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Tractor Chassis Control

Tractor chassis suspension is an effective measure taken to guarantee driving security and high driving comfort. In this respect, fully suspended tractors offer more advantages than conventional tractors, but they have higher production costs. This is especially true of hydro-pneumatically suspended chassis. In this paper various control drafts for tractor chassis are introduced, which were developed and examined by the Berlin Technical University.

Standard tractors have maximum speeds of up to 60 km/h. In addition to cabin and driver's seat suspension, these vehicles are equipped with front axles mostly having hydro-pneumatic suspensions. Fully suspended vehicles such as the Unimog, the JCB Fasttrac or special purpose machines such as self-propelled pest management machines, are rather exceptional today. When having full suspension, those systems have a considerable potential to reduce negative oscillation effects. These problems are dealt with in a study carried out by the Silsoe Research Institute. They examined whole-body vibration in modern tractors [1]. There have been detailed examinations of oscillation forces acting on the driver while using the tractor regarding different tractor suspension concepts(without suspension, with cabin suspension, with cabin and front axle suspension, with full suspension).

The examination shows that there are usually lower root mean square acceleration values and their dispersion with agricultural work than in case of tractors having front axle and cabin suspension.

Hoppe uses simulation calculations in order to examine the driving properties of fully suspended tractors [2]. He is also in the position to show the potential of fully suspended vehicles. He is especially interested in the modification of the oscillation and driving properties of tractors when equipped with rear axles with differing suspensions. By use of multi-body simulation, he compares three rear axle suspensions of the TU Berlin trac vehicle. In the course of further studies, to be presented in the following, this trac vehicle was modified to a fully suspended vehicle, with the rear axle suspension being done hydro-pneumatically, but still keeping the conventional front axle suspension.

Driving tests and experiments helped to verify and validate the simulation models, thus making them applicable for different examination purposes.

Chassis control drafts

Especially with mobile working machines, controlled chassis provide multiple possibilities to adjust the vehicle to the individual operation conditions. There is a considerable achievable potential, both in the area of driving security and the driving comfort, with the the type of control having a special influence.

The different systems are distinguished by their energy consumption, the frequency of use and the sensor technology.

Passive systems
are the simplest variety. They do not have any sensor technology, and they only consist of passive elements. Exterior action on the oscillation system is neither intended nor possible. Apart from their low costs and development expenditure, they are subject to the biggest limitations.

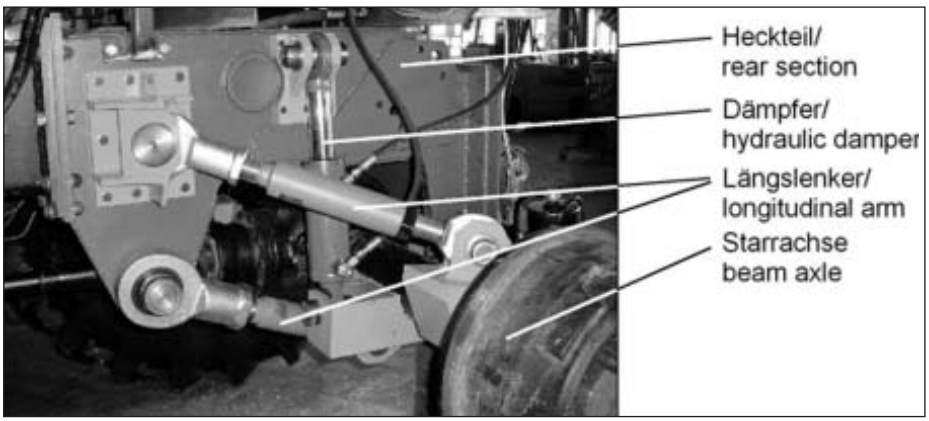

Fig. 1: Rear section of the test tractor

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Keywords

Tractor suspension, vibrations, semi-active chassis controller, fully suspended tractor

