THE STUDY OF CONSTRUCTIVE FUNCTIONAL ASPECTS OF THE STEERING SYSTEM FOR MOTOR ROAD STEADS

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ABSTRACT: *The paper presents the constructive functional aspects of the steering system of the motor road steads, types of systems, solutions adopted in practice, symptoms and defections and diagnostic methods. The purpose of the direction system is very important because it is a vital component for the safety and performances of a motor vehicle. For maximum safety, agility and comfort we need a good and precise operation of the steering system*

KEY WORDS: steering systems, motor vehicles, constructive types, road tests, checking.

1. THEORETICAL considerations

1.1. Generalities considering the steering system

Steering is made up from the totality of the components, bindings, etc. which allow a ship or a vehicle to follow the required course. The steering system, figure 1, is a group of pieces which transmits the movement of the steering wheel to the front wheel or sometimes to the back. When a motor vehicle is driven straight ahead, the steering system must keep the direction without needing constant corrections from the driver. The steering system must allow the operator to feel the roadway, to contribute to the maintenance of an adequate tyre cover- roadway contact. For a maximum traffic duration of the tyre covers, the steering system has to maintain an adequate angle between tyres during the curvatures and during the straight line driving as well. The driver must be capable to control the direction of the vehicle with little effort but not so easy as to be difficult to control.

The instrumental purpose of the direction is to ensure that the wheels are oriented in the required direction. This can be realized through a series of bindings, stems, pivots and other components.

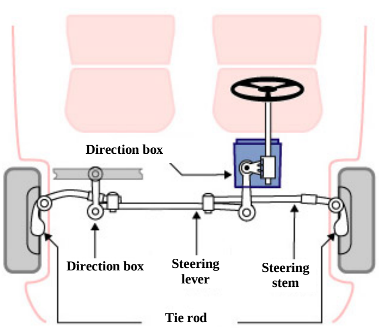


Fig.1 Steering System

The steering mechanism which binds the direction box and the wheels usually attends to the fact that in a curvature the interior wheel drives on a way with a range lower than the exterior wheels. The steering system must assure a good stability of the motor vehicle to the straight road but also to the curvatures. It also has to assure an easy driving and a minimum effort from the driver. During curvatures, the steering wheels are not parallel; the interior wheel veers much more than the exterior one. For assuring the stability and easiness during driving the wheels and pivots are fixed inclined. This way the wheels have the tendency of keeping the direction rectilinear when the wheel is left free for a short time.

To some motor vehicles the direction is with hydraulic action or electric (servo-assisted steering) for facilitating the driver's efforts. Servo-assisted steering is a system which helps the orientation of the wheels with an energy source, other than the driver's manual force with which he activates the steering mechanism. This characteristic adds up to the comfort during driving, a lower effort being necessary for the activation of the direction by the driver. Servo- assisted steering is very important for the cars which have the engine in front, this causing a significant weight inflicted on the front wheels. For the cars that have the engine at the back, one can drive comfortable even if the servo-assisted steering mechanism is missing due to the low weight on the front wheels. However, for the heavy cars servo-assisted steering is a necessary characteristic which facilitates the operating of the system.

The hydraulic power steering operates high pressure liquids to assist with the steering movement by using a piston type arrangement. When the driver operates the wheel this opens the flow of the pressurized fluid so that it contributes to the movement of the wheel movements in the required direction.

Electric servo - assisted steering functions with the help of an electric engine and a control unit with sensors. The engine runs on battery, uses electric energy to help the steering movement when the driver operates the steering wheel.

1.2. Wheels alignment – general notions

The motor vehicle position' represents the geometric condition of all components which contributes to the wheel position determination while driving either straight line or curved. This is checked only stationary.

When the motor vehicle is moving, due to the variable burdening states, multiple forces emerge created by the endurance to the advancement, weight, acceleration or deceleration, created by the couple engine, centrifugal force, brakes, etc. which tend to modify the geometric position.

When the geometric position is adapted in conformity with the data delivered by the producer, the above factors are taken into consideration but also the correct balance of the forces and also their application point during movement. All these mean that the true "forces balance" can be achieved exactly as if the motor vehicle would be moving.

