

Development of POP-UP HOOD SYSTEM

Ken HANAYAMA*

Kaoru NAGATOMI*

Tatsuya ISHIZAKI*

Kazuo MATSUDA*

Junichi NISHIMURA*

Masaomi TOTTORI*

ABSTRACT

A POP-UP HOOD SYSTEM has been developed to help reduce the severity of head injuries to pedestrians in pedestrian-to-automobile accidents. The system operates by lifting the rear portion of the hood upon vehicle collision with a pedestrian, therefore increasing the clearance between the hood and the solid components underneath the hood, such as the engine. This system, which is being used on the new LEGEND model, enables the automobile to have a lower styled hood and thus a sporty exterior design, while enhancing safety features in line with the European pedestrian protection regulations that took effect in 2005.

1. Introduction

Awareness of pedestrian protection continues to increase as evidenced by new regulations in effect in Japan and Europe since 2005. Honda has been a leader in pedestrian protection, using for example a new vehicle body construction launched to the market in 1998 that helps reduce harm to pedestrians. It has also developed the new POP-UP HOOD SYSTEM as a way of further helping reduce injury to the head of pedestrians. This system, which is being used on the new LEGEND model, enables the automobile to have a lower styled hood and thus a sporty exterior design while enhancing safety features in line with European pedestrian protection regulations. The following paper provides details of the technology associated with the development of the POP-UP HOOD SYSTEM.

2. Development Goals

In the majority of accidents that are fatal to pedestrians, the pedestrian is fatally injured after being struck by the front of the vehicle and hitting his or her head on the hood⁽¹⁾(Fig. 1).

To help mitigate the severity of the impact to the pedestrian's head during collision, Honda has developed a system for the LEGEND that lifts the rear portion of the hood upon collision between a vehicle and a pedestrian. This in turn provides more clearance between the hood and the solid components underneath the hood, such as the engine. The goals of this development were as follows:

- (1) Achieve rapid system operation
- (2) Achieve precision collision sensing
- (3) Achieve pedestrian safety performance in line with European regulations

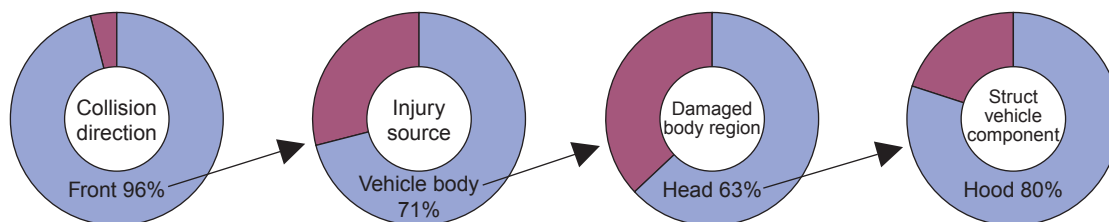


Fig. 1 Data of fatal pedestrian accidents

* Automobile R&D Center

3. System Overview

3.1. System Construction

The system configuration is shown in Fig. 2. The system consists of pedestrian crash sensor that detects collisions with pedestrians, wheel sensors to detect vehicle speed, an ECU for control, pyrotechnic actuators to lift the hood, hinges, and the hood.

The system's flow of operation is shown in Fig. 3. The operation of the system is controlled by inputs from both the pedestrian crash sensor and wheel sensors with thresholds set to match pedestrian impacts at a pre-defined speed or greater. Then, the pyrotechnic actuators lift the hood which deform the hinges. After this operation the position of the hood is maintained with the pyrotechnic actuators' lock mechanisms.

The distance that the hood raises is approximately 90 mm at the back end which is intended to not interfere with

the driver's vision during and after the system has been activated.

3.2. Pedestrian Crash Sensor

As Fig. 2 shows, a pedestrian crash sensor consists of an absorber supported by the bumper beam, which absorbs the energy of the collision with the pedestrian's legs and accelerometers. The absorber has three uni-axial accelerometers mounted on it.

These accelerometers are electrostatic capacitance type with environmental durability and reliability.

The ECU algorithm for operation is shown in Fig. 4. Accelerometer data are transmitted to the POP-UP HOOD SYSTEM ECU where calculations are performed and the results are compared to a preset threshold value. If the threshold value is surpassed, an electric current is sent to the pyrotechnic actuators for activation.

