation is the Clean Technology. Therefore, for this section, a survey on Clean Technology will be carried out.

1.2 Ideas on Pinch Technology

To have a good idea of what is going to be done in this project, it would be best to get an overview of Pinch Technology. Basically in Pinch Technology, an analysis called Pinch Analysis is an important method in doing resource optimisation especially for Heat Pinch. Therefore, it is vital to understand the basic step in Pinch Analysis.

In Pinch Analysis there are nine basic steps to be followed. The steps will be as shown below:

1. Identification of hot, cold and utility streams in process.
2. Thermal data extraction for process and utility streams.
3. Selection of initial dT_{min} value.
4. Construction of composite curves and grand composite curve.
5. Estimation of minimum energy cost targets.
6. Estimation of HEN capital cost targets.
7. Estimation of optimum dT_{min} value.
8. Estimation of practical targets for HEN design.
9. Design heat exchanger network (HEN).

CHAPTER 2

LITERATURE REVIEW

2.1 Resource Optimisation

2.1.1 Introduction to Resource Optimisation

Before discussing further on resource optimisation, this term should first be properly defined. According to Cambridge International Dictionary of English (1995), the term 'Resource' means a useful or valuable possession or quality of a country, organisation or person while the term 'Optimisation' means to make the best or most advantageous: most likely to bring success or advantage. From this definition, resource optimisation would give the meaning to make the best out of a useful possession of an organisation. In the industrial view, this would mean using of resources available as well as possible to get the most profitable return.

Optimisation of resource might include reduction of resource for example the amount of chemical used in the production system. It might also include the reuse of

certain suitable resource like water and heat. A specific technology that will be discussed in this report is the Pinch Technology.

2.1.2 Resource Identification

In order to understand the term "resource optimization", resources used in industry must first be identified. Resource can simply mean the raw materials that are directly used to produce a product. Raw material can be anything like chemicals, woods, metals, oils and plastics. Besides that, resources can also be production components that are indirectly utilised to produce a product. This type of resources is essentially important in the production of a certain product or in any industry. These resources are like the electricity, water and heat. Electricity in any plant or any factory is an important source of energy to power any mechanical parts or machines. Water is another useful resource that is widely used in almost any industry due to its characteristic and functionality. Water can be used in many condition or purpose: as a heat transfer agent, a cleaning agent, and solvents. With the wide purpose in industry, water is an important resource to be minimized. Heat is just another form of energy that must be produced to make sure that certain component works smoothly. Therefore, makes it an important resource to be optimized.

2.1.3 Introduction to Pinch Technology

Pinch Technology is one of the technologies used to optimize the resource of a certain plant. 'Pinch Technology' represents a new set of thermodynamically based methods that guarantee minimum energy levels in design of heat exchanger networks. Over the last two decades it has emerged as an unconventional development in process design and energy conservation. The term 'Pinch Analysis' represents the application of the tools and algorithms of Pinch Technology for studying industrial processes.

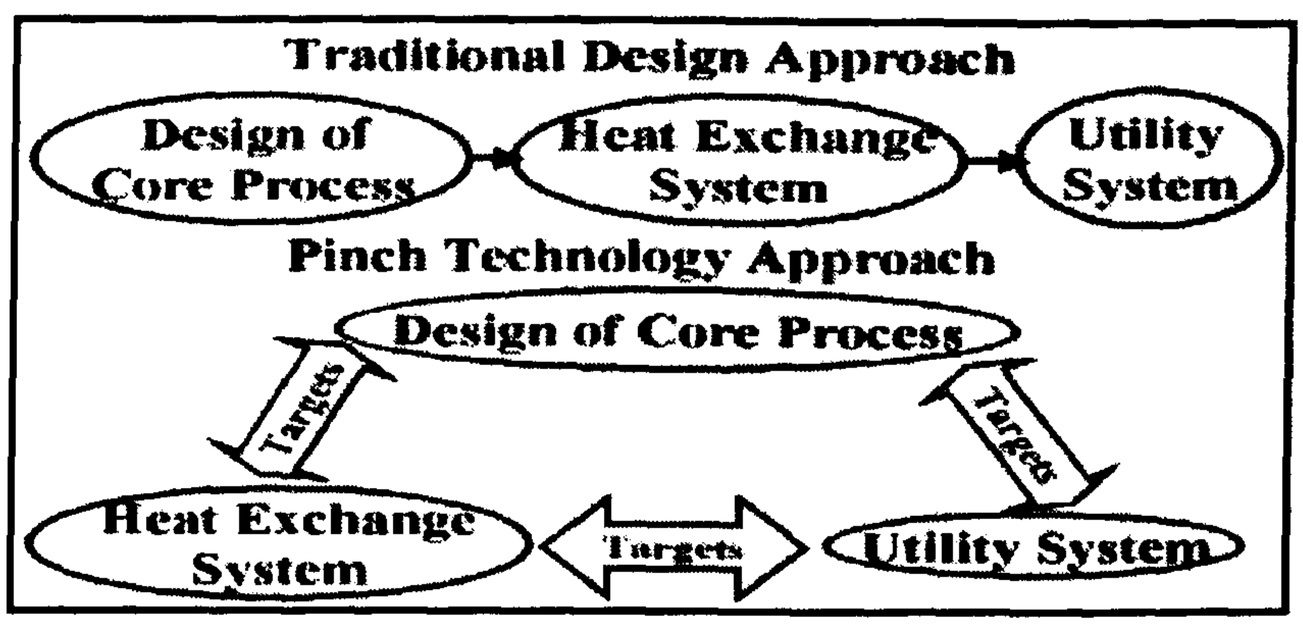

Figure 2-1: Difference between Traditional Approach and Pinch Technology Approach (Mukesh Sahdev, 2002)

