STUDY ON THE POWER PRODUCED FROM WASTE HEAT RECOVERY

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A report submitted
in fulfillment of the requirement for the degree of
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DECLARATION

I declare that this project report entitled “Study On The Power Produced From Waste Heat Recovery” is the result of my own work except as cited in the references.

Signature :.......................................

Author Name : Muhammad Syahmi Bin Rahmam

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 (Thermal-Fluid).

Signature :..................................

Name of Supervisor : En. Safarudin Gazali Herawan

Date :..................................

DEDICATION

This Report is dedicated to my beloved parents

Rahmam Bin Jantan

and

Rohani binti Sulaiman

ABSTRACT

Nowadays, Internal Combustion Engine (ICE) is used in most vehicles around the world as their system. ICE is one of the most inefficient systems for vehicles because most of the energy burned from the fuel is wasted to heat, mechanical and other losses. Either realizes or not, only 15 percent of the energy from the fuel is used to move the vehicles or run useful accessories. To recover the energy losses, Waste Heat Recovery (WHR) mechanism can be used. The mechanism recycles the wasted energy from the vehicle into power as electric current. Exhaust system of the vehicle play the important role in this mechanism, where the power produce for this mechanism is used the wasted heat from the exhaust. The exhaust will cover with good insulator to prevent the heat produced loss to the surrounding. The current produced can be stored in the battery. The electric energy also can be used as the source of energy for the hybrid vehicles. This project is considering the performance of the vehicle when equipped with the WHR system and not the power produced and its storage.

ABSTRAK

Pada masa kini, Enjin Pembakaran Dalaman (EPD) digunakan dalam sistem kebanyakan kenderaan di seluruh dunia. Enjin Pembakaran Dalaman (EPD) adalah salah satu sistem yang paling efisyen untuk kenderaan kerana pembaziran terhadap sebahagian besar tenaga yang dibakar dari bahan api kepada haba, mekanikal dan pembaziran lain. Sama ada sedar atau tidak, hanya 15 peratus daripada tenaga daripada bahan api yang digunakan untuk menggerakkan kenderaan atau aksesori digunakan. Untuk memulihkan pembaziran tenaga tersebut, mekanisme Waste Heat Recovery (WHR) boleh digunakan. Mekanisme ini mengitar semula tenaga yang terbazir dari kenderaan ke dalam kuasa sebagai arus elektrik. Sistem ekzos kenderaan memainkan peranan yang penting dalam mekanisme ini, di mana hasil kuasa untuk mekanisme ini menggunakan haba yang terbazir dari ekzos. Ekzos akan ditutup dengan penebat yang baik untuk mengelakkan haba yang dihasilkan terbazir kepada sekitarnya. Aliran elektrik yang dihasilkan boleh disimpan di dalam bateri. Tenaga elektrik juga boleh digunakan sebagai sumber tenaga untuk kenderaan hibrid. Projek ini sedang mempertimbangkan prestasi kenderaan apabila dilengkapi dengan sistem WHR dan tidak menumpukan kepada kuasa yang dihasilkan dan penyimpanan.

ACKNOWLEDGEMENT

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ICE	Internal Combustion Engine
MTOE	Million tons of oil equivalents
CO_2	Carbon dioxide
RPM	Rotation per minutes
TE	Thermal Electric
ORC	Organic Rankine Cycle
WHR	Waste Heat Recovery
MITC	Melaka International Trade Centre

LIST OF SYMBOLS

T	=	Temperature
w	=	work per unit mass
p	=	pressure
h	=	enthalpy
ρ	=	density
q	=	heat per unit mass
c_p	=	constant pressure specific heat
ΔH_{vap}	=	enthalpy of vaporization
$\dot{W}$	=	power
$\dot{Q}$	=	heat transfer rate
$\dot{m}$	=	mass flow rate
η	=	efficiency
m^3/min	=	metre cube per minutes

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CHAPTER I

INTRODUCTION

1.1 BACKGROUND

Over past century, the internal combustion engine (ICE) has been primary power source for the automotive and automobiles industry. Approximately, only 30% to 40% of the power produced from the internal combustion engine (ICE) is converted into mechanical energy. The remaining heat is expelled to the environment through the engine cooling system and exhaust (Jadhao JS and Thombare DG, 2013).

