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FAULT DETECTION OF HEAT EXCHANGER USING ACOUSTIC PULSE REFLECTOMETRY

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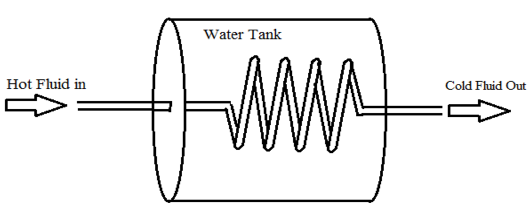
***ABSTRACT*--**Heat exchangers (HXs) are the devices used to transfer heat from one fluid to another. Most commonly, HXs can transfer or receive with thefluid materials and it can travel of hundreds to thousands of tubes in parallel. All are encased with a metal shell. HXs canoperatefor long periods of time;heat exchangers are subject to ultimateimpurity or failure into many mechanisms, including erosion, corrosion, attrition, thermal shock, deposit and pollute the contents.Review of Heat exchangers usually requires to shutting down an entire plant to analysis leakage and breakage of fluids but it may be costly for such stoppages of the plant therefore it isalso called as turnarounds. Hence my objective is to inspect and diagnose of Heat exchanges without shutting down the process by using a new technique called Acoustic Pulse Reflectometry (APR) to analysis the tubes very quickly.

***Index Terms*--MATLAB, Amplifier, loud speaker, pipes**

I. INTRODUCTION

A very common example for the use of heat exchanger [HXs] is in fossil-fueled power plants. So they are cool and condense steam by pumping cooling water through into the tubes. A geothermal power plant isanotherexample for heat exchangers. It is naturally heated water is pumped from the ground and then passed through a Heat exchanger to heat an organic compound like isobutene etc. The isobutene drives the electricity-generating turbines and then condensed in a second Heat exchanger tube. The second Heat exchanger most often has break water tubes which are air-cooled using large fans. The basic Heat exchanger is shown in fig.1



Fig,1 Basic Heat Exchanger

In general, Heat changers are found in most of the industries such as power plants, refineries, paper mills, HVAC, food and beverage, and chemical. Many different types of fluids are used in the Heat exchangers but some of these fluids are corrosive to various degrees.Plant operators are aware of these necessaryissues and thus inspect their Heat exchangers periodically, both to ensure their efficiency and to prevent harmful failures.

II. FLOW CHART FOR HEAT EXCHANGER

Analysis of all the sampling points is to identify the disturbance and noise waveform from the heat exchanger tubes. So the heat exchanger of fluids may set the time period of sampling point from the tubes to identify the different variation of sound point.In the triangular pulse waveformcan gathered from the sound form of fluid. Flow chart is shown in fig.2.

Fig.2 Flow Chart

III. HEAT EXCHANGER MAINTENANCE AND TYPICAL FAULT

Heat exchangers have been used in many industries which lead to turn their proper maintenance, inspection and repair. Before use the heat exchangersare first remove the sediments, deposits, and corrosion. Cleaning process can be a difficult process because some types of deposits are hard to remove and a large number of tubes must be cleaned in a short time. In case of cleaning process the

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individual tubes arefirst inspected and identify the fault are then plugged into the tubes.The most basic fault that can be found in Heat exchangers is foulingand it may not be harmful but can considerably impair the efficiency of the Heat exchangers. Fault can identify by using leakage or breakage of flow in the heat exchanger tubes. Most of the corrosion or erosion in the tubes is take place due to the continuous flowing of heat exchanger in the tubes. The corrosion or erosion of fluids leads to breakage or leakage in the heat exchangers tubes.

IV. SETUP DIAGRAM

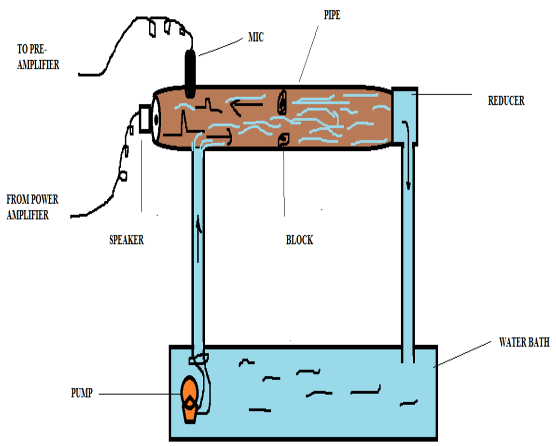

Fig.3 Hardware setup

In the flowing fluids of Heat exchanger can transfer one to other end of tube. If incase of any failure or fault in the HXs tubes may identify by the loud speaker sound variation in the tubes. The MIC is to record the HXs flow waveform variation and it is directly given to MATLAB coding in the personal computer or laptop.The circulating pump is to pump the flowing fluid. The water bath is to maintain the level of the fluid to circulate the pump and the preamplifier is to amplify the position of the system. Mostly pipes should be used as metal shell types because it helps to protect from the heavy Heat exchange. The hardware setup diagram is shown in fig.3.