1.2.1 The fundamental conditions of geometric vehicle.

Like the angle characteristic of the wheels, the motor vehicle must satisfy certain conditions of symmetry and perpendicularity to the axis, as shown in figure 2:

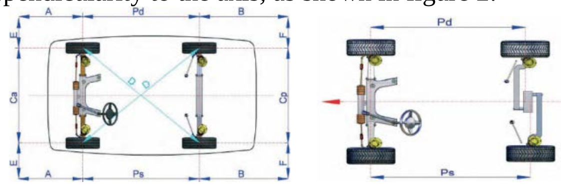


Fig.2

The wheelbase and the tracks do not need to be equal at all times. Actually, there is a large number of cases where the traces are different, and rarely, when the wheelbases are not equal. The typical cases where wheelbases are different can be found on some motor vehicles with front-wheel drive.

The symmetry condition of the carriage can be verified several ways: an easy method of verification is by projecting the measurement points to the ground level with a plumb line. This should be made at ground level, figure 3 and the essential condition is that the wheel pressure should be the one indicated by the producer. Another important condition that should be considered is the distribution of weight which operates upon the motor vehicle and the effects of the longitudinal and transversal towards the ground.

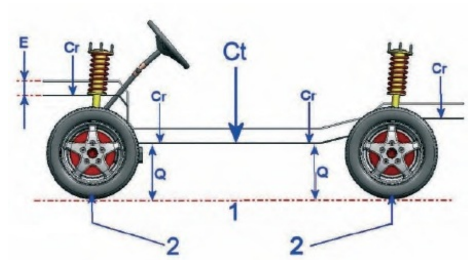


Fig.3

The motor vehicle can be empty (only with the driver inside) or with passengers, and with or without fuel or baggage; the influence of these variable conditions of loading towards the suspension's compression of the elastic parts and the effect of certain forces during the motor vehicle's displacement conduce to the variable position of the wheels' geometry. We draw the conclusion that a thoroughness knowledge of the wheels' geometry and of the effects generated by the conditions of usage of the motor vehicle is necessary for an intelligent interpretation of the data given by the producer and of the applied gaps.

The current practice of measuring the geometric position of the motor vehicle in a unloaded state, in the case where there is no other method specified by the producer: this is used so that the measurements can be made rapidly and because this unloaded state represents the closes variant to the conditions of daily usage of the motor vehicle, this motor vehicle operates most of the time with the driver on board; an exception is made when it is checked if the variants produced during the maximum loading of the motor vehicle have as effect the compression of the elastic elements of the suspension alters or not the elasticity characteristics and geometric positioning.

Before checking the geometric position of the motor vehicle it is essential that the following fundamental condition should be observed:

- The localization and elimination of any suspension gap or steering gap, figure 4;
- The positioning of the motor vehicle on a plane surface;
- Checking the pressure of the wheels
- Keeping and taking into consideration the specific loading condition;
- Keeping and taking into consideration the distribution of the capacity;
- Checking the possibility of an irregularity of the elastic parts of the suspension and of the inflexibility of the articulations

The elements of the suspension

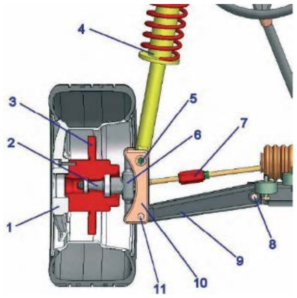


Fig.4 – The elements of the suspension:
1-Rim; 2-Pivot; 3-Hub; 4-Damper; 5-Damper articulation; 6- Steering pin; 7- Shim rod for adjusting the angle of camber and of camber of wheels; 8- Articulation; 9- Suspension arm; 10- Inferior toggle joint;11- Articulation

1.2.2. The dynamic of the motor vehicle and steering: Generally speaking, when the wheel turns into one direction, one expects that the car drives where indicated. At low speed, this situation will always be the case but once the speed increases, things change. During racings, aerodynamics wings, air classifiers help maintain an equilibrium of the motor vehicle in the curvatures together with the weight position and suspension configuration. The two most frequent problems are understeering, figure 5 and over steering, figure 6:

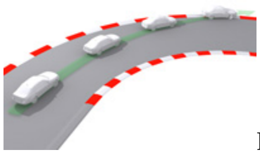


Fig.5

Understeering is called this way because the car veers less than it is required. The understeering can be caused by all kinds of problems of the carriage, suspension and speed but basically, this means that the car loses adherence on the front wheels. Usually this happens while the break and the weight is transferred to the front part of the car. In this moment the mechanic attachment of the front tyres may be overwhelmed and start losing adherence (for example, on a wet or oily roadway). The final result is that the car will enter in a broad curve. In order to get out from the understeering the bearing of the accelerator pedal can be reduced for the motor vehicles with front-wheel drive (it gives the tyres a chance of attachment) or the bearing of the accelerator pedal for the motor vehicles with back-wheel drive.

