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DETECTION AND REMOVAL OF DUST PARTICLES IN PIPELINES USING 3-D MEMS

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Abstract- Currently, the detection of dust particles is realized through manual sampling. Thus it is desirable to develop an automated online technique. Generally, industries run with the help of pipelines through which liquid can flow. The main aim of the work is to detect the dust particles which are present inside the pipeline when liquid is flowing through it. Distributed Acoustic Sensing (DAS) is a recent addition to the pipeline security world. Opta sense system is designed to prevent the damage in pipeline by providing the advance warning to the concern department and make them alert. The dust particles are detected by using MEMS, which can sense in three axis (Heat, Vibration, Movement). It is identified by the IR sensor. The approach can also be simulated by using MATLAB.

Index terms: Micro Electro Mechanical System (MEMS), Distributed Acoustic Sensing (DAS), Renewable Energy Sources (RES), Opta sense interrogator unit (OIU).

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I. INTRODUCTION

Pipeline management presents challenges that are quite unique. Their long length, high value, high risk and often difficult access require continuous monitoring as well as optimized maintenance interventions. The main concern for pipeline owners involves leaks that, if not detected, can severely impact the environment or render the pipeline out of service. Leaks can be detected and localized using distributed fiber-optic temperature sensors. Distributed Temperature Monitoring can also detect third-party tampering and non-authorized work before any damage is done to the pipeline. The damaged pipeline is shown in fig 1. Additionally, pipeline strain distribution and soil movement can be detected and localized by incorporating distributed strain monitoring systems. It has been an industry goal for many years to protect oil, gas and refined product pipelines against sabotage, illegal tapping and terrorist action, in addition to the everyday detecting of leaks and in-line equipment failure. This articlehighlights how a distributed acoustic sensing system called Opta Sense is helping to protect the world's critical oil and gas supplies. It has never been more important to ensure the safety and reliability of prod-uction and distribution assets for the oil and gas industry. In a fragile economy, any threat to pipeline infrastructure can have a significant effect, whether from an intentional disruption or simply inadvertent damage caused by everyday activity or natural events. Along with threats from theft and construction work, pipelines are also an easy 'soft target' for terrorist organisations aiming to damage Western economic and political interests. Common pipeline security measures include aerial surveillance, installation of pipeline warning boards/markers, deployment of security personnel, and conducting awareness campaigns to educate habitants and workers along the pipeline route. Advanced telecommunication systems and leak detection systems are also widely used to improve the monitoring and remote control of pipelines. However, armed security guards cannot be everywhere at the same time. While aerial surveillance vehicles that have a passing inspection window and Closed Circuit Television (CCTV) security cameras are effective for surveillance, they are not applicable over long distances, and are less useful if not incorporated into a complete security system shown in fig 2. Pipeline technology provides around-the-clock monitoring over very long distances. Operators can 'see' the entire length of the fibre optic cable continuously and detect, classify and locate multiple simultaneous disturbances with excellent resolution. Most importantly, the signal extracted from each section of fibre is unaffected by the vibration on any other section. Pipeline employs a processing architecture for analyzing acoustic activity that draws upon decades of military sonar research within QinetiQ, which is one of Europe's largest research and technology companies. This tells the operator what the threat is and minimises false or nuisance alarms. Customisable software allows the operator to create zones where specific activity can be activated, suppressed or tuned to account for differing environmental conditions or requirements. This allows the user to control what information they feel is relevant to their installation. Generally industries run with the help of different type of pipelines. The images of flow of water with dust particles is shown in fig .3. Those pipelines may contain liquids. It may not be pure due to the contamination of dust particles in some industries. The small particles are conveyed to temporary storage silos and then to furnace. Large particles are conveyed to further pulverization. Currently detection of dust particles is realized with the help of manual sampling. The types of dust particles is shown in fig 4.Thus it is desirable to develop an automated online technique. The pipeline setup consists of some sensor and MEMS. The movement, heat and vibration of the dust particles can be sensed by Micro Electro Mechanical System (MEMS). By using of this the dust can be detected. It can also be simulated by MATLAB software. Distributed Acoustic Sensing (DAS) is a recent addition to the pipeline security world, but one that has quickly established an international track record in providing benefits to pipeline operators is shown in fig 5..

