talenta PUBLISHER

Journal of Technomaterial Physics
Journal homepage: https://talenta.usu.ac.id/JoTP

Design of Fiber Optic Load Sensor for Low-Load Detection Using Microbending Method

Andi Setiono[1], Kerista Tarigan*[2], and Lamrouli Baruara[2]

[1]*Badan Riset Inovasi Nasional, Kawasan Puspiptek Setu Serpong, Muncul, Kec. Setu, Kota Tangerang Selatan, Banten, 15314, Indonesia*

[2]*Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Sumatera Utara, Medan, 20155, Indonesia*

*Corresponding Author: kerista@usu.ac.id

ARTICLE INFO

Article history:
Received 17 October 2022
Revised 20 February 2023
Accepted 24 February 2023
Available online 28 February 2023

E-ISSN: 2656-0755
P-ISSN: 2656-0747

How to cite:
A. Setiono, K. Tarigan, and L. Baruara, "Fiber Optic Load Sensor Design Using Microbending Method of Material Mixture Material to Detect Low Load," Journal of Technomaterial Physics, vol. 05, no. 10, Feb. 2023, doi:10.32734/jotp.v5i1.9991

http://doi.org/10.32734/jotp.v5i1.9991

ABSTRACT

This research aimed to design and investigate the fiber optic load sensor produced from the mixture of 100 mesh grains of sand, silicone rubber, and catalyst. The response of the resulted fiber optic load sensor was measured by detecting the microbending of single-mode fiber optic in the form of the power meter. The test was conducted using a light source as an input signal on the sensor. The laser is stable for each load sensor test, with a wavelength of 1500 nm. The study's results confirmed that the load sensor's response has a connection between the amount of load and the voltage; the greater the pressure or load, the less the output power will decrease and cause signal weakening.

Keyword: Fusion Splicer, MMD, Optical Fiber, Single Mode Fiber Optic

ABSTRAK

Penelitian ini bertujuan untuk merancang dan menyelidiki sensor beban serat optik yang dihasilkan dari campuran 100 mesh butiran pasir, karet silikon, dan katalis. Respon sensor beban serat optik yang dihasilkan diukur dengan mendeteksi microbending serat optik mode tunggal berupa power meter. Pengujian dilakukan dengan menggunakan sumber cahaya sebagai sinyal masukan pada sensor. Laser stabil untuk setiap pengujian sensor beban, dengan panjang gelombang 1500 nm. Hasil studi tersebut menegaskan bahwa respon sensor beban memiliki hubungan antara besaran beban dan tegangan; semakin besar tekanan atau beban maka daya keluaran akan semakin berkurang dan menyebabkan melemahnya sinyal.

Kata Kunci: Penyambung Fusi, MMD, Serat Optik, Serat Optik Mode Tunggal

1. Introduction

Optical fiber is a light transmission with a large capacity under high conditions. It is used for long-distance channeling applications. Along with the development of utilization, optical fiber was used for light refraction applications with a fairly long-distance fiber [1]–[3]. It is also widely used for measuring tools for a test that functions as light guidance [4], [5].

Fiber optics can be used and measured using the microbending method [6], [7]; fiber optics have advantages, namely selectivity, flexibility, accuracy, and smaller size. In this application, fiber optic is usually coated by a layer of resin which is usually said to be a jacket, generally made of plastic. Fiber optic cables are generally made with a microscopic size. Therefore, the fiber optic cable is not easily damaged [8]–[10].

Based on the above explanation, this research aimed to produce and investigate the fiber optic load sensor synthesized from the mixture of 100 mesh grains of sand, silicone rubber, and catalyst. The response of the resulted fiber optic load sensor was measured by detecting the microbending of single-mode fiber optic in the form of the power meter. The test was conducted using a light source as an input signal on the sensor.

2. Method

The flowchart of this research was provided in Fig.1.

