System for improving directional stability for articulated vehicles

Piotr Dudziński[1, a)] and Aleksander Skurjat[2, b),]

[1]*Technical University of Science and Technology, Mechanical Departament, Division of Off-Road Vehicle Engineering*
[2] *Technical University of Science and Technology, Mechanical Departament, Division of Off-Road Vehicle Engineering*
[a)]Corresponding author: Piotr.Dudzinski@pwr.edu.pl
b)Aleksander.Skurjat@pwr.edu.pl

Abstract. Articulated rigid frames vehicles maximum velocity is limited by a snaking phenomenon. In the article, a method for increasing directional stability is proposed. Authors presented a method for individual braking wheels for improving straight path running at high speeds. Two algorithms are described and tested. The simplified first control system uses only one of the front wheels for increasing dumping properties while a second system allows all wheels. A new technical stability criterion for comparing results is discussed and used. A straight path running test and moose test performed in Matlab/Simulink indicates that proposed by authors control algorithms increase maximum speed of articulated rigid frames vehicles and directional stability about 20-40%.

SAFETY PROBLEMS OF WHEELED VEHICLE

Safety of articulated vehicles becomes more and more important on public roads. This is due to a rising amount of vehicles and increasing their maximum velocity. In a group of car-like vehicles, we can find many both passive and active safety systems for minimalizing risk of an accident. In a group of wheeled articulated vehicles, many improvements can be adapted from the previous group to the truck–like vehicles. In this group, two main disadvantages can be found.

The first group of serious problems is enclosed with tipping over a vehicle. It happens because for example, bad driver decisions on curves, moving on slopes.

The second problem is made by not ideal mainly front/rear braking force distribution. This makes that braking distance is elongated. This happens because the braking system, in many cases, is manufactured to prevent rear wheels from lock and slip. These make that friction coefficient between tires and ground isn't fully used. An explanation is simple. Theory of tire stays, that wheel cannot produce lateral forces at 100% slip. This situation is very dangerous. Rear wheels, which are not producing tire-ground lateral forces, when for example centrifugal force or when a centre of gravity is shifted (because of unsymmetrical load) can put a rear part of an articulated vehicle around revolute joint situated between a front and rear vehicle parts. To prevent such a situation, manufactures introduces a special mechanical devices or (pressure) sensors to control maximum braking torque on tires. These systems are obtaining data from for example spring leafs deflection, from pressure sensor mounted in suspension gas spring, rotary sensors on wheels.

In a group of articulated rigid frame vehicles like wheel loaders, a maximum velocity is very limited. This happens because of stability problems in keeping the straight course of the vehicle. Steering system consists of two rigid frames (typically front and rear) and devices for steer situated between both frames. Problems were discussed in [1-4]. One

of the possibilities of increasing the straight path driving distance is increasing steering system stiffness and damping properties.

Because of a different steering system of articulated rigid body vehicles, solutions taken from cars-like and truck-like vehicles cannot be easily adopted.

MODEL OF A ARTICULATED RIGIF FRAME VEHICLE

Making of a simulation model is very difficult because of many nonlinear phenomena's between tires and ground and in a steering system (bulk modulus, wall expandability index of hydraulic hoses). This makes a very complicated mathematical model. Such a model is prepared an tested in Matlab/Simulink.

The aim of work is to prepare and test a special algorithm to control braking torque on vehicles wheels to avoid snaking phenomena and make a standard basic test of driving stability. Test procedure encloses in 2 test: straight path following and moose test. Two control algorithms are tested: braking only one wheel or two or more wheel braking. Determining a stability limit is problematic. An output data from the model are: x, y, z, a position of a centre of front driving axle, steering system angle, an angular velocity of tires and velocity. An input data: driving torque, steering torque (as an input function) and individual tire braking torque. There is a need to compare different tests. Because of nonlinearities in a model, there is a request to think out a method for comparing tests. Because of use tire model, not every equation are available and the author can observe results in some cases. This makes that there is no possibility for use a standard stability criterion (for example: Lapunow). For that reason, a special procedure taking into account path of a vehicle and articulated angle oscillations is presented and used for comparing results. This proposed and validated a method for comparing results uses the most important to manufacture parameters like: straight in line motion and as small as possible oscillations in steering joint.

CONCLUSIONS

Results show that presented control algorithm allows for increasing straight path course and diminish oscillations in the articulated steering system. We can observe that increased dumping properties reduces the amount of steering wheel corrections with are necessary for maintaining the desired trajectory. The system works well with algorithm controlling only one wheel in most situations. In the situation when external disturbance amplitude is below a certain level, using more brakes of wheels in more appropriate and gives a faster response.

Control system allows for automatic, without driver action, returning to the desired straight path motion. Snaking phenomena is very undesired because it leads to lowering maximum velocity of a vehicle. It increases costs and lowers an efficiency of work. In a case of military vehicles column, travelling speed refers to the slowest machine. For that reasons, investigation over methods for avoiding snaking phenomena in articulated rigid frame vehicles requires a new roadmap for solving a problem. Using brakes seems to be optimal from any point of interests both consumer and manufacturer.

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