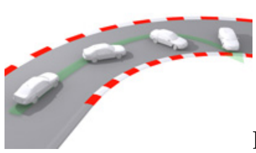


Fig.6

Over steering is the opposite of understeering. When over steering the car operates more efficient than necessary, the result being the entrance in the curve faster than expected. The over steering is determined by the loss of the back wheels' contact so that the weight is transferred from them when braking. Without counter direction the final result is that the car would spin and ends by driving inside the curve, back.

Aquaplaning: The state of floating of an automobile which drives with high speed on a layer of water. Has as an effect the control loss of the direction, the motor vehicle tending to continue its displacement on the inertia direction.

Sideslip: The aside slip of a motor vehicle which moves according to the advancement direction. This appears especially on slippery roadway (glazed frost, snow, square stone, etc.) at high speed and when the wheel or the brake are operated suddenly.

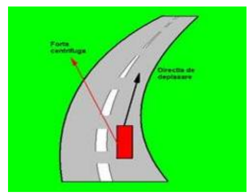


Fig.7

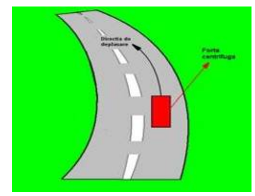


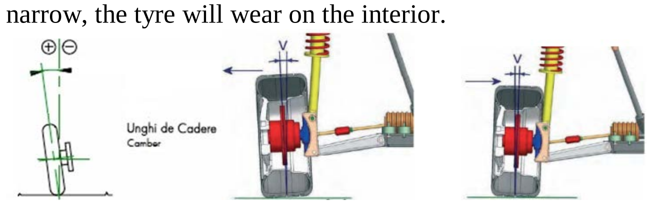
Fig.8

Centrifugal force: operates upon the motor vehicle during a curve and tends to move towards its exterior. If this force is higher than the adherence then the motor vehicle starts to slide-slip, figures 7 and 8.

1.3. The angles characteristics to the steering

Angles towards back axle: The camber angle of the wheel; the angle of convergence and negative convergence of the wheels.

1.3.1 The camber angle takes over the game bearings and it is the angle of inclination of the wheel in a vertical plan, figure 9. The camber angle is the angle, measured in degrees, between the median line of the wheel and perpendicular to the ground, when one looks at the vehicle from the front. If the camber angle is too wide, the tyre will wear on the exterior. If the camber angle is too narrow, the tyre will wear on the interior.

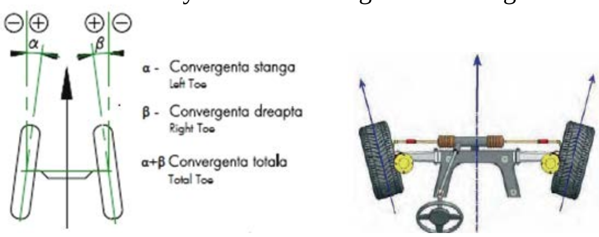


The camber angle | The positive camber angle | The negative camber angle

Fig. 9

The camber angle is the angle, measured in degrees, between the median line of the wheel and perpendicular to the ground, when one looks at the vehicle up front. If the superior part of the wheel is inclined towards the exterior of the vehicle, the camber angle is positive. If the superior part of the wheel is inclined towards the interior of the vehicle, the camber angle is negative. The reasons for which the wheel has a camber angle derives from the fact that if the tyre would be positioned perfectly on the ground and the wear on the course surface would be symmetric, then the wheel should have the camber angle 0 (i.e. perpendicular to the ground) for every situation that appears during the course. Considering that these situations are extremely variable, the existence of a positive or a negative camber angle adjusted correctly must be acknowledged.

1.3.2 The convergence angle is the inclination angle in horizontal plan between the wheels of the same bridge, figure 10. For the motor vehicles with back-wheel steering, the steering wheels are divergent or parallel. The convergence of the wheels is the angle formed by the median line of the vehicle (the line that crosses longitudinally through its centre) and the median line of the wheels when one looks at the vehicle from above. The sum of the convergent values of each wheel (α+β) gives total convergence. When the extension of the central lines of the wheels tend to meet in front of the vehicle, we say that there is positive convergence ; if these tend to meet behind the vehicle we say that there is negative convergence.