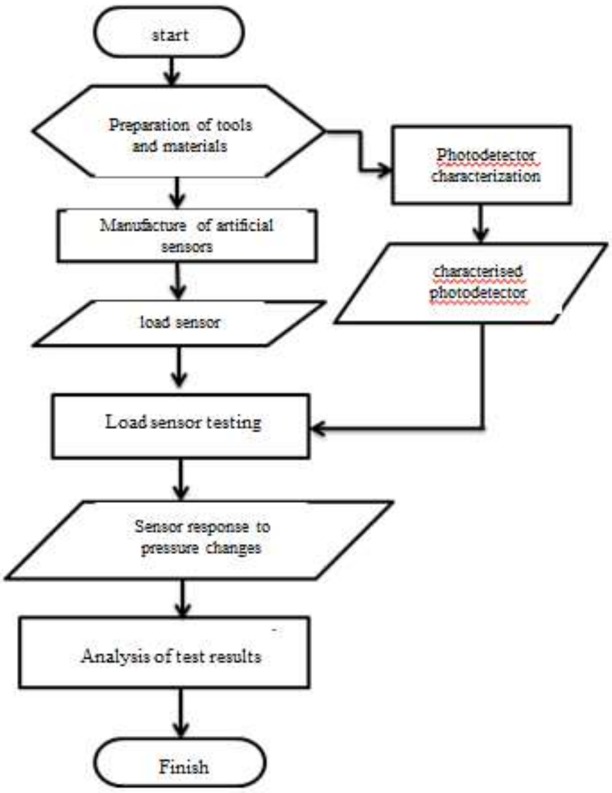

Figure 1. Flowchart of the research.

The main materials used were silicone rubber, sand, and hardener. Firstly, the sand was sifted. The purpose of sifting sand is to obtain smaller grains with the size of 100 mesh. Then, the materials were mixed using a composition or ratio of 7:3 (silicone rubber: granules of sand). After the material has been mixed, it was placed in an aluminum container, and optical fiber was placed on top of the mixture. Finally, the sample was dried for 1.5 hours (Figure 2).

Figure 2. The resulted sensor

The fiber connector was then connected using a fusion splicer. Then, the screen showed the process of connecting and calculated the estimated channel attenuation produced by the fiber optic.

3. Result and Discussion

3.1. Sensor test results with additional load U-structured fiber optic

During the measurement of the sensors, the setting/measuring the stability of the light laser was first carried out by setting the input power or laser power of 1.92 mW and the wavelength is 1500 nm. Data collection was carried out as many as 3 repetitions (Table 1).

Table 1. Load sensor measurement results.

Load (kg)	Power 1 (mW)	Power 2 (mW)	Power 3 (mW)
0	0.619	2.462	1.468
20	0.472	1.751	0.752
40	0.257	1.382	0.437
60	0.195	1.241	0.324
80	0.147	1.401	0.196
100	0.132	1.372	0.153
120	0.127	1.152	0.138

Based on Table 1, the graphic is depicted in Figure 3.

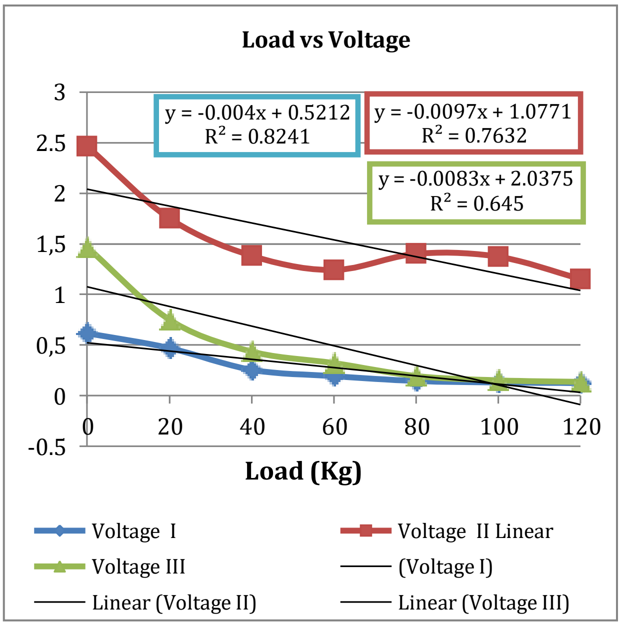

Figure 3. Graph testing of fiber optic variation load sensor U with granulated sand 100 mesh silicone rubber

