TEST VDA ISO TR3888 ON THE TESTING BENCH FOR STEER BY WIRE SYSTEM

Robert Voženílek, Pavel Brabec, Miroslav Malý

Technical University of Liberec, Department of Vehicles and Engines
Studentská Street 2, 461 17 Liberec, Czech Republic
tel.: +420 485 353154, +420 485 353159, +420 485 353144, fax: +420 485 353139
e-mail: robert.vozenilek@tul.cz, pavel.brabec@tul.cz, miroslav.maly@tul.cz

Abstract

The Technical University of Liberec, Department of Vehicles and Engines, has developed a design of a testing bench which would enable the testing of directional control systems. The objective of the newly designed equipment is to incorporate a real tyre as well as a flexible mounting of the axle components into the tested system.

Future of cars will be connected with systems of type steer by wire. This system need to be testing on the testing bench before real test in the car. One method for assessing can be investigation control deviation during test VDA ISO TR3888.

The paper will describe measurement of the real car with conventional directional control during test VDA ISO TR3888 and simulation of the system steer by wire on the testing bench. The experimental steer by wire system forms hydraulic circuit with two double-acting hydraulic cylinders with a unilateral piston rod and two proportional valves Parker D1FP. Every wheel front of axle is control alone. The PID regulators were used for control of the positioning action. In particular, the testing bench for the testing of steering at zero angular speed of wheels, VDA ISO TR 3888 tests on the testing bench are presented in the paper.

Keywords: *steer by wire, experimental laboratory establishment, vehicle axle*

1. Introduction

Future developments may result in vehicles with „an autopilot”, so while driving, the driver will either be allowed to have a rest or do something else. However, the current organization of the road transport does not make the autopilot implementation possible. The launch of the system will obviously be linked with the vehicle position identification, the navigation system development and with the higher precision GPS or the European Galileo System. Surveying precision and speed will be critical for such systems and their automatic control. For this reason, the launch of the vehicle automatic directional control can be expected first on primary routes - on specific parts of highways with heavy traffic and a potential for the construction of additional radars identifying the current vehicle position. Consequently, vehicles will have to undergo a transformation too. At present, car producers together with their suppliers have focused intensively both on the development of new systems and improvement of the existing ones. Both traditional groups and so called assistance systems which are supported by new forms of communication and in certain cases enable adaptation to new conditions are involved. The assistance system group includes inter alia: currently used vehicle stabilization systems (ESP – Electronic stability program), systems monitoring the vehicle surroundings, e.g. adaptive cruise controls (ACC – Adaptive Cruise Control) and e.g. newly introduced systems monitoring the driver’s alertness (DAM – Driver Alertness Monitoring, DSC – Driver Status Monitoring) etc.

Future development of the directional control of vehicles will be closely connected with steer-by-wire systems or the steering of the vehicle by means of an electric wire which is to replace a mechanical link between the steering wheel and wheels. It is a control system whose input signal is a movement of the steering wheel, this impulse is converted into an electrical variable, it goes to an action member and it responds accordingly – by turning the wheels at a relevant angle into a specified direction. The steer-by-wire system can be generally categorized in accordance with various viewpoints. The first one can be a link between the wheels which offers two basic options. The first is a traditional control of both the wheels simultaneously by one actuator which moves the tie rod and turns both wheels at the same time. The other is a separate turning of each wheel, i.e. each directionally controlled wheel has its own actuator which will initiate the turning.

The elimination of a rigid bond between the steering axle wheels offers a number of options for the setting of the combined extent of the inner and outer wheel angles. The required criteria can for example incorporate:

The same angles of the inner and outer wheel directional deflection

a) The identical inner and outer wheel angles
b) The outer wheel is turned more than the inner one – i.e. a fast cornering results in a higher angle of the directional deflection on the outer wheel compared to the one on the inner wheel (a higher tire cornering force is acting on the outer wheel, which significantly increases the directional stability).

2. Ride test with the real car

Passage of the car in the specified corridor is one from possible ways for verifying of stability of ride cars. Test VDA ISO TR 3888 ("moose test") is used very often for this tests. This test run over between cones which they have accurate positions. Testing driver goes to the corridor speed 90 km/h and before first cones he takes off the leg from the accelerator. Producers of cars preparing own cars for this extreme test. Because some cars were not successful and some cars himself were perverted during this test. Germans automobile club ADAC use test VDA ISO TR 3888 for comparative tests of the cars.

