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ADAMS AS A TOOL FOR ANALYSIS OF BUS BEHAVIOUR DURING THE TEST PROCEDURE “BRAKING IN A TURN” ACCORDING TO ISO 7975

1. Introduction

The Virtual Prototyping Technologies influence the developmental research of today in a prominent way. This is particularly true in the area of automotive industry, where serious efforts are made to achieve simultaneous satisfaction to many demands that are often different and contradictory. The vehicles need to be safer, more comfortable, faster and at the same time, cheaper for production, and with the lowest possible nuisance in the environment. The Virtual Prototyping Technology is one of the tools that the constructors can use to fight such challenges.

The "Braking in turn" test is one of the recent and most complex tests that vehicles need to pass in order to be positively accepted by the users. The conduct of the vehicle in such conditions depends upon almost all relevant features of the vehicle: mass and geometrical parameters¸ features of the suspension system, steering system, brake system etc. Only the harmonic interaction of all these systems may lead to acceptable features of the vehicle in the above mentioned test.

This study shows a possible approach to the possibilities for modeling of a bus in the program in the bus factory “11 Oktomvri” – Skopje, as well as the experimental way of control-calibration of the model. On the basis of good harmonization of results from the simulations it is possible to look for the optimal features of the suspension and steering systems as well as of the mass and geometric features of such buses.

2. Main remarks about the test procedure “braking in a turn” according to ISO 7975

The test “Braking in a turn” described in ISO 7975 is not fully implemented in obligatory regulations in every country, but it is undoubtedly one of the most complex, and most important tests in the field of conduct of motor vehicles.

The test is performed on a polygon. The vehicle is started in a movement in a circle with constant speed. In a certain moment the brakes are applied with constant intensity and the driver should not make any corrections of the direction with the steering wheel. By the use of adequate equipment, the conduct of the vehicle is monitored through the deviation form the initial path, lateral and longitudinal acceleration or deceleration, change of speed etc. The data as well as the drivers' subjective estimate about the acceptability of the vehicle in such conditions are registered.

3. Constructive and other features of the bus SANOS 515 that are significant for the performances during the test procedure “braking in a turn” according to ISO 7975, and ways of provision of these features

The complexity of the test “Braking in a turn” is the reason why most of its results are dependent upon almost all significant technical and constructive parameters of the tested vehicle. These parameters include mass and geometrical parameters, characteristics of the steering, suspension and the brake systems, tires, etc.

In order to provide all relevant technical data, a complex procedure of theoretical, experimental analysis and tests was made. Thus, part of the data is obtained by the producers of the components (air suspensions), part from the database of the manufacturers and by additional research (shock absorbers, brakes), and one part with special tests, devleoped for that purpose (rubber joins in the suspension system). One of the most robust tasks was made in cooperation with the manufacturer of the bus. This is pertinent to gathering of mass and geometrical parameters of all parts, even the tiniest ones that the bus is made of. Thus, theoretically, the mass, the position of the center of mass and its material inertia momentum are calculated. On the basis of the later experimental control of the mass and the position of the center of mass calculations were proven to have high accuracy.

4. Presentation of the construction and the basic features of the model

The basic features of the model made in ADAMS are the following:

- The sprung mass of the vehicle is considered as a rigid part;
- The tires are fixed to the road surface. They do not slide on the road surface, and the vertical and lateral rigidity are taken from the technical data of the manufacturer;
- The steering system is completely modeled starting from the exit of the hydrosteering gear up to the steered wheels. Fixed and movable parts, as well as joints were used accordingly to the real construction;
- The suspension system is modeled with all elements: elastic elements, shock absorbers, reaction rods and their connections to the axes and the sprung mass, stabilizer, and the rubber bumpers. Particular attention is paid to the real features of the pneumatic air suspensions and the rubber connections of the reaction rods;

Figure 1 shows a simplified schema of the vehicle with the marks used when this model was realized. Thus realized model has 66 degrees of freedom.

