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ATTACHMENT RESEARCH JUDGMENTS INDICATORS FOR COMFORT MANAGEMENT OF TRANSPORTATION VEHICLES

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ABSTRACT: When designing the vehicles it is difficult to specify which system is the most complex but one thing is certain management system along with the braking system carries a special degree of responsibility in terms of security. It should be an appropriate level of importance arises in the design. Here we analyze judgments indicators of comfort control force that is necessary to use the steering wheel depending on the angle of the steering wheel trades. Shown analysis using the study results of hydraulic power steering leads to the conclusion that the selected hydraulic power steering matching the motor vehicle.
Keywords: force, angle, steering wheel, power steering control

1. INTRODUCTION

The control system is used change or maintain the chosen direction of movement of vehicles and maneuvering to achieve it. In general, the steering control system consist of three parts: steering mechanism, steering gears and enhancers. The conditions of road transport and transport requires increase bearing capacity.

With the increasing capacity and increasing the effort that the driver – the operator. The combination of these factors requires the installation servomechanism in transport vehicles [1, 2, 3]. The purpose is to facilitate power steering driving force reduction in which the driver must make to overcome resistance on the road. In results in greater maneuverability massive all vehicles and greater security. Increased security is the result of a vehicle to facilitate handling, reduce driver fatigue, which is capable at any moment to respond quickly to unforeseen situations.

2. JUDGMENTS PARAMETERS OF STEERING SYSTEM

The control system as a whole is evaluated by many but the main features of which depend on the steering gearbox and steering gears, gear ratios that follow (angular and energy), ease of use and maneuverability in turning. Ease of use and maneuverability is a general term that is characterized by complex parameters of which are the main force F_v brought to the driver in steering wheels angle φ and vehicle turnaround management wheels, moving the steering wheel from one extreme position to another [1,2].

The ease of management can be used for comparative assessment of different control system in a vehicle after the same operation on the control point, but when different values of force and angle of steering wheel trades.

The force brought to the steering wheel $F_v^{'}$ when the tires are separated from the substrate and the angle $\varphi^{'}$ of free trade steering wheel with wheels down is characterized by loss of traction and frazzle steering mechanism of control system. For ease of handling and maneuverability of vehicle impact angle and energy transmission ratio.

2.1. Angular transmission ratio control

Angular transmission ratio control system is determined by the ratio of the control wheel angles crafts and steering wheels, can be expressed by the following differential dependence [1]:

$$i_{\omega_0} = \frac{2d\varphi}{d\alpha + d\beta} = i_{\omega} . i_{\omega}^{'} \qquad (1)$$

where are: $d\varphi$ - the angle of steering wheel rotation; $d\alpha$ and $d\beta$ - angles of the steering wheels; i_{ω} and $i_{\omega}^{'}$ - angular gear rations steering mechanism and the steering gear.

2.2. The energy transmission ratio

The energy transmission ratio is determined from the equality of papers on the control wheel and steering wheel[1].

$$F_{sw} \cdot R_{sw} \cdot d\varphi = 2 \cdot Q \cdot r \cdot \frac{d\alpha + d\beta}{2} \qquad (2)$$

where are: R_{sw} - steering wheel radius; r - turnaround radius steering wheels; Q - resistance to trade steering wheels.

From the relationship of resistance to steering wheels and the force on the steering wheel gets the energy transmission ratio.

$$i_{p_0} = \frac{2Q}{F_{sw}} = \frac{R_{sw}}{r} \cdot d\varphi \cdot \frac{2}{d\alpha + d\beta} = \frac{R_{sw}}{r} \cdot i_{\omega_0} \qquad (3)$$

2.3. Maneuvering in turning vehicle

To obtain a score of maneuvering in turning vehicle must have some parameters, e.g. inner and outer radius of crafts, the width of the transient, dimensions of base vehicles. These parameters do not give a complete assessment of a given as they talk more about the perviousness and induction of turnover for a given vehicle rotate. Obviously, the construction of the steering mechanism and its characteristics e.g. speed ratio to a greater degree of influence maneuvering in turning vehicle. To complement this capacity may be taken during that happens craft vehicles [2].

