

Study on Airbag Concept for Motorcycles Using Opposing Vehicle as Reaction Structure

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ABSTRACT

An airbag system for motorcycle applications was developed and commercially released in 2006 based on many research results on that system. In the airbag system, the bag should be supported during the period in a collision. The previously developed system employed a configuration in which the airbag was supported by the structures of the motorcycle, such as the instrument panel and the surrounding structures. These structures receive the reaction force to hold the airbag during a crash to properly absorb the rider's kinetic energy. Meanwhile, the previous system requires a larger area for these reaction structures and is applicable only to the motorcycles that can provide the area. To overcome this limitation, we propose an airbag system employing another concept. In this concept, the airbag does not use its vehicle structures as reaction structures but uses the structures of an opposing vehicle, such as doors and/or pillars. For evaluations of the proposed system, full scale motorcycle-to-car crash tests using 125 cm³ scooter-type models with and without the airbag were conducted in the seven impact configurations specified in ISO13232. Through the crash tests, benefits of protective effects of the airbag system were confirmed in particular impact configurations, and no significant risk for the rider due to the airbag was observed in the all tested impact configurations. It was concluded that the proposed airbag system is feasible for reducing rider's severity of injuries in a collision of a motorcycle not having sufficient reaction structures.

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INTRODUCTION

An airbag system has been focused on as a protective device to reduce critical injuries of riders in frontal collisions in previous studies. Among those, a series of studies on an airbag system using a large touring model (Kuroe et al. [1]) was successfully transferred into a practical application in 2006. Kuroe et al. also conducted research on an airbag system for a 600 cm³ scooter-type model to ascertain its feasibility [2].

An airbag generally requires structures to receive a reaction force (hereafter "reaction structure") to hold the airbag during a vehicle crash to properly absorb the occupant's or rider's kinetic energy. In the case of a driver front airbag in a passenger car, the steering wheel serves as the reaction structure. Kuroe et al. [1][2] installed a motorcycle airbag behind the handlebar to make the structural parts of the motorcycle, such as the instrument panel and surrounding structures, serve as reaction structures. In the airbag system developed by Kanbe et al [3], an airbag was installed at the front end of the rider seat of a 250 cm³ scooter-type model that restrained the rider in the lumbar area. In the system a limb structure (called a back plate) was employed as a reaction structure. It was pulled up in front of the airbag by the airbag deployment force.

However, a sufficient reaction structure is hard to be provided in some motorcycle models. For example, with the arrangement of an airbag behind the handlebar, an adequate reaction structure does not exist if the motorcycle is not equipped with an instrument panel and surrounding structures large enough for that function.

In view of the above, we propose in this project an airbag system applicable to a motorcycle not having a sufficient reaction structure. The concept of this airbag system is that the structures of the opposing vehicle, which the motorcycle is colliding, work as reaction structures, rather than structures of the motorcycle itself.

In this paper, the results of validation tests are described, together with the findings from the analyses on target configurations of impact, body regions to be protected and prototype design. A scooter-type model without an adequate reaction structure was selected as the test motorcycle. A prototype airbag system was installed on that motorcycle. The crash tests were conducted in seven impact configurations based on ISO13232 [4][5]. Research methods for making an overall evaluation of rider protection devices that are fitted to motorcycles are defined in the standard (see [Appendix 1](#)). Each test was carried out using a motorcycle equipped with an airbag and one without. The effectiveness was evaluated by comparing the results.

METHODOLOGY

Described in this section are the aims of the proposed airbag system, the design of the prototype airbag and the crash test method.

Aims of Proposed Airbag System

The fatal accident statistics for Japan [6] were analyzed to determine the target impact configurations.

- More than half of fatalities were brought about by injuries to the head area (Figure 1a).
- More than half of the head injuries were caused in collisions against opposing vehicles or roadside structures (Figure 1b).
- Regarding patterns of fatal motorcycle crashes, more than half of the crashes were classified as vehicle to vehicle collisions (Figure 1c), and approximately half of those were crossing collisions (Figure 1d).