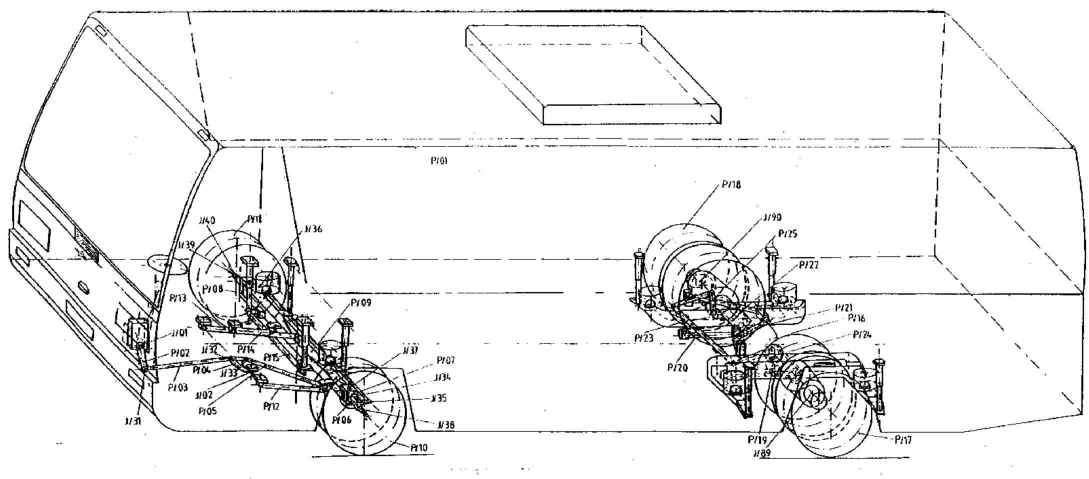

Figure 1 Bus scheme with the basic elements and links that are included in the model

5. Experimental procedure and calibration of the model

According to the need to check the precision and the possibilities to use the model in specific terms, it was necessary to conduct certain experimental research. This is particularly true because in the time of the modeling there were still no relevant experimental data of the conduct of the vehicles in the complex test for brake in turn.

The experiment is designed on the basis of main recommendations given in ISO 7975. Besides the recommended parameters of control (speed, acceleration , etc.), the testing was made with an enhanced number of measured parameters. Thus, the final number of parameters that were measured consisted of:

- The angle of the steering wheel;
- The pressure of activation of the brakes of the front axle;
- The pressure of activation of the brakes of the rear axle;
- Lateral acceleration above the front axle;
- Lateral acceleration above the center of mass;
- Lateral acceleration above the rear axle;
- Longitudinal deceleration;
- The speed in the longitudinal direction;
- The braking path;
- Pressure in the pneumatic suspensions of the front axle;
- Pressure in the pneumatic suspensions of the rear axe on the left side;
- Pressure in the pneumatic suspensions of the rear axe on the right side;
- Relative displacement between the sprung mass and the front axle near the left wheel;
- Relative displacement between the sprung mass and the front axle near the right wheel;
- Relative displacement between the sprung mass and the rear axle front left;
- Relative displacement between the sprung mass and the rear axle left behind;
- Relative displacement between the sprung mass and the rear axle front right;
- Relative displacement between the sprung mass and the rear axle right behind;

- The angle of turning around the vertical axe in the center of mass;
- Trajectory of the vehicle after the brake application.

Figure 2 shows the organized measuring system.