The Opta Sense system is designed to prevent pipeline damage from occurring in the first place by providing advance warning of the events leading up to an incident. Attaching an Opta Sense Interrogator Unit (IU) to one end of a standard fiber optic cable, such as those used for telecommunication, creates an acoustic array of virtual microphones every 10 m along the fiber. The sound received from the virtual microphones is analyzed and converted into a simple graphical display showing the operator what is happening along each individual section of fiber. Opta Sense works by sending a pulse of light down the fiber optic line from an IU. A small percentage of light is reflected back towards the source this effect is called 'backscatter'. Sound or vibration near the fiber changes the pattern of backscattered light, and these changes are analyzed by the IU to recreate the sound or vibration that caused them.

Fig 1: Pipeline in air closed compressor building

Fig 2: Hydro electric pipelines

Fig 3: Flow of water with dust particles

Fig 4: Dust particles

Fig 5: Damaged underground pipeline

II. Literature Survey

Currently, fossil fuels such as oil, coal and natural gas represent the prime energy sources in the world. However, it is anticipated that these sources of energy will deplete within the next 40–50 years. Moreover, the expected environmental damages such as the global warming, acid rain and urban smog due to the production of the emissions from these sources have tempted the world to try to reduce carbon emissions by 80% and shift toward utilizing a variety of Renewable Energy Sources (RES) which are less environmentally harmful such as solar, wind, biomass etc. in a sustainable way. Biomass is one of the earliest sources of energy with very specific properties. In this review, several aspects which are associated with burning biomass in boilers have been investigated such as composition of biomass, estimating the higher heating value of biomass, comparison between biomass and other fuels, combustion of biomass and coal impacts of biomass, economic and social analysis of biomass, transportation of biomass, densification of biomass, problems of biomass and future of biomass. It has been found that utilizing biomass in boilers offers many economical, social and environmental benefits such as financial net saving, conservation of fossil fuel resources, job opportunities creation and CO2 and NO2 emissions reduction. However, care should be taken to other environmental impacts of biomass such as land and water resources, soil erosion, loss of biodiversity and deforestation. Fouling, marketing, low heating value, storage and collections and handling are all associated problems when burning biomass in boilers. The future of biomass in boilers depends upon the development of the markets for fossil fuels and on policy decisions regarding the biomass market[1].The implementation of the Phase Locked Loop(PLL) Structured Observer in high frequency signal injectionschemes requires tuning of the PI Controller to lock on the rotorposition. The PI controller is tuned depending on the Signal to Noise Ratio(SNR)which is related to the amount of saliency/anisotropy presented in the machine, the amplitude and phase of the incoming modulated carrier signal. Thus, in case anyof the mentioned factors changes then the PI has to be returnedagain, otherwise it will lose track. A new PLLstructure is suggested to avoid any disturbance that affects thedemodulation and detection process. The new PLL scheme istotally independent of any machine parameters except thesaliency/ anisotropy, which is essential to obtain the rotor speedand position information[2]. Harmonic analysis makes available concise view of data windows and their affect on the detection of harmonic signals in the presence of broad-band noise, and in the presence of nearby strong harmonic interference. We also call attention to a number of common errors in the application of windows when used with the fast Fourier transform. Harmonic analysis includes a comprehensive catalog of data windows along with their significant performance parameters from which the different windows can be compared. Finally, an example demonstrates the use and value of windows to resolve closely spaced harmonic signals characterized by large differences in amplitude[3]. The detection ofwood Pellets in pneumatic conveying pipelines and removing system used to detect and remove the wood pellets in pipelines using robot. The objective is to remove the wood pellets to increase the combustion efficiency which increases the power generation. A human controlled robot is used that gives an insight view about the pipeline. A blower is used for maintenance. The robot is operated through PC using wireless zigbee technology and using wireless camera we can get information about the pipeline[4].

