SYSTEMATIC INVESTIGATION OF FAILURE ANALYSIS ON A STEAM TRAP BYPASS TUBE IN A COALFIRED POWER PLANT

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SYSTEMATIC INVESTIGATION OF FAILURE ANALYSIS ON A STEAM TRAP BYPASS TUBE IN A COALFIRED POWER PLANT

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A project report submitted in partial fulfillment of the requirements for the award of Masters Degree in Mechanical Engineering

Faculty of Mechanical and Manufacturing
Tun Hussein Onn University of Malaysia

NOVEMBER 2007

"I declare that this project report entitled Systematic Investigation of Failure Analysis on a Steam Trap Bypass Tube in a Coal Fired Power Plant is the result of my own research as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidate of any other degree"

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Date : 30 November 2007

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ABSTRACT

A steam trap bypass tube in a power plant was totally fractured. The aim of this study is to examine the evidence presented by the steam trap bypass tube failure, determining the failure mechanism, determining the root cause of the failure and to recommend appropriate corrective actions. The power plant is a coal fired power plant with its normal operation temperature of 540°C. This study consists of failure mode inventory collection of the steam trap bypass tube failure, collection of background information about the process, component function and operating conditions. Detailed investigation carried out by visual examination, nondestructive testing (NDT), metallurgical testing which consists of microstructure examination, chemical testing and mechanical testing. Optical Microscopy (OM), Scanning Electron Microscopy (SEM) combined with Energy Dispersive X-ray Spectroscopy (EDS), Glow Discharge Spectrometer (GDS) and Energy Dispersive X-ray Diffraction (XRD) experiments were used throughout the investigation on the sample obtained. From the evidence with considering the contribution factors such as temperature, pressure and environment, a fault analysis was made and it can be concluded that the cause of failure to the steam trap bypass is due to multi causes which consists of creep failure and hydrogen damage. The root cause of high temperature creep and hydrogen damage which occurred at the steam trap bypass tube is due to material properties that are inadequate for the actual operating conditions of a steam trap bypass tube which is not according to the specification. The material must be actually ASTM SA-335-P22 (2.25Cr-1Mo) with 490MPa minimum tensile strength and 320MPa minimum yield strength. However from the investigation found that the material used was ASTM SA-192 (low strength carbon steel) with 324MPa minimum tensile strength and 180MPa minimum yield strength.

ABSTRAK

Sebatang paip perangkap stim pada sebuah stesen janakuasa didapati telah musnah sepenuhnya. Tujuan kajian ini adalah untuk menkaji kesan yang diperlihatkan dari paip yang pecah, mengetahui mekanisma kegagalan, mengetahui punca utama kegagalan serta memberi cadangan kaedah supaya kegagalan tidak akan berulang pada masa hadapan. Stesen janakuasa tersebut adalah dari jenis stesen janakuasa yang menggunakan arang batu sebagai bahan bakar dan beroperasi pada suhu 540°C. Kajian ini terdiri daripada penemuan mode kegagalan, pengumpulan maklumat latar belakang prosess, fungsi komponen serta keadaan beroperasi. Kajian dilakukan dengan melakukan pemerhatian secara visual, ujian tanpa musnah (NDT), ujian metalurgi yang terdiri daripada pemerhatian mikrostruktur, ujian kimia serta ujian mekanikal. Optical Microscopy (OM), Scanning Electron Microscopy (SEM) gabungan Energy Dispersive X-ray Spectroscopy (EDS), Glow Discharge Spectrometer (GDS) dan Energy Dispersive X-ray Diffraction (XRD) eksperimen telah digunakan sepanjang melakukan kajian pada sample yang diperolehi. Hasil dari penemuan dengan mengambil kira faktor-faktor seperti suhu, tekanan serta keadaan sekeliling, satu analisis punca kegagalan dilakukan dimana punca kegagalan adalah disebabkan dwi punca yang terdiri daripada rayapan bersuhu tinggi serta kemusnahan hydrogen. Punca utama kegagalan pada pipe perangkap stim ini adalah disebabkan sifat bahan yang digunakan adalah tidak bersesuaian dengan keadaan operasi dimana bahan pipe yang digunakan tidak mengikut spesifikasi. Bahan yang digunakan pada pipe perangkap stim yang musnah haruslah ASTM SA-335-P22 (2.25Cr-1Mo) dengan 490MPa kekuatan tegangan minimum dan 320MPa kekuatan alah minimum. Namun demikian setelah penyelidikan, bahan pada pipe perangkap stim yang digunakan adalah ASTM SA-192 (keluli karbon rendah) dengan 324MPa kekuatan tegangan minimum dan 180MPa kekuatan alah minimum.

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LIST OF SYMBOLS

°C	-	Degrees Celcius
°F	-	Degrees Farenheit
%	-	Percentage
n_c	-	Grains cut by the circumference
n_i	-	Grains in area
M	-	Magnification
N_A	-	Number of grains per unit area
N_V	-	Number of grains contained in unit volume
HV	-	Vickers Hardness
σ_y	-	Yield strength
c	-	Constant
σ_{UTS}	-	Ultimate Tensile Strength
e	-	Elongation
σ	-	Stress

LIST OF ABBREVIATIONS

SEM	-	Scanning Electron Microscopy
OM	-	Optical Microscope
EDS	-	Energy Dispersive X-ray Spectroscopy
GDS	-	Glow Discharge Spectrometer
XRD	-	Energy Dispersive X-ray Diffraction
EDM	-	Electrodischarge Machining
NDT	-	Non Destructive Testing
OD	-	Outside Diameter
ID	-	Inside Diameter
ASTM	-	American Society for Testing Materials
UTS	-	Ultimate Tensile Strength

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CHAPTER I

INTRODUCTION

In a power plant industry, failures usually occur on tubes and pipelines. Establishing the causes of failures provides information of improvements in design, operating procedures and the use of components. Failure analysis is an engineering approach to determine how and why an equipment or component has failed. Failure occurs when it does not meet its requirements. Failure analysis can also be defined as an investigation to determine the underlying reasons for the nonconformance to system requirements and is performed to identify nonconformance root causes and to recommend appropriate corrective actions [1].

