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Monitoring of Corrosions and Leakages in Gas pipelines and a Safety Technique using LabVIEW

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ABSTRACT:A novel approach to detect and control the corrosion and leakage in the gas pipeline is presented in this paper. In most of the industries it is necessary that any damage such as leakage or crack which occurs in the pipeline has to be monitored continuously, in order to avoid hazardous situations. Pressure and temperature sensors are used in pipeline and their output varies when crack/leakage occurs. Major problems can be averted by consistent supervision of the pipeline system. This paper focuses on taking preventive measures for early detection of corrosion, leakage and also control the same by diverting the gas flow through auxiliary pipeline to avoid disrupting the whole process in the gas industry. The control strategy implemented in this case is ON-OFF control. The supervisory control and data acquisition (SCADA) is used with the aid of LabVIEW software and Bluetooth based smart monitoring system.

KEYWORDS: Corrosion, Rusting, Leakage,ON-OFF Control, LabVIEW, BluetoothIEEE 802.15.1

I.INTRODUCTION

The requirement to transport gas/fluids from the point of manufactured areato the userled to rapid increase in number of pipelines being designed and constructed. Many of the pipelines carry hazardous gas/fluids through areas where density of population is high and also is more prone to environmentaldisasters like earth quake.To prevent disasters in these areas, on-line tracking and 24-hoursupervision is necessary. The maintenance of buried gas pipeline has now become a major concern around the world due to less supplies of high quality materials for pipeline construction. Some pipelines are used without any changes in those pipelines, and some of the products may be rusted the products may be partially full for periods of time or environmental effects may cause damage to pipe. Steel pipes can easily start to corrode in the presence of Oxygen and Water.

As the corrosion product (rust) covers a greater volume than the original steel,the expansive pressure causes to crack or split. Therefore, the deterioration of pipeline is based on chemical reaction, the corrosion can also be considered as having temperature dependency.Similarly, the rate of material diffusion and the chemical reactions rise with increase in temperature and pressure. In this papera novel approach based on accurate monitoring using LabVIEW is built to detect the variations in temperature, humidity and pressure and thus an approximation of the pipe line.In case of a leakage detection the operator is alerted through short range message service based on Bluetooth and using ON-OFF controller controlling action is taken by diverting gas flow through the auxiliary pipe line using two valves. The valves are based on the ON-OFF Controller.

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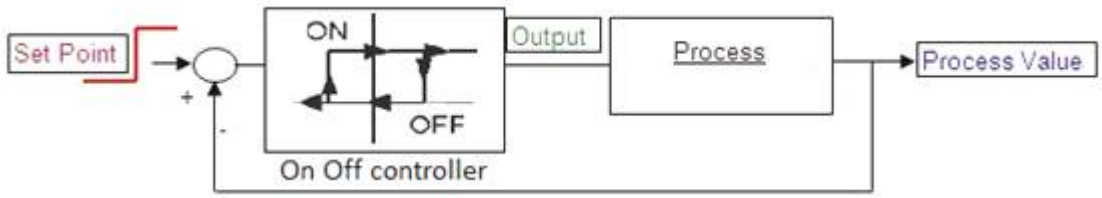

Fig:1 ON-OFF Control

ON-OFF control: This type of controller has an output as 100% of the manipulated variable. The advantage of this controller is its simplistic design and absence of controller tuning.The disadvantages associated with this type of controller are cycling and rigorous working load on the final control element (FCE).This type of controller is generally used in simple application like water level control for domestic purpose.

II.METHODOLOGY

Corrosion is a natural phenomenon for specific medium and substance the rate depends on the humidity content also on the temperature of the medium which converts a refined metal to a more stable form.