Key parameters such as particle velocity, concentration of solid particles, and stability of pulverized fuel flow in fuel pipelines are useful to power plant operators to detect fuel supply problems at an early stage. Flow measurement presents the use of a novel multichannel instrumentation system with circular and arc shaped electrostatic sensor arrays for the online continuous measurement of “mean” and “local” characteristics of blended biomass flow. Experimental tests were conducted on a pneumatic conveying test rig under various flow conditions on both horizontal and vertical pipes. The biomass fuels tested include willow, wood, and bark. A ground grain (flour) was used to replicate a biomass of fine particles. The results suggest that, due to the physical differences between the constituent biomass fuels, the characteristics of the flow depend on the proportion of larger biomass particles in the blend. It is found that pure flour particles travel faster and carry more electrostatic charge than those of larger biomass particles. As more biomass particles are added to the flow, the overall velocity of the flow slows down, the electrostatic charge level decreases, and the flow becomes less stable compared to the pure flour flow. Particles in the vertical pipe are found to be more evenly distributed, and the particle velocity profile across the pipe cross section is more regular when compared to those in the horizontal pipe[5]. The new developed Optical Multimode Online Probe (OMOP) can process images from either incident-light illumination (also called epi-illumination) or transmitted-light illumination (also called trans-illumination). The probe has an outer diameter of 38mm and the illumination is achieved by high performance Light Emitting Diodes (LEDs) with specifications of 1.96mm² and 493lm (251.53lm/mm²) at an Angular deviation of 0.37°. A camera probe is used with either an object-space Telecentric (telecentricity <0.2°, 2437mm virtual pupil distance) or entocentric objective (Köhler based illumination, 6238mm virtual pupil distance). Using the telecentric mode, the particle distance independency is located within 20mm while the focal depth is approximately 5mm. The local resolution is between 20 and 30µm, according to the used optics, with a standard deviation less than 4.5%. The error of false positives typically is below 5% while the error of wrong radiuses is below 1% for up to 90% of all droplets and below 5% otherwise. Up to five images per core and second (trans-illumination) can be analyzed automatically and online at densities up to 25% (trans-illumination, gap width less than 5mm) 40% (object side telecentric epi-illumination, single probe) respectively. The advanced pre-segmentation approach based on the Random Forest Classifier (RFC) is used to perform the more complex image analysis with epi-illumination. As long as the quality of pre-segmentation is high enough, the classification results in images, which can be analyzed in the following distance, transform approach. This is considerably depending on the quality of training the algorithm and recurring image features. Compared to the distance transform analysis at low densities the deviation increases. The RFC pre-segmented image gives an additional deviation of 1.1% (both in regard to the total amount of evaluated pixels) and a deviation of 12.9% in regard to the mean particle diameter. Below a particle size of 50 pixels the image analysis overestimates the actual number of particles due to the sensitivity of the Euclidian distance approach[7]. On-line non intrusive measurement of particle size distribution through digital imaging presents the further development in the design and implementation of an innovative optical instrumentation system that can measure the size distribution of particles in a pneumatic suspension. A low-cost charge-coupled device (CCD) camera is used to capture the images of the particulate flow field which is illuminated by a Low-cost laser sheet generator. The particle size distribution is then determined by processing the particle images through the use of novel processing algorithms[8]. An instrumentation system using combined sensing strategic for online mass flow rate measurement and particle sizing introduces new technology and unique approaches to particle monitoring, so people can meet the evolving demands of research and development. Microelectronics, data storage, display, aerospace and a myriad of other applications require the continuous development of products designed to meet the challenges of today and tomorrow. Get the data need to make informed decisions and improve product quality with Particle Measuring Systems[9]. Two different procedures for effecting a frequency analysis of a time-dependent Signal locally in time are studied. The first procedure is the short-time or windowed Fourier transform; the second is the wavelet transform, in which high-frequency components are studied with sharper time resolution than low-frequency components. The similarities and the differences between these two methods are discussed. For both schemes a detailed study is made of the reconstruction method and its stability as a function of the chosen time-frequency density. Finally, the notion of time-frequency localization is made precise, within this framework, by two localization theorems[10].

III. PROPOSED SYSTEM

The main aim of the work is to detect the dust particles which are present inside the industry pipelines. Using sound sensors and IR sensors dust particles can be detected. Opta sense system is designed to prevent the damage by providing advance warning. To monitor the dust particles inside the pipelines, MEMS is used. MEMS-micro electromechanical system which can senses in three axis that is movement, heat and vibration. The approach can also be simulated by using

MAT lab. In order to obtain an exact and required particle that is free from dust the above concepts are used. The set up consists of microcontroller, ADC, MEMS, UART, isolation amplifier, LPF, GSM, LCD, RS 232, IR and Sound sensors. This pipeline set up make us alert earlier so that dust particles can be detected easily. The alert message can be sent to either PC or mobile using GSM.Attaching an Opta sense interrogator unit (IU) to one end of the standard fiber optic cable, such as those used for telecommunication, creates an acoustic array of virtual microphones for every 10m along the fiber. The sound received from the virtual microphones is analyzed and converted into a simple graphical display showing the operator what is happening along each individual section of the fiber. The block diagram for the pipeline set up is shown in fig 6. The Opta sense works by sending a pulse of light down the fiber optic line from an IU.