A failure investigation and subsequence analysis should determine the primary cause of a failure, and based on the determination, corrective action should be initiated that will prevent similar failures. Although the sequence is subject to variation, depending upon the nature of a specific failure, the principal stages that comprise the investigation and analysis of failure is firstly the collection of background data and selection of samples [2]. Preliminary examination of the failed part which includes visual examination and record keeping will be the next stage of investigation. Nondestructive testing and mechanical testing that includes hardness test can also be done as part of the investigation. The next stage is the selection, identification, preservation or cleaning of all specimens. Macroscopic examination and analysis is the next stage where fracture surface, secondary cracks and other surface phenomena will be identified. After the macroscopic examination, microscopic examination and analysis is the next stage. Selection and

preparation of metallographic sections will need to be done thus the examination and analysis of metallographic sections. From the examinations, failure mechanism will be determined. For further investigation, chemical analysis which includes determining the bulk, local, surface corrosion products, deposit or coatings will be done. From the results, analysis of fracture mechanics will then be determined. Testing under simulated service conditions can be done for further analysis. The final stage is the analysis of all the evidence, formulation of conclusion and writing the report [2].

1.1 Statement of Problem

Cut-off a failed steam trap bypass tube of a coal-fired power plant was received. The tube is said to be made of a TU10CD9-10 (tube specification) which corresponds to ASTM SA335 P22. The outside diameter (OD) of the tube is 63.5 mm and the inside tube diameter (ID) is 53.34 mm. The received steam trap bypass tube was completely fractured and this study is to identify the root causes and to recommend appropriate corrective actions due to the failure. Figure 1.1 shows the insulated steam trap bypass tube in actual process and figure 1.2 shows the pieces of fractured steam trap bypass tube.

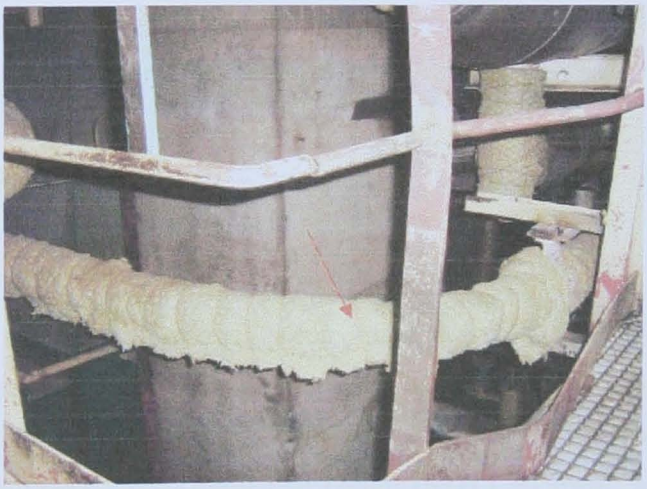

Figure 1.1: Insulated steam trap bypass tube in actual process.

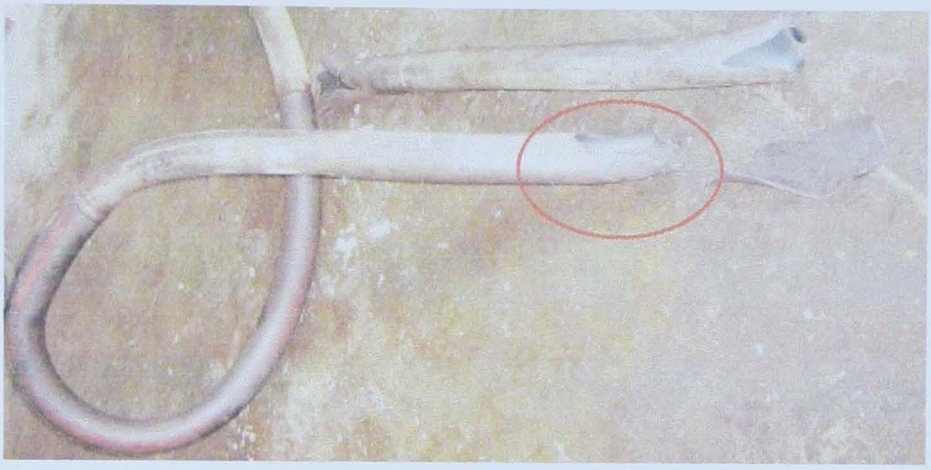

Figure 1.2: Fractured steam trap bypass tube (in circle indicates picture of sample received).

1.2 Objective of Study

There are three primary objectives in this study, the first objective is to examine the evidence presented by the steam trap bypass tube failure and determining the failure mechanism. The second objective is to determine the root cause of the failure. The third objective is to recommend appropriate corrective actions to overcome the problem.

1.3 Scope of Study

The study involves collection of failure mode inventory of the steam trap bypass tube failure. This study also involves collection of background information about the process, component function, operating conditions and failure event sequence. Detailed investigation carried out by Non Destructive Testing (NDT), microstructure examination using Optical Microscopy (OM), Scanning Electron Microscopy (SEM) combined with Energy Dispersive X-ray Spectroscopy (EDS), Glow Discharge Spectrometer (GDS) and

Energy Dispersive X-ray Diffraction (XRD) testing on the sample will be done. From these results, analysis of the result will be done to determine the root cause of the steam trap bypass tube failure.