$$t = \frac{S}{v_a} = \frac{R \cdot \gamma}{v_a} \qquad (4)$$

where are: S - the length of trajectory turning; v_a - vehicle's speed in turning; R - radius of crafts (in relation to the center axis of the last); γ - angle at which the vehicle rotates.

$$k = \frac{\sigma}{v_a} \qquad (5)$$

This assumes that angular velocity is constant turnover steering wheels. Gear ratio steering mechanism and steering system as a whole can be variable, because it properly applied a constant angular speed craft steering wheel rather than steering wheels. As a result of development of the presented method for the determination of maneuvering in turning vehicle on a given trajectory length S applies a constant angular velocity of rotation of the steering wheel $\omega = const$. The result obtained by angular rotation of the vehicle decrement.

$$k = \frac{\omega}{i_{\omega_0} \cdot v_a} = \frac{\omega}{i_{\omega_0} \cdot S} \cdot t \qquad (6)$$

This shows that the maneuver will be characterized by the time parameter and the comparative assessment of different vehicles.

3. DESIGNE OF FORCE ON THE CONTROL POINT

Comfort steering systems depends on the power F_v management control point at the wheel diameter R to be reversed the vehicle into place. This force has a maximum value at the turning of vehicles in place. The actual moment of the steering wheel that is spent for craft item must overcome the resistance torque resisting rolling wheels M_1, torque wheel slip resistance tire print on the surface M_2 and torque caused by the stabilization of the control point M_3 that can be disregarded in determining the maximum force $F_{v\max}$.

Wheel rolling resistance torque is equal to:

$$M_1 = G_t \cdot f \cdot a \qquad (7)$$

where are: G_t - vertical load point; f - coefficient resistance of rolling wheels; a - arm pivot point.

Moment resisting wheel slip is equal to (Lisov, 1972), (Majkić, 2012):

$$M_2 = 0{,}14 \cdot G_t \cdot \varphi \cdot r \qquad (8)$$

Taking into account, that are on the front axis of the two steering wheels, torque on the sleeve connected to the longitudinal control terminals is:

$$M_R = 2G_T(f \cdot a + 0{,}14 \cdot \varphi \cdot r) \cdot \frac{1}{\eta_i} \tag{9}$$

where is: η_i - the coefficient of efficiency, which takes into account the friction losses in branches and joint working steering gear.

In the calculation of recommended value for $f = 0{,}015$ and $\varphi = 0{,}85$.

$$F_{v\,max} = M_R \cdot \frac{1}{R \cdot i_\omega^{'} \cdot i_\omega^{''} \cdot \eta_D} \tag{10}$$

where are: $i_\omega^{'}$ - gear ratio steering mechanism; $i_\omega^{''}$ - gear ratio steering gears; R - radius of the steering wheel; η_D - direct coefficient of efficiency (the transfer of power from the control point to the control lever).

When moving vehicle on a curve at the moment M_2 of resistance to sliding tire footprint is many times smaller than the twist into place and depends on the speed of the vehicle. Figure 1 shows the dependence of force on the steering wheel on the speed of the vehicle.

Figure 1. Dependence of force on the steering wheel on the speed of the vehicle. (Gold, 1962), (Majkić, 2012)

Data were obtained by examining the transport vehicle ZIL-585. Reducing power F_V and ease of management it is possible to increase the radius R of the control point, also increasing the gear ratio steering gearbox $i_\omega^{'}$ and steering gear ratio transmission $i_\omega^{''}$, reducing up to certain limits arm pivot point and the friction losses in rotating branches, joint management and transmission control mechanism in setting the amplifier and the control system.

