Acoustic Steam Leak Detection System

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***Abstract*— The boiler tube failure is occurring frequently in thermal power plants. Boiler tube leakage is the significant reason for blackout of units and age misfortune in warm influence plants. Location of boiler tube leakage is a significant factor for power plant working as roughly 60% of boiler outages are because of tube leaks. Power plant engineers must cautious about boiler tube puncher so that further damages to pressure parts such as water wall tubes and headers, super heater tubes, re-heater tubes, and furnace refractory may be avoided. Boiler tube leaks have even been known to prompt to bending damage and deformation of the entire boiler. The costs of repair, substitution, and maintenance due to secondary damage can be maximum.**

There are several solutions are available to identify the boiler tube leakages such that analyzing the make-up water, survey of tube thickness and fitting sensors inside the boiler. The compact solution is fitting sensors inside the boiler. Here, we are using piezoelectric sensor to detect the tube leakages. There are two types of sensors available which are airborne sensor and structure borne sensor. Airborne contains a genuine microphone, which is totally insensitive to vibration. Structure borne is Piezo-electric based sensors can measure sound generated by a leak in the boiler structure by either acoustic frequencies or ultrasonic frequencies.

The airborne sensor is used in acoustic steam leak detection system. The Acoustic Steam Leak Detection (ASLD) system works on the principle of detecting the sound waves emanating from the steam leak, processing the same and then indicating the quantum of steam leak and the location. When a leak is detected by a change in the sound patterns, alarms are activated and the fault is localized. By using these methods the leak is detected and the many secondary damages were avoided.

Keywords- Thermal power plants, Boiler tubes, Airborne sensor, Steam.

I. INTRODUCTION

A. PROJECT OVERVIEW

Acoustics manages the production, control, transmission, reception, and impacts of sound. It is indispensable that abnormalities in power plant be detected in their early stages so that power failures will not seriously affect public life and vital installations and infrastructure. To this end, we have introduced a range of equipment monitoring systems, and development work is still going on. These monitoring systems are located with a number of sensors that work like human sense parts. Acoustic sensors are one of the most important kinds of these sensors.

This project presents a technique of police investigation abnormalities like boiler tube run, clinker formation and unbalance temperature profile within the combustion zone exploitation acoustic sensors. These abnormalities don't produce any harmful scenario however if neglected can result in secondary damages and additionally unit outages.

B. FITTING AND LOCATION

The air-borne sensing element arrangement is as shown below with a 3/4 in. (26 mm) one m stub pipe with a 3/4 in. BSP fitting needed to be fitted at a convenient purpose to induce the complete advantages of the mobile system. Locations like access doors, gaps in conduit around soot- blowers and infrequently gaps in webbing by cutting fins may be used for optimum leak coverage. The situation of sensing elements is the most vital one to spot the outflow as before long as doable. Otherwise, the adjacent tubes might have an effect on by near leakages. This leads the secondary damages in boiler.

It High pressure leaks cause extensive damage to near component parts. It increases the net weight of boiler system by mixing the water and fly ashes while occurring the leakages in tubes. It leads the additional problem in the process of producing steam.

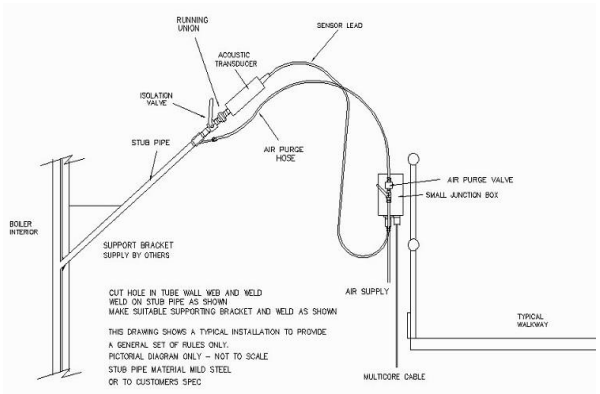

Fig 1. Fitting and locating the sensor.

