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ANALYSIS OF MICROBEND SENSOR ON BASIS OF DIMENSIONS OF OPTICAL FIBER USED

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ABSTRACT

In this paper an intensity based fiber optic sensor is designed for weight measurement which can be further modified to measure other analytical quantities. Two different core sized optical fibers having different lengths are used to analyze the characteristics of a microbend sensor. The calibration curves of the different optical fibers are compared and also the repeatability is tested to design the versatile microbend sensor. The output of the system is monitored using LabVIEW.

***Keywords:* Intensity Modulation, Labview, Microbend Sensor, Optical Fibers, Weight Measurement**

I INTRODUCTION

A sensor is a device which generally transmits an electrical signal while responding to some type of physical parameter [1]. Thus, the sensor is basically a type of transducer which converts a physical parameter into an electrical signal and is one of the most important elements in any kind of instrumentation system.

Usually in the field of communication, optical fibers are used but fiber optic cables are capable of sensing various physical parameters and can also generate information. So, they are widely used as fiber optic sensors [1]. The use of fiber optic sensors is advantageous mainly because of its immunity to external electromagnetic interference and can be easily used in hazardous and explosive environments [2]. Apart from these, the sensor is light weighted, smaller in size and has fast response.

The microbend loss in optical fibers in the field of communication is an unwanted phenomenon [5]. But this loss can be used for fabrication of optical sensors to measure various physical parameters like weight, force, pressure etc. [2-7]

In this paper, a microbend sensor was designed and tested and also the experimental results were evaluated.

II PRINCIPLE OF THE MICROBEND SENSOR

There are two types of bending losses: macrobend and microbend. Macrobend losses occur due to radiation loss at the bends of a fiber where the curvature of radius of bend, R is greater than the fiber core radius, a, i.e. R>>a. And microbend losses occur due to fiber deformations at the core-cladding interface [8].

The fiber optic sensor used in this paper is based on intensity modulation of light through a fiber which is sandwiched between two deformer plates to produce micro bends in the fiber. The fiber undergoes periodic deformation when pressure is applied on the movable plate i.e. the upper plate and form micro bends. Due to the deformations, there is a drop of intensity in the light transmitted through the fiber with increased pressure.

Fig. 1 shows the basic geometry of the microbend sensor about one deformation point. As the pressure is applied on the sensor, microbending occurs along the length of the fiber and these bending results in loss of guided power at the bend. The loss in intensity for a bent fiber is given by:

$$\text{Loss} = C(a / R)^2$$

(1)

where R = radius of curvature of bend

a = fiber core radius

C = a constant

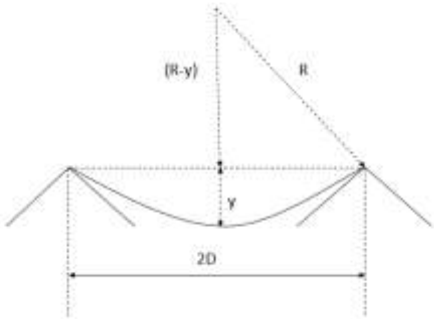

Figure 1: Geometry of the Microbend

Thus, for a given fiber the pressure applied can be related to the bend radius is given by:

$$R = \frac{y^2 + D^2}{2y}$$

(2)

where y = the displacement of the deformer element

2D = the distance between the contact points of the deformer elements which is equal to the pitch of the element

The Hooke's Law is given by [9]:

$$F = E_g A \frac{\Delta l}{l}$$

(3)

where Eg = fiber Young's modulus

A = area of the fiber

l = length of the optical fiber under perturbation

Δl = relative deformation imposed by the action of the perturbation force, F

Using Pythagoras Theorem and Taylor Series expansion, a mathematical relation is deduced as follows:

$$Loss = \frac{4Ca^2\left(\frac{1}{2}+K\right)^2}{\left(\frac{1}{2l}+K\right)} - \frac{4Ca^2D^2}{\left(\frac{1}{2l}+K\right)l^2}$$

(4)

where

$$K = \frac{F}{E_g A}$$

Thus, the transmittance T through the fiber is given by:

$$T = 1 - Loss \quad (5)$$

2.1 Construction of the microbend sensor

The microbend sensor consists of two corrugated plates: a fixed plate and a movable plate. The pressure is applied to the movable plate. The sensor is constructed with wooden material. The two wooden corrugated plates are constructed with the following specifications:

i. Length = 15cm

ii. Breadth = 14.8cm

iii. Mechanical periodicity = 2cm

iv. No. of grooves = 8

2.2 Components

The component specifications are as follows:

i. Laser Source (with mount): 650nm wavelength

ii. Photodetector (with mount)

iii. Eyepiece

iv. Digital voltmeter

v. Lux meter

vi. Two fiber chucks

vii. Microbend sensor

viii. Two step index multimode optical fibers of 240 µm and 263 µm core size (Refractive Index of core : 1.4 and numerical aperture : 0.5)

ix. Standard weights : 2-22 kilograms

x. Graduated tank : 20 Liters capacity

III EXPERIMENTAL SETUP

Fig. 2 shows the schematic diagram for weight measurement. Light from the laser source falls on the eyepiece and then focused on to the core of the optical fiber. The optical fiber was placed between the corrugated plates