The radius of the control point is selected depending on the driver circuit. The radius of the control point must be chosen depending on the morphological characteristics of the diver and the transparency of the driver's seat. It varies in the range of 190 mm (for cars) to 275 mm (for the larger capacity trucks and buses).

For a measure to reduce arm pivot point and the point of rolling resistance is reduced, but also increases surface friction between the tires and the base surface. For a given profiles tires, which have a certain flexibility is essential for a certain distance a_{min}, during which a given force for a minimum turnover of vehicles.

Projected size a_{min} of the vehicle shall be determined by test. It is common $a = 30 \div 60$ mm. For higher capacity trucks $a = 60 \div 100$ mm. Transmission of the steering mechanism $i_\omega^{'}$ for vehicles is changed within the limits $12 \div 20$ for trucks and buses within the limits $16 \div 32$. When increasing the number of transmission reduces the force applied to the steering wheel, necessary for the turnover of vehicles, but also reduces the angle of turnaround wheel vehicles, which corresponds to a given corner point turnaround management. If you are faster cars, faster to perform his craft wheels thus required lower gear ratio steering mechanism.

Exploitation of research has shown that it provides a good maneuver if the vehicle steering wheel to turn full angle occurs in 1,0 to 1.75 (but not more than 2.0) turnaround management wheels in each side of the middle position, which corresponds to rectilinear motion. So better comfort of the vehicle can be obtained by varying the gear ratios of the control (Gold, 1962), (Majkić, 2012).

$$i_\omega = i_\omega^{'} \cdot i_\omega^{''} \tag{11}$$

Figure 2 shows the change in speed ratios depending on the rotation angles of the control lever to the left and right.

For passenger cars of different types of control mechanism with constant transmission ratio law 3 in figure 2, which according to research (Gold, 1962), meets the requirements.

For vehicles with relatively low speeds with greater weight sometimes have the advantage of the mechanisms of transmission ratio, which changes the curve 2, the steering wheel a slight turn reduces the forces on the steering wheel.

With high-speed vehicles are sometimes used with steering gear ratio that changes the first curve. During the vehicle faster car respond quickly when the driver turnover point. In a sudden turn, which usually occurs at a moderate speed of the vehicle, the force on the control point is reduced due to increased transmission ratio. Reducing losses to friction and increase efficiency coefficient of direct control mechanism, can reduce the work of the steering wheel when the vehicle turnover. Also a significant increase in the coefficient of efficiency of the management mechanism in moving vehicles on rough road can lead to all the random lateral forces that act on the steering wheels can be transferred to the control wheel, which has resulted in the creation of the moment who should get the driver's hand –operator which makes driving in the given conditions of motion.

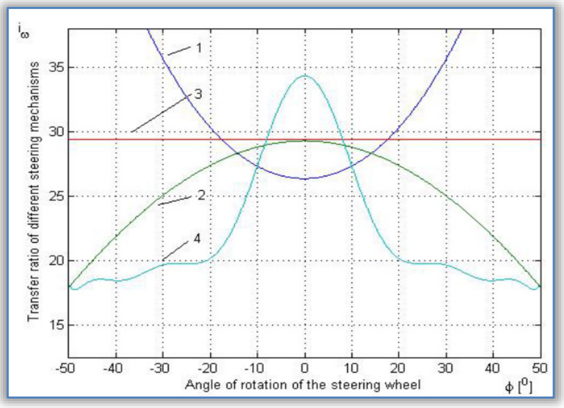

Figure 2. Dependence of transfer ratio of different management mechanisms depending on the angle of rotation of the control lever. (Gold, 1962), (Majkić, 2012).