V. ACOUSTICPULSE REFLECTOMETRY (APR)

The drawbacks of existing methods like eddy current testing (ET) and Internal Rotating Inspection System (IRIS)are overcome by this method called Acoustic pulse reflectometry (APR).In all the caserare to find plants in which 100% of HX tubes are regularly inspected, leaving room for critical failures. Therefore it is not surprising that engineers are constantly searching to improve on these methods. Particularly concentrateon the inspection/analysis speed. Imagine an acoustic pulse traveling through the air enclosed within a long tube. As long as the pulse does not encounter any changes in the tube cross section and the pulse continues to propagate with some attenuation due to friction between the molecules of air and the tube wall is shown in fig.4. If a discontinuity is encountered and reflected waves are created so that it can propagate back up to the tube. Recording and analyzing these reflections to determine fault of discontinuity caused those enables this technique to be applied to tube inspection.From the point of view of a pulse traveling down a tube for any changesin the system like blockage or caused by wall loss or bulges and a through hole. The reflections caused by these three cross-section alterations are very different from each other. In the reflection is increase in cross section is very different from a reflection is decrease in cross section and both are different from the reflection caused by a hole. Real-life signals are noisier and less uniform than theory. The acoustic pulse acts essentially used in a virtual probe.APR can travels up the tube and returns signals that report on the tube's internal condition. It differs in two significant ways, APR cannot get stuck and it operates at the speed of sound. There are plenty of obstacles to be overcome with the translating as a pulse form. The entire process of creating a pulse and measuring the reflections must be performed in as short a time as possible. In case of the process that can be repeated constantly many thousands of times.

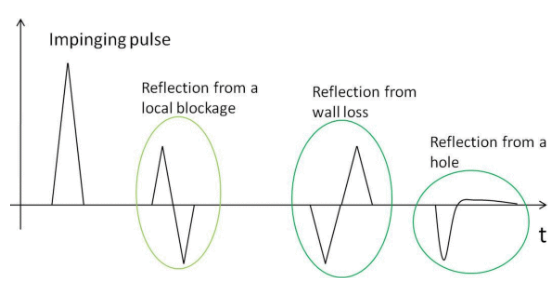

Fig.4 Principle of APR

VI. EXPERIMENTAL BLOCK DIAGRAM

The general block diagram of such a system is outlined in Fig.5controller; preferably computer can creates a pulse in software and outputs it to a D/A card, which drives a power amplifier. The amplifier drives a loudspeaker and it creates an acoustic pulse in the tube being inspected. The various waves propagating in the tube are recorded by a microphone, after which they are digitized by an A/D card and stored in the computer. The digital signals must be processed by software to interpret and classify them into various types of faults as well as to quantify them.

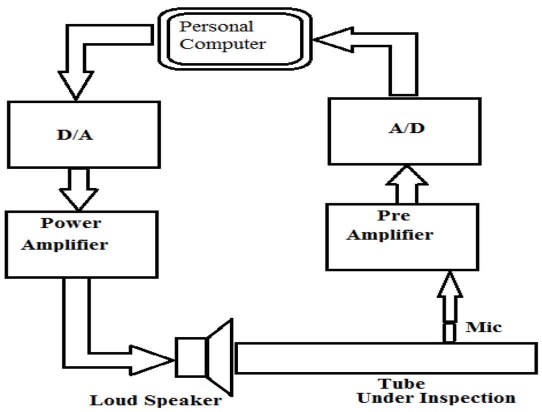

Fig.5 Block diagram

VII. WORKING PRINCIPLE

The whole of the work depends on the computing software (MATLAB software). The computer is well organized that it has the provision sound card features. The GUI model can controls with the complete execution is shown in fig.6. The process variation of HXs tubes can be directly measure with the help of the MATLAB. Any changes of waveform and sound can be identified through by MIC and Loud speaker respectively. The MATLAB consists of the load button to play the acoustic sound signal and it can be predominantly constructed using waveform generator tool. The sound is played through the loud speaker which is mounted on the inspection tube. In consideration of disturbances and environmental effects is the acoustic signal which is played is amplified by the power amplifier CTC 810, so that the gain reaches nearly to100dB. In the process of acoustic Pulse reflectometry the acoustic impinged signal propagates through the tube which has to be inspected. If the tube undergoes any cross sectional changes the impinged pulse changes in its electrical properties such as amplitude reduction, change of phase etc. These changes are recorded by the condenser microphone and fed to the MATLAB software.