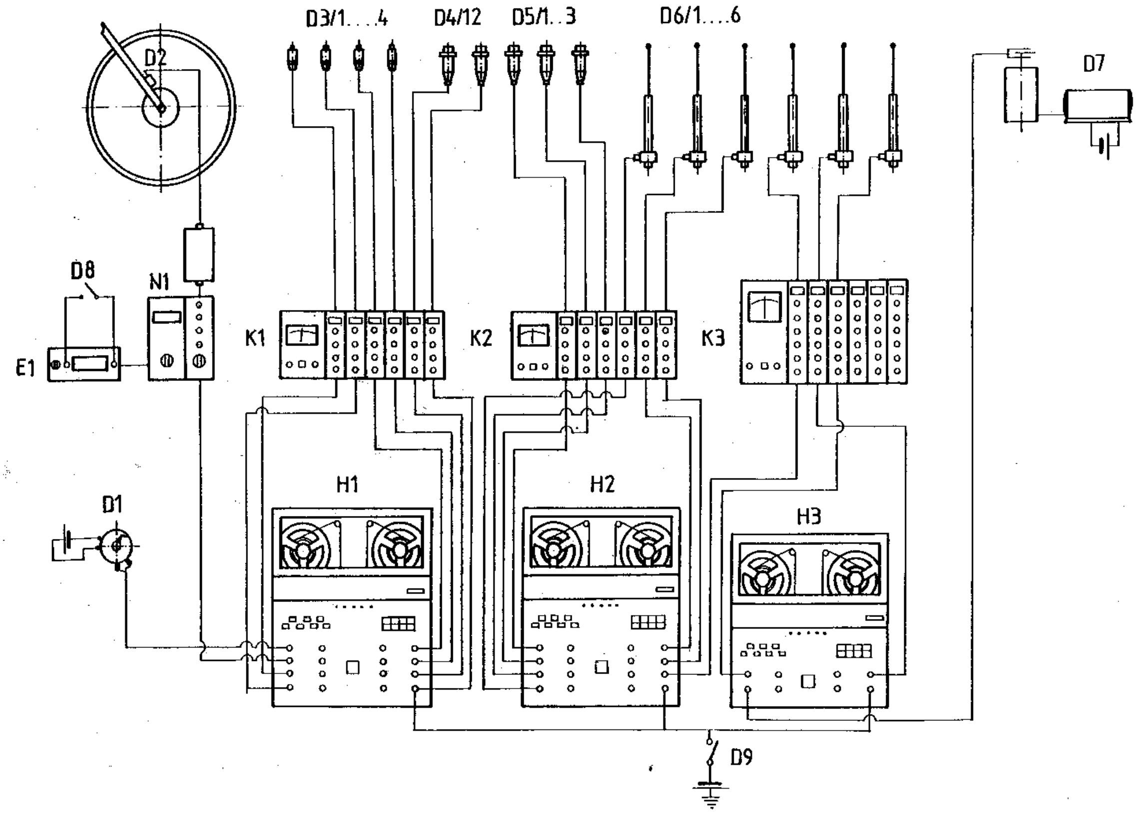

Fig. 2 Scheme of the measuring system

After the experiment was done and the records were carefully processed, we obtained results that may be compared with the results of the simulation.
The simulation procedure is conveyed on the basis of the information about the inertial forces in the center of mass of the sprung mass according to the experimental procedure.

The comparison of results that were obtained with the simulation and the experiment was made on the basis of the displacement of the displacements between the sprung mass and the two axes. Fig. 3 shows this comparison for the front axe and Fig 4. - the rear axle.