These circumstances allow the reduction efficiency coefficient control mechanism only to a certain extent. The coefficients of efficiency of the management mechanism, different direct (in the transfer of force from the steering wheel to control arm) and return the transfer of power from the control lever to the steering wheel. As soon as the more direct efficiency values that are smaller loses in the steering mechanism of the trade steering wheels and thus easier to steer. If the return is lower coefficient of efficiency therefore decreases more torque to the steering wheel under the influence of random lateral forces acting on the steering wheels on the bumpy road. Direct feedback and efficiency values are mutually connected. Reversibility steering mechanism, which can evaluate the rate of return steering wheels in the position corresponding to the rectilinear movement of the steering wheel and release of a given change in the law stabilizing moment will be even greater when the smaller losses to friction in a rotating branches and joint management of transfer.

Using hydraulic servomechanisms facilitate the conditions and increasing labor productivity drivers in addition to improving the handling, vehicle stability and thus increases the safety of movement and speed maneuvering in different road conditions. Wide are applied hydraulic servomechanisms in which the force required on the control lever provided at the expense of energy used fluids.

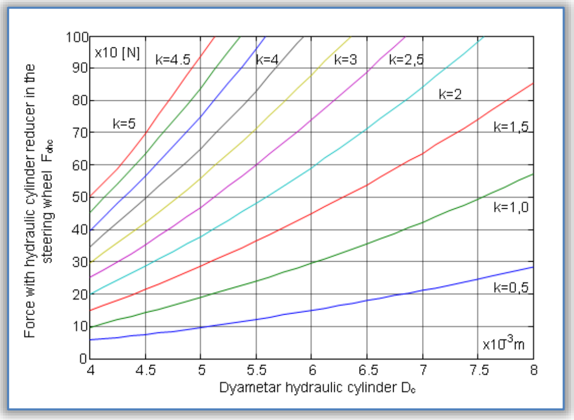

Figure 3. Curve of maximal force F_{ohc} reduced the power steering wheel, depending on the diameter hydrocilindry hot different rations k.(Lisov, 1972), (Majkić, 2012).

Before the control system with hydraulic servomechanisms set the following requirements: high speed action and good supporting effects, significant output power necessary for the execution of trades vehicles, reliability, stability, performance, etc. Figure 3 shows the dependence of force created hydraulic cylinder which reduced the steering wheel depending on the diameter for different values of k. The maximum force $F_{V\,max}$ at the steering wheel in somewhat difficult conditions with steering linkage assembly with power assisted steering gear is usually inflict. For passenger cars applied force is 30÷50 N and sometimes 70 N, for trucks 150÷180 N and for buses 140÷160 N.(Lisov, 1972).

Hydraulic intensifiers are evaluated with the following main indicators: the effectiveness of action, reactive effect on the control point, the direct involvement and feedback amplifier and amortization at break pneumatic tire effect on the control point, the direct involvement and feedback amplifier and amortization at break pneumatic effect on the control shaft, a sense of action, maneuvering in turning vehicle, consumption of the working medium.

Apart from these there are additional requirements such as, for example, changes in operating pressure cylinder or the time of entry into operation of the amplifier, the losses in the pipeline. Figure 4 shows the experimental curve 1 depending on the forces F_v, brought to a control point, the angle φ of his craft at craft steering wheels in place of buses LAZ-698 (Gold, 1962) .It may be noted that in the initial period when the control wheel to $\varphi = 360^0$ craft power is changed slightly, then rises sharply until the end of the craft. Turn right (curve 2) is done with a bit more power than the left (curve 1), since in this case the lower surface of the drive cylinder. This changes the character of the forces is explained by the fact that in the first period, steering wheels revolving account for the deformation of a tire in the last period occurs at slip surface.

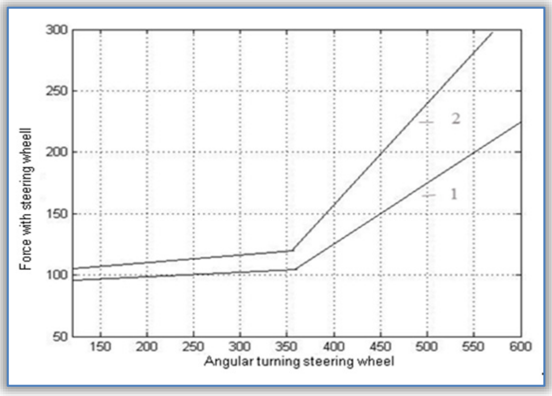

Figure 4. Dependence of force on the wheel steering angle of steering wheel rotation, the experimental data. (Gold, 1962).