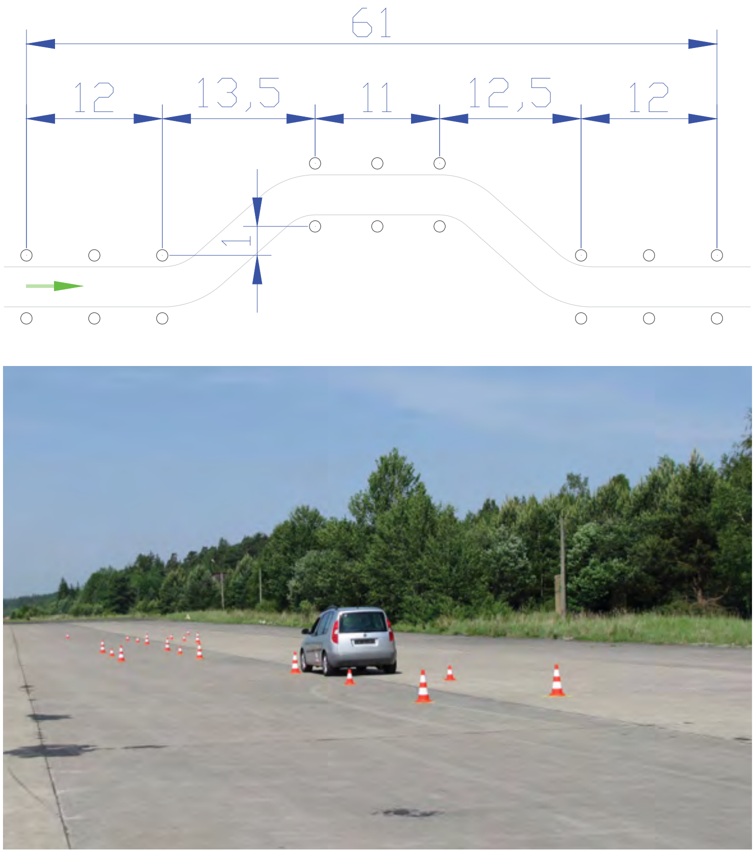

Fig. 1. Test VDA ISO TR 3888 – top view: track of the test (size in the meter), under view: Škoda Roomster during tests on the airport Hradčany-Mimoň

The car Škoda Roomster 1.6 16V/77kW was modified for acquirement of information about behaviour of driver during moose test. Part of the car with steering wheel was equipment with incremental sensor for record of angles changes turning of steering wheel. Rack and pinion power steering or Škoda Roomster has same constant ratio for all range between turning or steering wheel and shift of connecting rod. This knowledge was basic for calculation shifting of connecting rod during tests. This values shifting of connecting rod was used for simulation VDA ISO TR 3888 on the test bench as desired location for actuators.

The car Škoda Roomster was tested on the airport Hradčany-Mimoň and we did tests for different speeds (10, 20, 30, 40, 50, 60 km/h).

3. Testing bench

The Technical University of Liberec, Department of Vehicles and Engines, has developed a design of a testing bench which would enable the testing of directional control systems. The objective of the newly designed equipment is to incorporate a real tyre as well as a flexible mounting of the axle components into the tested system.