Based on Figure 3, the results showed an average sensitivity value of 0.0198 V/Kg, and sensor linearity (R_2) of 0.693. It can be said that linearity is a correlation coefficient value that is close to one; still, the coefficient value is not close to one because MMD is unstable when measuring the value of the output voltage to the load.

3.2. Sensor test results with straight-structured fiber optic load addition

In this study, the stability measurement of the light laser is first carried out by setting the input power or laser power of 1.92 mW and the wavelength is 1500 nm. Data testing/retrieval was carried out as many as 3 repetitions due to additional loads (Table 2).

Table 2. Measurement results/load sensor testing.

Load (kg)	Power 1 (mW)	Power 2 (mW)	Power 3 (mW)
0	345.6	340.5	338.1
20	299.7	254.1	278.2
40	251.5	204.8	234.3
60	213.8	168.3	158.4
80	184.2	125.6	120,6
100	162.3	108.3	105.4
120	142.4	96.2	99.4

From Table 2, the graphic is depicted in Figure 4.

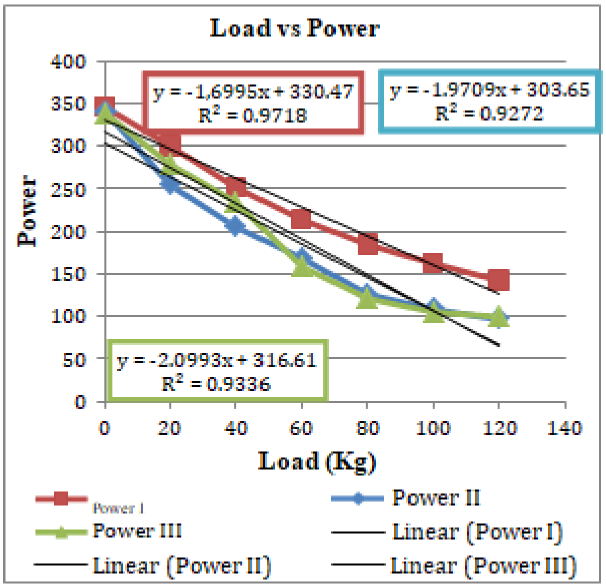

Figure 4. Graph of the test results of the fiber optic variation load sensor straight with granulated sand 100 mesh silicone rubber

In Fig. 4, it can also be seen that the load sensor test of a variation of 1000 mesh grains of sand with three repetitions of the load. The sensor response when tested had an average sensitivity value of 1.9232 and an average value of linearity was 0.9275.

3.3. Sensor test results with double u structured fiber optic load addition

The measurement for the stability of the light laser is first carried out, by setting the input power or laser power of 1.92 mW and the wavelength is 1500 nm. Data testing/retrieval was carried out as many as 3 repetitions due to additional loads.

Table 3. Measurements results/load sensor testing

Load (kg)	Power 1 (mW)	Power 2 (mW)	Power 3 (mW)
0	215.4	219.6	318.8
20	190.7	199.4	197.5
40	179.2	179. 4	176.8
60	151.2	155.2	152.3
80	106.7	133.5	109,8
100	87.11	98.75	91.97
120	65.81	87.66	62.25

From Table 3, the graphic is depicted in Figure 5.