4. GENERAL REQUIREMENTS FOR THE FORCE ON THE CONTROL POINT TEST METHOD

The requirements for the maximum power that can lead to the steering wheel as defined in ECE Regulation № 79. Steering vehicle and stability in general technical requirements component standard OST 37.001.487-89 and GOST R 52302-2004. Test methods are defined in competent standard OST 37001.471-88. Testing is performed on stationary and moving vehicle. When moving vehicle is a vehicle moving at a speed of 10 km/h. When the existence of booster testing is performed on a minimum number of engine revolutions, the absence of enhancers with engine not. Angular speed craft accurate control should not exceed the 60 o/s .

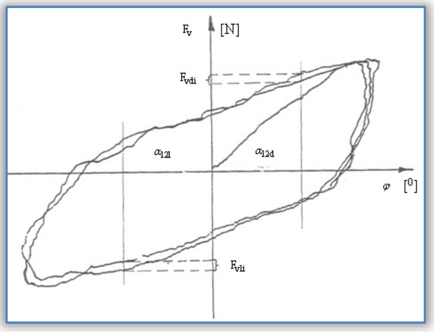

Figure 5. Form of records depending on the operating point of force from the corner of his turn.(OST 37.001.471-88, 1989) (Majkić, 2012)

In the examination record, the following quantities: the angle φ of turnaround management point, the force F_V applied to the steering wheel and the turnaround time t. Processing of the diagram represents the dependence of force F_V applied to the steering wheel angle of the steering wheel φ craft, which is obtained by transforming the two-time records in the specified parameter.

On the figure 5 shows the model of results depending on the operating point of force from the corner of his craft.

The diagram shows the angles of turnaround management point, corresponding to the movement of the front outer wheel in a circle $R = 12m$ and the left φ_{12l} and right φ_{12d}. The interval for $\alpha = 0$ to $\alpha = \alpha_{12}$, each of thei i-th experiment is the maximum value F_{vd} and F_{vl} power, which is taken for judgments indicator. In the event that the minimum radius trades vehicles on the outside front wheel is greater than 12 m, the value F_{vdi} and F_{vli} determined by the maximum steering wheel angles trades. If difference in value F_{vdi} or F_{vli} tests are repeated.

5. THE MATHEMATICAL MODEL OF THE CONTROL SYSTEM

Figure 6 is represented by the control system "driver - vehicle (with power repeater) - Environment" (Ulrich, et al, 1998). Since mutual relations in figure 6, the obvious there is no need for further detailed explanations.

The mathematical model of the control system which is presented in figure 7 is made in a special module Simulink Matlab which is intended to simulate the dynamics of the system in a graphical environment. Each element of the control system was introduced certain blocks containing mathematical relationship between inputs and outputs of this element. Variable inputs and outputs are seen as signals and the blocks are connected oriented lines that indicate the flow of signals from one block to another (Ulrich, et al, 1998), (Ćalasan, et al, 1996).