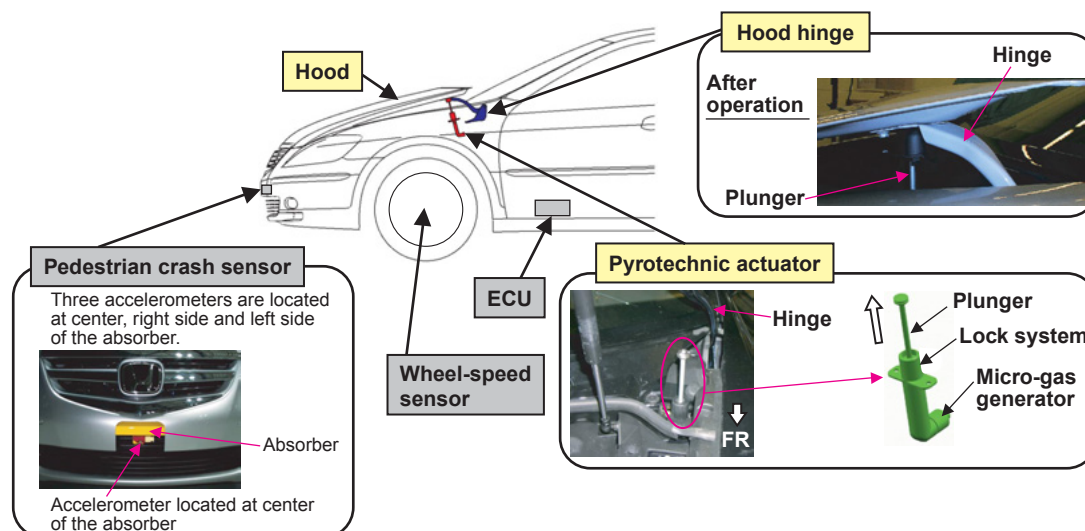


Fig. 2 System configuration

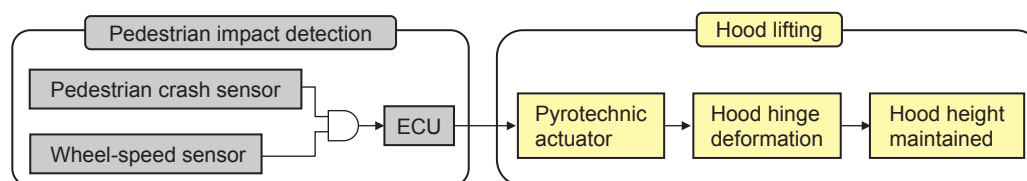


Fig. 3 Block diagram

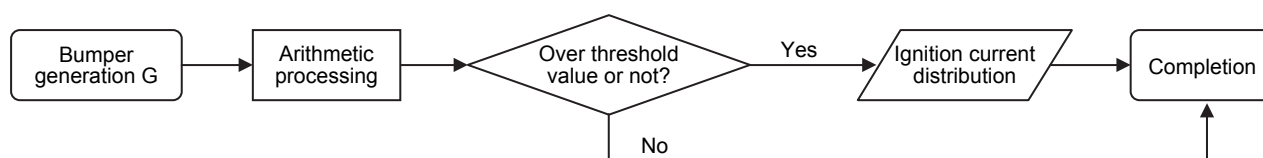


Fig. 4 Detection algorithm

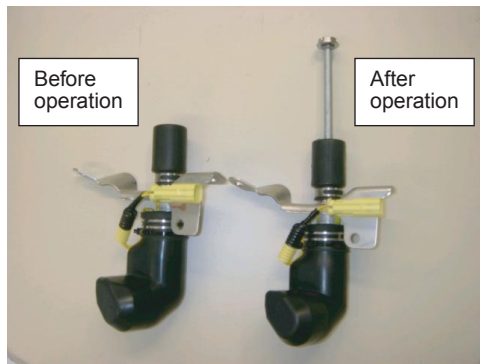


Fig. 5 Pyrotechnic actuator

3.3. Pyrotechnic Actuators

A pyrotechnic actuator is shown in Fig. 5. One pyrotechnic actuator is located under each of the vehicle's right and left hinges. As the pedestrian is struck by the vehicle, the pyrotechnic actuators activate and lift the hood prior to the pedestrian's head contact to the hood.

4. Performance confirmation

4.1. Confirmation of Instant System Operation

The system operation performance was confirmed in impact tests using pedestrian dummies (Fig. 6). The dummies tested included average American male adult size (175 cm tall, which is called AM50 henceforth and is a standard size crash dummy), and an average six-year-old child size (120 cm tall, which is called C6Y henceforth). The dummies simulate pedestrians struck by the vehicle from the side while crossing a road⁽²⁾. The tests were performed at a collision speed of 40 km/h with the pedestrian struck at the front of the vehicle along its mid-

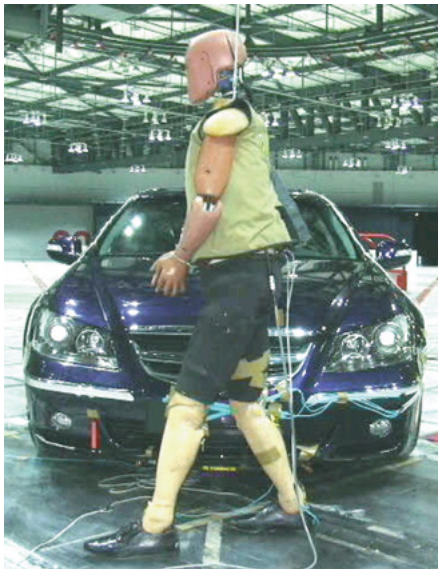


Fig. 6 Setting up of AM50 pedestrian dummy test

plane. Test results are shown in Fig. 7. The test confirmed that the system operation was completed quickly and prior to the head strike to the hood for both the C6Y and the AM50.