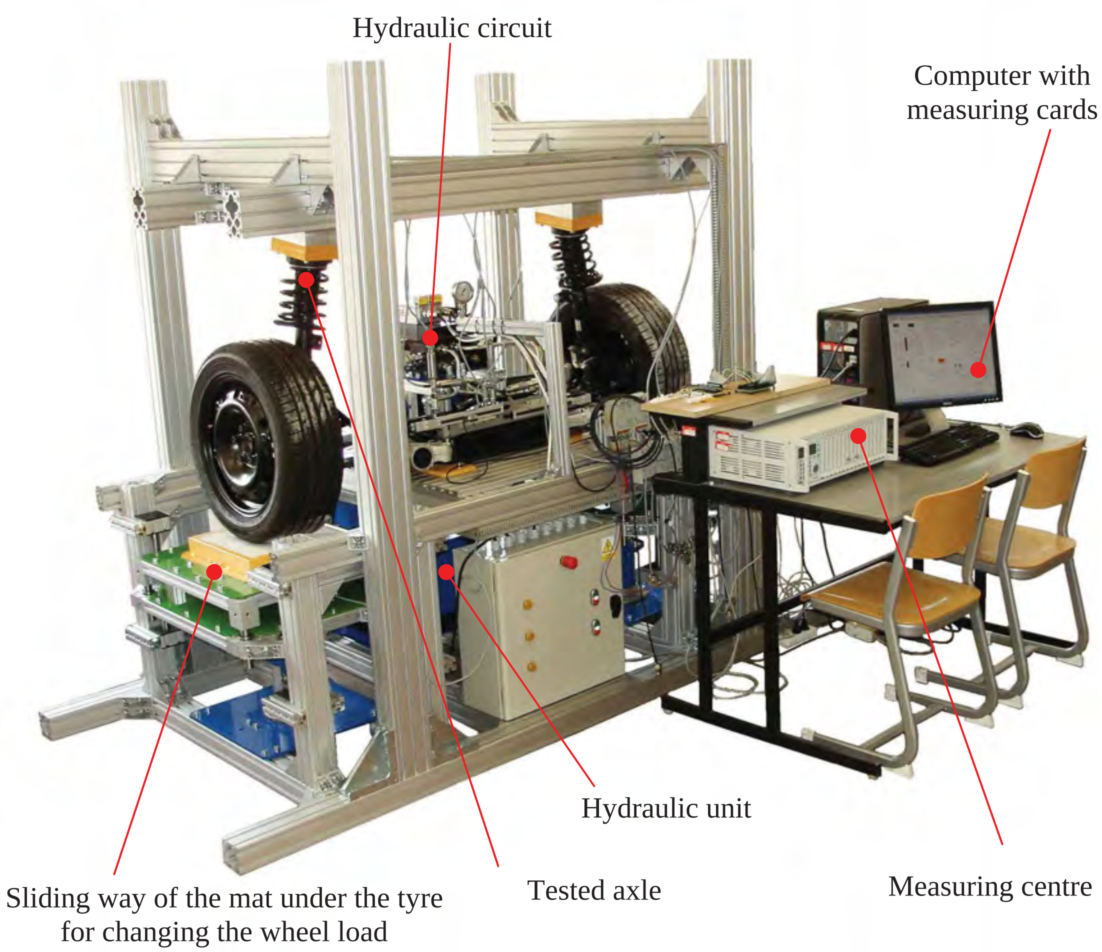

Fig. 2. View of the testing bench for the testing of steering at zero angular speed of wheels

4. Laboratory steer by wire system

Currently laboratory steer by wire system, the hydraulic circuit of the vehicle's directional control test bench consists of two double-acting hydraulic cylinder with a unilateral piston rod (dia. 32 mm/22mm) and two proportional valves (D1FP Parker, the rate of flow of 3 $dm^3.min^{-1}$ at the pressure gradient of 3.5 MPa) located on a body which houses a pressure valve, a relief valve and other accessories. The DF Plus proportional valve features very good dynamic properties allowing a frequency range between 0-400 Hz at –3 dB and 350 Hy with a phase shift of –90°.

An MF624 input-output card acting jointly with the Matlab/SimulinkReal/Time Toolbox program was used to control the hydraulic circuit. In this program, an application obtaining information about the current position of the DF Plus proportional valves are created. By means of the LM10 linear incremental sensor the application receives information about the current position of the hydraulic cylinders – an indirect measurement of the wheel's angle. The information is processed in the application of the mentioned program and then a relevant setting of the DF Plus proportional valves is calculated.

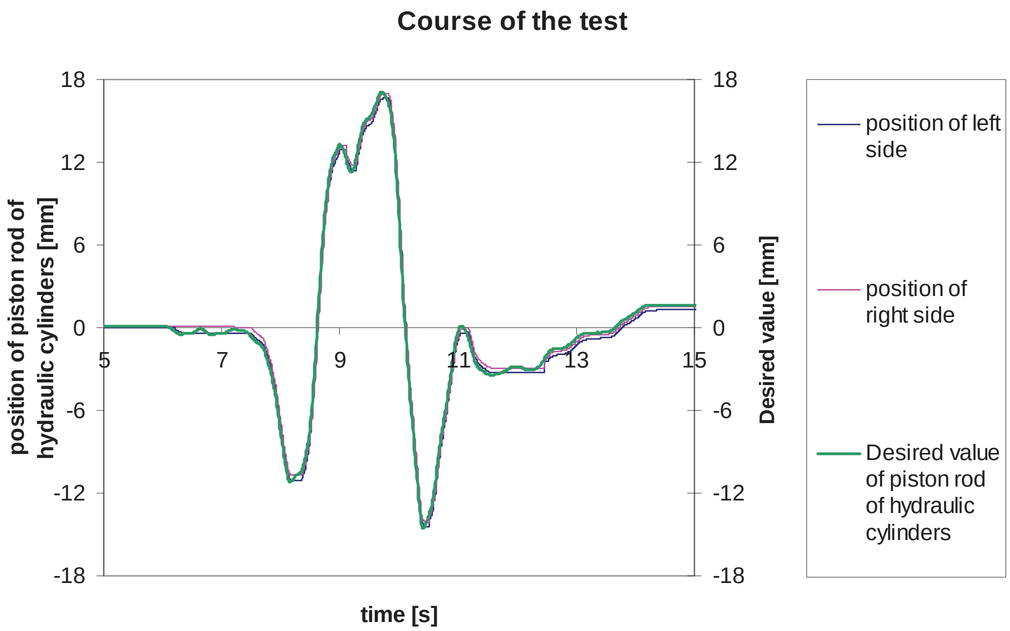

Fig. 3. Test VDA ISO TR 3888 on the testing bench - position of piston rod of hydraulic cylinders for supposed speed 60 km/h, sampling rate for control system 100 Hz, load for wheels 4.5 kN, tyres 15"