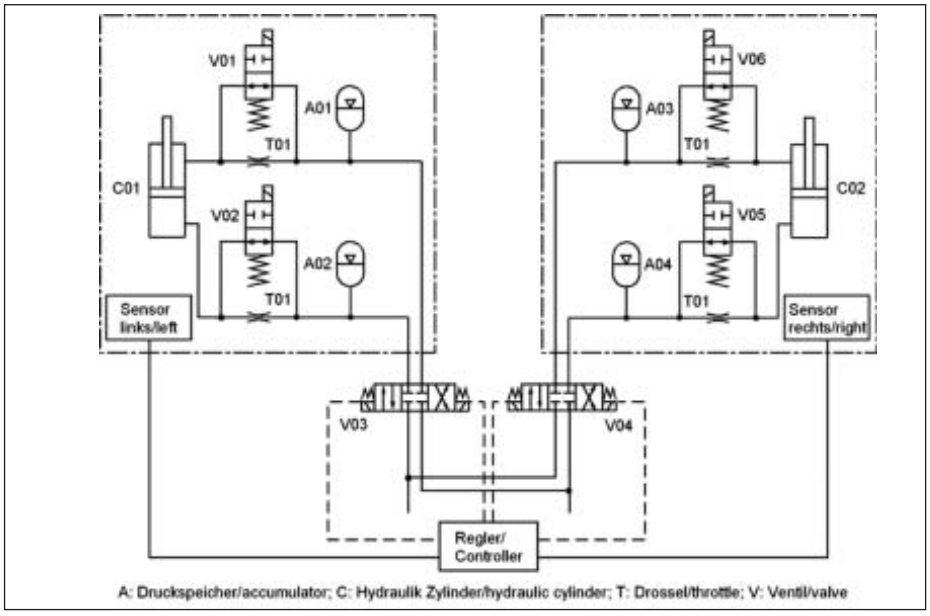

Fig. 2: Hydraulic connection diagram

Adaptive systems
are oscillation systems whose parameters can be varied by simple and often manual control. As a characteristic, there is only slow influence on the modification. Regarding the aspect of energy, this variety is relatively simple, and it is not possible to have active energy delivery, but only to adjust the characteristic features of the passive spring-damper elements. These systems do not dispose of sensor technology to record the actual condition either.

Semi-active systems
are equipped with sensor technology to record the actual conditions, and the system is completed by active actuators. They differ from the adaptive systems by their direct reaction to disturbance variables and the actual situation.

Active systems
replace or support the passive elements by active actuators (e.g. hydraulic cylinders). Compared to the other varieties, the active suspension has a higher energy consumption. Depending on values of the driving dynamics, its reaction can be controlled electronically, with electrical, hydraulic or pneumatic actuators supporting the system. Such a system is used e.g. in an all-terrain commercial vehicle with a total weight of more than 10 t [3]. Compared to a conventional system, it achieves a considerably higher chassis damping, and vehicle rolling movements could be well reduced. For practical and economic applications, semi-active suspension systems are an interesting variety. They usually cause lower energy consumption and technical expenditure. At the same time, there is a high improvement potential. In order to realize adjustable damping, it is useful to apply electro- or magneto-rheological fluids apart from switching measures.

Implementation of a semi-active chassis controller in a tractor

Figure 1 shows the composition of the modified rear axle, and *Figure 2* the simplified hydraulic connexion diagram of the hydropneumatic rear axle suspension. Modification of the damping characteristics is effected by operating the switching 2/2 way valves. The constructive realization tries to re-use as many parts of the original vehicle as possible. Thus, the rigid axle was reused, and a longitudinal control was realized, having two hydraulic dampers.

The modified vehicle was reflected in a simulation model realized with Matlab/Simulink. The simulation model was used to design a semi-active controller to suppress oscillations. The calculation method used to influence the damping is based on the Skyhook theory. A digital controller has been developed and integrated in the tractor for chassis control. Then the tractor was tested on the hydraulic roadway simulator of the Berlin TU.

In the course of the experiments significant acceleration values, speeds and ways have been recorded. Fig. 3 shows as an example the results of the experiment and the simulation. The experiments have been carried out with a passively and a semi-actively controlled rear axle suspension. The comparison shows that the root mean square acceleration values of the semi-active system for the chosen configuration are about 5 to 10 per cent lower than those of the passive system.

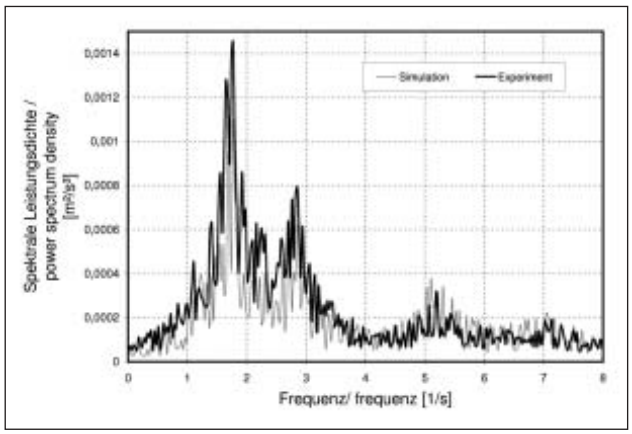

Fig. 3: Power spectrum density of the pitch acceleration (input: impulse, amplitude: 40 mm)

Summary

Controlled tractor chassis have an enormous potential to improve the driving security and the driving comfort. Tests carried out so far at the Berlin TU confirm this result with the example of a trac vehicle. Future examinations on the semi- active system with varying stress conditions and simulations of real working conditions as well as using different controller concepts are to deliver profound insights in the practical characteristics of such systems.

Literature

Books are marked by •

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