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Performance weight sensor using graded index optical fiber on static test with UTM

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Abstract. Overloading the vehicle on a highway cause the damage to roads, accidents and harm other road users. Required a weight sensor has a high sensitivity, resistant to corrosion and electromagnetic wave interference. Graded index optical fiber is a kind of fiber that has the potential to be used as a deformation sensor. This research aims to optimize the load sensor has been developed previously to detect a load on a ton scale. The weight sensor-based micro bending graded index fiber and LED as a light source capable of detecting a load from 0.7 to 1.93 tons with a standard deviation of 1.18 and 99.45% accuracy level in a static text using UTM. This sensor has been able to be used to detect heavy vehicles such as water truck wheels 6 and fuel trucks. The study will be further developed in order to detect the load to more than 8 tons.

1. Introduction

Research on the application of optical fiber as the sensor has been developed[1][2]. One application is the use of fiber optics as the load sensor with the principles of micro bending fiber[3][4].Overloading the vehicle on a highway cause the damage to roads, accidents and harm other road users. Required a weight sensor has a high sensitivity, resistant to corrosion and electromagnetic wave interference. The weight sensor that can be planted in highway structures can have a large role to detect the presence of heavy vehicles with a load exceeding the normal capacity. Therefore, it is necessary based optical sensor is resistant to EM waves and water.

Refer to the results of our previous studies [5], that using LED 1310 nm as the light source on the weight sensor is more stable than LASER 1310 nm and 970 nm. Bending period is an important factor that determines the precision level of a sensor[6][7][8]. In the our previous study [9], the weight sensor with a micro bending deformer double side and bending period is 1.5 mm with step index optical fiber is able to detect the load until 100 kg with an accuracy value of 98.77%, equivalent to the load of the vehicle wheel two. This study aimed to optimizing the weight sensor based on fiber bent techniques be able to detect loads up on a ton scale.

1.1. *Graded index optical fiber*

Plastic Optical Fiber (POF) graded index capable as deformation sensing system[10][11]. In this research, would analysis the performance of the weight sensor using graded index multimode optical fiber types GIF50C with static test.

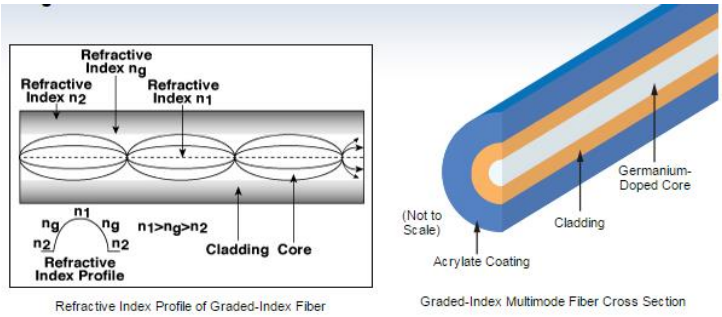

Figure 1. Graded index optical fiber type GIF50C

The refractive index of graded index optical fiber is a function of the distance to the optical axis. So that, the light will experience refraction storied away sheath and approaching the fiber core[12]. This is causes theoptical waves that propagate through multiple modes will arrive at the end of the fiber optic at the same time.

1.2. Micro bending fiber bent

Micro bending is the bending of an optical fiber in micro sized and affects the optical power loss. This bending is caused by mechanical stress on the optical fiber in an axial direction. Based on studies [7], if the optical fiber has bent in axial direction of the optical axis, the transmission coefficient of the light will change with magnitude as this equation:

$$\Delta T = \frac{\Delta T}{\Delta X} A_p k_f^{-1} \Delta P \tag{1}$$

Transmission of light in an optical fiber would result in attenuation. It is caused weakening of energyso that the amplitude of wave would arrived at receiver smaller than those sent by the transmitter[13].

Deformer micro bending consists of two grooved plates and between plates are optical fibers. When the bend radius exceeded the critical angle, the light began into the leak to the cladding results in intensity modulation. When a small bent exposed fibers or disorder, a certain portion of the propagation of light in the fiber core are incorporated in the radiation mode and lost. Mode merger can be achieved by using a corrugated plate that changes the shape of fiber into a series of bends. Therefore, micro bending causes the light intensity decreases

2. Experiment

The weight sensor consists of LED 1310 nm as a light source which propagated in a graded index optical fiber GIF 50c which has a refractive index of the core material 1,479 at 1300 nm, Numerical Aperture 0.20 ± 0.015 and a core diameter of 50.0 ± 2.5 um. These fibers are enclosed in micro bending deformer has a length 50 cm are made of PVC material with a thickness of 1.5 cm and 1.5 mm bending period. The method of static pressure test by pressing a fiber bent using UTM. This machine could generate the pressure until 100 kN. Output optical power after a sensor in the press by UTM captured by detector optical power meter with a minimum capability -60 dBm. All equipment will be setting as a Figure 2.Press test is intended to determine the maximum load that can be detected by these sensors. Tests conducted by the repeated 5 times in each load.

