NATIONAL TECHNICAL UNIVERSITY COLLEGE OF MALAYSIA

Analysis and Optimization of Heat Recovery System for Process Plant

Thesis submitted in accordance with the requirements of the National Technical University College of Malaysia for the Degree of Bachelor of Manufacturing Engineering (Honors) (Manufacturing Process)

By

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I hereby, declare this thesis entitled "Analysis and Optimization of Heat Recovery System for Process Plant" is the results of my own research except as cited in the reference.

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APPROVAL

This thesis submitted to the senate of KUTKM and has been accepted as fulfillment of the requirement for the degree of Bachelor of Engineering (Honours) Manufacturing (Process). The members of the supervisory committee are as follows:

.....

Main supervisor

Faculty of Manufacturing Engineering

ABSTRACT

Energy recovery has become very important these days due to the decreasing fuel supplies and expensive energy sources. Therefore, the requirement and incentive for heat recovery will be ever more important. One of the ways to overcome these problems is to recover waste heat generated by industries to generate energy. The heat transfer equipment can be applied to recover heat from industrial flue gas and waste water.

This project deals with recovering of a waste heat recovery system at an Oil Mill factory in Penang, to recover waste heat from exhaust gas that is currently being let out to the atmosphere at a temperature of 250°C. This waste heat is then used to produce hot water by using waste heat recovery equipment; thus improving the cycle efficiency. The hot water will then be supplied back to boiler for saving energy purpose.

In this project, numerical analysis was used to calculate the maximum waste heat recovery from the plant. For this, the Kern Method was used. The results show as that by using a relatively simple heat exchanger design, an increase in 2.81 percent in efficiency was calculated. This can translate to huge saving in energy usage per year.

Therefore effort should be taken to recover this waste heat as it will reduce the effect of global warming tremendously, thus making the planet earth a better place to live in.

ABSTRAK

Penggunaan sumber tenaga yang terbuang adalah penting pada masa kini disebabkan oleh sumber bahan api yang semakin berkurangan dan bertambahnya kos sumber tenaga. Salah satu cara untuk mengatasi masalah ini adalah dengan penggunaan semula haba yang terbuang yang dilepaskan ke sekeliling oleh industri-industri. Penukaran haba boleh digunakan untuk menggunakan semula haba yang yang terbuang ini.

Tesis ini adalah mengenai cadangan penggunaan semula haba terbuang daripada ekzos pada suhu 250°C dengan menggunakan suatu penukaran haba di kilang Soon-Soon Oil Mill di Pulau Pinang. Haba ini kemudian digunakan untuk memanaskan air yang akan dibekalkan semula kembali kepada sistem dandang untuk menperoleh penjmatan tenaga bagi proses pembakaran dalam dandang.

Di dalam projek ini analisis pengiraan digunakan untuk mengira tahap maksimum pemanasan haba yang terbuang daripada kilang. Oleh itu, kaedah Kern digunakan. Keputusan menunjukan bahawa dengan adanya penggunaan hubung kait penukaran rekabentuk pemanasan yang mudah, ia meningkatkan kecekapan pengiraan sehingga 2.81 peratus. Ini akan membawa kepada besarnya penjimatan penggunaan tenaga dalam tempoh setahun.

Akhir kata, usaha patut dilakukan dalam penggunaan semula haba terbuang, supaya suhu di muka bumi tidak bertambah.

DEDICATION

My mom and dad
Who has always been there for me,

My elder brother like my father,
Who taught me the fact that no one sat his way to success
And whose strict discipline brought me to where I am today,

My younger brother,
A 'friend' in the family

And my sister,
Who has always made me feel that it is great a have an elder sister.

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I would also like acknowledge the understanding and support given to me by my mother and my family that kept me during the progress of my 'Projek Sarjana muda'

Last but not least, I would like to thank the people whose names are not mentioned here; who made my project both educational and memorable.