C. METHOD APPROACH

- C.A.V.T. beside provide and installation of abrasion management Devices
- Software for maintaining tube outflow connected history and information
- Assistance in tube thickness survey
- Consultation and consultative services on any boiler tube leak drawback
- Tube thickness survey of varied zones throughout each boiler outage opportunity
- Maintain record of those surveys moreover as history of all tube outflow instances
- Supervision of H.P. attachment joints
- Sending the sample to laboratory and follow up to urge analysis report immediately. to hold out CAVT & take corrective actions
- Extensive boiler tube thickness survey throughout annual overhaul moreover as short shut downs
- Documentation of the tube thickness survey disbursed from time to time
- Proper operation and maintenance of water wall soot blowers
- Identify sources of air ingress within the boiler and take corrective actions. Effective and continuous direction of high pressure attachment activity
- watching water chemistry the tube failure
- Small cluster to be created to seem once numerous activities associated with boiler tube failure
- Quick analysis of the tube failure

D. OBJECTIVE OF THE PROJECT

The main objective of this project is to design an ASLD model for detection and correction of leakage fault in a boiler unit. This would eventually minimize forced outage and trips in power plants caused by tube failures and damages. Apart from that this study allows information on the behavior of boiler operation variables and common reasons of tube leakages. This project focuses on the early detection of boiler trip due to boiler tube leakage by implementing ASLD modeling through fitting and location. The ASLD model is designed to forecast a trip before the real shutdown. This will give time for plant operators to take measureable actions to avoid the real shut down.

This program is used for acoustic leak detection concepts applicable to heating and cooling systems and to work with industry to develop reliable, cost-effective, and field- implementable systems. The implementation of this technology could reduce energy costs of power plants and minimize the safety significance of steam leaks. A reliable leak detection and location system would also reduce the cost of excavation and the time required to fix a leak, and would minimize the general liability of a company.

Recent advances in commercially accessible acoustic sensors and signal process has created effective acoustic leak detection attainable. As a result multiple of industries are starting to use acoustic leak detection systems. This project implies the possibility of victimization acoustic ways to notice leaks in thermal power plants.

II. LITERATURE SURVEY

A. INTRODUCTION

The operation of the boiler is to convert water into super heated steam, which is then delivered to rotary engine to get electricity (Bamrotwar & Deshpande 2014). Pulverized coal is the common fuel employed in boiler at the side of preheated air. water wall, super heater and reheater tubes. Thermal power station boiler is one in all the vital instrumentality for the ability generation industries. Within the gift scenario of power generation, pulverize coal laid-off power stations The boiler consists of various vital elements like economizer, are the backbones of commercial development within the country, so necessitating their most convenience regarding plant ratio (PLF). At the same time responsibility and safety facet is additionally to be thought- about. The most important percentage of the forced termination of the ability stations is from boiler facet. Thus, it's necessary to predict the probable root cause/ causes of the forced outages, and additionally the remedial action to stop the return of comparable failure in the future. A drum kinds utility Boiler for thermal power generation usually consists of various pressure elements tubes like water wall, economiser, super heater and reheater. Totally different harm mechanism like creep, fatigue, erosion and corrosion are accountable of various pressure elements tube failure. Successful, reliable operation of steam generation instrumentality needs the appliance of the simplest obtainable ways to stop scale and corrosion. When instrumentality failures do occur, it's vital that reason behind the matter be properly known in order that respective corrective steps will be taken to stop a return. An incorrect designation of a failure will result in improper corrective measures; so, issues continue.

B. ECONOMIZER TUBES

Water tube economizers are usually subject to the intense harm of element corrosion. The foremost severe harm happens at -the economizer water and, once gift, at the tube welds seams. Wherever economizers are put in, effective deaerating heater operation is completely essential. The appliance of a fast-acting element scavenger, like catalyzed Na sulphite, additionally helps defend this important a part of the boiler. Whereas element corrosion is the most typical type of waterside corrosion that causes

saver tube failures, hydrated oxide has sometimes accumulated beneath deposits and caused caustic gouging. Usually, this sort of attack develops in a part of an economiser wherever steam generation is happening at a lower place a deposit and free sodium hydroxide is present within the feed water.

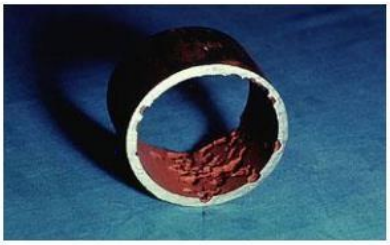

Fig 2. Oxygen pitting

C. COMMON BOILER TUBE MATERIALS

Boiler tubes are typically factory-made victimization alloy materials which may face up to each extreme temperature from the flue gases and high steam generation inside the tube. The employment of warm temperature heat resistant alloys not solely improves the super important steam quality for higher boiler potency; they additionally enable reduction in volumes of fabric for fabrication, each that promotes positive economy advantages. In step with Viswanathan (1993), boiler tubes are usually classified into 3 types of alloys; carbon steels, ferritic alloys and solid solution untarnished alloys during which all the tubes are then stratified according to its material compositions.