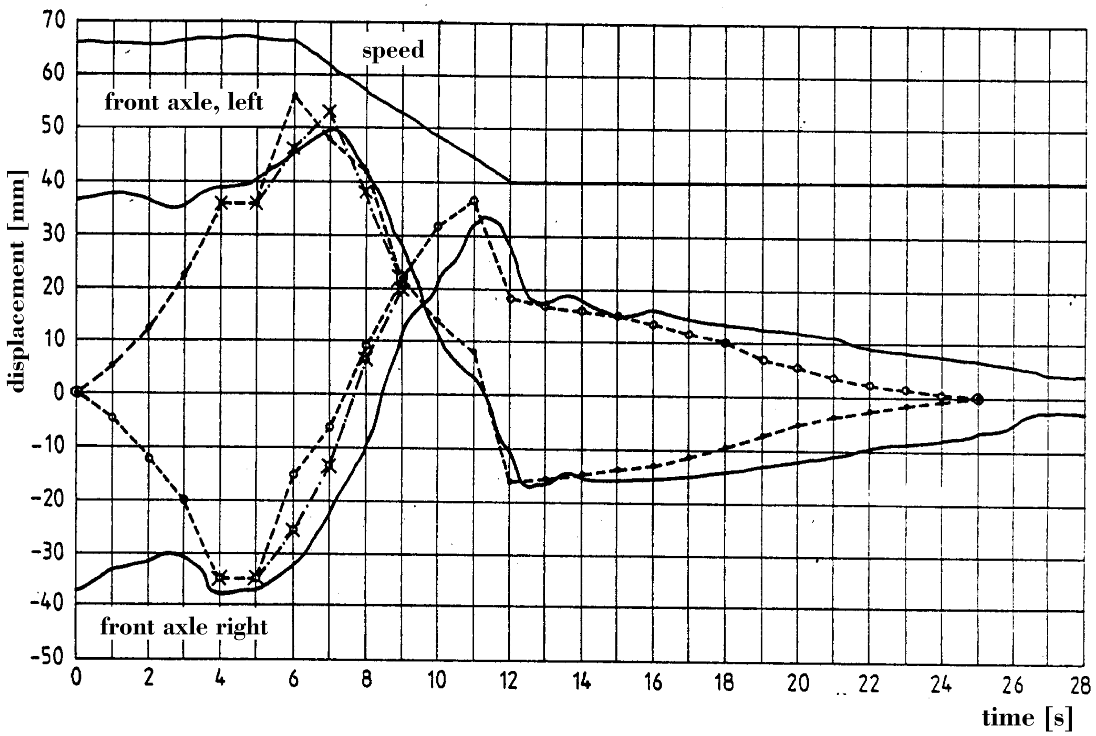

Fig. 3. Comparison of the change of the displacements of the sprung mass and the front axle during the simulation and the experiment

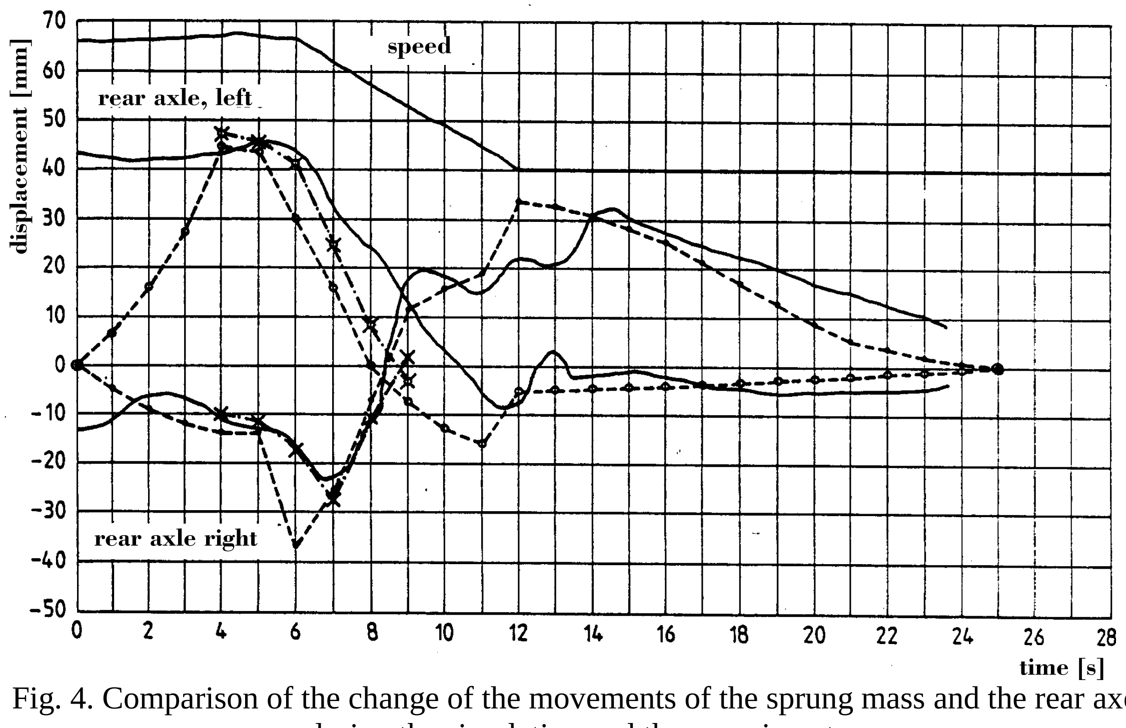

Fig. 4. Comparison of the change of the movements of the sprung mass and the rear axe during the simulation and the experiment.