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(BFW)	: Boiler Feed Water
HVAC	: Heating Ventilation and Air Conditioning
(m_t)	: Mass Flow Rate
(P_t)	: Density of Fluid
(u_t)	: Velocity Of Fluid
(A_c)	: Area of Tube
(N_t)	: Number Of Tube
(μ_t)	: Viscosity of Fluid
(Re)	: Reynold Number
(Pr)	: Prandtl Number
f	: Friction Factor
Nu_t	: Nusselt Number
P_T	: Tube Pitch
PR	: Pitch Ratio
D_s	: Shell Inside Diameter
LMTD	: Log Mean Temperature Different.
(OS)	: Over Surface Design
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CHAPTER 1
INTRODUCTION

1.0 HEAT TRANSFER

When two objects with different temperatures are in contact, energy transfers from the hotter object to the cooler object. Heat is the amount of energy that is transferred from the hotter object to the cooler object. Heat transfer changes the internal energy of both systems involved according to the First Law of Thermodynamics.[Olszewski, 1981].

1.1 Waste Heat Recovery Systems

Maximizing the thermal efficiency of processes is critical to the operation of a profitable process production facility. Whether they are producing electricity, paper products, chemicals, pharmaceuticals, food products, crude oil/gas, plastics, or any other processes, chances are that the industrial facilities is consuming more energy than necessary. Waste heat is normally generated through a process and then 'dumped' into the environment because it is considered waste by product.

1.2 Background of the Project

The first part of this project involves literature study on waste heat and heat exchanger design. The literature study was carried out both in the library and the industries. Information on the availability of heat exchanger from the heat exchanger manufacturers is also collected. The first part of this project also involves an identification of an industry where the project will based on.

The second part of this project will deal with thermodynamic and heat transfer calculations, selection of the waste heat recovery system that will be recommended or improved.

1.3 Objective

The objective of this thesis:

1) To calculate the maximum waste heat recovery from the plant.

2) To suggest a simple design to recovery the work heat.

1.4 Scope of the project

The scope of this thesis includes a system improvement and research of a boiler operation at an edible oil processing company where the project is to be carried out. A study on heat exchanger will also be conducted using thermodynamic and heat transfer calculation will be carried out. Based on a numerical analysis, an appropriate design of exchanger will be evaluated to obtain the optimum waste heat recovery from the existing system using computer software.

1.5 Benefits of Waste Heat Recovery Benefits

Recovering waste heat is definitely a benefit to the industries. Basically it can be grouped recovery benefits into three categories [Boyen, 1975]:

1. Reduction of energy cost
2. Reduction of equipment cost and size
3. Reduction of energy use.

Reduction of energy cost is the primary benefit of heat recovery. Any heat recovered from the exhaust and return to the process reduces the energy cost. Furthermore, any increase in energy cost will, result in increased heat recovery benefits. A heat recovery system is both inflation and price increase proof. Very few other investments are free of economic risk. Additional cost benefits for heat recovery systems are available as equipment cost and size reduction.

The usage of recovered waste heat reduces the amount of heat required by using purchased energy. Oil and gas supply pipes, electrical facilities, burners and boilers often can be reduced. If stand by facilities are required, temporary, rather than permanent, equipment can be provided, preserving the cost reduction.

The reduction of process heat requirement can permit greater utilization of existing process or ventilating equipment. Increased amounts of product or ventilation can be handled without increasing energy use and without additional new equipment. Where cycling or peaking conditions are present, heat recovery allows a flexible way of accommodating periods of high heat demand without providing additional heating facilities.

Energy shortages have become part of the risk of operating a business or a facility. When energy supply is curtailed and supply allocations are established during an emergency, the amount of energy conserved by a heat recovery system available to keep other processes or facilities in operation. Heat recovery systems are useful in avoiding expansion or service facilities. Where additional energy use might force the installation of boilers, electrical sub stations, and so on, heat recovery systems can provide the additional energy requirement, if designed optimally.

1.5.1 Benefits Of Waste Heat Recovery In A Plant

A small percentage of heat recovery will increase the efficiency energy usage. This can calculated based on the cost of heating, for example, boiler feed water. Even a 1^0C increase in heating translate a huge saving in heating cost. Below is the possible list of benefit derived from the increase in efficiency:

- The system will make profit by producing hot water and supplying back to boiler. This is because partially of the money paid for the water goes to the system.
- Reduction of energy cost. This is because the heat recovered from the exhaust gas to produced hot water need not be supplied by purchased energy.
- The heat lost to the surrounding from the exhaust gas would be reduced. Therefore this will automatically reduce the lost or energy to the surrounding as it is not desirable to loose energy.

