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# Design Study of Leak Detection System and the Protection of Crude Oil Pipelines

***Abstract***- *In this paper, the Oil leakage sensor utilized photonics crystal fiber interferometer (PCFI) is proposed and experimentally investigated. The principle of operation of this sensor is detected the gas emission from pipe. This sensor is operate in transmission mode which designed by splicing the LAM-10 PCF with single mode fiber (SM) with two side. To increase the sensitivity of this sensor the splice region is coated by special polymer doping by nano sliver silver particles to increase the sensitivity. The experimental result s shows the sensitivity of fabricated sensor is high, and the response time is very short reach to 2min the max sensitivity is equal to (62 Co./sec ). Due to the low fiber loss, the sensing range can be as high as 1 km.*

***Keywords***-*Oil leakage .Pipelines, PCF sensor , MZ interferometer*

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## 1. Introduction

Leakages of gas and oil from pipeline are unsafe for environment and the people: oil pollutes groundwater and soil, whereas gas leaks can result explosions and are detrimental to atmosphere and vegetation. Moreover, gas and oil leakages may cause economic losses.

The pipe oil monitoring can significantly improve the pipeline management and safety. Providing regularly with parameters featuring the structural and functional conditions of the flow line, monitoring can help 1: prevent the failure, 2: detect the problem and its position in time, and 3: undertake maintenance and repair activities in time. Thus, the safety is increased, maintenance cost is optimized, and economic losses are decreased [1].

Different wide range approaches have been used to detect starting from natural gas pipeline leaks to advanced satellite based hyper spectral imaging [2]. In addition, these approaches divided into two types, non-optical and optical approaches. The non-optical approach consist of acoustic monitoring; gas sampling, soil monitoring, flow monitoring, and software based dynamic modeling [3-6].

Optical approach consist to passive or active method [7]. The effective light approaches is based on detect the pipeline crakes by using broadband light source. The scattering or absorption resulted by inbred gas molecules above the level is supervised using an array of sensors at particular wavelengths. If there is prominent scattering or absorption above a pipeline, then a leak is supposed to exist. [8].

An optical fibers are concealed length through the pipe for evanescent sensing. At inbred gas leaks, the topical variations in concentration either pressure results a variation upon transport properties of the optical fiber. The variation in the transport idiosyncrasies is managed by optical and lasers sensors. Communication cables and optical fiber leads have very scarce transfer losses and are idealistic for long farness sensing. With an expedient software interface, FOS can supply data that allow the operator to set work parameters in true time. FOS manners can measure temperature, vibration, pressure, strains, and structural displacements. There are three types of detector systems in the mart; each operates on a various rule. Some of its uses contain supervising wall thinning due to erosion and corrosion, pipeline motion, buckling and bending strains. Many interferometers types are based on a variant manner of fibers. Therefore, there are two types of a variant manner, which are primary and secondary types. The primary works as recombining/splitting to multiple monochromatic optical rays, which spread in variant fibers. The configuration of photonics crystal fiber interferometer is used to confirm a high compassion and their wide extend of application operations. MacPherson et al was given the fist attempted to connect the interferometer with PCF [7]. This idea is depend on the double-cores of PCF (two interferometer arms) which based on Mach-Zehnder interferometer. On the other hands, many researchers have decided installed a many deferent of interferometers with respect a variant types of PCFs in order to change the phase

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displacement between two types are used. These types are required a small segment of PCF or syllogistic that the optical fiber effects by the critical parameters such as the polarization which is directly affected for optical fiber sensing [8]. In order to overcome of these barriers, there is a new idea has been applied which introduced a PCF microstructure for two types by using a high interval tapering, splicing method or gratings [7]. The traits of PCF modal interferometers construct with the later mechanisms are wide operation wavelength range. The specific characteristic of PCF type interferometers method based on the wide wavelength range low temperature sensitivity, compactness, and a conventional optical fiber loud fixity over time a PCF and loud fixity over time a PCF, In the electrical-arc method, the PCF directly affected (breakdown) by air-holes at the area of link. The size of fallen area is less than 300 to 400 μm.

