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Driver Assistance Systems for Tractors

Today's automobile and commercial vehicle industry without driver assistance systems is hardly imaginable. These systems will probably become increasingly important for tractor design as well. The assistance systems described below can improve the braking process, increase driving stability and, thus, decisively improve driver safety, as well as for the other traffic participants. This paper describes the basic conception of such systems and how they can be used in tractor design.

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Keywords

Tractor, brakes, driver assistance system

Literatur

Bücher sind mit • gezeichnet

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Driver assistance systems are designed to support and relieve the vehicle driver. There are two categories: There are systems which serve to improve the comfort (e.g. parking assistants) and help the driver in difficult situations. The second category is for systems regarding safety aspects, i.e. they support the driver with tasks which can be done better or at least as well by a technical system. The best-known systems regarding safety are the anti-block system (ABS) and the electronic stability program (ESP) which will be described in detail below.

Furthermore, there are the following systems:

- antiskid system (ASR) which is designed to avoid the wheels slipping when the vehicle is started
- braking assistant which effects full braking in case of need depending on how fast the pedal is pressed
- adaptive cruise control (ACC)
- distance control

However, the systems mentioned above are mainly installed in automobiles. Whereas there is a legal obligation to install ABS in the area of bigger HGV and even ESP is gaining importance in this area, there is a different development in the tractor area. There are only few tractors (some special purpose machines set aside) which are equipped with assistance systems. The reason for this different development is the basically different vehicle conception of tractors compared to commercial vehicles and automobiles and, on the other hand, the different application area. The motivation to discuss those systems for tractor design was given by the definitely existing advantages of driver assistance systems in commercial vehicles and automobiles for the driver and for other traffic participants.

Function of the driver assistance systems of ABS and ESP

The focus of developing tractor driver assistance systems should be put on the successfully established ABS and ESP systems. Both systemsí function will be described in the following. Please notice that new ESP varieties already contain ABS function.

Anti-block systems (ABS)

ABS surely is the most widespread system. It is the ABS task to impede the wheelsí locking, thus maintaining the tractability and setting the optimum tyre slip. In this process, the main focus is set on the vehicleís tractability, i.e. keeping the machine controllable and stable. This means that ABS does not necessarily bring an improved braking distance. This is only possible when the static friction coefficient is higher than that of the

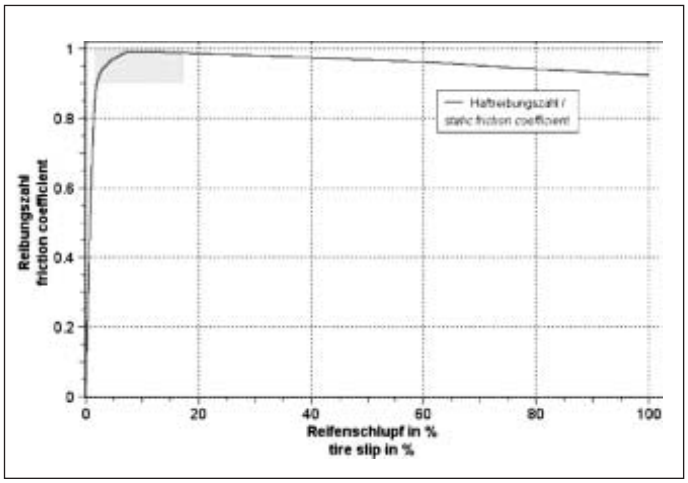

Fig. 1: Course of the static friction coefficient depending on tire slip on a dry street

dynamic friction. Luckily, this is the case with most friction combinations of tyre/road, but there is an exception in case of snow. According [1], this effect comes up by the additional braking effect of accumulated snow. Such an effect may even be transferred to the off-road area, so that we should put the main emphasis on driving stability and tractability.

In order to meet its requirements, ABS tries to record the tyre slip (in most cases, this is done by auxiliary data, such as the comparison of wheel speeds) and keep it within the range of the maximum static friction coefficient in case of braking. According to [1], *Figure 1* shows a typical friction coefficient process depending on the tyre slip. It also marks the ABS control range. We can see that the control process is started in an area of relatively little slip, keeping the friction coefficient at the maximum level. Activating ABS means reducing the braking pressure when needed. By closing a valve, on the other hand, the pedal is uncoupled from the brake. So the driver cannot additionally increase the braking pressure when increasing the pedal pressure. *Figure 2* explains the basic conception of an ABS system.

