Intelligent Piezoelectric Sensor For Traffic Monitoring

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Abstract

This paper describes an intelligent piezoelectric traffic sensor which can be detected the over-weighted vehicles in motion. Based on finite element analysis for the sensor, the sensitivity was analyzed and the design was optimized. Studied parameters are the material properties of constitutional parts, the geometry of the sensor, the weight of the vehicle, and the speed of the vehicle. To verify the simulated results, we manufactured the sensor having the optimized geometry and the sensitivity was measured in the range from 0.5 to 3 ton of tensile and compressive stress. The measured results shows that the sensitivity and linearity of the sensor are closely agree with the designed values.

1. Introduction

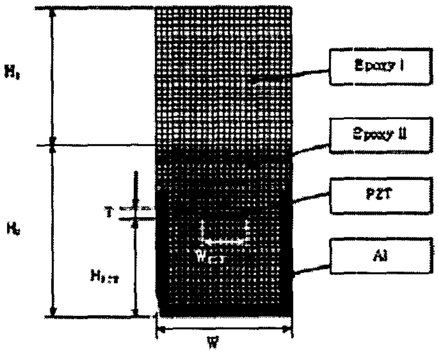
Over-weighted vehicles caused damages to roads or bridges and shorten their duration period. They required to spend a lot of money on maintaining and repairing the roads and, moreover, resulted in the heavy traffic accidents due to the loss of efficiency of steering power of vehicles.

Generally traffic monitoring system can be collects various data like as vehicles type and weight without the traffic disturbances. The system consists of two sensors and one induction loop circuits. Piezoelectric type sensors are suitable for this system because it is easy to mounting on the road and has a superior sensitivity and durability than other type sensors.

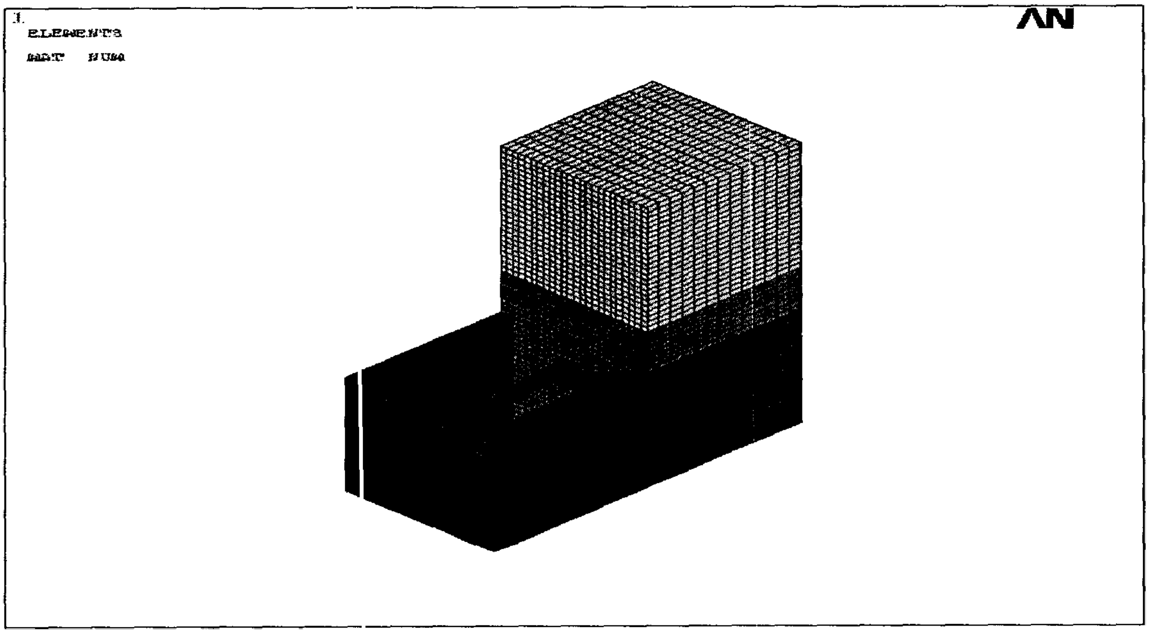
In this paper, to develop the intelligent piezoelectric traffic sensor, the sensitivity of the piezoelectric traffic sensor is evaluated and the designs are optimized with finite element method (FEM). Also the effects of the vehicle speed on the sensor response are analyzed and the optimal material properties of the constitutional parts are determined.