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as shown in fig. 2. Standard weights were placed over the sensor one by one and as the pressure in the sensor increases, consequently the loss in the optical fiber increases and hence the intensity of light decreases which is detected by the lux meter. The output is detected by the photodetector which gives us an electrical signal in terms of voltage.

2 kg to 22 kg range was fulfilled in 5 kg steps.

Repeatability of the experiment has been studied.

The calibration curves were plotted and the loss was calculated.

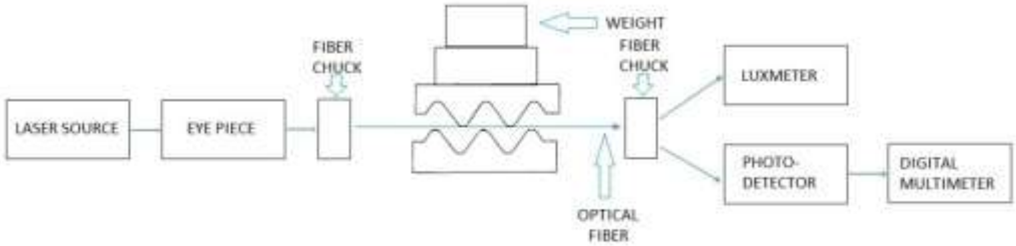


Figure 2: Schematic Diagram of Weight Measurement

IV RESULTS AND DISCUSSIONS

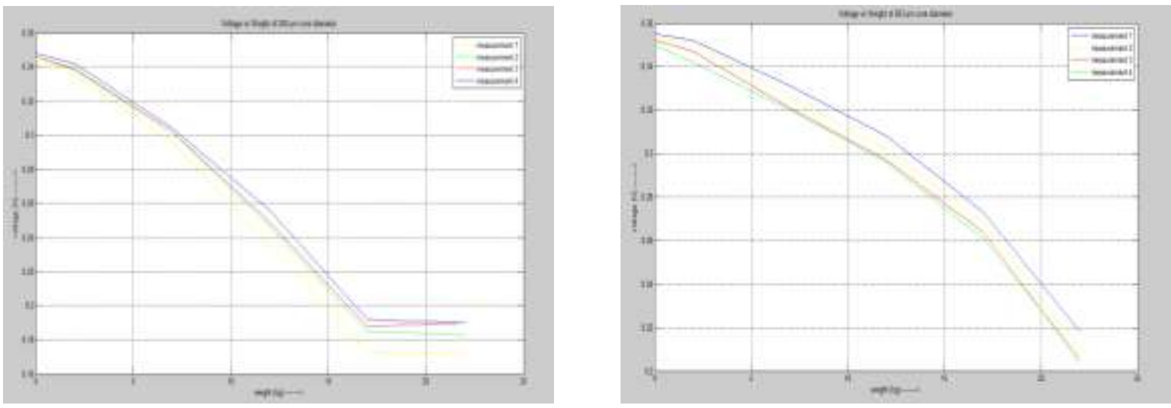
The test on the microbend sensor was conducted by varying the lengths of the optical fibers and with different core sizes of the optical fiber. Also the intensity loss and transmittance were calculated and graphs were plotted.

4.1 Different core size

The two optical fibers of 240µm and 263µm were used in the experiment with lengths of the fibers equal to 15cm on the microbend sensor. The output of the sensor is in terms of voltage and illuminance.

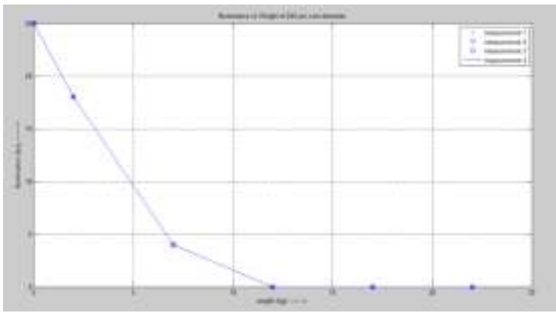
Fig. 3(a) and fig. 3(b) shows the calibration curves of voltage vs weight and correspondingly fig. 4(a) and fig. 4(b) shows the calibration curves of illuminance vs weight. It is observed that in both the cases, the intensity of light decreases as the weight increases and for each optical fiber the repeatability is achieved. In all the four figures, it is observed that of all the 4 sets of measurement in each experiment, the curves are nearly similar, so it can be concluded that the system is working precisely.