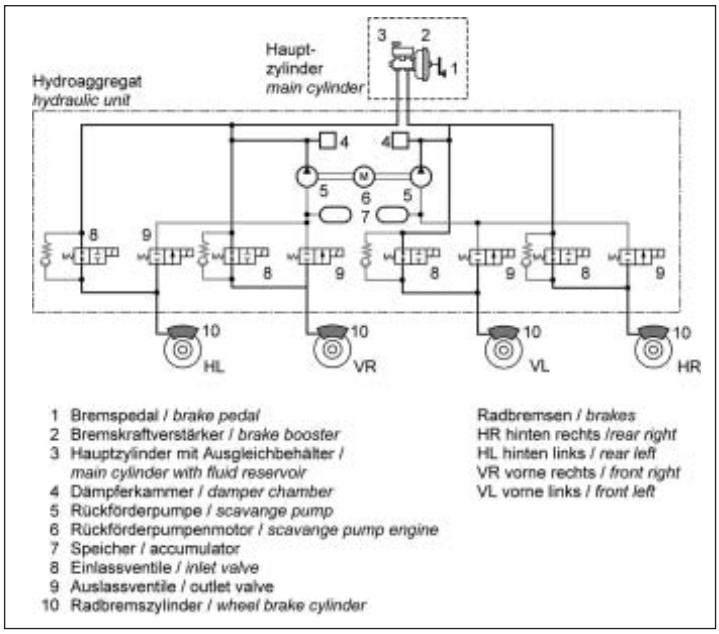

Fig. 2: Schematic structure of ABS

Electronic Stability Program (ESP)

The electronic stability program is something like an overall control system. Integrating the ABS and ASR assistance systems, it works at the braking system as well as at the engine management (engine drag torque control, MSR). It is the aim to ease critical situations the driver might not be able to handle correctly. So, the braking system will be "abused" to steer the vehicle , holding the vehicle' course by selective braking of individual wheels. This task requires a considerable variety of sensors. In addition to the obligatory slip recording of all 4 tyres, sensors have to collect information on the desired driving direction or course, i.e. the steering wheel angle. Furthermore, to reveal critical driving situations, it is important to register the yaw speed around the vehicleís vertical axis. However, ESP facilitates significant security improvement, as was shown with the already famous "Elch-Test" with Mercedes Benz A-Klasse automobiles. As is the case with the A-Klasse, tractors may also overturn due to their high centre of gravity, huge displacements and different load situations when they are driven at higher speeds.

Technology standards - tractor braking systems

In order to get a survey of possible applications of driver assistance systems , it is important to consider the available braking systems and their suitability for the systems mentioned.

It has become a standard to install rear and front axle brakes in modern tractors. Formerly, work machines were mostly equipped with rear axle brakes only, which would have impeded influencing the driving stability by means of the brakes. However, it is a positive fact that at least the rear axle brakes can be activated separately for the individual brakes. The pedals activated by the driver have to be coupled mechanically during normal transport processes, but there is already a possibility of separate hydraulically activating, facilitating few modifications regarding a complete ESP implementation in the tractor. The front axle brake is a more critical factor in this discussion as there often is a brake in front of the differential, thus braking the whole axle. The most unfavourable case is in all-wheel driven tractors where the front axle is coupled with the rear one which has to take the total brake power. In order to install a system similar to the ESP in tractors, it will be useful to have separate braking possibilities for the individual brakes.

Interaction with other control systems

When developing a tractor brake management system, it is important to consider the interaction of the different control circuits. Thus, modern machines even make use of the engine for braking effects, so that engineers will have to take into account the engine as well as the currently utilised continuously variable transmissions. This area will be examined in detail in [2], taking an important step towards an overall control concept, towards a braking management considering the engine management as well. In addition to the engine management, it is also important to reflect the chassis management as there will only be an optimum braking effect with sufficient soil contact. Apart from the braking management, the area of "Machinery System Design" of the TU Berlin set a main research focus on increasing the safety by actively working at the chassis. Furthermore, the EHR of the rear three point power lift must not be neglected. All these control circuits have to be adjusted to work together well before being ready for the market.

Conclusions

Tractor braking systems differ from those installed in typical vehicles having ESP or ABS. Thus, using such driver assistance systems in tractors require adjusting the braking systems and the assistance systems to the special tractor demands. There is also the necessity to optimise the interaction of the different control circuits existing in a tractor.