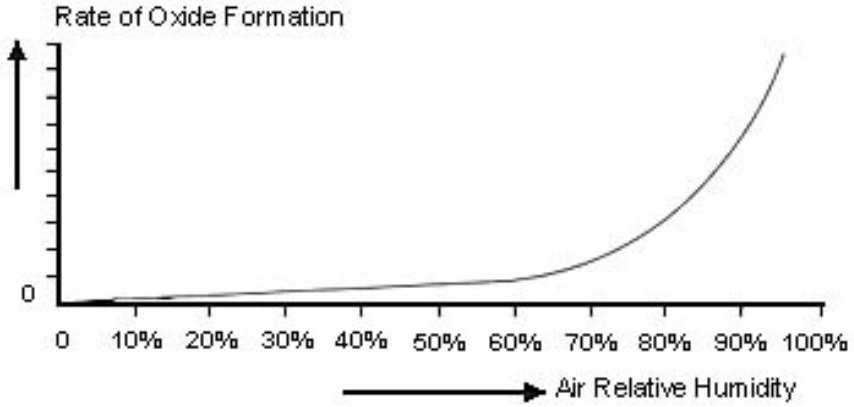

Fig:2 Rate of Corrosion with relative Humidity

The plot in fig 2 shows that apart from high atmospheric pollution, high air humidity increases corrosion rate.A relative humidity of less than 60% is considered to be safe for steel pipes. When iron surface is coated with layers of metals more active than iron, then the rate of corrosion is retarded. More the conducting (reactivity) metal getting rust. A rise in temperature increase corrosion rate and also presence of electrolytes in water increases the corrosion.In the proposed method two pipelines are used to prevent leakage which otherwise needs complete shutdown of the whole process. In the event of leakagedetection, the automated system diverges the fluid flow to the auxiliary line using two valve system in which main line is shutdown along with the opening of the auxiliary pipe valve; thus bifurcating the flow. The rateof corrosion and rate of rusting is determined from the fluid temperature and humidity content of the process fluid. The leakage of the process fluid is detected using a drop in the pressure and the operator is alerted in real time through an android based app. which uses Bluetooth IEEE 802.15.1, based server client protocol. The proposed topology is shown in fig 3.

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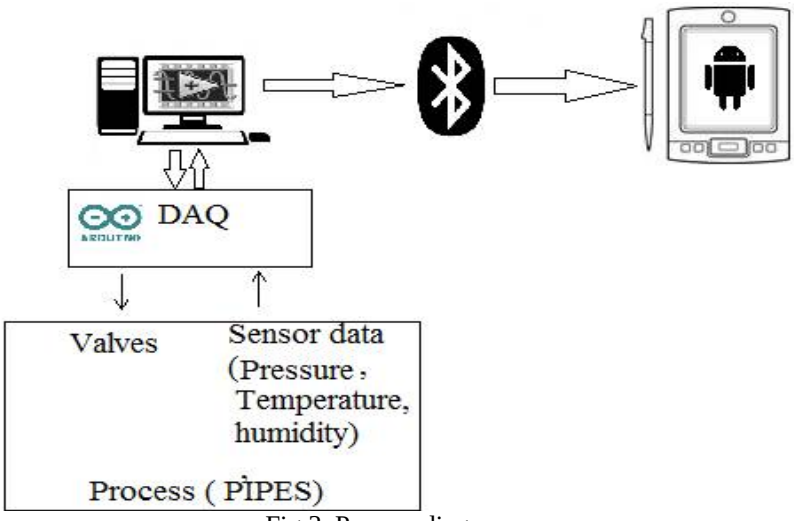

Fig.3. Process diagram

III. IMPLEMENTATION

The proposed system is implemented in LabVIEW using Virtual Instrument system architecture (VISA) and LINX resources, LINX provides an easy way to use LabVIEW Virtual Instruments(VIs) for interacting with common embedded platforms like chipKIT, Arduino and myRIO. Use the built in sensor VIs to start getting data to PC in seconds or use the peripheral VIs to access devices digital I/O, analog I/O,SPI, I2C,UART,PWM and more.
Virtual Instrument system architecture(VISA) it communicates LabVIEW to hardware setup and helps to gives data. The Bluetooth Action Engine is developed using VISA and Functional Global Variable. The whole block diagram is developed using following subVIs.
Pressure subVI: This VI converts the input voltage from the INA122PA amplifier to pressure in the range of 0-10 KPa using the following equation.

$$P = \frac{(V_{in}/96) - 0.024}{0.0035} \quad (1.1)$$

Where,
V_{in} - is sensor-amplifier output in volt.
P – Pressure in KPa and 0.024 is the offset

The block diagram of the VI is shown in fig. 4(a).

