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ANALYSIS OF THE TORQUE APPLIED TO THE STEERING WHEEL IN STATIC CONDITIONS

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ABSTRACT: *The subject of this paper is the study of the torque applied to the steering wheel of a vehicle in stationary conditions. A theoretical model for calculating the steering torque was presented, followed by the experimental measurements that validate it. There was chosen the static mode that is similar to parking conditions, for analyzing the maximum torque values. The vehicle chosen for the tests was a city version with a non assisted steering system. A transducer for torque measurement was created by using strain gages, and was mounted on the pinion shaft from the steering box. For obtaining a torque steering angle dependence, there was applied a linear transducer for displacement measurements. This was rigidly fixed to the shell of the steering box and connected to one of the outer parts of the rack. For data acquisition, there was used a Spider 8 model data acquisition system. The transducer was calibrated by using a force transducer mounted on the steering wheel and pulled on a tangent direction. The results obtained are part of a dynamic analysis of a steering mechanism that takes into account the deformability of its elements.*
KEYWORDS: *steering, torque, static, shaft, transducer*

INTRODUCTION

The steering system is one of the main subsystems of road vehicles and has a major role in assuring safety during traveling. In technical papers the steering has many approaches especially concerning kinematic and dynamic models, optimization of various steering systems and studies on several types of steering mechanisms and parts.

One of the most important aspects of this subject was the study of the resistant torque at the steering wheel, during the steering maneuver of the vehicle. Technical papers focus on studies made on steering torques measured at parking speed [3]. In the paper [1], there were also taken in consideration the maximum steering angle conditions.

This paper presents experimental tests with the purpose of obtaining the variation of the steering wheel torque in static conditions. For this, it was chosen a Daewoo Matiz vehicle with a non assisted steering mechanism.

METHOD FOR MEASURING THE RESISTANT TORQUE AT THE STEERING WHEEL

For obtaining the desired values of the torque, it was created a torque transducer by using a half bridge strain gage circuit. The strain gages type KFG-10-350 were applied on the pinion shaft from the steering box, positioned at 45° from the longitudinal axis. Figure 1 describes the steering box with the pinion shaft where the transducer was applied and also the way of obtaining the torque characteristic.

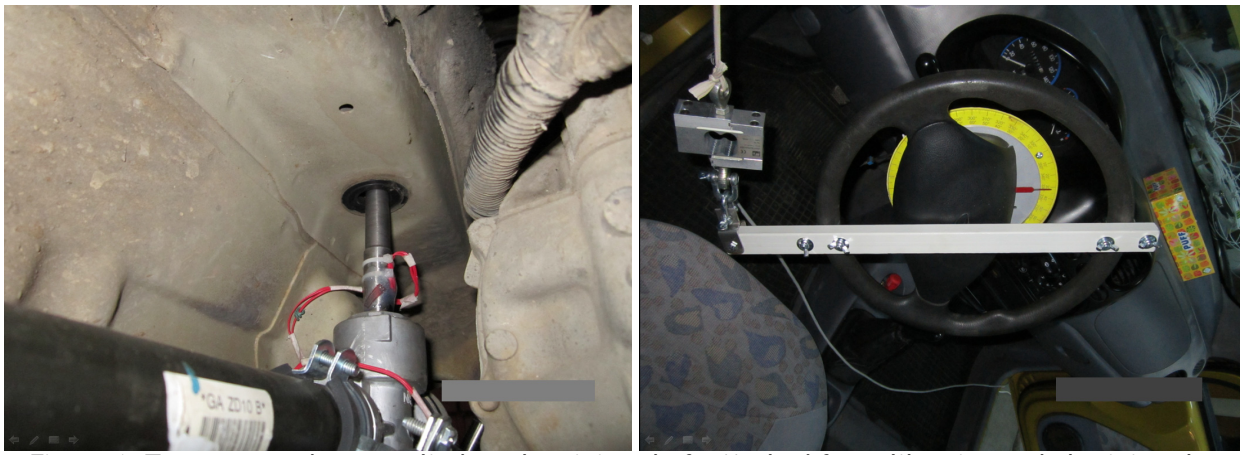

Figure 1. Torque transducer applied on the pinion shaft. Method for calibrating and obtaining the characteristic of the torque value

For obtaining the torque characteristic, the steering wheels were blocked. On the steering wheel there was mounted a bar with the length value known. A radius of 280 mm from the centre of the steering wheel was chosen to mount the force transducer type S2 100N with a maximum load accepted of 100 N produced by the Hottinger manufacturer. The force transducer was pulled perpendicular to the bar, so over the steering wheel it was acted with a progressive increasing force. The steering wheel was turned to the left and then to the right, permanently taking into consideration to maintain of the angle between the bar and the force applied to a value of 90°. Both the S2 100N force transducer and the half bridge circuit transducer were connected to the Spider 8 type data acquisition system.

