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Research of influence of the tyres on steerability of car applying RSV experimental tests

In this paper the results of experimental tests of van type of car equipped with three sets of tyre according to Research Safety Vehicle (RSV) specifications is presented.

The main results were obtained on the basis of RSV returnability performance test but steady state circular test and steering wheel input test has been also taken into consideration.

In conclusion the results were evaluated from point of view of estimation the tyres properties.

Key words: tyres properties, steerability of car, RSV tests

Badanie wpływu opon na kierowalność samochodu z zastosowaniem eksperymentalnych prób RSV

W pracy przedstawiono metodykę oceny wpływu opon na kierowalność samochodu. Podczas badań wykonano eksperymentalne próbę stosowane dla tzw. samochodu bezpiecznego (RSV), tzn. badanie reakcji na skokowe wymuszenie obrotem kierownicy i badanie zdolności samoczynnego powrotu do jazdy na wprost.


Słowa kluczowe: właściwości opon, kierowalność samochodu, prób RSV

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1. Introduction

Among testing of car properties special attention deserve testing concerning active safety i.e. its stability and steerability.

A big part in creating active safety of car (i.e. steerability and stability) is being contributed to tyres. Their features essential from the point of view of stability and steerability are:

- lateral stiffness which influence to cornering stiffness,
- circumferential stiffness – from which depend longitudinal forces during drive and braking,
- type and tread pattern – from which depend road adhesion and above mentioned longitudinal and lateral forces.

In tyre industry laboratories are being performed specialistic product testing, mainly on testing stands according to adequate program and methods. There are also being performed tyre road tests but mainly in respect to estimating tyre performance durability, noise level, tread pattern water drainage ability and other parameters, but concerning only tyres.

Examination of steerability and stability performed on different tyre types according to methodologies applied to the whole car can also provide valuable information referring to tyres. After stated changes in car properties one can conclude also about tyre properties.

In this elaboration are presented results of such examinations performed several years at the Institute of Automobile and Inner Combustion Engines Cracow University of Technology and mutual research results from Research and Developing Centre of the Tyre Industry “STOMIL” Poznań.

2. Short information concerning test methodology

At present are available several ISO documents concerning methods utilised for examination of stability and steerability of cars. Four of them are considered as the most important: ISO 4168 concerning in procedure for steady state circular test, ISO 7401 with procedure for test of response on various steering wheel inputs, TR/ISO 3888 concerning procedure for a Severe Lane-Change Manoeuvre (the so-called “elk test” is also applied recently for testing of car stability and steerability) and ISO 7995 concerning for braking on the turn.

One should remind here that in the early seventies was established International Committee which accepted program of building and testing of a safety vehicle RSV. This abbreviation originates from full English name – Research Safety Vehicle. On the turn of the seventies and the eighties this vehicle was built (even several such vehicles in several countries) according to foredesigns elaborated by the Committee. In the RSV vehicle there was a possibility of changing essential parameters of chassis and motor – car body in quite a wide range. On the basis of testing such vehicle were established later on boundary values of basic factors for steerability and stability estimation which should show cars with favourable properties.

There were mainly performed steady state circular test, response for steering wheel input and returnability performance.

The first one provides important information concerning both passenger cars and trucks (also special ones) or buses. The tests of steering wheel input, returnability performance and severe lane change manoeuvre are mainly applied for testing passenger cars.

Magnitude of steering wheel angle in steering wheel input test and returnability performance test should be matched so as to obtain lateral acceleration in steady state movement (circular motion) amounting to 4±0.2 m/s². This is requirement and strictly speaking limitation connected with necessity to keep linear driving range. Steady state should be kept during 3 s.

Measured parameters during this test, essential for assigned estimation factors are: drive velocity, steering wheel angle, yaw velocity and lateral acceleration.