The designed microbend sensor is calibrated and compared with standard weight sensor.

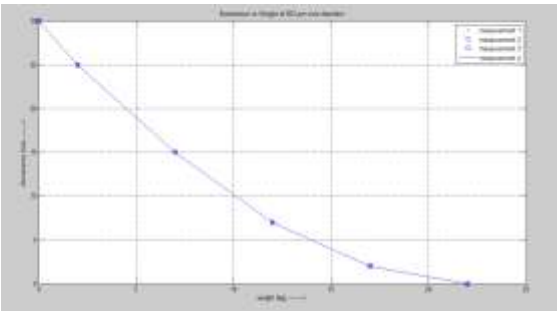


(a) (b)

Figure 3 (a) Voltage vs Weight of 240µm core diameter of the designed microbend sensor and also its repeatability and (b) Voltage vs Weight of 263µm core diameter of the designed microbend sensor and also its repeatability



(a)



(b)

Figure 4(a) Illuminance vs Weight of 240µm core diameter of the designed microbend sensor and also its repeatability and (b) Illuminance vs Weight of 263µm core diameter of the designed microbend sensor and also its repeatability

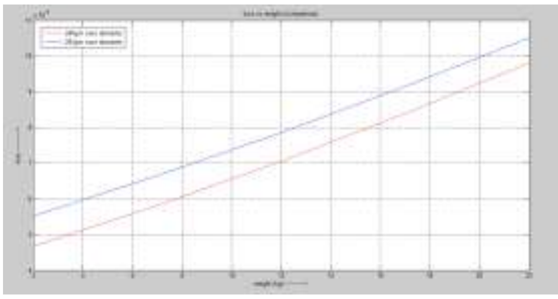
4.2 Varying lengths of optical fiber

Different lengths of optical fiber of 240µm and 263µm core diameters were taken for the experiment. The lengths of the fiber were 15cm, 31cm, 47cm, 63cm etc. Similar experiments were conducted with all the lengths. The calibration curves were plotted and also its repeatability was determined. It has been observed that the microbend sensor is working with the same repeatability.

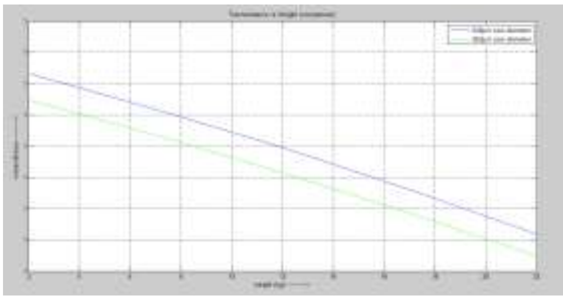
4.3 Loss and transmittance graphs

From fig. 5(a), it is observed that as weight increases, the intensity loss increases significantly and as the core diameter increases, the intensity loss increases. Similarly, from fig. 5(b), it can be concluded that as weight increases, transmittance decreases and increment in core diameter leads to decrement in transmittance.

From fig. 6(a) and fig. 6(b), it is observed that as length of optical fiber increases, the intensity loss in the fiber increases.



(a)



(b)

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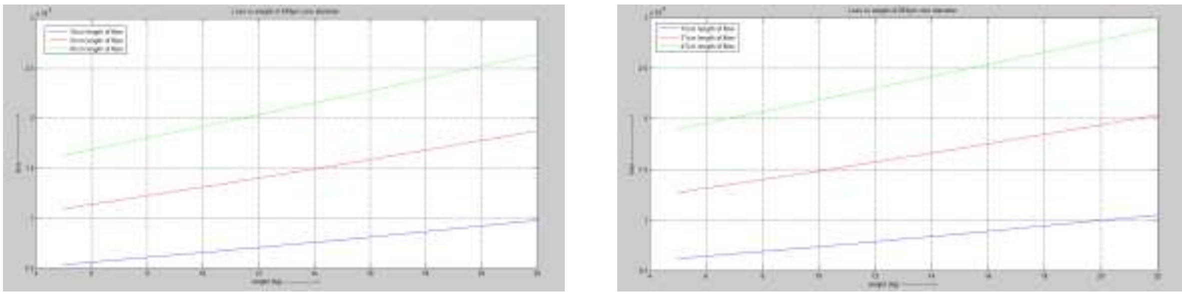
Figure 5(a) Comparison of loss vs weight of both the optical fibers and (b) Comparison of transmittance vs weight of both the optical fibers



(a) (b)

Figure 6(a) Comparison of loss vs weight of 240µm core diameter of various lengths optical fiber and (b) Comparison of loss vs weight of 263µm core diameter of various lengths optical fiber

V SOFTWARE

The block diagram of the experimental set up with the arduino board is shown in fig. 7. The output of the photodetector is fed to pin 0 of the arduino development board and the arduino board is connected to the LabVIEW software through LIFA base .INO program. In LabVIEW, real time monitoring of the weights can be observed. Fig. 8 shows the front panel of the LabVIEW software and fig. 9 shows the picture of the experimental set-up.