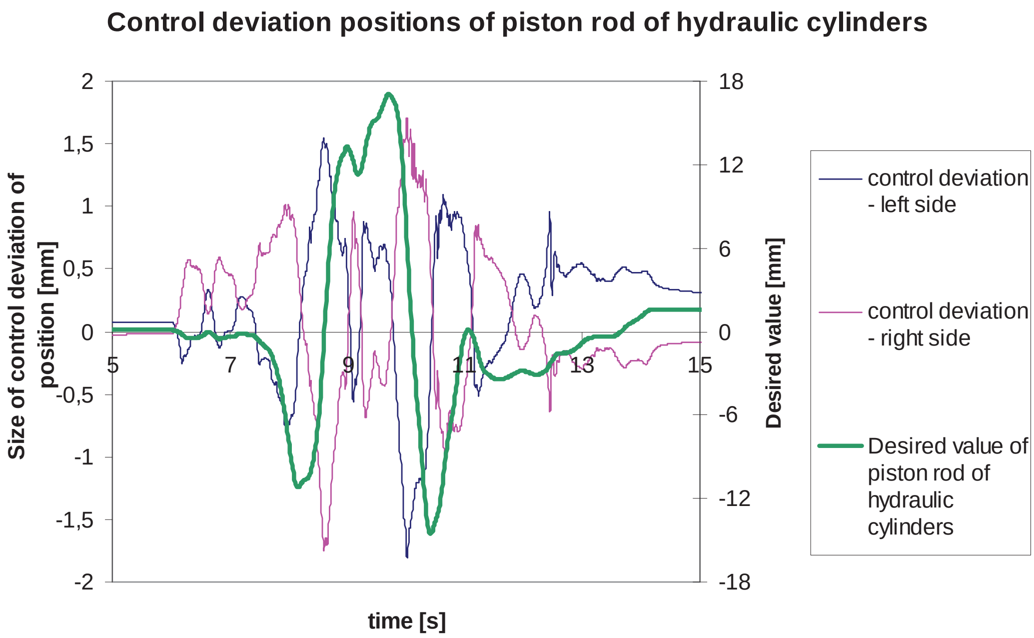

Fig. 4. Test VDA ISO TR 3888 on the testing bench – control deviation positions of piston rod of hydraulic cylinders for supposed speed 60 km/h, sampling rate for control system 100 Hz, load for wheels 4.5 kN, tyres 15"

Every wheel front of axle is control alone. The PID regulators were used for control of the positioning action. The constants for PID regulators were debugged in programming for achievement minimal control deviation position of actuators (hydraulics cylinders). Maximum of disengagement hydraulics cylinders is 17 mm. The sampling rate for control system was 100 Hz. Loading of wheels were 4.5 kN. It is maximum load for Škoda Roomster.

Maximum of control deviation surveyed of hydraulic system is 1.8 mm for test with supposed speed 60 km/h. Reduction of control deviation can bring elevation of sampling rate of control system or creation of adaptive regulator.

5. Conclusion

The objective of the project was to design a steer-by-wire directional control mechanism with a suitable arrangement. The comparison focuses on various design options to arrange the action members (actuators) of this mechanism. The first phase investigates the properties of the electric and hydraulic arrangement, where each steered axle wheel has its own actuator for the setting of a wheel angle. An electromechanical system for wheel turning is being prepared for the next phase of the project. An electromechanical system of own construction is designed on the basis piece of knowledge from measurement with hydraulic circuit.

The initial setting of parameters for control unit constants will be carried out before real vehicle driving tests. The control unit will obtain information from relevant sensors and issue commands for a proper setting of the action members.

Acknowledgments

This paper was developed thanks to the contribution of the Ministry of Education, Youth and Physical Education as MSM 46 74788501 project.

References

[1] 15th Aachen Colloquium Automobile and Engine Technology, October 2006.

[2] Voženílek, R., Brabec, P., Malý, M., *Action of force in steering mechanisms of vehicles in an experimental laboratory establishment,* Journal of KONES Powertrain and transport, Vol. 16, No. 3, pp. 55-62, Warsaw 2009.

[3] Voženílek, R., Brabec, P., Malý, M., *Hydraulic circuit control of a steer by wire system*, Journal of KONES Powertrain and Transport, Vol. 16, No. 4, pp. 477-483, Warsaw 2009.

[4] Voženílek, R., Brabec, P., Malý, M., *Model steer-by-wire. Hydraulika a pneumatika*, 1/2009, č. 25, s. 1-3, 2009.