MOTORCYCLE SAFETY AND ACCIDENT RESEARCH

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ABSTRACT

The procedures followed in the Faculty of Transportation Sciences of CTU, concerning the research on passive safety of one-track vehicles (OTVs) are here partially described. From OTV peculiar construction, several basic specifications emerge, which condition a different approach to the problem of passive safety.
Keywords: one-track vehicle, passive safety, crash test, head performance criteria.

INTRODUCTION

The fact that driver (and passenger) of a motorcycle can not be protected inside of the vehicle radically changes the answers to the problem of passive safety for OTVs. For such a vehicles it is impossible to use the same components as car passive safety, like deformation zones, safety belts and airbags; an exception should be the small group of so-called “cabin motorcycles” or “cabin scooters” which anyhow is not statistically significant, for modifying the OTV basics in a way unacceptable for most OTV users. The OTV safety measures are oriented to the personal protection (helmets, protective clothing, ...) or trajectory optimization (the seating position, leg protection frames, ...).

So we can generally say that motorcycle users are less protected against road accidents than the users of other vehicles, which is also proved by road accident statistics. This situation can be changed by several means:

- researching and developing special components for passive safety of motorcycles;
- a properly designed equipment for riders, like crash helmet, protection gloves and clothing;
- using the protection capabilities of the other collision object.

The Faculty of Transportation Sciences of CTU in Prague has performed two crash tests, motorcycle vs. passenger car, whose description and experimental results are the objective of this article.

MOTORCYCLE VS CAR CRASH TESTS

Statistics. To assess the test specifications several pieces of information were collected by reviewing current statistics:

- the level of OTV users protection during collisions;
- the OTV collision partners;
- the most frequent configuration of OTV and collision partners;
- the direction and location of the primary contact;
- the most frequent speed of impact.

The following statistical results were taken into account.

Tab. 1: Number of killed road users per 1000 road accident for different kinds of vehicles

vehicle	2001	2002	2003	mean
Moped	26,00	34,40	16,50	25,60
Motorcycle	38,90	45,30	41,20	41,80
Passenger car	6,50	6,90	6,90	6,80
Van	5,00	5,60	4,50	5,00
Bus	8,30	6,70	23,10	12,70
Tractor	8,50	16,20	10,80	11,80
Others	3,20	5,10	4,50	4,30
Unknown	1,50	1,50	1,30	1,43

Tab. 2: Table of probability of survive for different kinds of vehicles

Vehicle	Chance of survive [%] on level of probability 0,9
OTV	95,0 - 98,2
Passenger cars	98,4 - 100,0
Vans, Trucks, Tractors	98,5 - 99,8

1. For quantifying the number of killed road users involved in road accidents national and European wide statistic (IRTAD) were used (see Tables 1 and 2).

Table 2 shows that probability of survival of motorcycle users involved in road accident is 95-98%, whilst probability of survival of car occupants is 98-100%. If the bus accidents are not included for high number of affected persons, the situation for passenger cars is even better. This confirms the common sense that motorcycle users are less protected against road accidents than other vehicle users.

2. For assessing the most frequent collision partners of OTV the Bundesamt and DEKRA statistics were used:

Tab. 3: Number of killed motorcycle users – percent proportion of collision partners in urban and rural area

Collision partner of OTV	% urban area	% rural area
Passenger car	38	43
Van	19	15
Pedestrian	9	1
OTV	4	5
Unknown	1	2
Road or road furniture	29	34

Table 3 shows that personal cars are the most frequent collision partners of OTV. The second most frequent partners are road surface or road furniture: this type of accident is also noticed as the only OTV casualty. Commercial vehicles are the third most frequent partners.

3. For assessing the most frequent configuration of OTV and their collision partners both the standard ISO 13232 statistics and DEKRA statistics were used.

Although their figures are slightly different, the most frequent configurations can be clearly assumed: they are the situations coded 413 and 114 in Figure 1 (motorcycle running into the side of a car perpendicularly, or in front at a general angle).

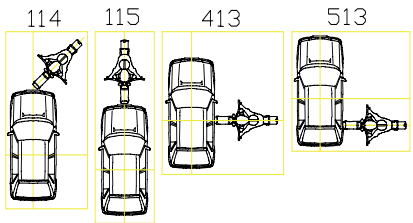

Fig 1: Collision partner configurations according to ISO 13232 and their number code

The selected configurations (from 25 types) represent type 114 - 5%, 115 - 6%, 413 - 10%, 513 - 5%.

4. Figure 2 shows the frequency distribution of directions and locations of the primary contact with collision partner, according to statistics and renowned authors.

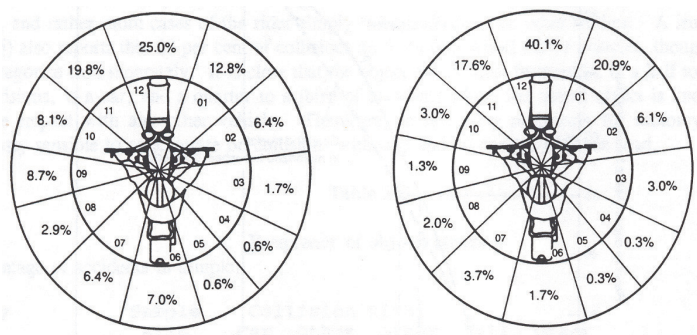

Fig 2: Frequency of first direction contact for mopeds (left) **and motorcycles**

It can be recognized that the most frequent impact direction for OTV is frontal one and the most frequently affected parts are frontal wheel and operating part of OTV.

5. Figure 3 shows the distribution function of relative impact rates with respect to speed of impact. It can be noticed that 80% of accidents occur at speed up to 50 km/h. The dashed line does not start at the origin of axes because 7% of collisions refers to motorcycles bumping into standing cars.

