## Rider / Motorcycle Interaction – a Human Approach to Motorcycle Safety

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#### Introduction

In the rider/motorcycle system the rider has great influence due to the mass distribution between him and the motorcycle, and the rider's forces on the connective points. Furthermore, the rider is exposed to stress such as static workload, vibrations and climatic influences, <u>fig. 1</u>.



figure 1: Man / machine system rider, motorcycle and environment

For further investigation of the rider/motorcycle interaction the Department of Automotive Engineering in cooperation with the Ergonomics Institute, both at Darmstadt University of Technology, measure the rider's forces at the connective points handlebars, footrests and seat. For this purpose, measurement devices have been built and a test layout has been developed. This research project is funded by Deutsche Forschungsgemeinschaft.

# **Test layout**

The test layout has been developed on the basis of some hypothesis [FUN00]. Each test starts with a questionnaire determining anthropometric driver data and the test person's riding abilities. It is known from experience that this self assessment possibly does not reflect the true riding abilities of the combination of the test person and the test motorcycle used for the tests, especially for medium and expert riders. For further investigation on the rider's abilities with the test motorcycle, a BMW R 1100 RS, a simple test was proposed by SPIEGEL: the test person is asked to drive circles with full steering angle. From the number of the quarter circles and the development during a sequence of tests conclusions about the rider's control of the test motorcycle can be drawn. An excellent rider can keep up driving until he feels sick, see fig. 2, while absolutely inexperienced riders don't succeed at all.



figure 2: Driving circles with full steering angle – excellent rider

A stationary connective force measurement in combination with a photometric measurement should provide an answer to the question, if the operation angle of the driver's connective forces is linked to the physical position angle of the driver's extremities. To show the driver's change in position in relation to the vehicle speed because of the acting aerodynamic forces, further photometric measurement is taken while driving with constant speed. The differences in the positions of stand still and 100 km/h constant driving tests for one test person are shown in fig. 3. As illustrated, these differences in position are unexpectedly small. In addition, these tests can show a possible tendency for the test person's preference to dispense her or his inner force distribution while riding.



figure 3: Comparison of position during stand test / at a speed of 100 km/h

With lateral dynamic tests such as 10 x 18 m slalom, 15 m radius circle, 50 m radius curve the way a test person initiates changes of direction and the test person's force contribution strategy while riding in curves can be investigated. What is more, from the ergonomic point of view physical stress by means of connective forces depending on longitudinal accelerations or changes of driving direction (and so rolling angle, steering angle, etc.) can be quantified.

In the pre-test phase the above described tests have been carried out with a small collective of right-handed test persons. Some data is shown in <u>table 1</u>:

Test Person	TP1	TP2	TP3	TP4	TP5	TP6
Gender	f	m	m	f	m	m
Age	22	29	58	26	23	24
Height [cm]	170	194	170	163	176	196
Mass [kg]	63	75	83	65	73	114
Experience*	1	5	1	2	3	4

table 1: Data of test persons

\* 1 = inexperienced rider; 5 = excellent rider

## Results

This paper concentrates on first results of handlebar forces during constant speed driving tests. Depending on the vehicle speed, forces are considered to reflect the aerodynamic forces acting on the rider. As represented in <u>fig. 4</u>, at a vehicle speed of about 100 km/h the taller riders usually start acting with connective forces on the handlebar in negative x-direction, i.e. pulling at the handlebar. The development of the average forces' amount and their direction mainly depends on the vehicle speed and grows quite linear, so the aerodynamic forces on the rider can be said to greatly influence average handlebar forces. An exception in the determined collective is test person 5, who acts with x-axis positive forces even at high speed. Test person 4 claimed that she changed her longitudinal position at higher speeds. Pictures taken confirm this allegation. A comparison of the forces shown below at low speed and the handlebar forces while standing still shows a significant deviation in the cases of test persons 1 and 3. A reason for this might be, that these two absolutely inexperienced riders cannot properly fulfill the posed task: "Sit on the motorcycle as if you were riding."



figure 4: Left handlebar force arrows at different vehicle speeds

As it can be seen in  $\underline{\text{fig. 5}}$ , all tested persons (view table 1) preferably set higher resultant forces on the left end of the handle bar while riding straight with constant vehicle speed.



figure 5: Right and left handlebar forces at different speeds

## Motorcycle's measurement devices

The necessary measurement devices have been adapted to the specific needs of motorcycle measurements, i.e. little space requirements, light weight, shock and vibration resistance, and reasonable costs. Furthermore, motorcycle's measurement devices must not change rider's haptic perception and should not change the motorcycle's appearance. The rider should have the impression of sitting on a normal motorcycle to avoid a "guinea pig" feeling. Some of the applied measurement devices are described in the following.

Considering the above described requirements, measurement devices have been designed and constructed on the basis of strain gage applications. The handlebar connective force sensor, see <u>fig. 6</u>, is an accurate copy of the genuine motorcycle part and passed the strict German admission procedure for handlebars.



figure 6: Handlebar connective force sensor, inner and outer appearance

The construction of the footrests fulfills adequate stiffness with full sensor abilities, view <u>fig. 7</u>. Furthermore, they are crash protected. For safety reasons, the footrests don't exceed the genuine part's dimensions, and the mounting still folds.



figure 7: Footrest and seat measurement devices, without coverage

The measurement device for the connective seat forces is located under the seat, fig. 7. Its work principle is the parallel duct, the connective forces are recorded by load cells in the inner of the construction.

All test data is sampled in the so-called measurement box,  $\underline{\text{fig. 8}}$ . This box with a mass of only 8 kg has been constructed for the needs of motorcycle application and to fit on the back seat of the motorcycle.



figure 8: Measurement box on the passenger's place

# Outlook

The pre-test phase has been completed, main tests – also on public roads – are planned. For the completion of the measurement devices, a rider position sensor and a sensor measuring the connective forces between the rider's knees and the tank is being designed. Furthermore, the development of an innovative rolling angle sensor is in progress.

With the knowledge of the rider's behavior regarding his position and the body forces applied, the basis for the development of novel motorcycle assistance systems is created. Another result of this research project is the compilation of more detailed data for simulation of the rider/motorcycle complex.

#### Literature

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