Research Article

IJCRR
Section: Technology
Sci. Journal
Impact Factor
4.016
ICV: 71.54

Fiber Sensor Based Pulmonary Function Test

Manjusha S.[1], Preethi S. Babu[1], Swapna M. S.[1], S. Sankararaman[1]

Department of Optoelectronics, University of Kerala, Trivandrum, Kerala-695581, India

ABSTRACT

Aim: Development of fiber optic vibration sensor based Spirometer.

Methodology: A fiber vibration sensor is set up and is used to measure the variation of wind velocity with distance. For a source, driving air at constant speed, the variation of the light intensity level of the optical fiber sensor is studied. The experiment is repeated for various separations of source and detector fiber. The set up has also been used to measure the wind velocity. The results obtained from these preliminary studies tell the possible functioning of the sensor as a spirometer. For calibrating the fiber optic spirometer, commercially available spirometer is used. Noting down the air volume a person can inspire, from the standard spirometer, and the light intensity level at the output fiber while blowing, the spirometer can be calibrated.

Results: A fibre optic vibration sensor is constructed and is used to measure the wind velocity. The set up is used as a fiber optic spirometer by calibrating it against a standard spirometer.

Conclusion: The study thus reveals the application of fiber sensor as a fiber spirometer.

Key Words: Fiber optic sensor, Spirometer, Anemometer, Pulmonary function test

INTRODUCTION

The changing life style, food habits, and environmental pollution has proved to affect the health adversely. Now a day's lots of people are suffering from lungs related diseases. Increased number of vehicles and factories lead to high-level air pollution. In connection with world Spirometry Day, Forum of International Respiratory Societies (FIRS) released the data that lung diseases kill 4 million people every year [2]. The ignorance of people about lung diseases has doubled the mortality rate during the last three years. Hence, continuous monitoring of lungs is essential for maintaining good health. The efficiency of lungs can be understood from a spirometer. A spirometer is equipment used for basic pulmonary function test for measuring the volume of air involved in respiration. A test for measuring the movement of air into and out of the lungs can help to diagnose various lung conditions, most commonly Chronic Obstructive Pulmonary Diseases (COPD). It is also used to monitor the severity of some other lung conditions and their response to treatment. The earlier the test is performed, the earlier lung disease can be detected and treated.

The advent of lasers and fiber optic sensor system has revolutionized the medical field of diagnoses and treatment of diseases [3]. Optical fiber sensors work on the principle of analysis of the optical energy flowing through the fiber. Fiber sensors have gained the attention because of their smaller size, lighter weight, higher sensitivity, larger bandwidth and immunity to electromagnetic interference [4]. Because of smaller size and easiness in implementing, fiber sensors find applications in biomedical field [5]. Since measurands alter the light energy in the fiber, even smaller changes in the parameters can be accurately measured. Temperature, pressure, strain etc are the widely studied measurands. Various types of fiber optic sensors used are temperature sensor[6,7], pressure sensor [9-11], rotation sensor [12], vibration sensor [8, 13], fiber optic current sensors [14], fiber grating sensors [14] etc. In the present work, we have extended the principle of fiber optic vibration sensor as anemometer and spirometer.

METHODOLOGY

The Fig. 1 shows the experimental arrangement for the Fiber optic spirometer. The light from the He-Ne laser with a wavelength of 632 nm and a power of 5mW is focused on to

Corresponding Author:
S. Sankararaman, Department of Optoelectronics, University of Kerala, Trivandrum, Kerala-695581, India,
E-mail: drssraman@gmail.com

Received: 03.03.2017 **Revised:** 25.03.2017 **Accepted:** 12.04.2017

the step index multimode fiber of core diameter 120 micron meter and cladding 200 micron meter. The other end of the fiber is fixed inside a box as shown in Fig.1. The light from the source fiber is coupled to another identical fiber whose end inside the box can vibrate freely. When the detector fiber vibrates, the amount of light coupled into it varies. The pipe attached to the box directs the air onto the detector fiber. The amount of light coupled to the detector fiber also depends on the separation between the source and the detector fiber tips.

The experimental setup is calibrated by studying the variation of wind intensity with distance. For this study, a hair drier generating wind at a constant speed in a given direction is used. When the wind source is close to the detector fiber the misalignment for the detector fiber is maximum. Hence the amount of light coupled into the detector fiber is a minimum and we get a low voltage at the output of the photodetector. The deviation of the detector fiber from the initial aligned position depends on the amount of force exerted by the wind on the detector fiber. This setup can be used as anemometer or spirometer.