4.2. Precision Collision Sensing Confirmation

Sensing performance was confirmed with pedestrian dummy tests. The tests were performed at a collision speed of 40 km/h using the C6Y dummy which is lightweight and gives less input to the bumper, and therefore is more challenging to detect. Figure 8 gives representative test results. The tests confirmed that the sensors detected collision with the pedestrian across a wide area of the bumper quickly.

4.3. Confirmation of Pedestrian Safety Performance in Line with European Regulations

New pedestrian protection regulations took effect in Europe in October 2005. The tests involve the impact of pedestrian representative heads and legs with a vehicle and applicable injury criteria applied (Fig. 9). The head impact test is performed at an impact speed of 35 km/h.

The head impactor test for the European pedestrian protection regulations is shown in Fig. 10. The test results

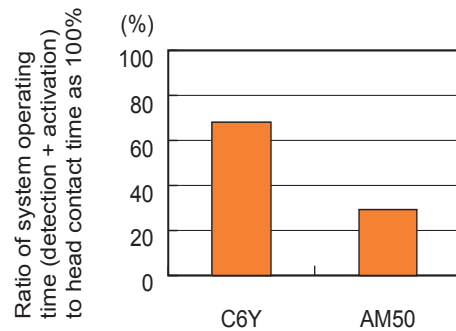


Fig. 7 Results of pedestrian dummy test struck at center of vehicle

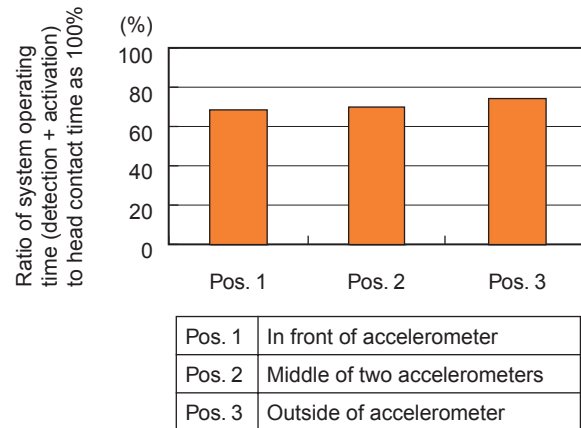


Fig. 8 Results of C6Y pedestrian dummy collision test at various crash positions

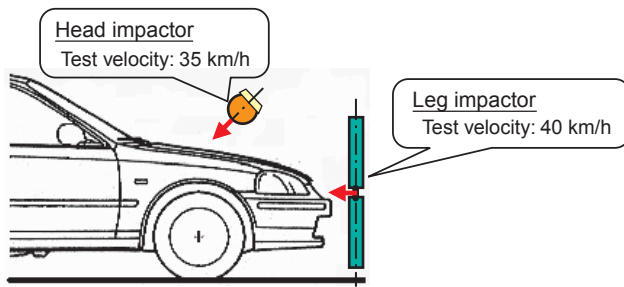


Fig. 9 European regulation test

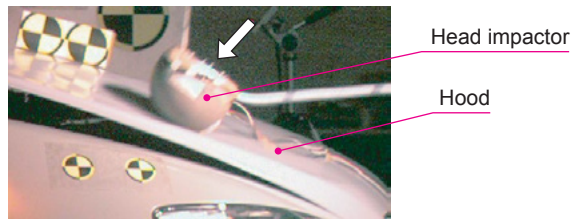


Fig. 10 Head impactor test with POP-UP HOOD

confirmed the Head Injury Criterion (HIC) did not exceed 1000 over two-thirds of the head impactor test area and 2000 for the remaining one-third of the head impactor test area.

5. Conclusion

A POP-UP HOOD SYSTEM has been developed to help reduce the severity of head injuries to pedestrians in pedestrian-to-automobile accidents. The system incorporates the following performance characteristics:

- (1) Using pedestrian crash sensor and pyrotechnic actuators, the system operation was completed rapidly and prior to the time the head struck the hood.
- (2) Precision collision sensing was achieved to detect collision with the pedestrian rapidly across a wide area of the bumper.
- (3) Pedestrian safety performance in line with new European regulations was achieved with a design that lifts the rear portion of the hood and provides more clearance between the hood and the solid components underneath the hood, such as the engine.

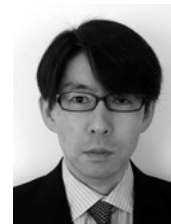
References

- (1) Institute for Traffic Accident Research and Data Analysis: Traffic statistics (1995)
- (2) Nagatomi, K., Hanayama, K., Ishizaki, T., Sasaki, S., Matsuda, K.: DEVELOPMENT AND FULL-SCALE DUMMY TESTS OF A POP-UP HOOD SYSTEM FOR PEDESTRIAN PROTECTION, 19th International Technical Conference on The Enhanced Safety of Vehicles, No. 05-0113 (2005)

■ Author ■



Ken HANAYAMA



Kaoru NAGATOMI



Tatsuya ISHIZAKI



Kazuo MATSUDA



Junichi NISHIMURA



Masaomi TOTTORI