The characteristics were determined by experiments and can be seen in figure 2. The black mark represents the traction force, given by the standard transducer S2 100N, while the red mark is the variation of the value provided by the transducer mounted on the pinion shaft. On the vertical axis of the graphic there is represented time measured in seconds.

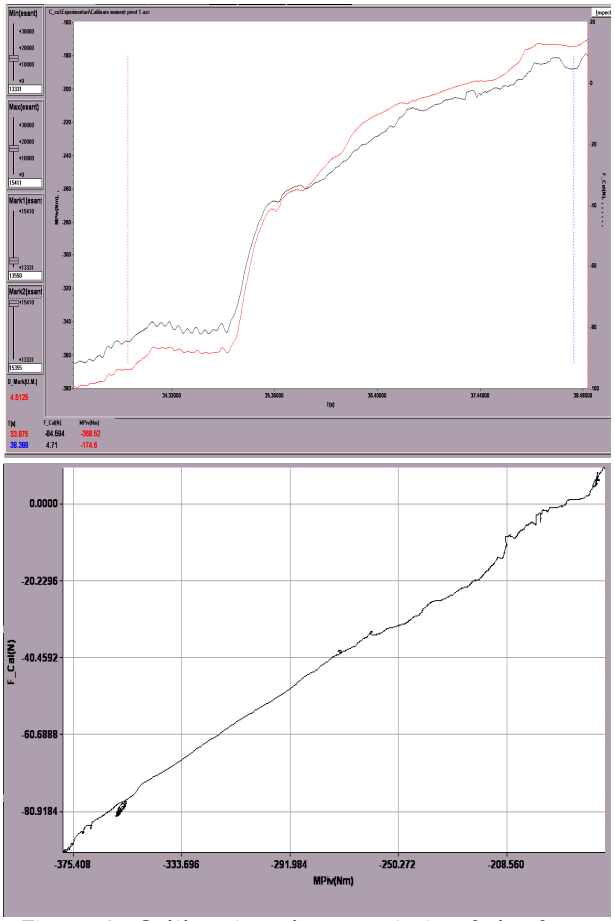

Figure 2. Calibration characteristic of the force transducer for determining the resistant torque on the pinion shaft

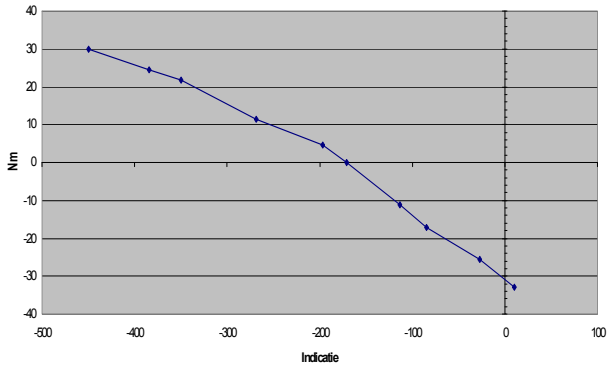

Figure 3. Calibration characteristic of the transducer for determining the torque from the pinion shaft of the steering

Considering the length from the steering wheel centre to the point where the force acts, there was obtained the calibration characteristic of the torque transducer mounted on the pinion that can be observed in figure 3. From this characteristic analysis it results that the transducer has a linear behaviour, considering the conditions of determining the characteristics.

STATIC EXPERIMENTS FOR DETERMINING OF THE RESISTANT TORQUE FOR THE STEERING WHEEL

The experiments were done in static conditions, with the car stopped, and took place in the Vehicle Dynamics Laboratory, from the Faculty of Mechanics in Craiova, having the purpose of accurately determining the torque values for the steering column in case of steering the vehicle.

The vehicle chosen for the test was a Daewoo Matiz urban model. As this application is part of a larger test that studies more parameters to describe the steering and front suspension, on the vehicle were mounted several transducers : inductive linear transducers for measuring the rack and the two dampers travel, strain gauge transducers for measuring forces, accelerometers and force transducers for calibration operations.

For obtaining the desired parameters, the Spider 8 data acquisition system was used during the left and right steering operations.

For the static tests, there were obtained the same parameters as for the dynamic conditions. The system measured them simultaneously and their variation is represented on the same graphic. These parameters are:

- *The longitudinal force measured in the right tie rod - FBDr[kN];*
- *The longitudinal force measured in the left tie rod - FBSt[kN];*
- *The torque in the pinion shaft - MPiv[Nm];*
- *Linear displacement of the right damper - CADr[mm];*
- *Linear displacement of the left damper - CASt[mm];*
- *Linear displacement of the rack- CCr[mm];*
- *Steering wheel turning angle- UV[grade].*

For each parameter there can be observed the annotation and also the unit. Each of them is marked on resulting graphics. In figures 4 and 5, there are presented the graphics corresponding to two of the tests. There has to be mentioned that the turning angle of steering wheel resulted by interpolation from the rack displacement.