Figure 7: Block Diagram of the experimental set-up

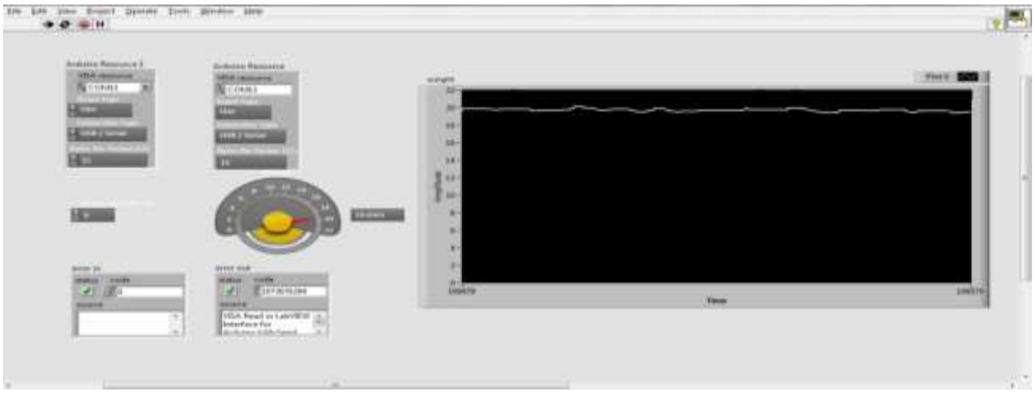


Figure 8: Front Panel of LabVIEW

Figure 9: Picture of the experimental set-up

VI CONCLUSION

A mathematical relationship exists between liquid volume and weight which is different for different liquids. If the density of the liquid is known, then knowing the weight, volume of the liquid can be easily determined. For e.g., for water of 1000kg/m^3 density, 1L=1kg; for density of sunflower oil (20 ^{0}C) of 920kg/m^3 density, 1L=0.92kg etc.

A versatile microbend sensor has been designed for weight measurement. As this experiment is based mainly on intensity loss, so it can be concluded that a large core diameter step index multimode fiber with greater lengths can be used for better resolution. Thus, a low cost and efficient microbend sensor is designed.

VII ACKNOWLEDGEMENT

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REFERENCES

[1] Shivang Ghetia, Ruchi Gajjar, Pujal Trivedi, "*Classification of Fiber Optical Sensors*", International Journal of Electronics Communication and Computer Technology (IJECCT), (ISSN: 2249-7838), *Vol. 3, Issue 4*, July 2013, page 442-445

[2] Sona Sediva, Marie Havlikova, "*Fiber Optic Sensors for Liquid Level Measurement*", 13th International Carpathian Control Conference (ICCC),2012, Page 623-627

[3] J Z Gao, Y L Zhao and Z D Jiang, "*Design and performance characterization of a fibre optical sensor for liquid level monitoring*", 7th International Symposium on Measurement Technology and Intelligent Instruments, Journal of Physics: Conference Series 13 (2005) 77–80

[4] N.K. Pandey, B.C. Yadav, "Fibre *optic pressure sensor and monitoring of structural defects*", Optica Applicata, *Vol. XXXVII, No. 1–2*, 2007, Page 57-63

[5] Jabir Hussien Al-Asadi, Bushra R.Mhdi, Rabi N. Al-Waali, *"Applied Force Micro Bending Fiber Sensor*", Asian Journal of Applied Sciences (ISSN: 2321 – 0893)*:Volume 02 – Issue 03*, June 2014, Page 274-277

[6] J. Červeňová, M. Iglarčík, "*Weight Measurements Using Microbending Optical Fibre Sensor and OTDR*", Proceedings of the 9th International Conference, Smolenice, Slovakia, Measurement 2013, Page 243-256

[7] Lhaten, Rosly Adb Rahman, "*Investigation on the Sensitivity of Optical Fiber Sensors, for Pressure Sensing, Based on the OTDR Technique*", Global Journal of Computer Science and Technology Interdisciplinary (ISSN: 0975-4350), *vol. 13, issue 4, version 1.0*, year 2013, page 28-33

[8] Joyeeta Singha, Rajkumar Joydev Borah, "Recent *Advances in Microbend Sensor in Various Applications*", page 757-760

[9] Paulo Antunes, Fátima Domingues, Marco Granada and Paulo André, "*Mechanical properties of optical fiber*" in Selected Topics on Optical Fiber Technology (ISBN 978-953-51-0091-1), February, 2011, page 527-550