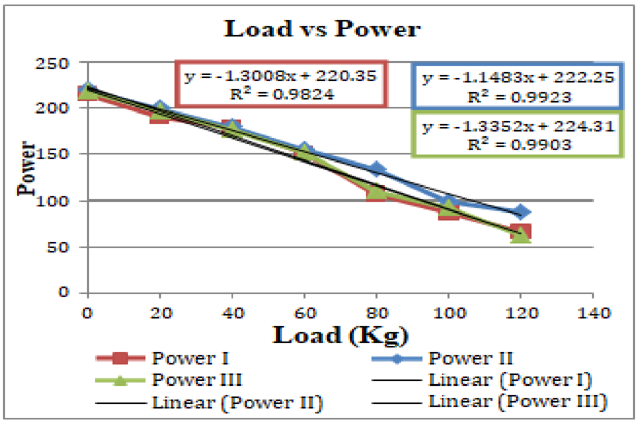

Figure 5. Graph of load sensor test results of double U fiber optic variation with 100 mesh sand grains and silicone rubber

Based on Table 3 and Figure 5, the sensor has an average sensitivity value of 1.2614 and a linearity average value of 0.9883. Each load addition has an average value of 21.11 μW. The sensor response to the linearity value of the silicone rubber type RTV- 586 with a material mixture of 100 mesh grains of sand achieves a better value with the composition of the sand: silicon rubber of 7:3. For bent optical fibers, signal attenuation/loss will be subjected to signal attenuation.

4. Conclusion

To conclude, the test results showed that the influence of a mixture of silicone rubber and 100 mesh grains of sand resulted in measurements that had different values in each iteration of the sensor test. It is concluded that in this test linearity is the value of the correlation coefficient close to one. The sensor response to the linearity value of the RTV-586 silicon rubber type with a 100 mesh sand grain mixture material achieves a better value with the sand composition: silicone rubber 7: 3. For bent optical fibers, signal attenuation/loss will be subjected to signal attenuation.

References

[1] B. Lee, "Review of the present status of optical fiber sensors," *Opt. Fiber Technol.*, vol. 9, no. 2, pp. 57–79, 2003, doi: 10.1016/S1068-5200(02)00527-8.

[2] T. G. Giallorenzi *et al.*, "Optical Fiber Sensor Technology," *IEEE Trans. Microw. Theory Tech.*, vol. 30, no. 4, pp. 472–511, 1982, doi: 10.1109/TMTT.1982.1131089.

[3] D. Marcuse, *Principles of Optical Fiber Measurements*. Elsevier, 2012.

[4] P. Lu *et al.*, "Distributed optical fiber sensing: Review and perspective," *Appl. Phys. Rev.*, vol. 6, no. 4, p. 041302, 2019, doi: 10.1063/1.5113955.

[5] B. Lee, S. Roh, and J. Park, "Current status of micro- and nano-structured optical fiber sensors," *Opt. Fiber Technol.*, vol. 15, no. 3, pp. 209–221, 2009, doi: 10.1016/j.yofte.2009.02.006.

[6] J. W. Berthold, "Historical Review of Microbend Fiber-Optic Sensors," *J. Light. Technol.*, vol. 13, no. 7, pp. 1193–1199, 1995, doi: 10.1109/50.400697.

[7] X. Yang *et al.*, "Textile fiber optic microbend sensor used for heartbeat and respiration monitoring," *IEEE Sens. J.*, vol. 15, no. 2, pp. 757–761, 2015, doi: 10.1109/JSEN.2014.2353640.

[8] A. Arifin, Yusran, Miftahuddin, B. Abdullah, and D. Tahir, "Comparison of sensitivity and resolution load sensor at various configuration polymer optical fiber," in *AIP Conference Proceedings*, 2017, vol. 1801, no. January 2017, p. 050002, doi: 10.1063/1.4973100.

[9] W. Tan, Z. Shi, and R. Kopelman, "Development of Submicron Chemical Fiber Optic Sensors," *Anal. Chem.*, vol. 64, no. 23, pp. 2985–2990, 1992.

[10] A. F. Gmitro and D. Aziz, "Confocal microscopy through a fiber-optic imaging bundle," *Opt. Lett.*, vol. 18, no. 8, pp. 565–567, 1993, doi: 10.1364/ol.18.000565.