RESULT AND DISCUSSION

The experimental setup is calibrated using constant wind source. The variation of detector output with distance is shown in Fig.2. The experiment is repeated for different separation between the source and the detector fiber tip. The separation between the fiber tips decides the maximum amount of light intensity entering the detector fiber. From Fig.1, it is clear that for a given wind velocity as a separation decreases the detector output increases. Also it can be seen that the response curve is linear. That is as the distance of the source from the detector fiber increases the wind intensity decreases and this in turn reduces the force exerted on detector fiber and thus the deviation of the fiber from the aligned position. Hence we get the increasing value of detector output with increasing distance.

The experiment setup can be used for measuring the wind velocity and hence function as an anemometer. For this the source is kept at a distance (d) and noting down the time required for the detector output to change the time (t). The wind velocity (v) can be calculated as $v = d/t$. The setup can be used as an anemometer once calibrated against a standard anemometer. The variation of wind velocity is shown in Fig.3.

For working the experimental setup as a fiber optic spirometer, it is calibrated against a clinical spirometer as shown in Fig.4. The standard spirometer gives a measure of the maximum air a person can breathe in.

The amount of air a person can breathe in depends on the efficiency of the lungs. People of different age group are participated in the study. Each person is asked to breath in using a standard spirometer and the volume of air intake is noted. Then the person is asked to blow the air inhaled through the pipe provided in the fiber optic spirometer with a maximum speed possible to him. The amount of air the person exhale is related to his inhaling capacity. The detector output changes with respect to the amount of air blown in. Since the input air pipe is fixed, the error that may occur when different persons blow air can be avoided. The different people who inhale the same amount of air are grouped together and the average value of the detector output while blowing air is calculated. The graph relating the amount of air a person can inhale and the corresponding detector output is shown in Fig.5.

Since blowing of air pushes the detector fiber away from the initial aligned position. There is a greater chance of no light falling on the detector fiber. This problem can be overcome by introducing a slight modification in the fiber optic spirometer as shown in Fig.6. Here the detector fiber is initially kept misaligned as shown in Fig.6. When air is blown in the detector, fiber moves towards the aligned position, where the amount of light coupling between the source and the detector fiber is a maximum.

CONCLUSION

Thus, the present work fiber optic vibration sensor is constructed and demonstrated how it can be used as an anemometer. By calibrating against standard spirometer, the device can be used as a high sensitive fiber optic spirometer for getting information about one's lungs efficiency.

ACKNOWLEDGEMENT

Authors acknowledge the immense help received from the scholars whose articles are cited and included in reference of this manuscript. The authors are also grateful to authors / editors / publishers of all those articles, journals and books from where the literature for this article has been reviewed and discussed.

Conflict of interest : Nil

Source of funding: Nil

REFERENCES

1. J. Parikh Meera, P. Gharge Anuradha , "A Survey Paper on Optical Fiber Sensor", vol2, pp.2321-8169, 2014.
2. Forum of International Resipiratory Society (FIRS) United for Lung Health, Home page- Publications, https://www.firsnet.org/ Access date April 1, 2017.
3. O. Temitope. Takpor, Member, IAENG, and Oboyerulu E. Agboje, "Advances in Optical Biomedical Sensing Technology",vol1. WCE 2016, 2016.
4. "Review of the present status of optical fiber sensors", Byoungho Lee, vol.9, pp.57-79, 2003.

5. Alexis Mendez "Biomedical fiber optic sensor application", pp.521-1069, 2015.
6. A.T. Augousti, K.T.V. Grattan and A.W. Palmer, "Visible- LED pumped fiber optic temperature sensor". IEEE Trans. Instrument. Measurement 37, vol.37, pp.470-472, 1988.
7. Zengling Ran, Shan Liu, Qin Liu, Yanjun Wang, Haihong Bao, and Yunjiang Rao "Novel High-Temperature Fiber-Optic Pressure Sensor Based on Etched PCF F-P Interferometer Micromachined by a 157 nm Laser, IEEE sensors journal,vol.15, p. 7, 2015.
8. J. R. Guzman-Sepulveda1, I. Hernandez-Romano2, M. Torres-Cisneros3, and D. A. May-Arrioja, "Fiber Optic Vibration Sensor based on Multimode Interference Effects", p.117, 2012.
9. A. Daniel May-Arrioja, Victor I Ruiz-Perez, Yaneth Bustos-Terrones, and Miguel A. Basurto-Pensado, "Fiber Optic Pressure Sensor Using a Conformal Polymer on Multimode Interference Device", vol.16, p.1956, 2016.
10. J.N.C.K. Asawa,O.G.Ramer, and M.K. Barnoski, "Fiber optic pressure sensor", J. Acoust. Soc.,vol. 67, p.816, 2016.
11. Sven Poeggel , Daniele Tosi , Dinesh Babu Duraibabu, Gabriel Lee, Deirdre McGrath and Elfed Lewis,"Optical Fiber Pressure sensor in medical application", vol.15, pp.17115-17148, 2015.
12. W. C. Goss, R. Goldstein, M. D. Nelson, H. T. Fearnehaugh, and O. G. Ramer, "Fiber Optic Rotation Sensor Technology", vol.19, pp.852 858,1980.
13. J.R. Guzman-Sepulveda, I. Hernandez-Romani, M. Torres-Cisneros, and D.A. May-Arrioja, "Fiber Optic Vibration Sensor based on Multimode Interference Effects", Optical Society of America, JW2A117 (2012).
14. K.T.V. Grattan, Dr. T. Sun, "Fiber optic sensor technology: an overview", vol.82, pp.40-61, 1999.

