ENERGY LOSS THROUGH THE STEAM TRAP IN A STEAM SYSTEM

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

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Date:	: 6 DECEMBER 2010

STUDENT'S DECLARATION

I hereby declare that the work in this project is solely of my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

This thesis is about the energy loss through the steam trap in the steam system. In industry, steam traps frequently fail but they are not noticed except when they are leaking. If steam trap fail in failed open, live steam can escape to surrounding. High amount of energy will loss from the steam system. It takes weeks or months before it being repaired or replaced. The first objective of this study is to measure the heat loss for normal thermodynamic steam trap in respond to operating pressure for different condensate load. The second objective is to measure the heat loss for failed open thermodynamic steam trap in respond to operating pressure for different condensate load. The last objective is to compare energy loss between normal and failed open steam trap. From the last objective, the actual energy loss if failed steam trap is not repaired is determined. Thermodynamic steam trap has been tested in the experiment and the operating pressure is below 1 bar. Condensate that discharges from steam trap is collected to record the reading of its temperature and weight. These data is used to determine the energy loss through the steam trap. For normal steam trap, energy loss for high condensate load is higher than low condensate load. For failed open steam trap, energy loss for high condensate load is lower than low condensate load. Finally, after comparing the result, steam system that has low condensate load has higher energy loss compare to high condensate load.

ABSTRAK

Tesis ini adalah berkenaan tenaga yang hilang melalui perangkap stim pada stim system. Di industry, perangkap stim sering mengalami kegagalan tetapi tidak dapat dikesan kecuali ia bocor. Jika perangkap stim gagal dan injapnya sentiasa terbuka, stim akan terbebas ke udara. Sejumlah tenaga akan dibazirkan. Ia mengambil masa yang lama untuk dibaiki atau diganti. Objektif pertama kajian ini ialah untuk mengukur tenaga yang dibazirkan oleh perangkap stim yang normal. Objektif yang kedua ialah untuk mengukur tenaga yang dibazirkan oleh perangkap stim yang mengalami kerosakan. Objektif yang terakhir ialah membandingkan jumlah tenaga yang dibazirkan antara perangkap stim yang normal dengan perangkap stim yang mengalami kerosakan. Daripada objektif yang terakhir, jumlah tenaga yang dibazirkan andai perangkap stim yang mengalami kerosakan tidak dibaiki dapat ditentukan. Perangkap stim jenis termodinamik digunakan dalam eksperimen ini dan tekanan stim yang digunakan adalah bawah 1 bar. Air yang terhasil akan dikeluarkan oleh perangkap stim dikumpul dan bacaan suhu dan berat diambil. Data ini digunakan untuk mendapatkan jumlah tenaga yang dibazirkan oleh perangkap stim. Untuk perangkap stim normal, tenaga yang dibazirkan apabila sistem stim yang mengandungi jumlah air yang tinggi adalah lebih tinggi daripada sistem stim yang mengandungi jumlah air yang randah. Untuk perangkap stim yang mengalami kerosakan, tenaga yang dibazirkan apabila sistem stim yang mengandungi jumlah air yang tinggi adalah lebih rendah daripada sistem stim yang mengandungi jumlah air yang randah. Akhirnya, dengan membandingkan data, sistem stim yang mengandungi jumlah air yang randah membazirkan lebih tenaga daripada sistem stim yang mengandungi jumlah air yang tinggi.

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LIST OF ABBREVIATIONS

C_p	Specific Heat
E	Energy
h	Enthalpy
M	Mass
SDPJ	Sime Darby Plantation Jabor
T	Temperature
TD	Thermodynamic
W	Weight

CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

Water steam is thermal fluid that is widely used in industry due to two main characteristics: which is high energetic content and easy to transport.

Water can be in three phases: solid, liquid and gas or steam. The process of changing phase from solid to steam uses energy while from steam to solid gives energy. To produce steam from water, boiler is used. Boiler will supply heat to water and it will change form to steam.

Steam has high amount of energy. Steam will conveyed through pipeline to be used to run steam turbine, or used for cooking vegetables, steam cleaning of fabric and carpets, and heating buildings. Condensate will form inside the pipe when steam gives up its enthalpy of evaporation (latent heat) due to heat loss.