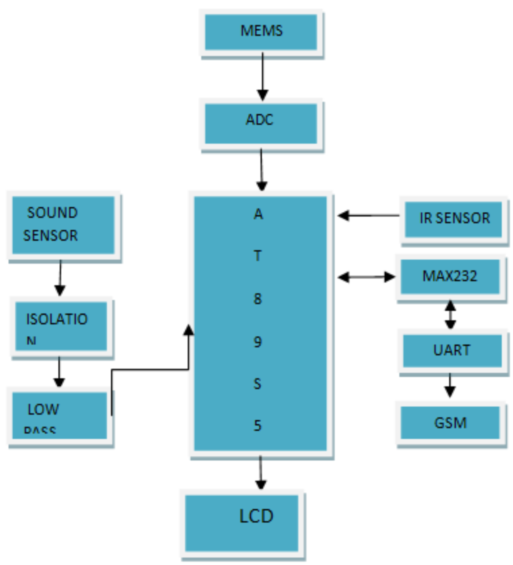

Fig.6 Detection of dust particles in pipelines using 3-D MEMS.

A small percentage of light is reflected back towards the source – this effect is called BACK SCATTER. Sound or vibration near the fiber changes the pattern of back scattered light and these changes are analyzed by the IU to recreate the sound or vibration.

IV. MEMS

Micro-electromechanical systems (MEMS) incorporate miniature electro-Mechanical components fabricated with processing techniques and Equipment originally developed in the semiconductor industry. While existing MEMS sensors and actuators have enabled automotive crash sensors, ink jet printer nozzles and catheter tippressure sensors, new market opportunities for MEMS technology abound in the telecommunication, biomedical, semiconductor, and aerospace industries.

V. ANALOG TO DIGITAL CONVERTER

The ADC0808, ADC0809 data acquisition component is a monolithic CMOS device with an 8-bit analog-to-digital converter, 8-channel multiplexer and microprocessor compatible control logic.

VI. AT89s52 MICROCONTROLLER

AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the Indus-try-standard 80C51 instruction set and pin out.

VII. UART

An UART, universal asynchronous receiver / transmitter is responsible for performing the main task in serial communications with computers. The device changes incoming parallel information to serial data which can be sent on a communication line. A second UART can be used to receive the information. The UART Performs all the tasks, timing, parity checking, etc. needed for the communication. The only extra devices attached are line driver chips capable of transforming the TTL level signals to line voltages and vice versa. The diagram for UART is shown in fig 7.

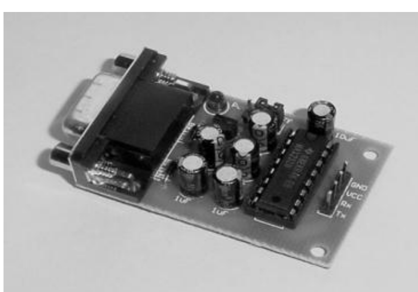

Fig 7 UART

VIII. MAX 232

The **MAX232** is an IC, first created in 1987 by Maxim Integrated Products, that converts signals from an RS-232 serial port to signals suitable for use in TTL compatible digital logic circuits. The pin diagram for MAX232 is shown in fig 8

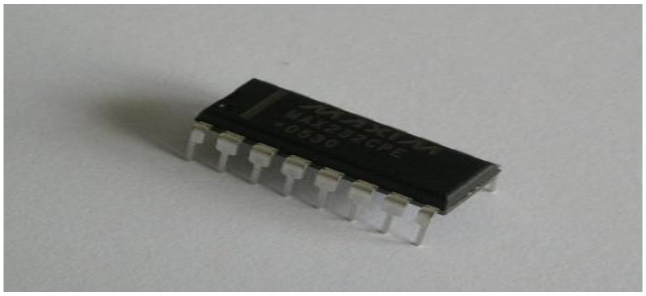

Fig 8 MAX 232

IX. GSM MODEM

The GSM system is the most widely used cellular technology in use in the world today. Global System for Mobile Communications was designed as a second generation (2G) cellular phone technology by using a digital TDMA (time division multiple access approach). The diagram for GSM modem is shown in fig 9.

Fig 9 GSM

X. EXPERIMENTAL RESULTS

The pipeline set up kit is shown in fig.10. which consists of MEMS, sound sensor, IR sensor, GSM, UART, ADC. At first, kit is connected with the PC using RS-232 cable. Transformer needs 230v supply, IC needs 5v.Step down transformer is used. Bridge rectifier is used for converting AC to DC. The capacitor range is 1000uf which is used for removing unwanted noise(store DC pulse). LED is used to check the woking of IC. Initially, MATLAB program is run, if there is an error it will indicate in the command window. After compiling the program the output will be displayed. At first LCD display will show a “#” symbol. After getting an output image LCD display will show X, Y, Z value. Generally X, Y, Z values Swill change. If dust particles are present then the X, Y, Z values gets decreased. When the X, Y, Z values are different from normal defined values the ALERT message is displayed in the LCD display meanwhile, ALERT message is also sent to the given mobile number through GSM.