Waste heat is heat. Generated by way of combustion fuel and chemical reaction. Due to substantial potential of the amount of heat that can be recovered, waste heat recovery has attracted a significant interest (Alias MN, Rosnizam CP, Srithar R, 2014). By recovering useful energy, the fuel consumption can be reduces besides adding power produce by engine.

The heat energy losses occur from the engine to the exhaust and cooling system in vehicles. By using the waste heat recovery mechanism, the energy losses still can be recycled. The waste energy that flow through the exhaust system will reuse by the recovery system, thus, increases the efficiency of the engine. The thermal losses from the exhaust also can be covert to electrical energy for the other accessories of the vehicles uses (Nawawi, 2015)

1.2 PROBLEM STATEMENT

Since its invention in early 19^{th} century, Internal Combustion Engine (ICE) remains the most dominant methods of world transportation. The engine manufacturers has do the extensive research and technologies development base on two main methods to improve engine thermal efficiency by optimizing the combustion process and recover the waste heat energy for the engine (Alias MN, Rosnizam CP, Srithar R, 2014). About 75% of the fuel energy loses by typical internal combustion engine (ICE) through the engine coolant, exhaust and surface radiation. The chemical energy in the fuel is converted to the mechanical energy generated most of the heat in turn thermal energy is produced. Thermal energy is unutilized and wasted (Jasdeep S.C., 2012). Therefore, waste heat recovery is suitable mechanism can use to overcome this problem.

1.3 OBJECTIVES

The objective of this project is to determine the power produce from waste heat recovery of the exhaust gas.

1.4 SCOPE OF PROJECT

In this project, the result from the conducted experimental session will be analyzed and interpreted. The scopes of this project as follows:

1. To study the current waste heat recovery mechanism.
2. To determine power produced from waste heat recovery.

CHAPTER II

LITERATURE REVIEW

2.1 REVIEW OF THERMODYNAMICS

Steam power generation has consistently been based on the Rankine cycle or its modification. However, in order to fully understand its operating principles, it is useful to introduce the Carnot cycle first, since it represents the starting point for all the following analyses (Gianmarco Capano, 2014).

2.1.1 Carnot Cycle

Nicolas Sadi Carnot (1769-1832), a French military engineer, the person that responsible to introduce the concept of thermodynamics. The main purpose of the concept is to determine the system which could operate at maximum efficiency by using heat at constant temperature that have four transformation phase, two isothermal and two adiabatic.

Figure 2.1 that shows the cycle on a T-s diagram, the transformations that take place are:

1→2: Reversible adiabatic compression (isentropic). Work is done on the fluid.

2→3: Constant temperature evaporation. The working fluid receives heat from an external source.

3→4: Reversible adiabatic expansion (isentropic). The working fluid generates useful work.

4→1: Constant pressure and temperature condensation. The fluid is giving off heat to the environment and returns to the initial conditions.

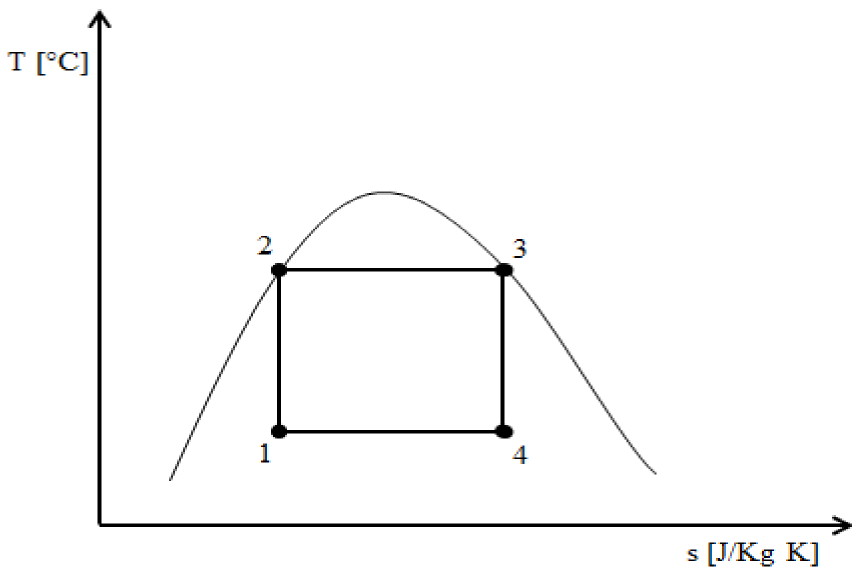

Figure 2.1: Carnot cycle on T-s diagram (Gianmarco Capano, 2014)