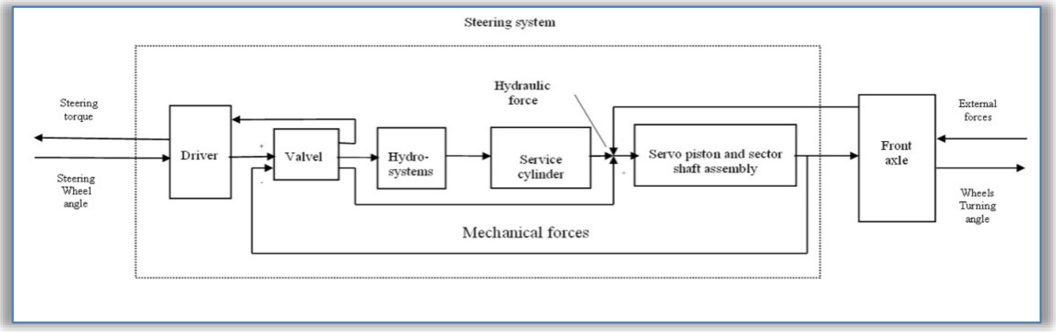

Figure 6. Block diagram: Driver - Vehicle (with power repeater) - Environment (Ulrich, et al, 1998), the mechanical part of the system for managing

Model control system, with the construction of the steering mechanism gear-rack with power repeater, provides data acquisition, output displacement of the rack depending on the simulated inputs, rotate control point (the wheel), which is generated in the form of a sinusoid for 4 s.

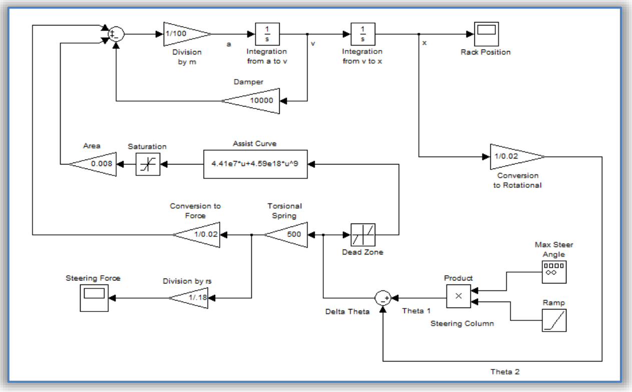

Figure 7. The model of the hydraulic control system

Scrolling is obtained by performing a double integration of acceleration moving the rack. In connection gear – rack effect three powers: the friction force created by torque steering deflection and moments of friction in the transmission mechanism, the driving force obtained by the torque generated by the driver on the steering wheel, and the power obtained from power amplification, figure 7 see that the force of positive and which negative sign.