From steering wheel step input test one can assign several factors among other: steady state yaw velocity response gain, yaw velocity response time yaw velocity peak response time, yaw velocity overshooting, TB factor (i.e. product of yaw velocity peak time and steady state sideslip angle) and others. The curve of yaw velocity presented in time function must lie in appropriate permissible – zone defined in RSV requirements (see e.g. [1], [2]).
Described test is usually utilized for other characteristic i.e. for defining car ability to automatic return to straight drive (so called returnability). At the end of steady state drive on a circle driver releases steering wheel and car "driving out" from circular track, again performs several amplitudes of complex spacial vibrations and then after these vibrations cease car continues straight drive. For evaluation of returnability one assigns ratio of the first extremum of yaw velocity, after releasing steering wheel to this velocity in steady state (before release). This ratio characterize damping ability of above described spacial vibrations. Besides, it is being assigned "residual" value of yaw velocity, 2 s after steering wheel release and yaw angle, obtained after integration of directional angle velocity (of course from the moment of steering wheel release). For test with velocity 80 km/h residual yaw velocity cannot exceed ±4°/s. Curve of car angle rotation course round vertical axis in time function, must lie in permissible zone defined by requirements for RSV.

Analog test is being made at 40 km/h velocity releasing steering wheel during steady state drive on a circle. Residual yaw velocity after 2 s since releasing steering wheel should not exceed ±2°/s value. There is also a different permissible zone for directional angle.

3. Presentation of exemplary results

In this chapter the results of test of FORD Transit car equipped with three sets of tires will be presented.

This car is usual equipped with tires 195 R14 C dimension. In father on this set will be marked with symbol A. During the tests the two sets tires of dimension 185 R14 C were applied also. The main difference between respective set of tires was in tread design and applied material. These tires will be marked with symbols B ad C.

The inflation pressure was 2.8 bar (both for front in rear wheels).

The runs of yaw velocity after steering wheel release during steady state drive on circle with 40 km/h velocity are presented in figures 1 and 2. These runs are average from several tests.

The curves of yaw angle of car with permissible zone defined by RSV requirements are showed in fig. 3 and 4.
The tests of returnability performance have been also realised with velocity of 80 kmph. The results analogous to showed upper for 40 km/h are presented in figures 5 to 8.
Fig. 7. The average curves of yaw angle and RSV permissible zone after release the steering wheel during steady state circular test with velocity 80 km/h – left turn

Fig. 8. The average curves of yaw angle and RSV permissible zone after release the steering wheel during steady state circular test with velocity 40 km/h – right turn

Evaluation factors of returnability performance assigned on basis of test results of steering wheel release during steady state tests with 40 km/h velocity are put together in table.

<table>
<thead>
<tr>
<th>Evaluation factors</th>
<th>Tyre designation</th>
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<tbody>
<tr>
<td>$U_{dw}$</td>
<td>A 0.10(±0.02)</td>
</tr>
<tr>
<td></td>
<td>B 0.04(±0.02)</td>
</tr>
<tr>
<td></td>
<td>C 0.13(±0.03)</td>
</tr>
<tr>
<td>$\omega_z (2)$</td>
<td>A 0.65(±0.67)</td>
</tr>
<tr>
<td></td>
<td>B -0.51(±0.42)</td>
</tr>
<tr>
<td></td>
<td>C 1.05(±0.71)</td>
</tr>
<tr>
<td></td>
<td>L -0.94(±0.50)</td>
</tr>
<tr>
<td></td>
<td>C 1.62(±0.94)</td>
</tr>
</tbody>
</table>

$U_{dw} = \omega_{max}/\omega_z (0)$ – the ratio of damping of spatial vibration of car after steering wheel release, $\omega_z (2)$ – residual yaw velocity after 2s from steering wheel release, P - right turn, L - left turn. In brackets - standard deviations.

3. Concluding remarks

On the basis of results presented in chapter 2 it follows that three various sets of tires which were applied for researched car have not essential influence for its properties. Similar conclusions can be stated on the basis of results of other test i.e. steady state circular test and steering wheel input which were also made during experiments.

References