Presence of condensate in the pipeline will decrease the steam energy and maybe will make damage to the equipment if water hammer happens. So, the proper removal of condensate from steam plant of all types is very important if the plant is to work efficiently and this operation is commonly performed by a steam trap.

A steam trap is a self-contained automatic valve which automatically drains the condensate from a steam-containing enclosure while remaining closed to live steam. Some traps pass live steam at controlled rate. Most traps also pass air and other non condensate gases while remaining closed to live steam.

The difference between condensate and steam is sensed in several ways. One group of steam trap reacts to a difference in temperature, another group detects the difference in density and the third relies on the difference in flow characteristics.

In industry, steam traps frequently fail but they are not noticed except when they are leaking. If steam trap fail in failed open, live steam can escape to surrounding. High amount of energy will loss from the steam system.

Many factors that affect the amount of energy loss through failed open steam trap. Different operating pressure and amount of condensate load in the pipeline will influence the amount of steam loss and energy loss.

Efforts and methods implementation needs to be considered are: study on the steam trap characteristics and how it work in real application in industry. The methodology uses is by experimental.

1.2 PROBLEM STATEMENT

A common problem of steam heating systems is steam loss through the steam trap. In normal operating, there is some energy loss through steam since the efficiency is not 100%. Steam trap has mechanical part inside. As the time passed, this mechanical part will fail due to wear and corrosion. Live steam will manage to escape if the steam trap is failed open, which mean the trap is blowing steam continuously across the valve seat and will not close. Live steam has great amount of energy and will become energy losses. The difference of energy loss for failed open steam trap and normal operating steam trap is the actual energy loss if the failed steam trap in industry is not replace by new one.

1.3 OBJECTIVE

The objectives of this research are as following:

i. measure the heat loss for normal thermodynamic steam trap in respond to operating pressure for different condensate load.
ii. measure the heat loss for failed open thermodynamic steam trap in respond to operating pressure for different condensate load.
iii. compare energy loss between normal and failed open steam trap

1.4 SCOPES

In this project, thermodynamic steam trap is the type of steam trap that will be tested in the experiment. New steam trap will be used in the first experiment. Then, in second experiment, failed open steam trap is tested. Low steam pressure is applied to the steam trap due to safety of the experiment, since high pressure steam is dangerous to operate and not suitable for experiment setup. The tested pressure is below 1 bar.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter explains about the literature review that has been done. It evaluates in detail about thermal properties of steam, the steam system, water hammering, and the need of steam trap in steam system and type of steam traps that are available in market.

2.2 THERMAL PROPERTIES OF STEAM

2.2.1 Boiling Point

The boiling point is the temperature at which water starts to boil and turn into its vapor phase. At sea level or when atmospheric pressure is at 101.4kPa, the boiling point of saturated water is 100°C. At high altitude, the atmospheric pressure will decrease and make the boiling pressure decrease. Conversely, when pressure increase, the boiling pressure will also increase. In steam system, usually boiling point is also called “saturation temperature” (S. Schmidt, 2004).

2.2.2 Saturated Steam

When the water begins to boil, steam is produced. As long as the pressure remains constant, the temperature remains at the saturation temperature, and when more heat is added, more liquid is converted to steam. This steam we called as “saturated steam” (S. Schmidt, 2004).

2.2.3 Superheated Steam

After the water is completely boiled off, the saturated steam will turn into superheated steam if more heat is added to the system continuously (S. Schmidt, 2004).

2.2.4 Enthalpy

This is the term given to the total energy, due to both pressure and temperature, of a fluid (such as water or steam) at any given time and condition. More specifically it is the sum of the internal energy and the work done by an applied pressure. The basic unit of measurement is the joule (J). Since one joule represents a very small amount of energy, it is usual to use kilojoules (kJ) (1 000 Joules). The specific enthalpy is a measure of the total energy of a unit mass, and its units are usually kJ/kg (Sarco, 2007).

2.2.5 Condensate

Condensate is the liquid produced when steam condenses on a heater surface to become water. Steam gives up its enthalpy of evaporation (latent heat) and condenses either by raising its pressure or lowering its temperature.