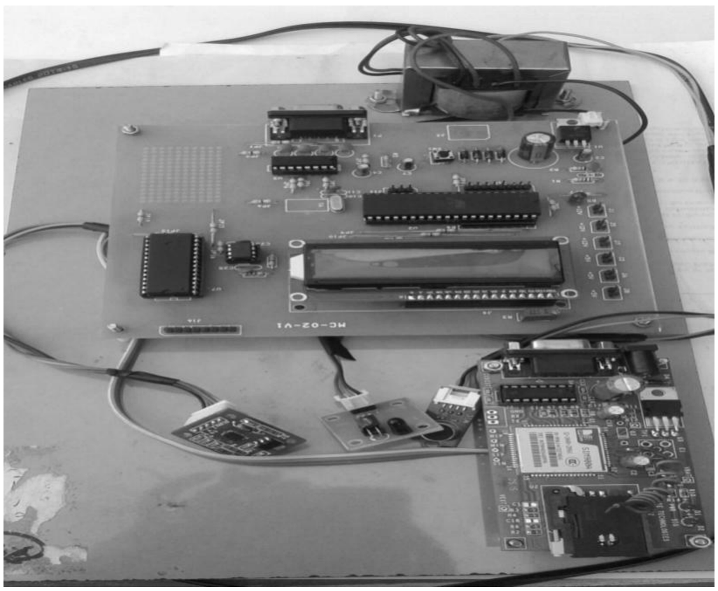

Fig 10 Experimental protocol setup

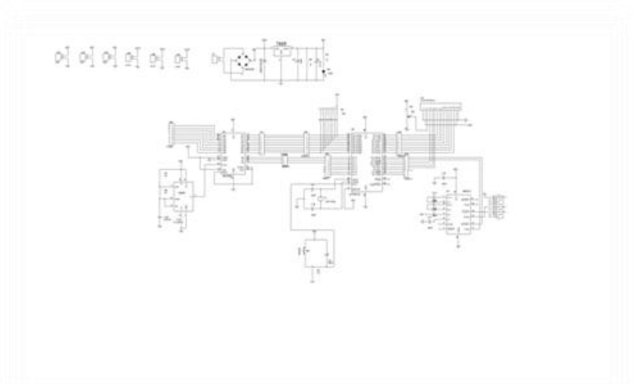

Fig 11 Circuit diagram of detection of dust particles in pipelines using 3-D MEMS

The circuit diagram is shown in the fig 11 which consists of ADC with 8 data pins and 3 control pins(select, read, write). 8 data pins are given to the port 0.1 to 0.7 of ATMEL. 3 control pins are given to port 1.0 to 1.7 of ATMEL. Port 2.0 to 2.7 of ATMEL are given to the LCD display. Port 3.0 to 3.7 are given to the MAX 232.

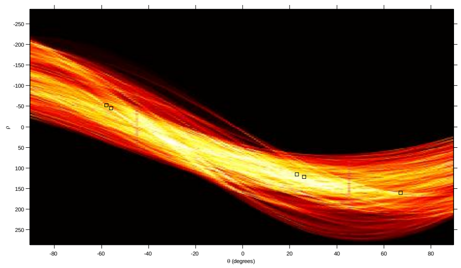

Fig.12 Graph for dust particles

The graph 12 tells about the inclination of liquid flow with dust particles. When liquid is flowing through the pipeline, there are different inclinations are seen with different types of dust particles. From this graph, the level of dust particles are shown.

XI. CONCLUSION

The detection of dust particles in pipelines using 3-D MEMS can sense the three axis such as HEAT, VIBRATION and MOVEMENT. On the other hand high accuracy is achieved by our method. This pipeline setup is a reliable system. It is easy portable and more sensitive. It is thus desirable to develop an automated on-line technique for the improved efficiency in many industry pipelines. By the use of GSM the location of the dust particle is easily be determined.In future it will be applied with the detection and correction of dust particles present in the pipeline with high efficiency and portability.It can applied not only to the liquid flowing industrial pipeline but also to the gas flowing industrial pipeline.

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