Convergence Divergence

Fig.10

When the median lines of the wheels are parallel with the median line of the vehicle we say that there is 0 convergence. Negative convergence is rarely given in degrees by the producer, usually it is given as measured value in mm between the wheel rims; the two measurements are made in front and in the back of the hub, at the half height of the rims/wheels.

Convergence is adjusted by turning the cross-bar connection bar.

The glide of the wheel

The convergence can be expressed in another way.

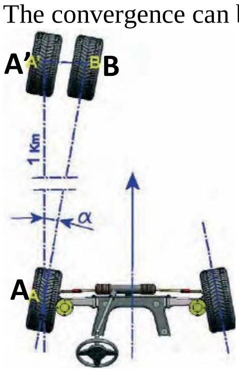


Fig.11

If the wheel under the convergence angle is allowed to run freely, without an impediment, in the direction generated by the convergence with respect to the longitudinal axis of the vehicle, after a certain distance this will be in a different position towards the one that is actually in reality, the position in reality being forced by the vehicle's weight and by the resistance created by the other wheel of the same axle.

It is obvious from figure 11 that, after running 1 km, the free wheel will be in position B but the reaction of the other wheel forces it to get in position A'. Therefore, for each reversion/ rotation, the wheel operates a lateral movement which based on the 1 kilometre distance has a value equal to A'B segment, segment which is increased concordantly with the amount of the convergence value.

The lateral movement is defined as a lateral move which, based on one kilometre distance has a value equal to segment A'B, segment which grows concordantly with the capacity of the convergence value.

Lateral movement is defines as wheel slip and can be measured in degrees, namely, the angle between the longitudinal axis of the vehicle with the direction axis of the steering wheel axle; for a value in meters , the A'B segment is measured on a certain distance A'A. Conventionally, it has been established that the wheel slip is measured in metres per kilometre, which means how many m the wheel slides per each km travelled by the vehicle.

1.4 Steering pivot angles. The transversal inclination of the steering pivot or simply 'the kingpin inclination' ; longitudinal wheel caster angle or simply 'caster wheels', figure 12.

1.4.1. The transversal inclination of the steering pivot has a stabilizer role for the wheels and it is the angle between the pivot's axle and the vertical line.

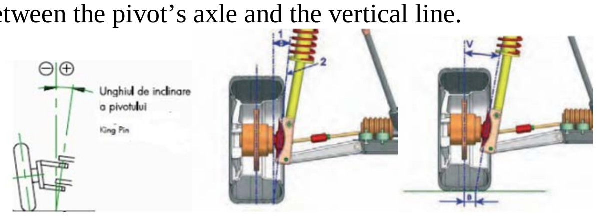


Fig.12

The kingpin inclination is the angle, measured in degrees, formed between the median line of the pivot and perpendicular to the ground when one looks at the vehicle from the front. The camber was invented for the purpose of reducing the deviation of the pivot, represented by distance "B" between the projection of the pivot's axis to the ground and the point of contact of the wheels. However, it was observed that an amplification of this angle creates negative effects, especially when there are used wheels with tubeless tyres. Therefore, it was felt the need of reducing very much the angle of camber almost to value 0; this being necessary for obtaining uniform tyre wear. The problem has been solved by tilting the pin towards the inferior part of the wheel, figure 13.

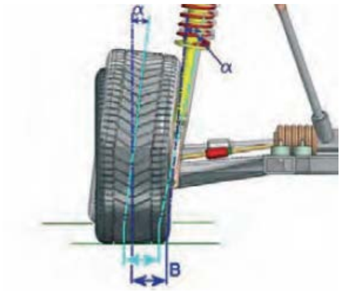


Fig.13

In the case of rigid axle suspension, kingpin inclination does not vary under the effect of the weight and vertical movement of the wheel, provided the axle does not distort; in the case of independent suspension , the weight and vertical movement of the vehicle makes both the angle of camber and the inclination of the pivot to vary the same, since the pivot moves together with the wheel hub. The kingpin inclination is considered positive when the pivot axis projection reaches almost to the point of contact of the wheel running surface (inclined to the opposite part of the angle of camber); it is difficil , if not impossible to have a negative inclination of the pivot.