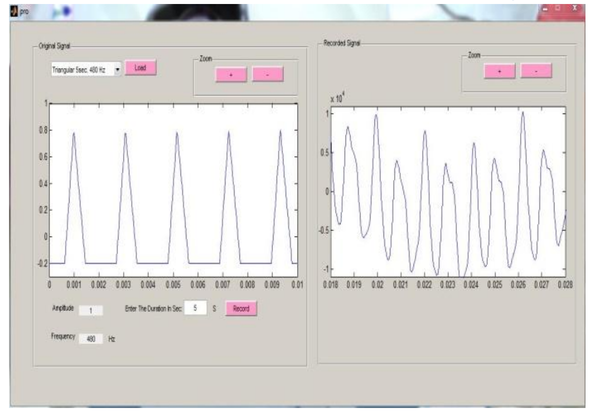

Fig.6 MATLAB GUI window for Data Acquisition

VIII. FIGHTING AGAINST NOISE

The main challenge in applying APR is to get a high signal to noise ratio (SNR), since reflections from small faults can get lost in every present background noise. The stronger the initial pulse will get the stronger the reflections. The output voltage of the amplifier cannot be increased beyond practical limits and the loudspeakers are limited with respect to the maximum voltage that can be used to drive them. In fact that the long before dangerous power levels are achieved, most loudspeakers begin to distort the signal until it becomes unusable moment. One approach to increasing SNR [signal to noise ratio] is to conduct the same measurement hundreds or even thousands of times and to get the average the results. This strengthens the signal while averaging out the noise. This process is overtime to be consuming for analysis the result. One such signal is known as the maximum length sequence (MLS) used also in measurements of room acoustics pulse. Various components are include in the amplifier, loudspeaker, microphone, and A/D and D/A circuitry is carefully selected and achieve very high SNR levels upto 120 dB. The MATLAB further consists of algorithms such as Blind source separation wavelet noise decomposition to separate the noise from the original signal. The signal changes can be measure in the fig.7.

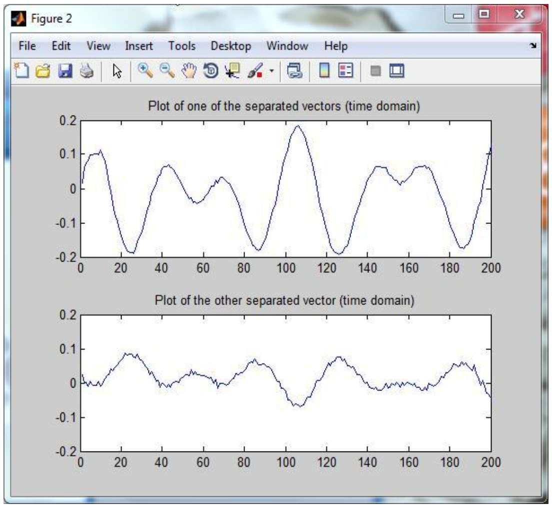

Fig.7 MATLAB GUI Window for Noise Cancellation

IX. VALIDATING RESULTS

The recorded output of APR pulse will not contain any changes in its electrical properties. This positive Vs negative calibration method is being used to find the harmful failures such as blocks, leaks and losses. The table.1 below represents the validation table which has been experimentally proved by our system.

Table.1.Inspection Tube Validation

Positive peak Amplitude (volts)	**Negative peak Amplitude (volts)**	**Blockage Rate (%)**	**Leakage Rate (%)**
.92	-.92	0	0
.32	-.32	75	0
.1	-2.5	0	20
.78	-4.5	25	45
.1	-.1	100	0
.45	-.45	50	0

X. CONCLUSION

All over thecompanies are involved in many different industries have to adopt APR for HX tube inspection. They are having many tubes and pipes throughout the world that require effective inspection to ensure safety, efficiency, and reliability and it is impossible to achieve 100% inspection coverage for all the tubes. Acoustic Pulse Reflectometry potential is applied to efficiently and it is examine with the percentage formfor larger variety of tubes and pipes. At final stage of these companies will be able to prevent many critical failures and avoid serious harmful failure by performing continuous inspection and maintenance in the industry.

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