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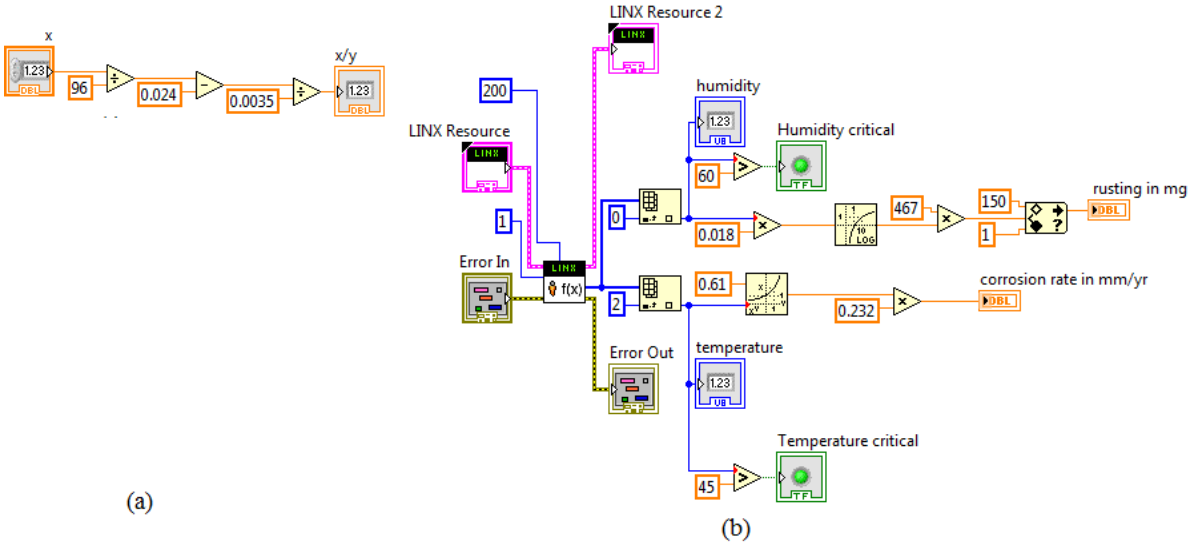

Fig.4.(a) Pressure subVI and (b) Humidity subVI

Humidity subVI: This VI uses the custom command feature of linx library to get the relative humidity and temperature from the DHT11 sensor and with the acquired data corrosion rate are determined using the following equations.

$$Rusting(in\ mg/yr) = 467 \times \log(x \times 0.018) \tag{1.2}$$

Where,
x is relative humidity

$$Corrosion\ rate(in\ mm/yr) = 0.232 \times x^{0.61} \tag{1.3}$$

Where,
x is temperature in deg. Centigrade

The Bluetooth action engine employs VISA resources to relay data to the operator's android device. The Bluetooth client for the android app is developed using Massachusetts Institute of Technology(MIT)app inventor.The interface is shown in the following figure