Pressure experiments are cyclically performed to test the security of the pipeline even though the reliability of the experiment is relatively poor due to the impact of temperature differences along the pipeline. As an effect pipeline, employees have been looking at new methods for the disclosure of leakage through the supervising of the pipeline periphery temperature .

Temperature supervising mechanisms by using optical fibers have offered to be a competent way to disclosure and centralize leakages along pipelines [10]. These mechanisms utilize a notion identical to Optical Domain Reflectometry (OTDR) for the centralization, since the temperature data is intimated from the assay of the scattered ray through Brillouin or Raman scattering processes. Raman-based method were first offered [2] and utilized in feasible performances, whilst the Brillouin-based mechanism has been advanced in the early nineties [11, 4] and presents longer farness ranges [5].

The optical fibers can be installed immediately in the soil or concealed in concrete. Furthermore, they are planned to work over a large gas dismay extent. Also, a loud stability (the cables are built to last more than thirty years), the cables are planned to be unimpressible to humidity, corrosion while the optical fibers are completely inexpugnable to electromagnetic noise.

As soon as the leakage occurs, a gas leakage over much is first perceived and in this phase was measured to raise leakage at time. The operation of the evanescent wave profiles obtains into account this development in two processes in order to separation leakages from natural daily time alterations. The competence of the mechanism has shown the capability to discover leaks in small percentage. This mechanism enables the centralization of the leakage with accuracy in the extent of one meter [12].

The new research is used PCFI as a sensor for the gases emitted from the crude oil leak and to increase the sensitivity was coated with polymer doping with sliver material.

## 2. Experimental Work

We fabricated PCFI by short part of PCF fore-and-aft sandwiched between syllogistic single mode fibers was offered of the PCF length L of 2 cm. The produce sensor SM-PCF-SM is coated by malty layer of polymer doping by nano sliver particles to increase the sensitivity of detection of leakage gas such as So2 and Methane.

The advantage of this approach is applied in PCF field and it's widely used in term of optical fiber sensor applications, however, this applications have some limitations for inspect information at traditional optical fibers.

The disadvantage of using this application will highly cost at using different interferometers. Moreover, the performance interferometers are directly effects depend on the PCF type. In the real world applications, the interferometers are manufactured based on micro-holes approach provide a perfect stable interference signal with wide broadband of wavelength (~800 nm). The two collapsed regions were manually introduced by a high precision fusion splicer. This sensor is stick on the leakage pipe.

The main part of experimental work of this gas leakage sensor are laser, PCFI and detector. Laser 650 nm is used as light source at power 10 mw and optical spectrometer HR-2000 provides from (Ocien comp.) is used as detector. Figure 1 shows the practical set up**.**

## 3. Result and Discussion

At the binging, the sensor is testing on the leakage So2 gas the result is shown in Figure 2. This figure shows the observed transmission spectra at period. The relationship of the high peak value with the time is a good idea as shown in Figure 2, this idea will give a high indication of gas environment detector at a peak intensity by excess the of exploder time of the extrinsic medium accesses that of the PCF. In the 1-30 min the attenuation of transmitted light through fiber is calculation by absorption coefficient .Figure 3 shows the absorption coefficient at a period exposure time.