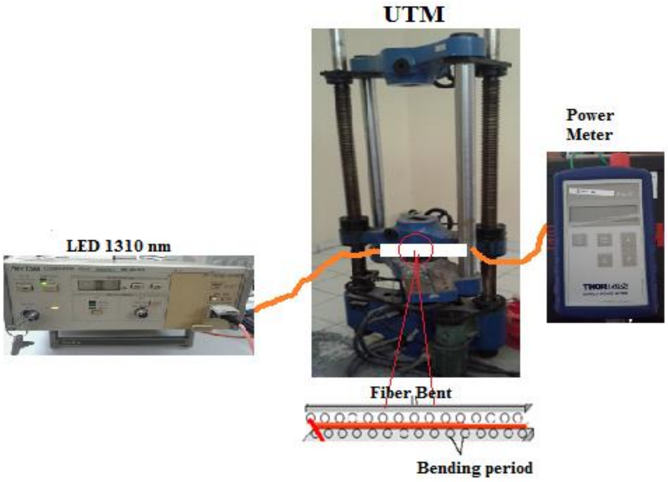

Figure 2. Set up experiment static pressure test

3. Result and discussion

Several of the most important to static characterization of sensor are repeatability, resolution, sensitivity, linearity and accuracy[14][15]. From experimental data obtained graphics are 1,2,3,4 and 5 represent the output optical power meter as a function of pressure of UTM as in Figure 3. Graphics 1 and 2 have different profile with graphic 3,4 and 5. This is due to the time of data collection is done shortly after the equipment assembled; do not wait for the stability of the optical wave propagation in the fiber. Nevertheless, this sensor has a good repeatability.

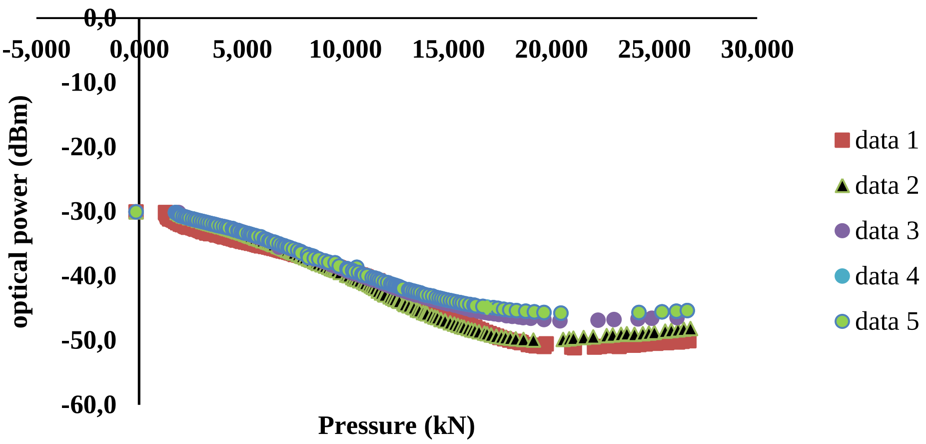

Figure 3.Response the optical power causes pressure on weight sensor

From 5 data of repetitions performed the calculation of average output optical power due to the pressure UTM and represented in the Figure 4.

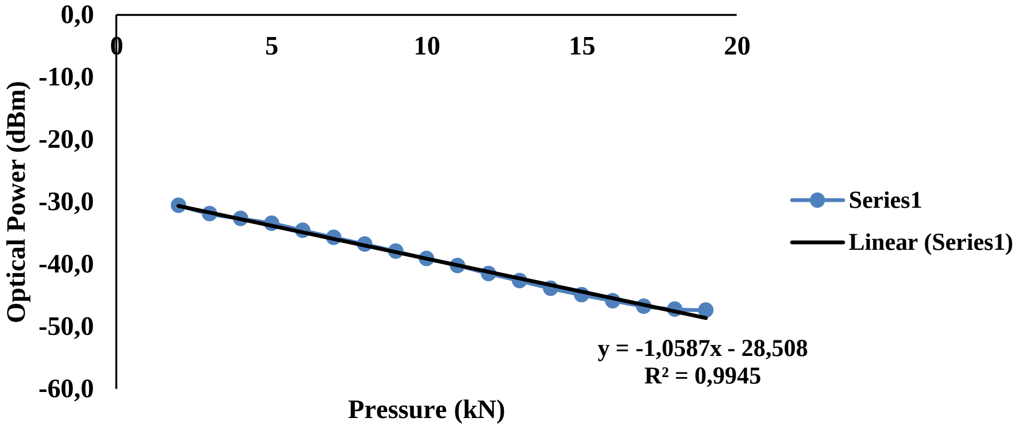

Figure 4.Fitting linear of average optical power on weight sensor

Linear graph in the Figure 4 representation the linearity have a equation y = -1,0587x - 28.508, that means for every 1 kN pressure exerted on the weight sensor will result in a decrease of -1.0587 dBm optical power. In other words, the resolution of this sensor is every 1 dBm on the detector shows the pressure on the sensor caused by load of 92.106 kg.

This sensor has been able to detect a load in the range of 0.7 - 1.93 ton at 99.45% accuracy level. This success can already be applied to detect load 6 wheel vehicles such as water vehicle and vehicle fuel.

4. Conclusion

Weight sensor using graded index optical fiber on deformer micro bending double side 1,5 mm and LED 1310 as a light source able to detection the load in the range of 0.7 - 1.93 tonnes with good repeatability. Has resolution 92.106 kg/dBm and the accuracy is 99.45%.

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