The whole LabVIEW block diagram is shown below

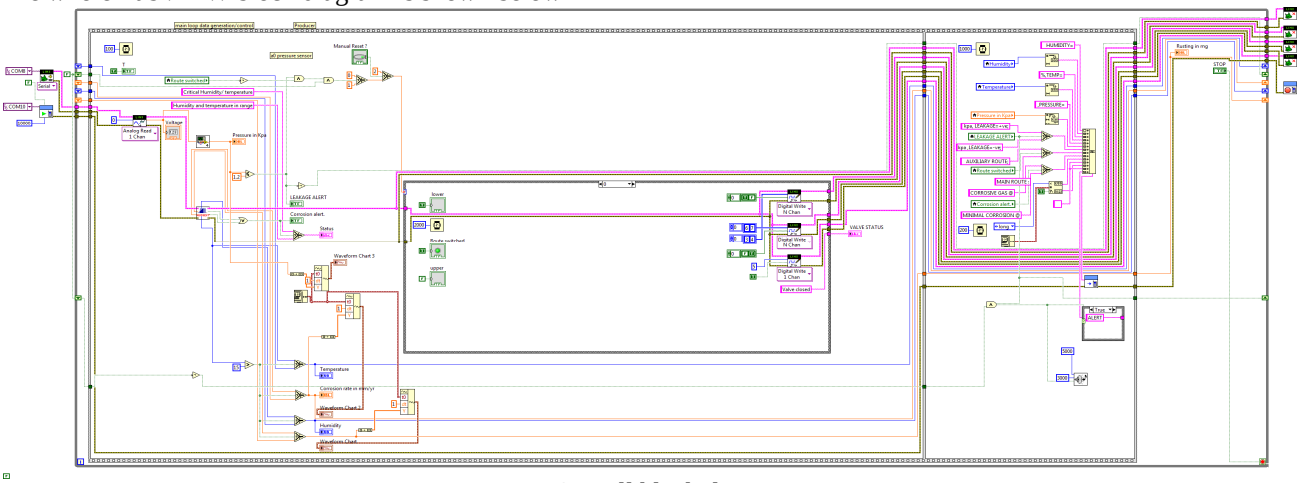

Fig.5. Overall block diagram

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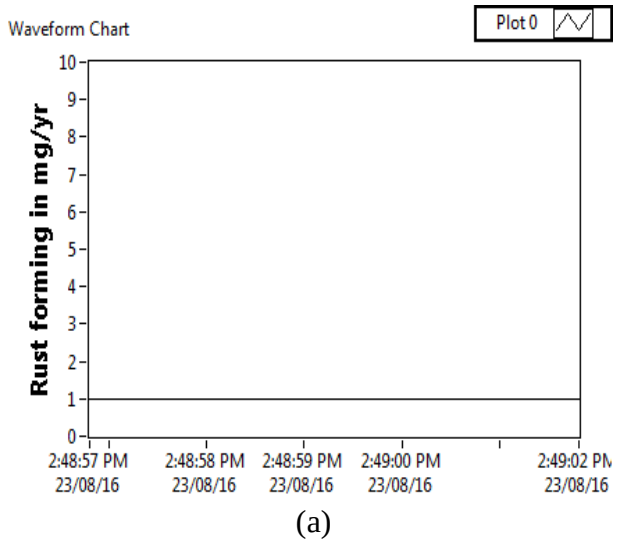
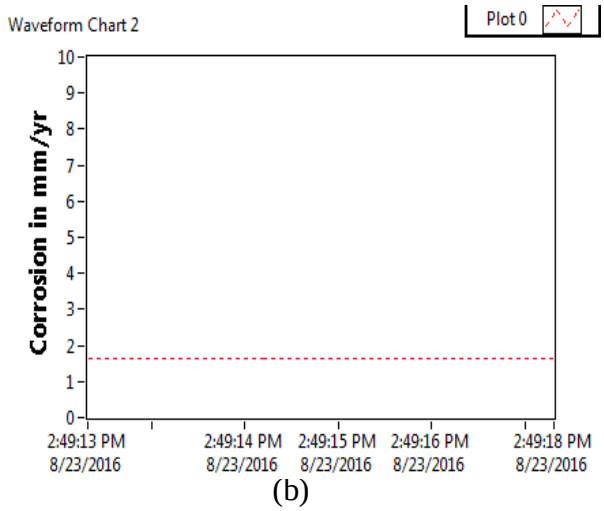
IV.RESULT AND DISCUSSION

The proposed setup is tested in real time and can be inferred that the system is working as predicted
In this projecta substitute pipe line for gas flow is used for preventing the gas flow in the corroded pipe line pathway. In this methodwhole process need not be shut down during maintenance. LabVIEW based Distributed control is used to change the gas flow direction using control valves.The pressure and temperature variations in the pipe line are measured.If a leakage or crack occurs the pressure varies.These varied values are measured and displayed in the LabVIEW and flow is diverted using ON/OFF controller.