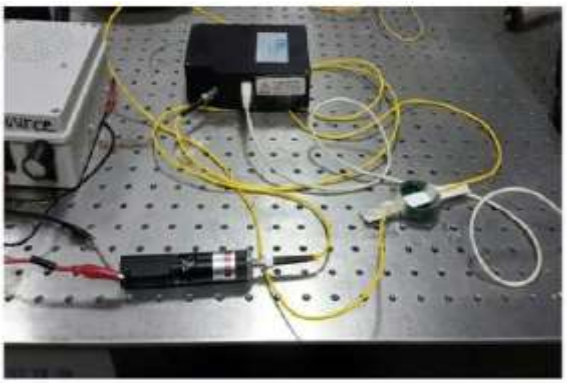

**Figure 1: the experimental setup**

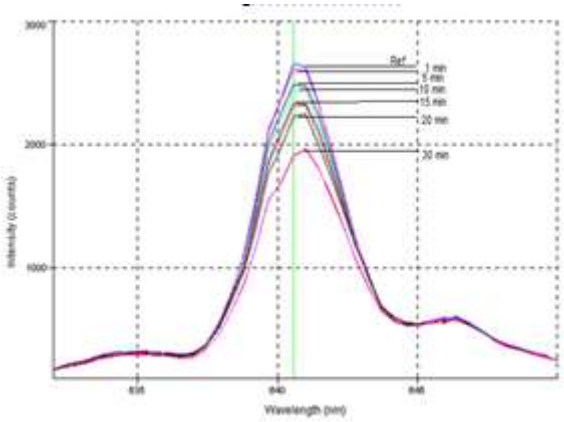


**Figure 2: The transmission spectrum of So2 at period of time**

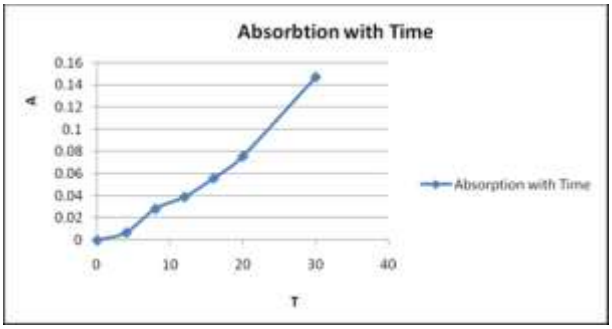


**Figure 3: The absorption coefficient at a period exposure time**

The same sensor is tested in a case of really leakage gas from cruel oil provided from Kirkuk .The same producer is applied on the PCFI sensor. Figure 4 is shown the transmission spectrum at period of time equal to 30 min .We can show the intensity peak decrease with increase the exposure time to gas, that means when the time increase the leakage gas increase. The absorption is calculated at exposure time .These relation is shown in Figure 5. From this relation calculated the sensitivity of this sensor is equal to (62 Co /sec).

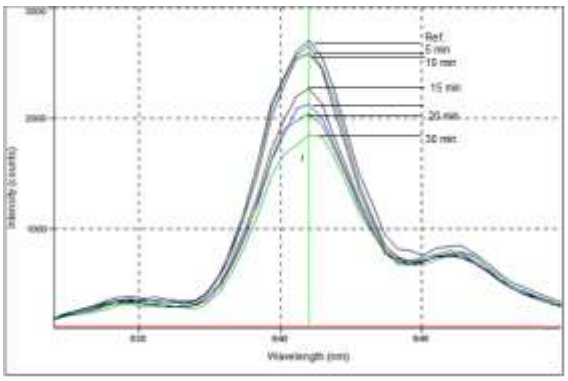


**Figure 4: The transmission spectrum of leakage gas from Oil at period of time**

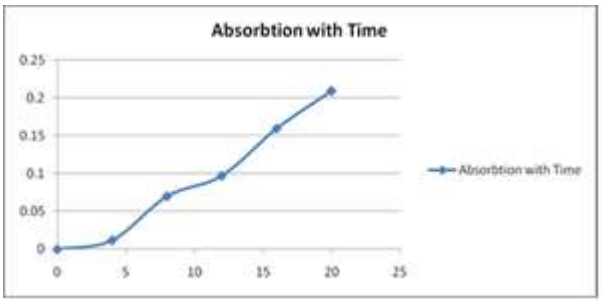


**Figure 5: The absorption coefficient of leakage oil at a period exposure time**

## 3. Conclusions

PCFs are considered the high advanced fiber optics creativity. These advanced optical fiber detection are able to detect instead of many detector performances. PCFs present variant equivalents for the production of different types of interferometers PCFs award them significant advantages for instance, low thermal passible, wide range wavelength extent and loud fixity long period time. Howbeit, other phases does not have in traditional fibers. The interferometers are used for a diffraction resulted by a short district with foundered spaces.

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