III. EXISTING SYSTEM

A variety of outflow detection methods are currently available. The application and effectiveness of each method depend on the piping system construction and installation technique, location of the outflow, system operating elements, and knowledge of the system outline and elements. The most common systems used nowadays for leak detection and location are classified according to their principle of operation as follows: acoustic emission, infrared spectroscopy, tracer gas, and electrical methods.

- Acoustic steam leak emission
- Electrical measurement methods

IV. PROPOSED SYSTEM

A. OVERVIEW OF BOILER

A boiler is an indoor vessel that has a method for combustion and transfers heat to water till it becomes quandary or steam. The hot water or steam struggling is then usable for transferring the warmth to a method. Water is helpful and low-cost medium for transferring heat to a method. When water is converted into steam its volume will increase regarding one, 600 times, manufacturing a force that's nearly as explosive as explosive. This causes the boiler to be very dangerous instrumentation and may be treated rigorously.

Liquid once het up to the gasified state this method is named evaporation.

B. ELEMENTS OF BOILER

- Feed water system
- Steam system
- Fuel system

The feed water system provides water to the boiler and regulates it mechanically to fulfil the steam demand. The water provided to boiler that's born-again to steam is named feed water. The sources of feed water are the feed water system provides water to the boiler and regulates it mechanically to fulfil the steam demand. The water provided to boiler that's born-again to steam is named feed water.

C. CIRCULATING FLUIDIZED-BED COMBUSTION TECHNOLOGY (CFBC)

CFBC technology is employed in tps2 boiler. The CFB system serves the subsequent functions: Environmentally acceptable combustion of solid fuels and liquids within the CFB combustor by staged combustion air addition so guaranteeing suppression of Night formation and a high carbon burnout. The options of current fluidized-bed boilers square measure delineated below,

- Compatibility with big selection of fuels
- Low contamination
- High combustion potency
- Space-saving, simple maintenance

It provides a rough summary of CFBC. Generally, CFBC consists of a boiler and a high-temperature cyclone. The intra-furnace gas rate is as high as four to eight m/s. a rough fluidizing medium and char within the flue gas are collected by the high-temperature cyclone and recycled to the boiler. Employment maintains the bed height and will increase the denigration potency. to extend the thermal potency, a pre-heater for the fluidizing air and combustion air, and a boiler feed warmer.

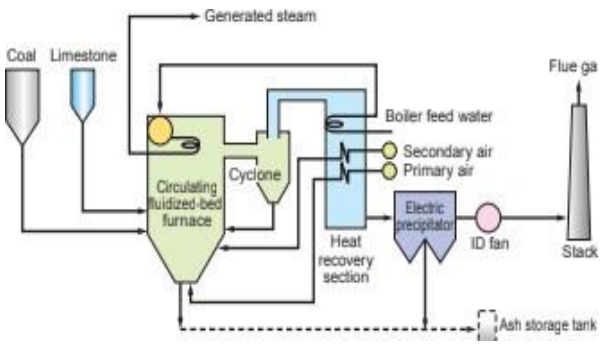

Fig 3. *Process flow of circulating fluidized-bed boiler*

D. ASLD TECHNOLOGY

The Acoustic Steam Leak Detection (ASLD) system works on the principle of identifying the sound waves emanating from the steam leak, process an equivalent so indicating the quantum of steam leak and therefore the location. the standard methodology of identifying boiler tube steam leaks is by ear. But, this methodology would cause secondary damages within the boiler tubes due the delayed actions. compared, the computer-based acoustic tube leak- detection system uses dynamic pressure device to get audio spectrums and analyze plant conditions. once a leak is detected by a modification within the sound patterns, alarms are activated and therefore the fault is localized. Mimic diagrams change plant operators to spot the affected part and plot the progress of the leak for planned shutdowns.

E. PRINCIPLE AND WORKING OF ASLD

Acoustic stem leak detection system may be a non-contact technique supported the link of between the speed of sound and also the density of the medium through that it travels. it's acknowledge that the speed of sound varies with the temperature of the medium through that it travels which changes in speed sound will thus offer an instantaneous measure of the medium's temperature.

The fundamental principal of leak detection system is predicated on the very fact that controlled steam or water passing through an passageway produces sound energy. The name given to the present energy is acoustic emission and it's a large band of frequencies from below 1Hz to higher than 1MHz.

F. WORKING OF A PIEZOELECTRIC SENSOR

The normally measured physical quantities by a piezoelectric device are Acceleration and Pressure. each pressure and acceleration sensors work on constant principle of piezo-electricity however the most distinction between them is that the approach force is applied to their detector.