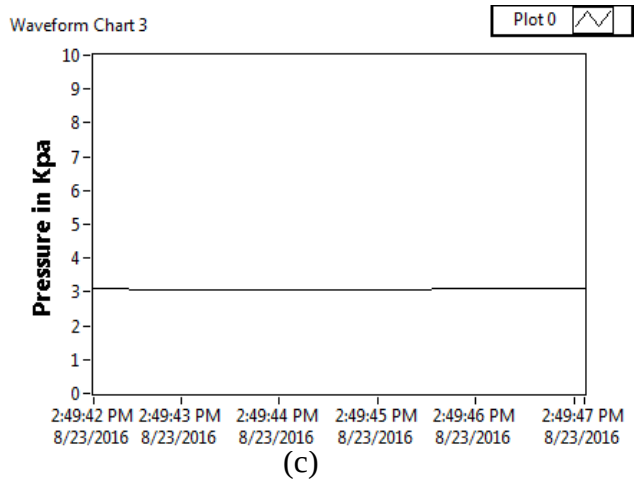
The Fig.6 shows the measured output of the Rust forming in mg/yr, Corrosion in mm/yr and the Hardware setup used in this paper. Occurrence of rusting in the main pipeline can be measured from the humidity and corrosion rate is measured from temperature variations.If pressure goes below 1.2 Kpa then a leakage can be inferred at any point in the pipeline.If temperature goes above70^{0}C, then rusting and corrosion rates will increase. If humidity increases above 60% then corrosion rate will increase.



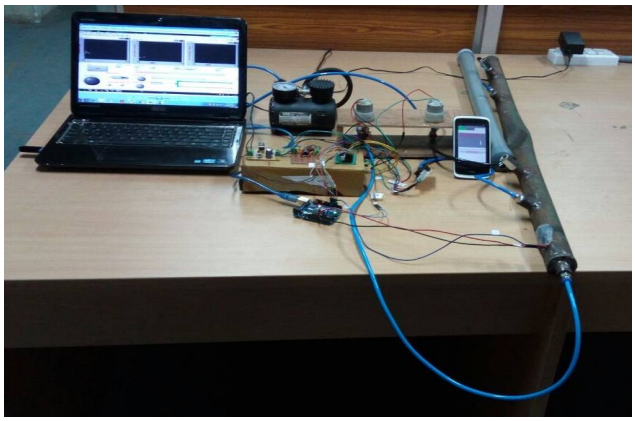
(a)



(b)



(c)



(d)

Fig.6.(a) Rusting in mg/yr, (b) Corrosion in mm/yr, (c) Pressure in kpa, (d) Experimental setup.

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Here we can monitor the variation of Humidity, Temparature,Pressure, Leakage and Alarming condition using the Bluetooth messenger developed by MIT as shown in figure 7. In fig.(a)we can see monitored nominal conditions of main pipeline and leakage status, whereas fig.(b) shows Alarm condition which means there is a Leakage Detection.