1.6 Current Method in Thermal Control

Industrial processes consume energy and usually reject surplus heat. In the right circumstances, heat recovery techniques try to make the most effective use of this heat by using various equipment or systems, and by taking into account resources such as capital, manpower and materials. This surplus heat may arise as [Arpaci 1999]

- hot exhausts from ovens and furnaces;
- warm air or water flows from process cooling systems; or
- Heat from an effluent source.

When applied correctly, heat recovery techniques produce substantial energy savings and improve quality and production levels. Recovered heat can be used in two ways [Arpaci 1999]

- It can be reused within the process from which it was extracted.
- It can provide space heating or other process heating which will improve the overall efficiency of energy use.

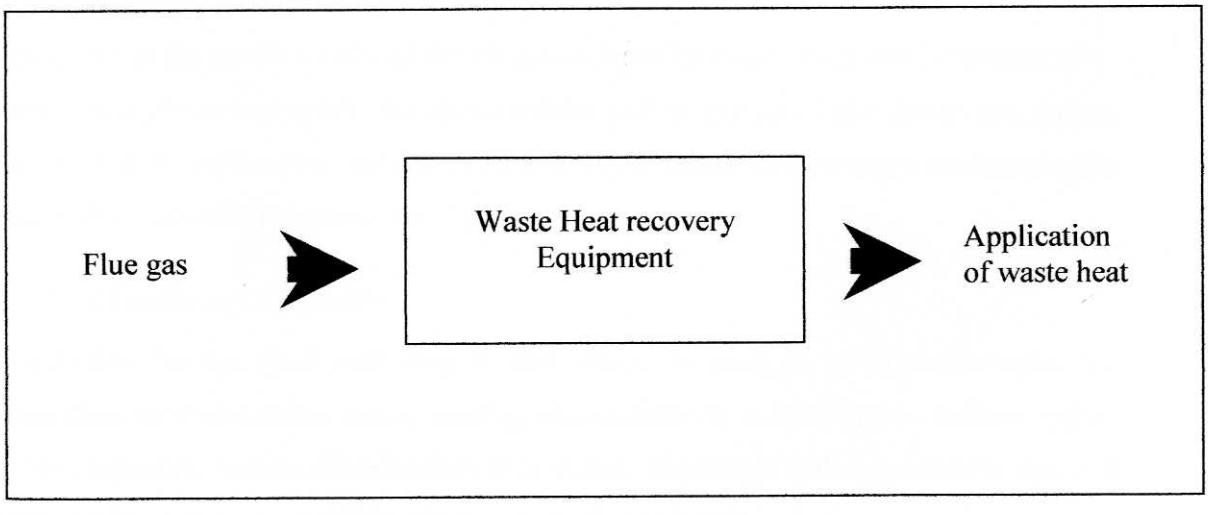

Figure 1.6: Simplest mode of waste heat recovery

1.7 Brief Overview of This Project Sarjana Muda (PSM)

1. Chapter 1- Introduction

In chapter one consists of the overview, current practice/method, and future development, background to the studying and motivation and scope of study. This entire element is to describe the purpose/ design or description that related to this study.

2. Chapter 2- Literature View

In literature views, it shows that the applications of heat recovery and also include implementation. It concludes the design has been used, operations and also some selected journal.

3. Chapter 3- Methodology

Methodology is a method that include in analysis of fundamental of heat recovery system. This is per from the design selections into the real product. Basically, the method that used is heat recovery design as a processing unit. By this methodology, the process ability of the design can be known and whether it needs an improvement according to the design and characteristic of process plant.

4. Chapter 5- Analysis and Results

Analysis and the result consist of the observation and research from the implementation. From the analysis and result, the characteristic and properties of the design can define. Beside that, the calculation and also simulations can make data by using a mathematically calculations whether it achieve the objective or not.