2. Finite element modeling and analysis

The piezoelectric sensor consists of PZT ceramics, two layers of polymer and cover metal as shown in Fig. 1(a). To analyze the sensor response to the various vehicles, three-dimensional finite element models are constructed (Fig. 1(b)) and a transient response of the sensor is carried out. The modeling and analysis is carried out with commercial finite element analysis software, ANSYS. The responses of the sensor are analyzed through transient analysis. The influence factors on the sensor response are the PZT shape (width and thickness of the PZT ceramics), the installation height (Hpzt), and the material properties of the constitutional parts. To analyze the influence of both the vehicle type and speed on the sensor response, step pressures that have appropriate load and duration time are applied at each case.



(a)



(b)

Fig. 1 (a) Cross sectional view and (b) finite element model of the piezoelectric sensor.

3. Results and Discussion

Figure 2 shows the simulated response characteristics of the piezoelectric sensor with the geometry of PZT ceramics. The geometry includes the thickness, the width, and the installation height of the PZT ceramic in the sensor. As shown in Fig. 2, the sensor response is increased as the PZT thickness increased, but the response is decreased as the PZT thickness increased. Also the optimal installation height of the PZT ceramics in the sensor is about 5 mm.

Figure 3 shows the simulated response characteristics of the piezoelectric sensor with the various type and speed of the vehicle. As shown in Fig. 3, the sensor has a good linearity with the vehicle speed for either the light vehicle or the heavy vehicle.

Figure 4 shows the experimental response characteristics of the piezoelectric sensor with the various type and speed of the vehicle.

As shown in Fig. 3 and Fig. 4, the piezoelectric sensor has a good response characteristic for the intelligent traffic monitoring system without traffic disturbances.