Pinch technology presents a simple methodology for systematically analysing chemical processes and the surrounding utility systems with the help of the First and Second Laws of Thermodynamics. The First Law of Thermodynamics provides the energy equation for calculating the enthalpy changes (dH) in the streams passing through a heat exchanger. The Second Law determines the direction of heat flow. That is, heat energy may only flow in the direction of hot to cold. This prohibits 'temperature crossovers' of the hot and cold stream profiles through the exchanger unit. In a heat

exchanger unit neither a hot stream can be cooled below cold stream supply temperature nor can a cold stream be heated to a temperature more than the supply temperature of hot stream. In practice the hot stream can only be cooled to a temperature defined by the 'temperature approach' of the heat exchanger. The temperature approach is the minimum allowable temperature difference (dT_{min}) in the stream temperature profiles, for the heat exchanger unit. The temperature level at which dT_{min} is observed in the process is referred to as "pinch point" or "pinch condition". The pinch defines the minimum driving force allowed in the exchanger unit. The prime objective of pinch analysis is to achieve financial savings by better process heat integration (maximizing process-to-process heat recovery and reducing the external utility loads).

2.1.4 Concept of Pinch Analysis

Most industrial processes involve transfer of heat either from one process stream to another process stream (interchanging) or from a utility stream to a process stream. In the present energy crisis scenario all over the world, the target in any industrial process design is to maximize the process-to-process heat recovery and to minimize the utility (energy) requirements. To meet the goal of maximum energy recovery or minimum energy requirement (MER) an appropriate heat exchanger network (HEN) is required. The design of such a network is not an easy task considering the fact that most processes involve a large number of process and utility streams. With the advent of pinch analysis concepts, the network design has become very systematic and methodical.

In Pinch Analysis, there are a few key concepts that are closely related and are important in pinch analysis. The first is Combined (Hot and Cold) Composite Curves, which is used to predict minimum energy (both hot and cold utility) required, minimum network area required and minimum number of exchanger units required. The second is dTmin and Pinch Point where the dTmin value determines how closely the hot and cold composite curves can be 'pinched' without violating the Second Law of Thermodynamics. The third is Grand Composite Curve that is used to select appropriate levels of utilities (maximize cheaper utilities) to meet over all energy requirements. The fourth is Energy and Capital Cost Targeting that is used to calculate total annual cost of utilities and capital cost of heat exchanger network.

The fifth is Total Cost Targeting that is used to determine the optimum level of heat recovery or the optimum dTmin value, by balancing energy and capital costs. Using this method, it is possible to obtain an accurate estimate (within 10 - 15%) of overall heat recovery system costs without having to design the system. The essence of the pinch approach is the speed of economic evaluation. The sixth is Plus/Minus and Appropriate Placement Principles where the "Plus/Minus" Principle provides guidance regarding how a process can be modified in order to reduce associated utility needs and costs while the Appropriate Placement Principles provide insights for proper integration of key equipments like distillation columns, evaporators, furnaces, heat engines, heat pumps, etc. in order to reduce the utility requirements of the combined system. The last is Total Site Analysis, a concept that enables the analysis of the energy usage for an entire plant site that consists of several processes served by a central utility system.

2.1.5 Application of Pinch Technology

Pinch originated in the petrochemical sector and is now being applied to solve a wide range of problems in mainstream chemical engineering. Wherever heating and cooling of process materials takes places there is a potential opportunity. Thus initial applications of the technology were found in projects relating to energy saving in industries as diverse as iron and steel, food and drink, textiles, paper and cardboard, cement, base chemicals, oil, and petrochemicals.

Early emphasis on energy conservation led to the misconception that conservation is the main area of application for pinch technology. The technology, when applied with imagination, can affect reactor design, separator design, and the overall process optimization in any plant. It has been applied to processing problems that go far beyond energy conservation. It has been employed to solve problems as diverse as improving effluent quality, reducing emissions, increasing product yield, debottlenecking, increasing throughput, and improving the flexibility and safety of the processes.

One of the main advantages of Pinch Technology over conventional design methods is the ability to set energy and capital cost targets for an individual process or for an entire production site ahead of design. Therefore, in advance of identifying any projects, we know the scope for energy savings and investment requirements.

A well-designed CHP system significantly reduces power costs. Pinch shows the best type of CHP system that matches the inherent thermodynamic opportunities on the