Carnot cycle efficiency can be obtained from the highest cycle that can be achieved by any other cycle operating within the same temperature range ($T^+$and T^-), also defined as:

$$\eta_{carnot} = \frac{Q_{23} - Q_{41}}{Q_{23}} = 1 - \frac{Q_{41}}{Q_{23}} = 1 + \frac{T^-}{T^+} \tag{2.1}$$

Where T^+=T_2=T_3 is maximum temperature reached by the fluid correspondent to the vaporization temperature and T^-=T_4=T_1 is minimum temperature or rather condensation temperature.

It has been doable to form the last simplification as a result of heat is changed at constant temperature. This expression provides rise to a crucial consideration: even there is no irreversibility within the cycle, the efficiency cannot be equal to 100% unless the low temperature source (T^-) was at 0K, but, the condition never possible.

Nevertheless, the practicality of Carnot cycle is very difficult because of the problem of elimination of irreversibility in actual process and also difficulties in expanding and compressing partially wet vapor in purely mechanical view. Despite of its thermodymanics advantages, Carnot cycle is not used in any application (Gianmarco Capano, 2014).

2.1.2 Rankine Cycle

Most of standard vapor cycle that represents practical modification for the Carnot cycle known as Rankine cycle. The Rankine cycle named came from William John Macquorn Rankine (1820-1872), one of founding contributors to the science of thermodynamics (1820 - 1872). William, who is a Scottish engineer and physicist also credited for the “Rankine” temperature scale (M.O. Bamgbopa, 2012). Figure 2.2 shows a typical system layout of a Rankine cycle, the components utilized are a feed pump, an evaporator (or boiler), an expander and a condenser.

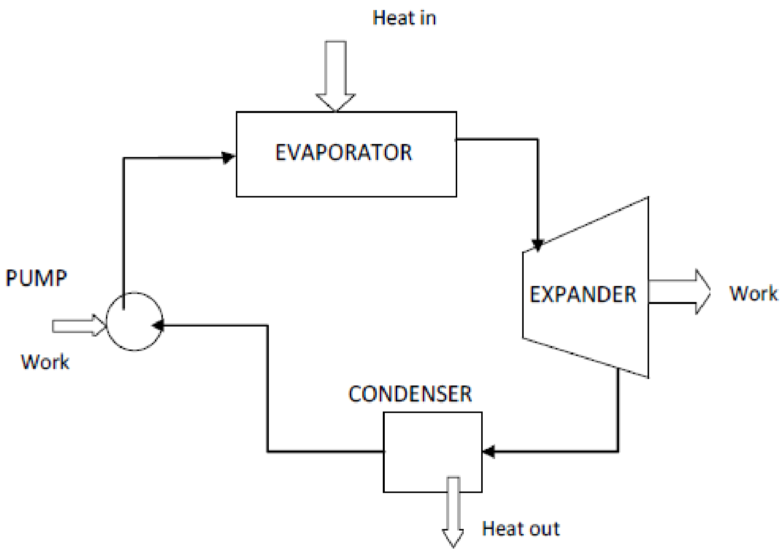

Figure 2.2: Rankine cycle system layout (M.O. Bamgbopa, 2012)

Figure 2.3(a) and Figure 2.3(b) respectively shows the T-s and p-h diagrams that provide a visual representation of the ideal Rankine cycle diagram (1-2s-2‟-3-4s), the changes that take place are explained below:

1 → 2s: Saturated liquid at low pressure and temperature is isentropically compressed (“s” indicates an isentropic transformation) up to the high pressure p_{2s}. The changes of