Experiments and results. The Faculty of Transportation Sciences of CTU in Prague has performed two crash-tests of motorcycle vs. passenger car:

a) the frontal collision of a passenger car running at 40 km/h against a standing motorcycle (configuration according to ISO 13232: 115);

b) the collision of a motorcycle running at 50 km/h against the side of a standing passenger car (configuration according to ISO 13232: 513).

In both cases the following parameters were measured:

- speed of colliding objects;
- time history of the accelerations in the head and thorax of the dummy motorcyclist;
- time history of the tension of motorcycle chassis;
- time history of the trajectory of the dummy (description way).

A brief summary of crash test (at CTU) follows.

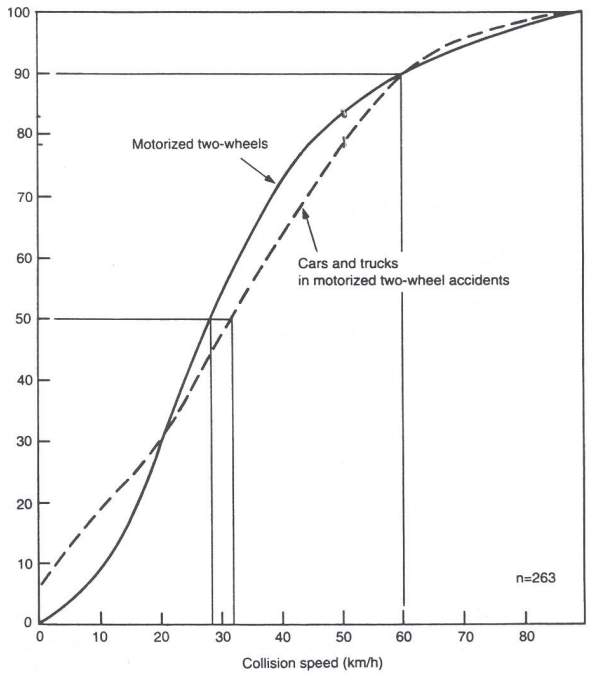

Fig. 3: Distribution of motorcycle impact speed

Test a)

Actual parameters	Mass of motorcycle – dummy system	218 kg
	Velocity of motorcycle – dummy system	0 km/h
	Mass of passenger car	1085 kg
	Speed of impact of personal car	35 km/h

Experimental progress

From the high-speed camera recording, the whole action take approx. 3 seconds, during which two contacts of dummy's head occurr: with car bonnet, then with road surface.

Result of experiment

Head acceleration (HPC) has a calculated maximum under 923, fulfilling the safety requirement (max. 1000)

Note: the maximum acceleration value (HIC_{MAX}) is reached by the head contact with road surface during the secondary collision.

Test b)

Actual parameters	Mass of motorcycle – dummy system	261 kg
	Velocity of motorcycle – dummy system	50 ± 2 km/h
	Maximal pre-crash kinetic energy	25.2 kJ
	Mass of passenger car	935 kg
	Personal car velocity at the time of impact	0 km/h

Experimental progress

The high-speed camera recording shows an action taking about one second at all. Whilst the head contact with the side of car is not significant, the most serious occurrences are the secondary head contact with the road surface and the motorcycle impact against the lying dummy.

Result of experiment

Head acceleration of dummy: head performance criteria (HPC), see Table 4

	HPC_{36}	HPC_{15}
Primary collision (with vehicle)	**63** (T_1 = 129.3 ms; T_2 = 165.3 ms)	**46** (T_1 = 154.7 ms; T_2 = 190.7 ms)
Secondary collision (with road surface)	**253** (T_1 = 910.7 ms; T_2 = 946.7 ms)	**345** (T_1 = 911.1 ms; T_2 = 947.1 ms)

The maximum computed value HPC = 345 is lower than the critical value 1000. The head impact with the compartment area is influenced by the dummy initial position and the motorcycle spring fork deformation and is documented by the high speed camera record.

Thorax acceleration of dummy

The maximum value of thorax acceleration a = 134,1 $m.s^{-2}$ occurs at time 90 ms, without any dummy contact with its surrounding. It is approx. the time point at the end of frontal fork deformation and the moment of front wheel contact with engine unit.

Tab. 4: Head acceleration of dummy, test b)

Motorcycle chassis acceleration

The maximum value of motorcycle chassis acceleration a = 34,4 $m.s^{-2}$ occurs at time 49 ms.

Motorcycle chassis tension

In 7 measuring points (out of a total of 9) a plastic deformation of chassis occurrs; a relative prolongation is noticed in the interval 300 to 3500 μm/m. In the other measuring points only elastic deformations are noticed.

Conclusions.

The following considerations can be drawn after the two tests:

a) Performed tests provided quantitatively and qualitatively sufficient data for future research trends assignment in the field of motorcycle passive safety.
b) Obtained data can be used for mathematical simulation of this action.
c) Calculated values of head performance criteria HPC from head acceleration history and thorax acceleration values didn't reach critical values. We can assume that motorcyclist should survive this type of accidents without serious injuries. It is necessary to take into account also the motorcyclist's collision trajectory, because of the relative movement of parts of his body which can cause injury of spine, pelvic area or extremities.
d) Secondary collision with the road surface was more serious for motorcyclist because of the highest noted head acceleration values.
e) Absorption ability of motorcycle operational parts (fork and wheel) is dependent on the type of motorcycle.
f) Motorcycle passenger's collision trajectory is dependent on the seating triangle (influenced again by the type of motorcycle).
g) Results are only valid for tested types of vehicles and real conditions of performed experiment. For different types and conditions neither obtained values nor their extrapolation can be used.
h) Testing program, which allow finding out behavior of other types of vehicles under different conditions, should be extended.

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