Fabrication and Analysis Signal Optical Fiber Sensor Based On Bend Loss for Weight in Motion Applications

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Abstract
Road network plays very important role in economic development. Overweight is one of the main factors contributing to road damage. To minimize this factor, road authority has to make sure that all vehicles operate in according to maximum vehicle regulation set by the government. The one solution can use from this problem is Weight in motion (WIM) technology. WIM technology allows measuring vehicle weight quickly. The sensor is one of the important components in the WIM system.

This paper presents a model of WIM fiber sensor work based on bend loss. Fiber sensor has made by coiling optical fiber. Coiling optical fiber has managed in the elliptical shape rubber coil. Rubber coil then is planted in the pad of sensor. The principle of this sensor is a detecting of the shift light intensity output of optical fiber when the vehicles a passing through on fiber sensor. Loading was carried out using loaded truck model. Data was carried out with variations of load and load positions in the truck.

The results can be concluded that the shift light intensity is greater with the more shift loads. The loader of the truck has also resulted in the greater loss. Loads in the truck distributed on the axles due to the position of loads.

1. Introduction
Road network plays very important role in economic development. However, many roads quickly damaged. That has resulted in the distribution of goods are obstructed. Overweight is one of the main factors contributing to road damage. To minimize this factor, road authority has to make sure that all vehicles operate in according to maximum vehicle regulation set by the government. The one solution can use from this problem is Weight in motion (WIM) technology. WIM technology allows measuring vehicle weight quickly [5].

The principle of WIM technology is a detecting of the shift light intensity output of optical fiber when the vehicles a passing through on fiber sensor [1]. Different with the weighbridge method, vehicles must be stopped to measure vehicle weight. So, this is causes of the traffic congestion. Some advantages of WIM technology are more efficient and saving time, especially when the traffic is busy. Some WIM technologies are there current now use piezoelectric cable, capacitive mats, hydraulic, and load cell system [6]. However, these sensors have some weakness are corrosion, can be affected electromagnetic interference and has a low accuracy.
Sensor technology based on optical fiber seems to be a good solution. The optical fiber is the transmission media or cylindrical light waveguide. Optical fiber sensor has some advantages, such as hold up with electromagnetic interference and radiation, high sensitively, and hold up to corrosion [3].

2. Experiment
This experiment aim is to designing and fabricating optical fiber sensor for weight in motion application. Fiber sensor created by coiling optical fiber in the elliptical rubber shape with the specific diameter. Rubber coil then is planted in the pad sensor. Then, the analysis optic signal shift in the fiber sensor when the weight in motion effect occurs. This experiment consists of some main components: a light source, optical fiber sensor, a light detector, analog digital converter (ADC), and the software of taking and data processing.

![Figure 1. Schematic of the experiment model](image1)

Figure 1 is the schematic model of used in this experiment. Light from the light source has split into 2 arms. One arm is coming in to optical fiber as the modulation intensity. One arm again is coming in to optical fiber as the reference intensity. Fiber sensor will be through on loss light or disappearance of light transmittance. The transmitted light signal then detected by a light detector. This light signal still in the analog signal. Analog signal compared to a digital signal with the analog digital converter (ADC). Digital data from the ADC process then connected to a personal computer to display with the LABVIEW 2012 program. Figure 2 is the Weight in motion data acquisition using LABVIEW 2012 program.

![Figure 2. Weight in motion data acquisition program](image2)
3. Results and Discussion
The taking data carried out by variations of load positions in the truck. The load positions are in the front, in the middle, and in the back of a truck. Measurement data carried out with the toy truck. Figure 3 is the measurement data result shown on the weight in motion data acquisition.

![Figure 3](image)

Figure 3. Chart of transmittance fiber sensor when passing through on the truck

The chart on figure 3 shows light transmittance value at the time. The chart there are 2 valleys depth. Valleys depth are shows light transmittance value in the fiber sensor when a truck is passing through on fiber sensor. First valley depth is in the front tyre of the truck. Second valley depth is in the rear tyre of the truck.

![Figure 4](image)

Figure 4. Data results in this experiment (a) Front tyre variation, (b) middle tyre variation, (c) rear tyre variation
Figure 4 shows that the valley depth is greater with the greater of loads is passing through on fiber sensor. The great of the valley depth shows the optical fiber loss in the fiber sensor. The loss is greater with the greater of loads. Figure 4 also shows that the loads distribution is following the position of the load in the truck. On the front load variation, the loads distribution on the front tyre is greater than on the rear tyre. The greater of the loads has resulted in the greater valley depth. In the otherwise, The valley depth on the rear tyre constant at the front variation of the loads. On the rear load variation, the loads distribution on the rear tyre is greater than on the front tyre. While on the middle load variation, the loads distribution is evenly distributed on the both tyre. It can be explained with the physical illustration below.

![Figure 5](image)

Figure 5. The illustration of distribution loads in the weight in motion

Figure 5 shows that the loads distribution has set in the buffer. The buffer is analogous as the front tyre and rear tyre of the truck. The mass has set in the middle of the buffer. It is giving a force $F$ downward direction. That is due to Newton’s Third Law where the action force same the reaction force and opposite direction, shown in the equation (1).

$$F_{\text{action}} = -F_{\text{reaction}}$$

(1)

$F_{\text{action}}$ is the weight of the mass acting downward direction. $F_{\text{reaction}}$ is the force exerted by the ground on the mass in the upward direction. The reaction force is the total force from the both buffers, shown in the equation (2).

$$F_{\text{action}} = -(F_1 + F_2)$$

(2)

$F_1$ is the reaction force in the front tyre, $F_2$ is the reaction force in the rear tyre. Therefore, each of the buffers will give the same of the reaction force. It is shown that the reaction force distributed in the both buffers. The magnitude of reaction mass on the both buffers depends on the position of the loads. The magnitude of each force from the both buffers can write:

$$F_1 = F \frac{\Delta l_2}{L}$$

$$F_2 = F \frac{\Delta l_1}{L}$$

(3)
4. Conclusions
The fabrication of fiber sensor to weight in motion application has made. Fiber sensor has made by coiling optical fiber sensor in the elliptical shape rubber coil. Rubber coil then is planted in the pad of sensor. This experiment consists of some main components: a light source, optical fiber sensor, a light detector, analog digital converter (ADC), and the software of taking and data processing. The results can be concluded that the shift light intensity is greater with the more shift loads. The loader of the truck has also resulted in the greater loss. Loads in the truck distributed on the axles due to the position of loads.

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