As both figures show, there was a satisfactory level of harmonization of results obtained by simulation with the ADAMS model and those obtained experimentally.

6. Results from the simulation that may be used for the development of the construction of the vehicle

When the ADAMS model is accepted as a verified tool for analysis of the process of braking in turn, the changes in those quantities which measurement is difficult or not possible for experimental use, may be calculated. It is also possible to vary certain parameters of the vehicle, its systems and subsystems and to conclude about their impact on the conduct of the vehicle in general in a simple and easy way.

From the aspect of the test “braking in a turn”, it is particularly important to assess the impact of construction of the steering system through the additional spin of the steered wheels due to change of the relative position between the sprung mass and the front axle. Also, the effect of spinning - "steering" of both axes as a result of the applied system of their suspension may be assessed.

For instance, Fig 5 shows a change of the angle of the front axle related to the bus body in the vertical and horizontal plane. Fig 6 shows the same but for the rear axle

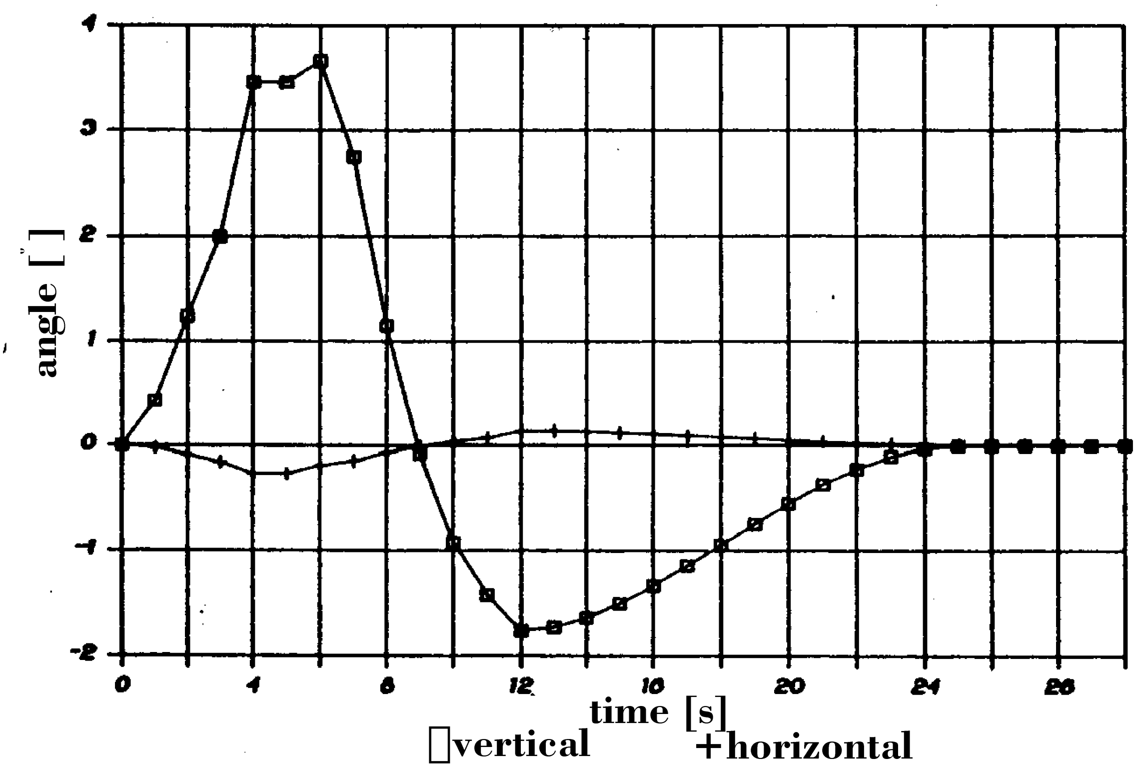

Fig 5 Relative axe of the front axe and the bus body

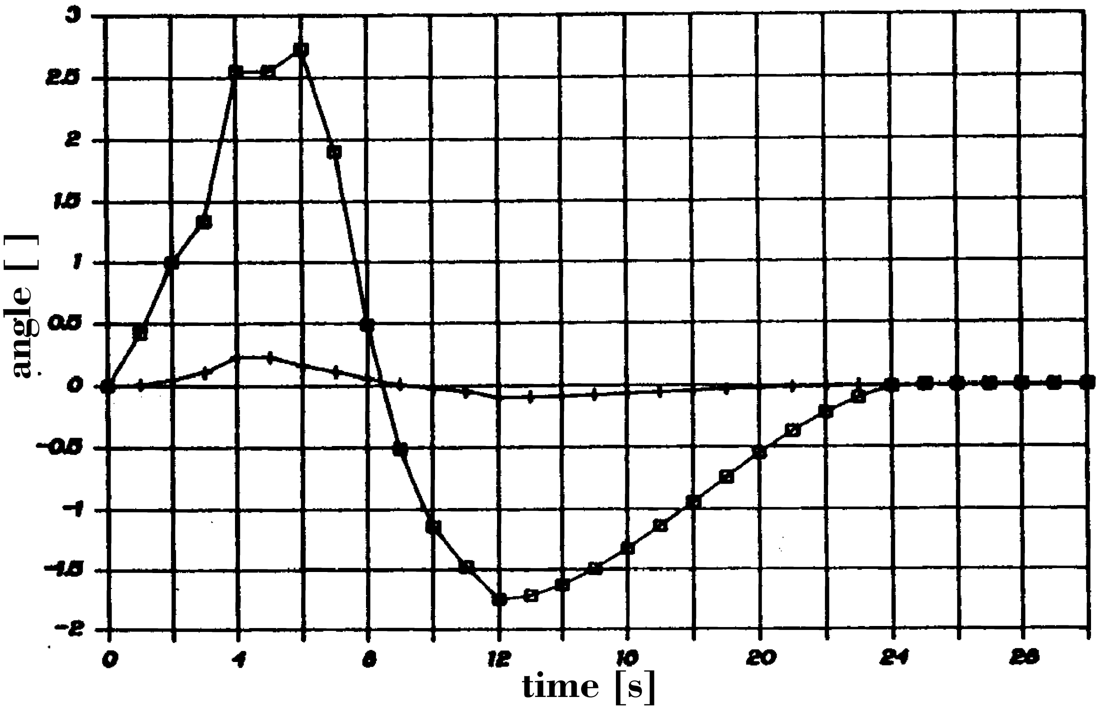

Fig 6 Relative axe of the front axe and the bus body

During the further analysis by several simulations, we showed the impact of different parameters like the position and the length of the reaction rods, the rigidity of the elastic elements and other parameters on the most important output features of the vehicle. On the basis of this approach it is possible to optimize the construction and the features of the elements that are important in the construction of the system of steering and suspension system.

7. Conclusion

Several important conclusions may be drawn:

- The process of braking in turn in motor vehicles is one of the most complex and according to the safety aspects it will be subject to further attention of the professionals in this area;
- Implementation of the experiment "braking in a turn" is an expensive and slow procedure which may even be dangerous in case of heavy vehicles (buses, trucks, trailers, etc.);
- ADAMS model provided acceptable results with a high level of conformity with the experimental results;
- Verified ADAMS model is a comfortable and safe tool which may be used for simulation of the process "braking in a turn" and on the basis of such results rational decisions about the constructive solutions may be made for certain systems or the vehicle in general.

8. References

1. ADAMS, User ‘s Manual
2. ADAMS, Application Manual
3. Kosevski Milan, Dejstvuvanje na oddelni parametri vrz karakteristikite na sistemot za vodenje na trkalata kaj avtobusite so pnevmatski elasticni elementi vo sistemot za elasticno potpiranje, doktorska disertacija, Skopje, 1991 godina.