Parameters were calculated for a left and right static steering, and the maximum values can be seen in charts 1 and 2.

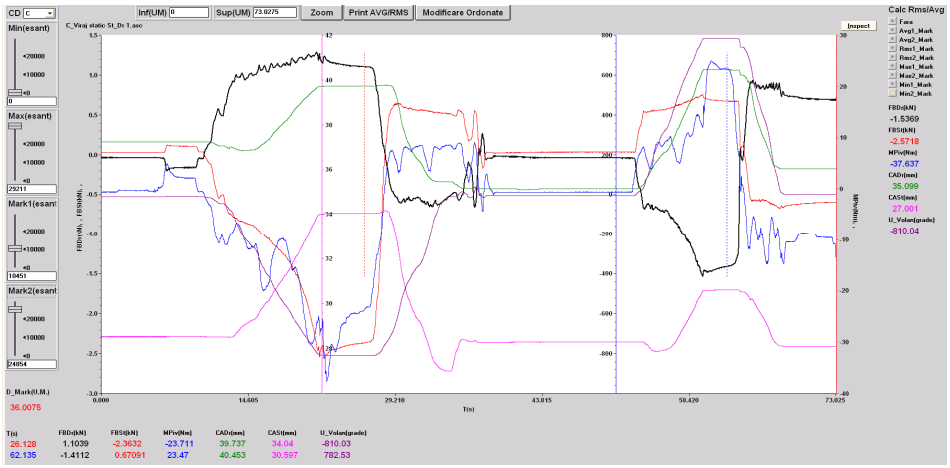

Figure 4. Specific parameters for St_Dr 1 static steer

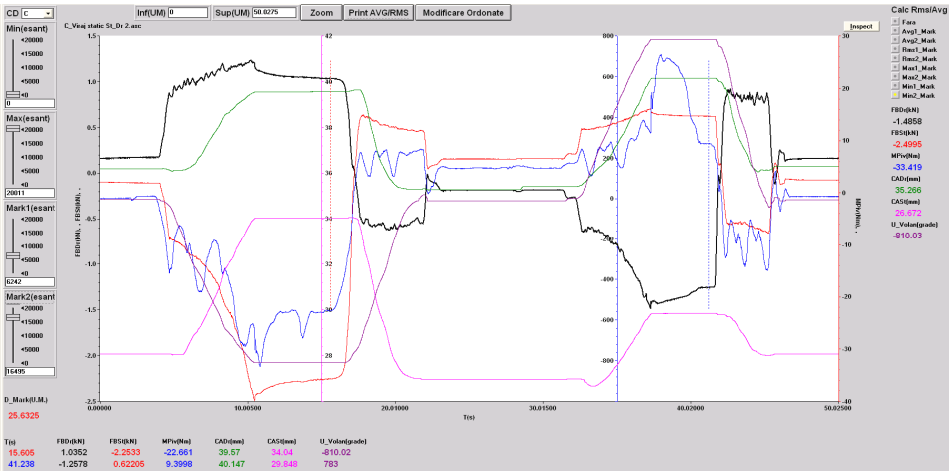

Figure 5. Specific parameters for St_Dr 2 static steer

Chart 1. Specific parameters for St_Dr 1 static steer

Tip	FBDr	FBSt	MPin	CADr	CASt	U_Volan(grade)
	(kN)	(kN)	(Nm)	(mm)	(mm)	U_Volan(grade)
Max	1.29	0.75	24.98	40.46	34.16	782.84
Min	-1.54	-2.57	-37.64	35.10	27.00	-810.04

Chart 2. Specific parameters for St_Dr 2 static steer

Tip	FBDr	FBSt	MPin	CADr	CASt	U_Volan(grade)
	(kN)	(kN)	(Nm)	(mm)	(mm)	U_Volan(grade)
Max	1.23	0.70	26.49	40.15	34.05	783.00
Min	-1.49	-2.50	-33.42	35.27	26.67	-810.03

CONCLUSIONS

The method of obtaining the resistant torque at the steering wheel is part of a more complex research that studies the variation of different parameters that characterize the steering system. It describes the rack and pinion type steering system, considering the flexibility of some of its mechanical parts.

Tests showed that the maximum value of the resistant steering torque is obtained at a very low speed of the vehicle, a fact that is confirmed by the theoretical model. As a result the model presented in the paper was done in static conditions, simulating parking. The experimental way of obtaining the desired values was based on using strain gages, oriented on the pinion shaft at 45° from the longitudinal axis. On the same graphic, there were represented simultaneously the maximum values of the forces that act longitudinal on the tie rods, the steering angle and the vertical displacements of the dampers.

To conclude, the method for obtaining the torque value by applying strain gauges on the steering shaft proves to be efficient, the only main disadvantage is the fact that the torque transducer made of strain gages cannot be reused on another vehicle after its first use.

ACKNOWLEDGEMENT

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