6. Chapter 6- Conclusion

Conclusion for the final year project that related to analysis to implementation the simulations and also make saving costing substantially. It is including to the next report in next semester. Assume that conclusion is include the design and characteristic that will establish also the process ability whether it good or opposite.

CHAPTER 2

LITERATURE REVIEW

2.0 INTRODUCTION

A heat exchanger is a heat transfer device that is used to transfer thermal energy between two or more fluids available at different temperatures. In most heat exchangers, the fluids are separated by a heat transfer surface and ideally they do not mix. Heat exchangers are used in the process, power, petroleum, transportations, air conditioning, refrigeration, cryogenic, heat recovery, alternate fuels, and others industries.

Common examples of heat exchangers related to our daily use are automobile radiator, condenser, evaporator, air preheated and oil coolers. Heat exchangers could be classified in many different ways.

Waste heat comes both in the form of gas (for instance flue gas) and liquid. This liquid is actually called drain water. Like the flue gas that is let out to the atmosphere, the drain water is let to flow to the river or pond after it is treated. **Figure 2.0** gives a simple illustration of a process that produces waste heat when an input is given to the process. The output of the process depends on the input.

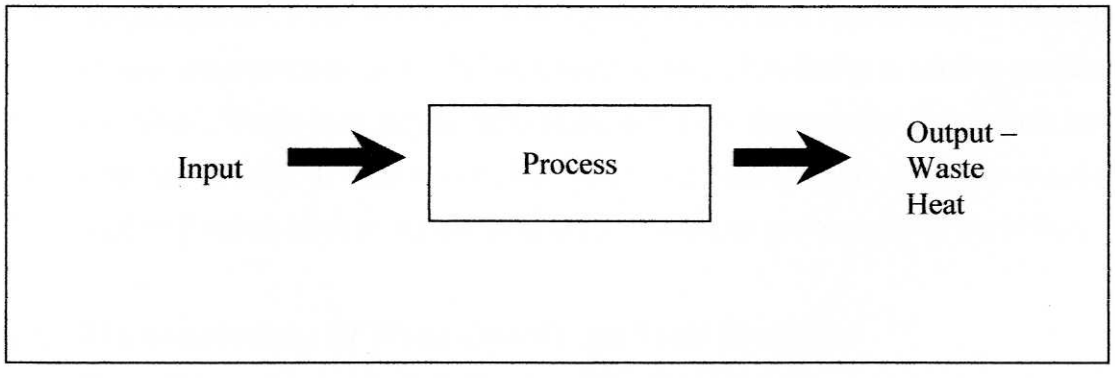

Figure 2.0: An illustration of a process that produces waste heat.

2.1 Sources of Waste Heat

The strategy of on how to recover waste heat depends on the temperature of the waste heat gas or the drain water and the economics involved. Source of waste energy can be divided according to the temperature into three temperature ranges. Firstly the high temperature range, that is for temperatures above 650°C. Secondly for the medium temperature range, temperature between 239°C and 650°C and lastly for the low temperature range that is below 220°C [Robert. 1986]

High and medium temperature waste heat can be used to produce steam. For the low temperature range, waste energy which would be otherwise useless sometimes is made useful by application of mechanical work.

2.2 Waste Heat Recovery Applications

The waste heat from the industries can be used for various purposes. The device that transfers energy from this waste heat to useful energy is called a heat exchanger. The principle of this heat exchanger is according to the low temperature fluid. A heat exchanger can come in either a simple or complex form.

Some of the waste heat applications:-

- To heat such as refinery, feed mill, maize plant and oil mill in the food industries. In some cases in the food industries, there is a need an increase the temperature of the maize plant to certain level.
- To generate hot water in boiler. Presently one of the main applications of waste is to generate hot water. In the boiler, usually a waste heat boiler is used to produce hot water. Waste heat gasses from stack will flow through the economizer and after the transfer of heat occurs, hot water is produced. This hot water usually used to generate back to the boiler in order to increase the capacity of the boiler.

2.2.1 The Temperature Of Waste Heat That is To Be Recovered

Most of the processes in the industries or in the process plant produce waste heat. The waste heat that is produced by one process is different from another process. As discussed earlier the waste heat whether in the form of flue gas or drain water is category