To reduce the number of fatalities in motorcycle crashes, we considered it effective to reduce head impact received from an opposing vehicle in crossing collisions. Crossing collisions include crashes into the side body of an opposing vehicle. Therefore, it was considered a feasible option to use the side of the opposing vehicle as a reaction structure. Accordingly the goal for the proposed airbag system was set as reducing critical injuries by mitigating impact to head areas received from the opposing vehicle at the time of collision to the side of the opposing vehicle.

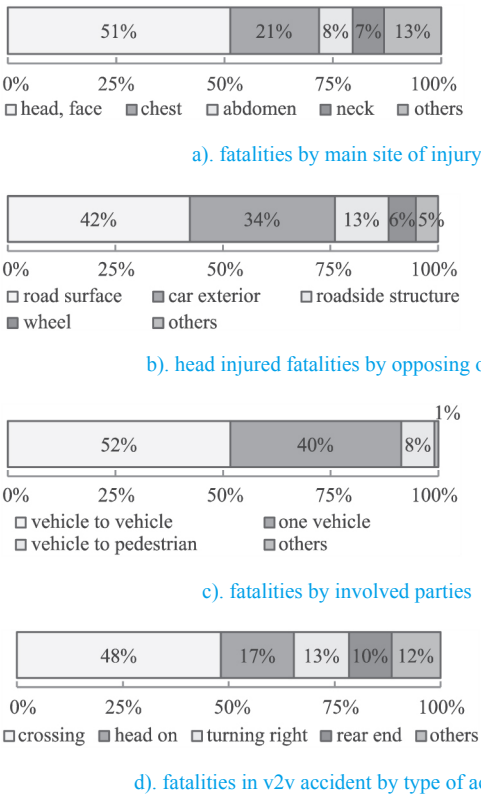


Figure 1. Analysis of fatal motorcycle crashes in Japan

Design of Prototype Airbag

A scooter-type model was selected as the test motorcycle. The specifications of the test motorcycle are shown in Table 1.

Figure 2a and 2b show the scooter-type model equipped with the prototype airbag system. The airbag module is located in the rear of the steering column. The surface around the instrument panel is not large enough to serve as an adequate reaction structure.

This airbag consists of three areas, and each area has a different function (Figure 2c). The topmost area A is intended to support the airbag by contacting the roof side of the opposing vehicle. The center area B is intended to protect the rider's head, and is thicker than other areas. The bottom area C is intended to hold the airbag in the upper direction and control the area B in appropriate position.

The airbag height is determined considering the heights of passenger cars. Taking into account the different moving directions of the rider and the motorcycle that has the airbag at the time of collision, the width of area B is set to a wider side. The airbag volume is approximately 80 L, and it has no vent holes. The folded airbag is stored in the retainer box along with the inflator. The specifications of the airbag are shown in Table 2.

Table 1. Specifications of test motorcycle

Manufacturer	Honda
Model	PCX, Japan
Year	2012-2013
Type	Scooter
Mass (empty, as tested, no airbag)	127.3 kg
Mass (empty, as tested, with airbag)	132.0 kg
Length, overall	1915 mm
Width, overall	740 mm
Height, overall	1090 mm
Wheelbase	1315 mm
Engine displacement	124 cm ³

Table 2. Specifications of prototype airbag

Volume	78.5 liter
Height	1180 mm
Width	680 mm
Length	340 mm
Vent	No vent

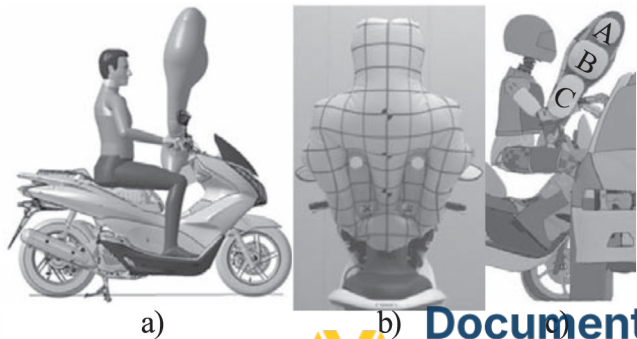


Figure 2. Test motorcycle with prototype airbag

Sensing System With Sensor on the Frame of Motorcycle

One of the research issues in the crash sensing system of a motorcycle airbag is how to overcome the space limitations of accelerometer layout.