Included angle – angle between the pivot axis and wheel axis is equal to the algebric sum of the kingpin inclination angle and the angle of camber, figure 14.

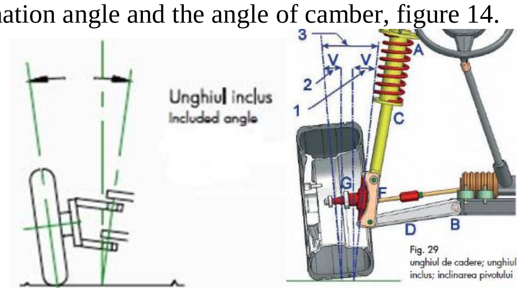


Fig.14

The angle of inclination of the pin, among other things, creates the phenomenon of return of the wheel forward position; also, it tends to maintain this position after an impact with an obstacle. This natural effect, which is of a vital importance, because of the pivot inclination, derives from the fact that the wheel, when it revolves around this oblique axis, forms a cone pointing down.

1.4.2. Caster angle – helps recover the wheels straight after turn to come back in and it is the angle of **longitudinal inclination of the pivot**.

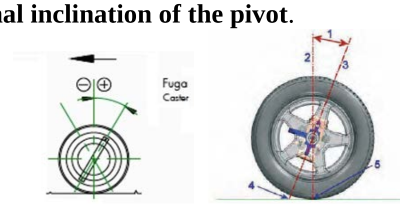


Fig.15

1-Inclination of the pivot; 2- Vertical axis; 3- Pivot axis; 4- The point of contact between the pivot axis and running surface; 5- Point of contact with the ground

The caster angle is the angle measured in degrees, formed between the pivot axis and perpendicular to the ground, one looking at the vehicle in lateral position. Since this angle is formed longitudinal with respect to the vehicle, the more precise definition is: the longitudinal caster angle. In the practice usage it is known simply "caster". Conventionally, it has been determined that if the pivot axis extension falls in front of the contact point of the wheel running surface, the caster angle is defined as being POSITIVE, and if this falls behind the contact point of the wheel running surface, the caster angle is defined as being NEGATIVE. The caster angle given by the pivot creates two very important tendencies of the running vehicle: the first tendency is connected by the stability, keeping the vehicle running straight with the wheels relative return after a curve and the second is the inclination of the wheels during veering.

Stability

This phenomenon is created because of distance 'B', distance between the projection point of the pivot axis, point 'l' (in relation to the direction of travel) and point of contact of the tyre with running surface (figure 16). The figure shows two wheels with caster angles positive (the extension of the pivot falls before the tyre point of contact with the running surface) using two systems: one is to bend the pivot and the other one is to move the position of the pivot related with the wheel axis. The stability when driving in a straight line is present in both cases. Actually, in the case of the positive caster angle, the wheel is pulled, since it is in the line of action of the force applied to the axles, force that goes through point 1 present in the front of the wheel (without considering the direction of travel)

Any attempt of the wheel to deviate from the direction of travel (in a straight line) will be counteracted by the couple alignment generated by force 'S' and the endurance to the rolling wheel 'R'. However, in the case of the negative caster angle, the wheel is pushed since it is on the application line of the force which operates on the axe, force which goes through point 1 present behind the wheel (without considering the direction of travel). Any attempt of the wheel to deviate from the direction of travel (in a straight line) will be supported and amplified by the couple generated by the force 'S' and the rolling endurance of the wheel 'R'. Consequently, the best condition of stabilization for the travel in a straight line of the wheel is obtained with a caster angle positive and so, the pulling of the wheel. Actually in this case, the oscillation phenomenon of the wheel and its negative effects are eliminated.

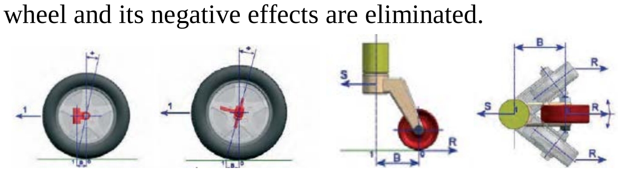


Fig.16

The inclination with the wheels in veering position phenomenon. The wheels angle of camber varies concordantly with the position or with the length of the suspension arms under the compression and expansion effect. This effect is useful when we veer, when the centrifugal force which distorts the parallelograms (formed by the suspension arms) modifies the caster angle, negative for the exterior wheel of the veering and positive for the interior one. The same result is obtained for the wheels which present caster angle.