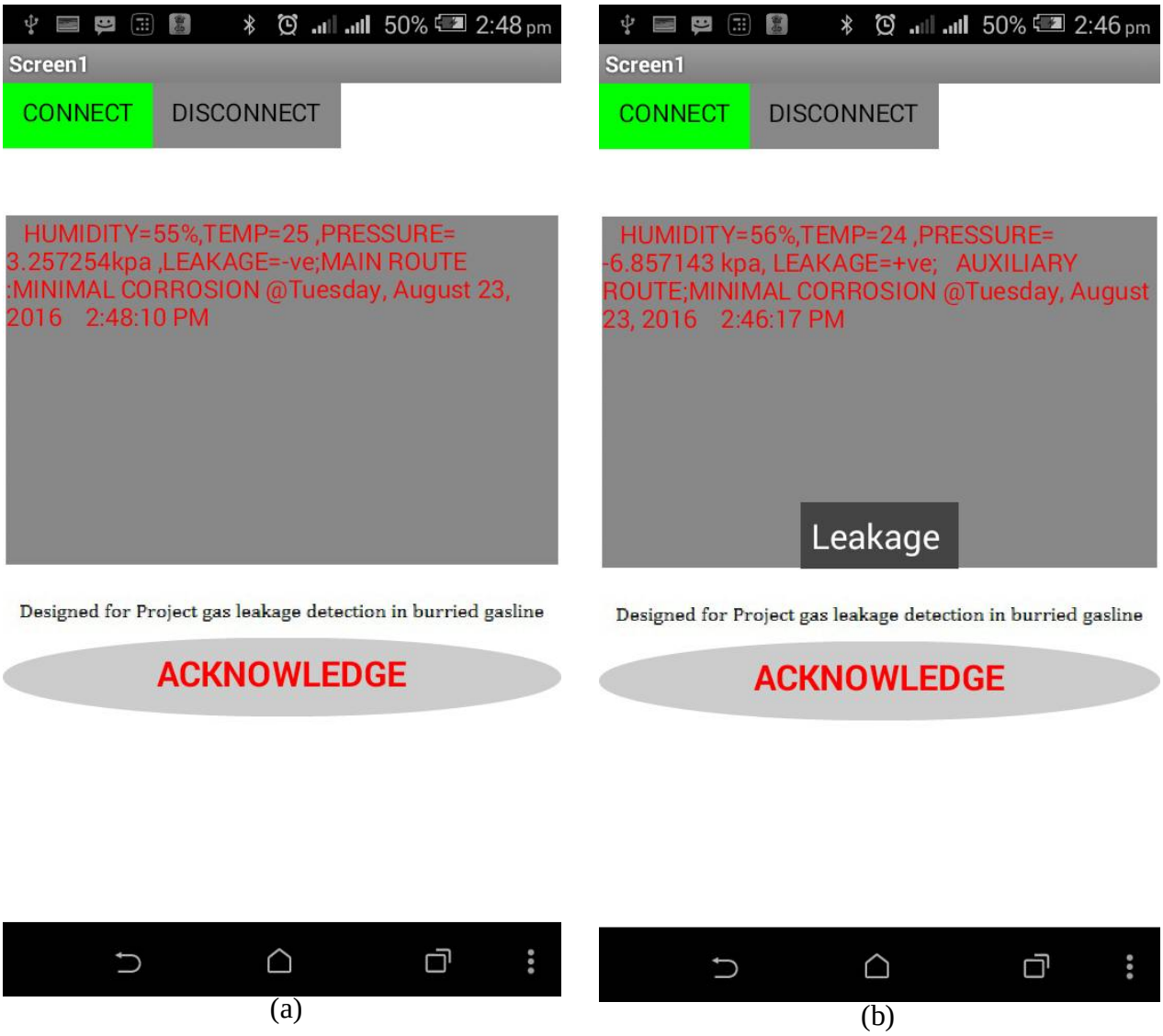

Fig: 7. (a) Nominal Condition, (b) Alarm condition - Leakage Detection

V. CONCLUSION

Based on this study, variations of parameters due to corrosion in the pipeline like temperature, pressure and humidity are measured by their respective sensors and acquired data are monitored on front panel diagram of the LabVIEW.The system also provides the operator with mobility in a range of 100m due to the application of Bluetooth messaging service.This versatile system also cuts down the cost of a platform and process specific SCADA system as LabVIEW DCS toolkit provides all the necessary blocks like alarm enunciation and citadel database management for historical trends.

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