In the studies of Kobayashi et al [7], it is proposed to reduce the number of accelerometers installed in the front suspension fork from 4 pcs (2 pcs in each leg) to 2 pcs (one in each leg) to overcome the space limitations. The front wheel-suspension system is the part of the motorcycle that experiences the initial impact forces in a typical motorcycle frontal collision. Because of this, the crash deceleration pulses from the front suspension fork are utilized in the conventional sensing system. The sensor location, however, is not necessarily in the front fork if the collision can be detected at an adequate timing to attain protective effect of the airbag.

With a target at further reduction of restrictions in accelerometer layout from the construction of motorcycle, employment of a sensing system using accelerometers located in the motorcycle frame having a large space rather than in the limited space of a front fork was considered.

In this paragraph, the crash detection method is described, together with the conditions under which the airbag “should be deployed” or “should not be deployed” and the performance to judge whether to deploy or not.

Conditions under Which Airbag Should be Deployed

The deployment conditions of the airbag system were set at “shall be deployed in a front collision in that the rider separates from the motorcycle in the forward direction.” The specific conditions are set at “should be deployed when the speed at the time of collision is 30 km/h or higher” both in a collision on the front and on the side of an opposing vehicle. These conditions are set on the basis of the findings in the studies of Kuroe et al. [2] that investigate collision conditions to cause forward separation of riders.

Conditions under Which Airbag Should Not be Deployed

The non-deployment conditions are set in the same manner on the basis of the findings in the studies of Kuroe, et al. [2], that is, “except for special conditions under which continuing to ride is impossible, the airbag should not be deployed under defined road conditions such as rough road or irregularities during operation.” Kuroe et al. [2] conducted riding tests on curbs and set conditions that riding can be continued.

Crash Detection Method

The crash detection method and the judgment threshold were determined using the deceleration of motorcycle frame body measured from a series of tests in accordance with the abovementioned deployment/non-deployment conditions. The block

diagram of crash detection method is shown in Figure 3. The performance to judge whether to deploy or not is shown in Figure 4. That indicates the ratio of “the maximum computed values for each condition” to “the judgment threshold”. This sensing system appropriately identifies deployment conditions and non-deployment conditions using the deceleration of motorcycle frame body.

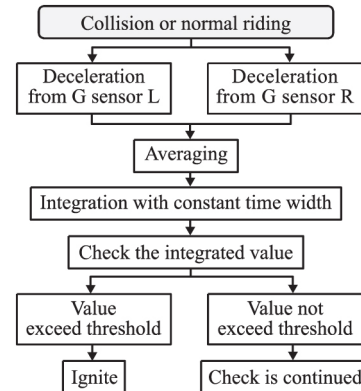


Figure 3. Decision flow for deployment.

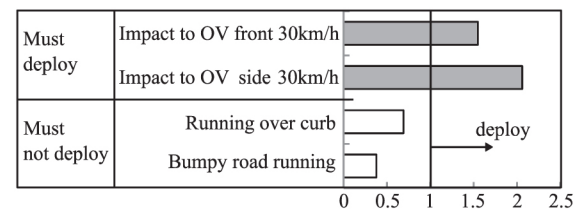


Figure 4. Test motorcycle with prototype airbag.

Crash Tests

The crash tests for validation of the airbag were conducted as per ISO13232. Figure 5 shows seven impact configurations required for crash tests.

Crash tests of motorcycles without airbags (baseline test) were tested prior to tests of motorcycles equipped with airbags (airbag test). A total of 14 crash tests were conducted.

The trigger timing of airbag in each airbag test was determined from the results of simulation following the earlier-mentioned crash detection method using the decelerations of motorcycle frame body measured in the baseline tests as inputs. Though the airbag was set to not deploy in 143-9.8/0, in which the opposing vehicle collides into the side of the motorcycle, the airbag test was conducted without an airbag deployment to clarify the risk from the equipped airbag module.

The same saloon (sedan) type passenger car was used as an opposing vehicle in all the tests. Table 3 shows the specifications of opposing vehicle.

To assess under severe conditions, the impact speed was set 4% higher than the speed specified in ISO13232.