The resistance is that the internal resistance or material resistance. The inductance is thanks to the inertia of the detector. The capacitance is reciprocally proportional to the physical property of the detector material. For the right response of the detector, the load and escape resistance should be massive enough so low frequencies are preserved. A detector will be referred to as a pressure electrical device in associate electrical signal. Sensors are referred to as primary transducers.

G. LIMITATIONS OF ASLD

The main disadvantage of the sensing element is that the dependability to get sound signals loud enough to be detected within the presence of significant background. This downside has been overcome recently with the event of proprietary technology that contains a high intensity gas sound generator, in addition to a complicated reception algorithms. The sound generator produces a high-energy acoustic wave (over one hundred seventy dB) employing a distinctive proprietary gas device as shown in figure. The new sound supply allows the measuring of gas temperatures in furnaces over 30meters wide, and among soot blower lanes (up to twenty five m), that has antecedently not been potential. It additionally permits the utilization of long (up to thirteen meter) pipes to deliver the sound to the required measuring location, like the tip of the boiler "bullnose". this allows mounting arrangements through wind boxes and/or around obstructions while not moving the standard of the resultant measuring. The high-energy acoustic wave additionally allows the utilization of smaller and additional subtle receivers which will be pronto put in through boiler tube webbing exploitation twelve metric linear unit by twenty five metric linear unit slots. This has had a serious impact on reducing installation prices and eliminating the requirement to bend boiler tubes

H. ADVANTAGES OF ASLD

Soot blowing operations has been optimized by the use of Acoustic Pyrometer resulting in significant reduction in steam combustion and over blowing operations.

Reduction in Super heater & Reheater spray leads to reduction in efficiency, so once real time temperature gradient is known to operator, combustion conditions are analyzed to reduce over heating combustion.

V. COST ANALYSIS

Based on Tubes steam leak about observation and study of FBHE, the tube leak replacement was carried out approximately 200 tubes per occasion (Installation and commissioning of ASLD system). Only average number of tube failures is taken for evaluation of cost analysis.

A. RESTOREATION TIME

It is the time required for bringing back the unit for generation after attending tube leak puncture works which includes Boiler cooling including FBHEs, puncture locating, Refractory breaking, preparatory works for coils pulling, damaged tubes cutting, edge preparation, spools preparation, fit-up joints welding, post weed heat treatment (stress relieving), normalization of coils, men and material removal and clearance for unit light up.

B. NUMBER OF DAYS SAVED

For attending 200 tubes replacement the time required for restoration is 10 days (approx.). For attending 80 tubes replacement the time required is 7 days (approx.).

Actual time saved after the Installation of ASLD 10-7=3days(approx.)

C. UNIT GENERATION COST

Unit generation cost is=Rs.5.35 (Power selling price) (1)

D. MAINTENANCE COST

Maintenance cost for tube replacement Rs 5000/- per tube (2)

E. MATERIAL COST

For 120 tubes, the total length of tubes used = 120x0.5meters = 60 meters.

Tube material cost per meter = Rs. 5000/- (for SA213T91 material).

Total material cost saved = RS.5000x60 = 3lakhs (3)

F. CALCULATION

Number of days saved x full generation per day in million units x generation cost per unit + maintenance cost for replacement work+ material cost.

Number of days saved = 3days

Number of tubes saved due to earlier detection of failure = 200-80 =120

Full generation per day in million units = 6 million units(6 x 10^6 units)

Generation cost =Rs. 5.35 crores

Actual cost saved in crores after the installation and commissioning of ASLD system =(1)+(2)+(3)={[3days x (6x10^6) x 5.35]+[5000x120]+[5000x60]} =9.72 crores

Average no of occasion = 10 per annum

Cost saved per annum= 9.72x10 = 97.2 crores

By installing ASLD system multiple tube failure is minimized by early detection of tube steam leaks. Hence it saved an approximate cost of **Rs.97.2 crores per annum.**

VI. RESULT AND CONCLUSION

In this project, we tend to summarize the acoustic steam outflow identification applications in boiler of a thermal power plant station. According to our research, the acoustic technology has wide application in boilers. Early detection of faults will decrease the amount of repairs to be made and the unit downtime.

The main monitoring system is the frequently used for reading analysis. The positive mark indicate the normal level of boiler and whenever the leakage occurs it will turn off from green indication to red indication. It indicates the leakages in water tubes and steam tubes.

Fig 4. *Channel Specification*

The results of the proposed model were superior compared to the other states. The proposed model yielded an average classification accuracy of 99.25%, which is at least 4.25% better than any of the state to which it was compared. Therefore, it is ended that the planned model is accustomed effectively observe and classify leaks during a boiler tube.

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