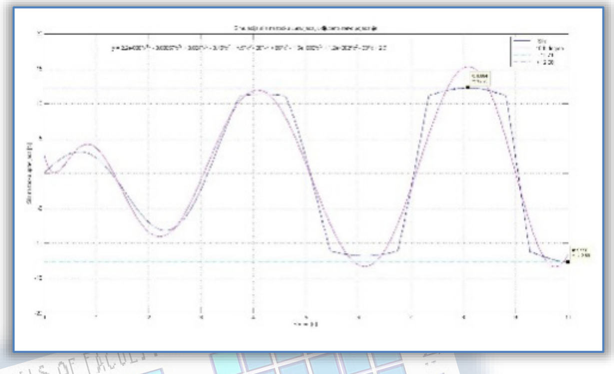

Figure 8. The model of the hydraulic control system

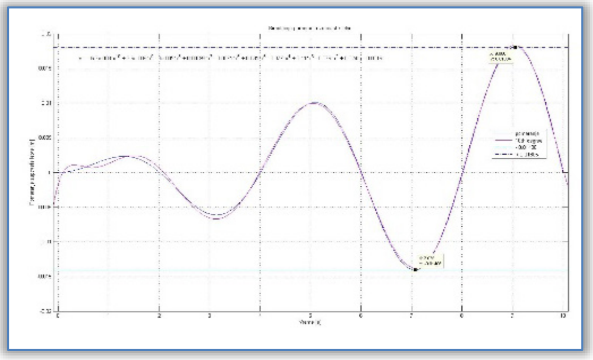

Figure 9. Move the rack with the included power amplifier

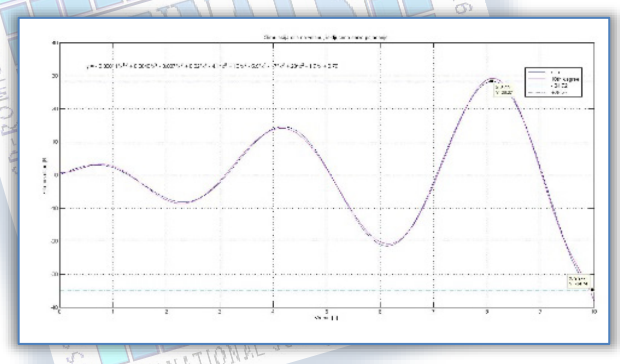

Figure10. Simulation force on the steering wheel, turned off power amplification

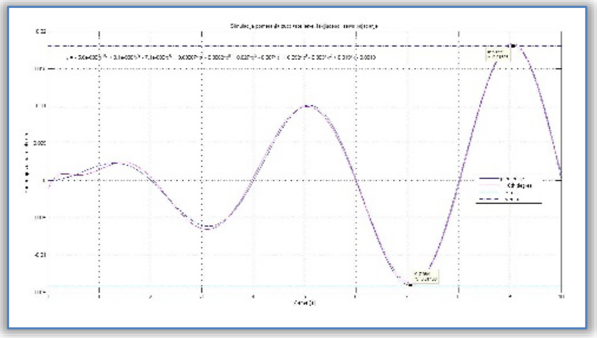

Figure 11. Simulation of moving the rack, off power amplification

Behavior power amplification described mathematical formula. Model of this system is given a period of 4 sec for input management with increasing magnitude which is 0 when t=0, and 1 radian achieved for t=10 sec. When involved hydraulics maximum force on the steering wheel is 12,28 N. With off hydraulics maximum force on the steering wheel is 35 N.

Turning off the power amplification, it is made in such a way that the completed model brings to the surface of the piston is equal to zero.

From the results of displacement of the rack, it can be seen that the displacements shown no difference with or without a power amplification, which corresponds to the real situation, the difference at the time or rotation of steering wheels and lodged force on the steering wheel.

6. VERIFICATION OF SELECTING AN APPROPRIATE HYDRAULIC POWER STEERING

Verification of selecting an appropriate hydraulic power steering was done by examining the forces at the point of control for mobile, stationary and in the work without enhancers on the structure of prototype truck configuration axle 6x6. Using power steering gear with drop arm travel of 96^0 on 6,1 steering wheel turns, and with steering gear ratio 22,7:1. According to the criterion ECE 79 for the vehicle category N2 is predicted maximum force at 250 to the extent steering wheel when entering vehicles speed 10 km/h from the direction of the radius of curvature 20 m at the time of 4 sec., in case of accident servo system forces the extent steering wheel should not be greater than 350 N. For stationary vehicle maximum force on the steering wheel with servo gain is included 180 N wile off with servo gain amount 350 N. Test results are presented in Figures 12, 13 and 14.

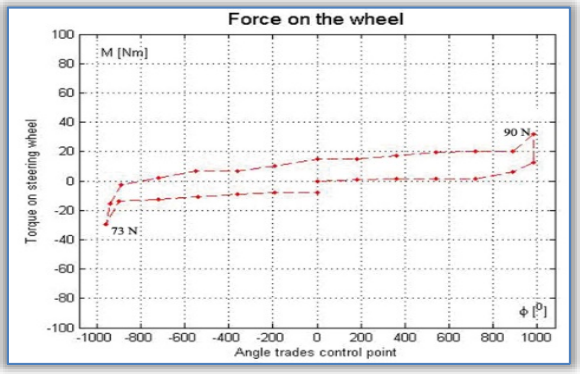

Figure 12. Force on the wheel, included hydraulics, movement speed(brzina 8-10 km/h).(Minić, 1992), (Majkić, 2012)