2.2.6 Flash Steam

The term 'flash steam' is traditionally used to describe steam issuing from condensate receiver vents and open-ended condensate discharge lines from steam traps. Flash steam occurs whenever water at high pressure (and a temperature higher than the saturation temperature of the low-pressure liquid) is allowed to drop to a lower pressure. Conversely, if the temperature of the high-pressure water is lower than the saturation temperature at the lower pressure, flash steam cannot be formed. In the case of condensate passing through a steam trap; it is usually the case that the upstream temperature is high enough to form flash steam (Sarco, 2007).

2.3 STEAM SYSTEM

Nearly half of the energy used by industry goes into the production of process steam. Why is so much of our energy resource expanded for the generation of industrial steam?

Steam has many performance advantages that make it an indispensable means of delivery energy. Steam has low toxicity, ease of transportability, high efficiency, high heat capacity and low cost compare to other alternatives. This advantages make steam is one of the most abundant, least expansive and most effective heat-transfer media available. Furthermore, water is found everywhere, and only need relatively little modification from its raw state to make it directly usable in process equipment (Tuner, 2004).

Figure 2.1 below shows the complete steam cycle operation. There are four important categories in steam system components that will lead to enhance steam system performance: steam generation, steam distribution, steam user and recovery. These four categories will follow the path of steam as it flow out from boiler as pressurized steam and returns through condensate return system.

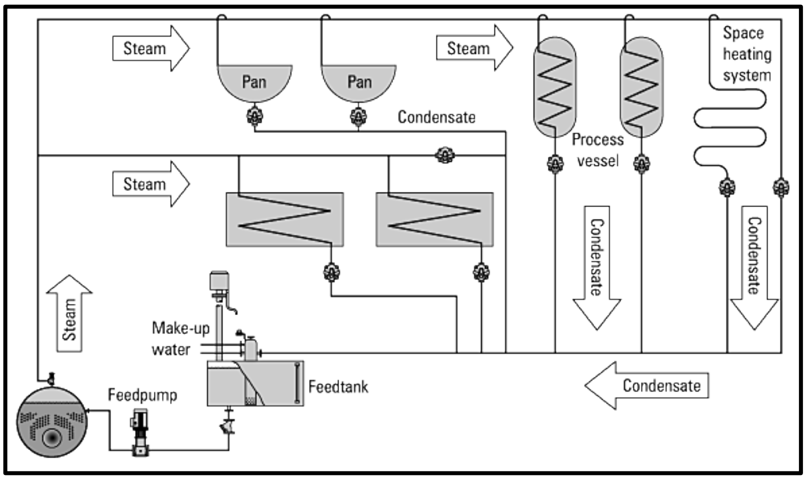

Figure 2.1: Steam system operation.

Source: www.spiraxsarco.com

2.3.1 Steam Generation

Boiler is a device used for generating steam for power generation process use or heating purpose. Water that enters the boiler will be heated and temperature will increase until it reached boiling point and saturated steam will be produce. At 1atm pressure, pure water will boil at 100°C (Chattopadhyay, 2001).

If the saturated steam produced in a boiler is exposed to a surface with a higher temperature, its temperature will increase above the evaporating temperature. Superheated steam cannot be directly from water, as any additional heat simply evaporates more water and become saturated steam. The saturated steam must be passed through an additional heat exchanger. This may be a second heat exchange stage in the boiler, or a separate superheater unit. The primary heating medium may be either the hot flue gas from the boiler, or may be separately fired.

Figure 2.2 shows the process of producing steam. Water in the boiler is heated until it changes into steam. This less density steam will flow out from the boiler and again, heat is supply to the system through superheater. This process makes the saturated steam change to superheated steam. Superheated steam has higher energy than saturated steam. So, superheated steam usually used in heavy work such as generate electrical energy, or it can use the steam energy directly as seen in machines such as steam-powered trains, steam engines, and steam shovels (*Marick*, 1980).