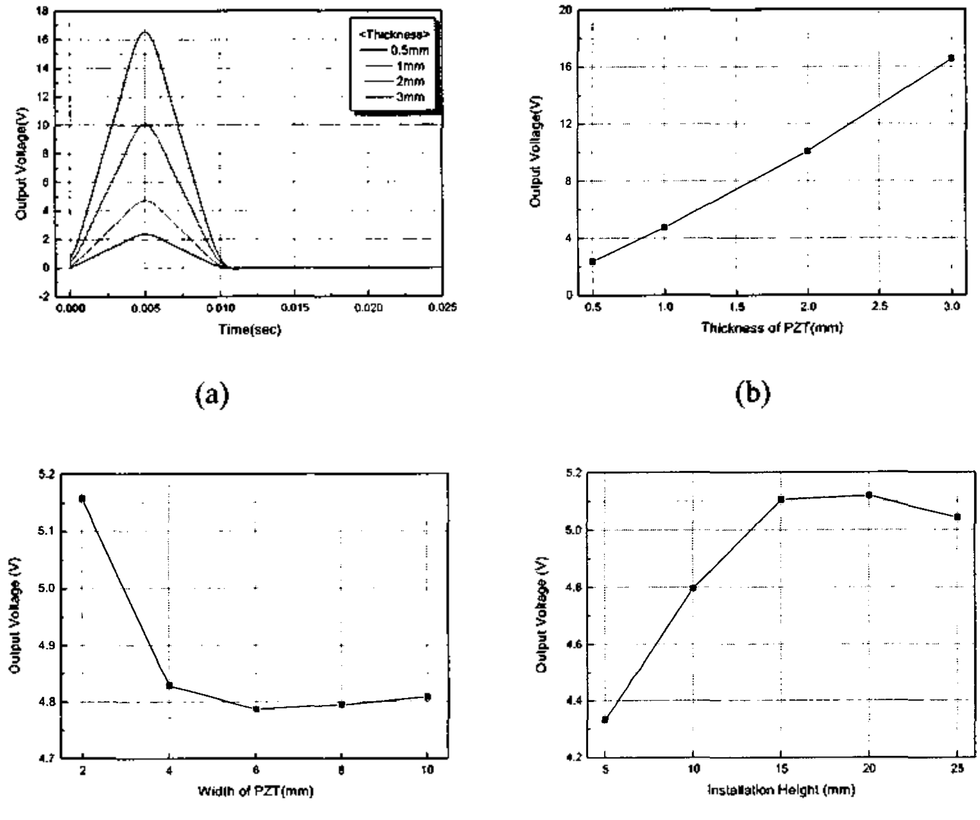
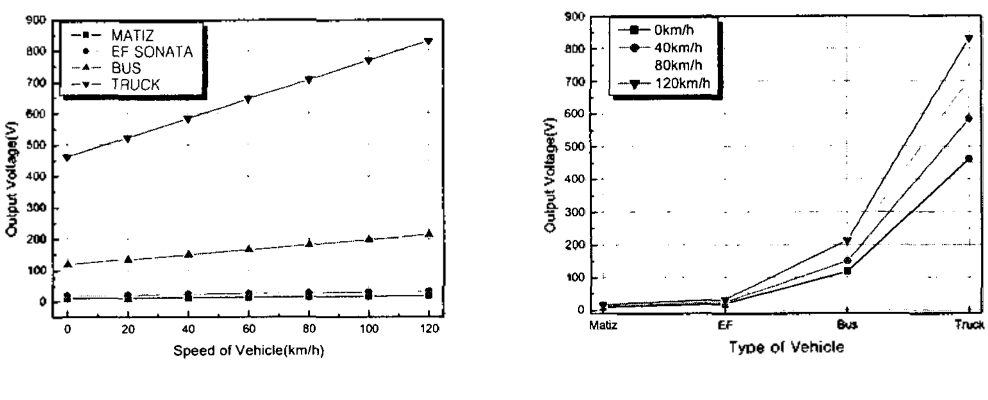
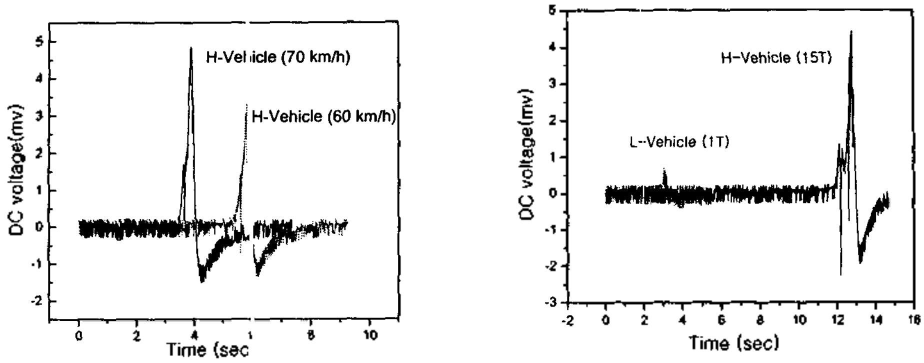


Fig. 2. The simulated response of the sensor with the geometry of the PZT ceramics



(a) (b)

Fig. 3. The simulated response of the sensor with the various type and speed of the vehicle.



(a) (b)

Fig. 4. The experimental responses of the sensor with the various type and speed of the vehicle.

4. Conclusions

The response characteristic of the piezoelectric sensor was analyzed and the design was optimized with FEM. The design parameters investigated included the material properties of the constitutional parts, the geometry of the sensor, the weight of the vehicle, and the speed of the vehicle. According to the results, the sensor with the optimized geometry has about 5 times higher response characteristic than the original one. Also the piezoelectric sensor has a good response characteristic for the intelligent traffic monitoring system.

References

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