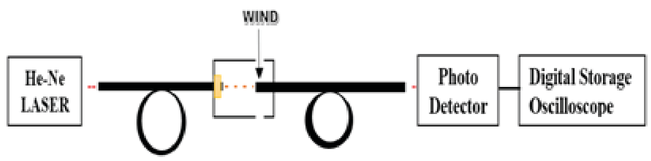

Figure 1: Schematic arrangement for the Fiber optic anemometer.

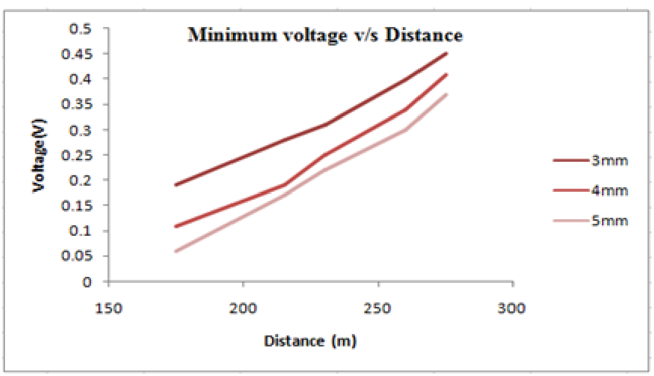

Figure 2: The variation of detector output with distance of wind source.

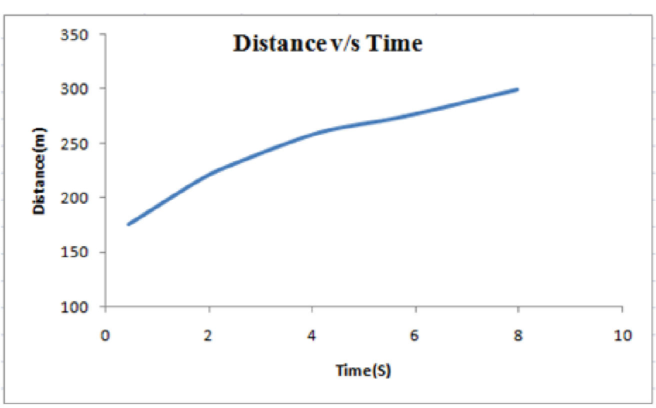

Figure 3: Distance-Time graph for wind.

Figure 4: Clinical spirometer.

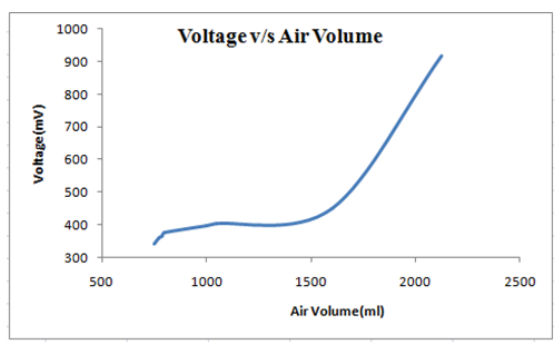

Figure 5: Output voltage v/s air volume.

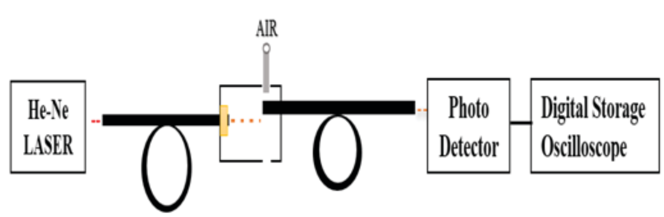

Figure 6: Fiber Optic Spirometer.