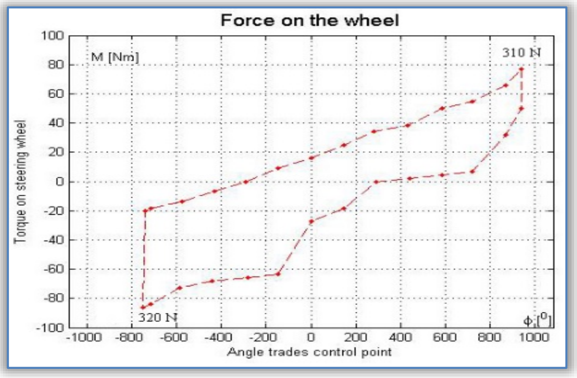

Figure 13. Force on the wheel, driving without hydraulics.(Minić, 1992), (Majkić, 2012).

The figure 12 shows that the maximum torque on the steering wheel 327 Nm which corresponds to the force 90 N a which is less than the upper allowable limit 250 N. From the results it can be seen that the force when reversing to the left side is equal 73 N. From the figure 7 it can be seen that the movement excludes the amplification maximum torque at the steering wheel 320 N which is realized in 2.1 the steering wheel crafts, which is less than 350 N.

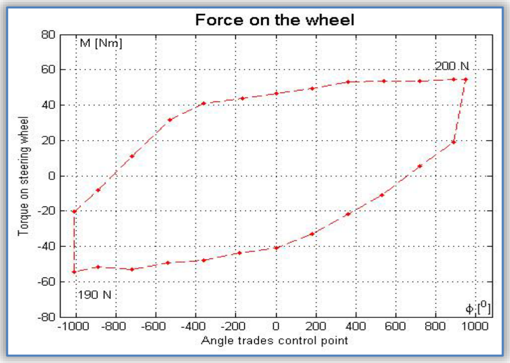

Figure 14. Force on the wheel, included hydraulics, without moving (Minić, 1992), (Majkić, 2012).

The figure 8 shows that the maximum force in reversing the steering wheel in the hydraulics is included 200N, corresponding to craft the steering wheel 2.63. According to the criterion obtained value is beyond the permissible values for 20 N.

7. CONCLUSIONS

By designing the control system for motor vehicles define the basic parameters of its elements and systems, ensuring the achievement of required driving. The main input in the design servomechanism is to determine torque turning the front wheels. To achieve proper torque values turning steering wheels it is necessary to take account of the above influential factors, as this ensures less load elements in the system of management on the one hand, and on the other hand it is possible to facilitate management by reducing the torque or force at the wheel. In ECE Regulation No.79 is defined by the maximum force that can lead to the steering wheel, on this parameter management system in the development of vehicles should take into account. Piston stroke length and hydro cylinder determined angles for maximum turnaround of steering wheels and composed scheme nears within the control system of the vehicle, then determines the diameter of the piston as it nears. Preference reconnects hydro booster, would be undermined basic requirement to be placed in front of the control system and it is the return of steering wheels after leaving the curved position linear movement under the influence of stabilizing torque. To prevent reconnects the servo is mounted reactive and centering element. Initial force of the central spring ensures the return of the steering wheel and the steered wheels, under the influence of stabilization torque without the involvement of enhancers. The force of friction in the control mechanism must be less than the prestressing force of the central spring F_n. Properly designed enhancer must ensure that the momentum of the executive summary of the cylinder and the driver exceeds torque throughout the range of angles of rotation of the wheels. Displayed analysis showed that a reduction of force on the steering wheel can be reached by increasing the angular gear ratio steering mechanism, reducing unnecessary losses to friction in it and increasing its efficiency coefficient reducing arms trade control wheels and applying enhancers. A large enough angle gear ratio steering mechanism is a factor that allows substantially reducing the forces acting on a wheel of the vehicle turnaround time. Considering the results of tests on a control point depending on its angle trades can be concluded that the selected hydraulic servo corresponding to a given transport vehicle drive formulas 6X6.

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