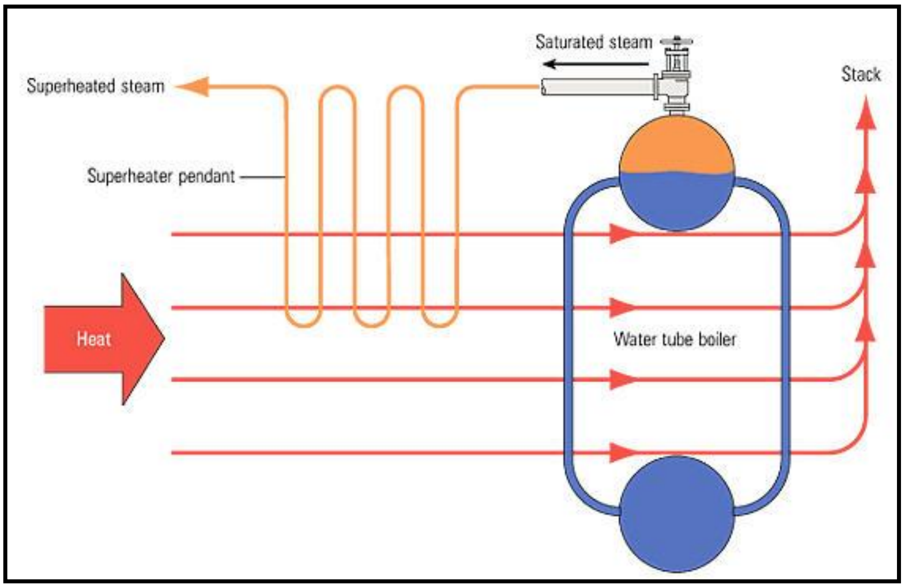

Figure 2.2: Boiler with superheater

Source: www.spiraxsarco.com

2.3.2 Steam Distribution

The steam distribution is the essential link between the steam generator and the steam user. The steam generated in the boiler must be conveyed through pipe work to the point where its heat energy is required. Initially there will be one or more main pipes, or 'steam mains', which carry steam from the boiler in the general direction of the steam using plant. Smaller branch pipes can then carry the steam to the individual pieces of equipment.

2.3.3 Steam User

There are many different steam users. Common steam user includes heat exchanger, oven for bakery and restaurants, laundry presses and plastic molding. When steam flow through these devices, it will transfer its latent heat until it condenses. In power plant, the steam user is turbine. Steam that flows in turbine will transfer its energy to mechanical work to drive rotating machinery which is electric generator. The steam that has condensate will pass steam trap into the condensate return system.

2.3.4 Recovery

The condensate return system sends the condensate back to the boiler. The boiler already has certain amount of pressure. So feed pump is used to increase the feed water pressure to above boiler pressure and bring it into the boiler to complete the cycle.

2.4 THE NEED OF STEAM TRAP

Steam is generated in the boiler and conveyed through piping system to the steam user. The steam pipe is usually well insulated to prevent heat loss to the environment. But in real life, heat loss still happen due to convection and radiation process. Steam traveling along the pipe line will make up to heat loss and will condense forming condensate in bottom of pipeline.

This condensate will exact heat from steam, thus decrease the steam temperature and more condensate will be form. If this condensate not be removed continuously, it will fill up the pipe and blocking the route of steam.

Condensate also will cause water hammer occur in the pipe work. Water hammer is the term used to describe the noise (and sometimes movement of pipe work) caused by slugs of condensate colliding at high velocity into pipe work, fittings, plant, and equipment. This can result in fracture of the steam line or fittings leading to hazardous conditions, loss of steam, and downtime. Therefore, an automatic device is required to allow condensate to drain from the pipe without allowing the steam to escape.

Such a device is known as steam traps and become an important parts of any steam system. Their basic function is to prevent the passage of steam while allowing condensate to flow. Large steam systems often include hundreds or even thousands of traps used in similar installations (Tuner, 2004).

Steam traps represent a common type of process equipment used in virtually all steam systems. Depending on their design, they may perform one or more of the following functions.

i. Keep steam from escaping. Steam that escapes through a trap reduces the overall efficiency of the steam system and wastes valuable resources. Wasted steam is expensive.
ii. Remove condensate. Condensate that forms when the latent heat of evaporation is reclaimed from steam must be removed as it accumulates or the steam system will not function properly. A backup of condensate, known as water logging or flooding, can adversely affect heat transfer, promote corrosion of carbon steel components, and cause a potentially dangerous condition known as water hammer.
iii. Remove air. Air and other no condensable gases must be removed from any steam system because they can combine with condensate to form a corrosive mixture. This mixture can be very detrimental to the long-term performance of certain metallic components, particularly those made of carbon steel. The noncondensables can also act as an insulator and impede the transfer of heat from the steam. Removal of air and any other gases that may be present is usually most critical during system start up.

(Oland, 2000)