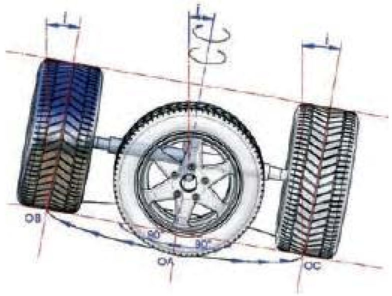


Fig.17

When the wheel, figure 17, reverses around the pivot axis with the caster angle positive, if it is in the exterior position of the curve, it will gain a negative angle of camber which increases at the same time with the veering wheel, and therefore will move against the tilting of the vehicle; on the other hand, if it is in the interior position of the curve, it will gain positive angle of camber, and assists to the veering. Consequently, when the vehicle follows an wide curve at a very high speed, the centrifugal force, through the deformation of the parallelograms, will be the one which helps to the positioning on the road; when the curve is very narrow and the speed is moderate, the caster angle will be the one which determines the modification of the angle of camber to support the following of the trajectory.

Frontal axis angles or directional axis of the vehicles are:

-the wheel angle of camber

-the convergence of the wheels

-the negative convergence of the wheels when veering, figure 18

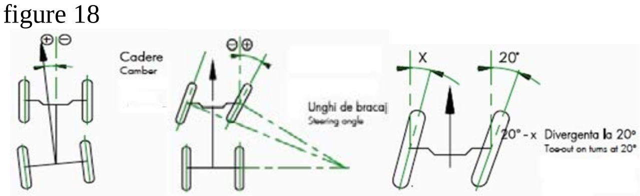


Fig.18

1.5 Steering geometry: The characteristic angles previously discussed, position the wheel precisely during the rolling in a straight line; besides this fact, there are other particular effects sensed during a curvature negotiation. When the wheels are locked, another important condition is created, condition directly connected by the radius of the negotiated curve, figure 19.

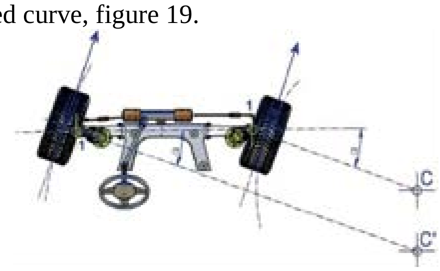


Fig.19

For understanding this condition, it is better to consider the rolling speed of the wheel being very low, without interferences. In this situation there are no disruptive forces that operates on the vehicle, for instance, the centrifugal force, the later push caused by the wind, accelerator forces caused by the motor couple, etc.

An essential condition for preventing the wheel to be subject to lateral braking which would be bad for the tyre, is that, when it follows the imposed trajectory, this has to be perfectly perpendicular to the radius of the curve. The monitored vehicles are veered due to the articulations of the pivots; the wheels behave as they were on two separate bridges.

Curve convergence

The steering geometry is defined as the negative convergence position taken during veering; it is expressed in two ways, first one being in degrees, degrees of wheel reversion (considering a 20°, fixed value of the reversion, conventionally determined)

Steering centring

The steering centring, figure 20, is represented by the perfect symmetry condition of the steering parts related with the longitudinal axis of the vehicle. The steering of the vehicle is centred when the steering connecting rods converge towards the centre of the back axle:

- The axis which go through the front wheels (regardless if they have or not convergence) are symmetrical related with the back wheels (distance A)
- The steering connecting rod, the pivot and the steering come back into the central position;
- The adjustable steering connecting rods have the same length (distance B)

When the steering is centred, the steering geometry is perfectly symmetrical over area, either we veer left or right. The same principle applies in relation with the maximum reversing limit of the wheel.

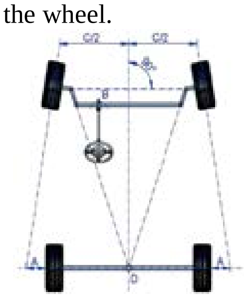


Fig.20

2. TYPES OF STEERING SYSTEMS, SOLUTIONS ADOPTED IN PRACTICE

2.1 The types of mechanism/steering systems.

Figure 21 presents the classification of the steering system types and figure 22, 23, 23 and 25 present the constructive functional schemes for the most represented steering systems. For the hydraulic steering, figure 26 presents the block scheme of the hydraulic installation which deserves this system.

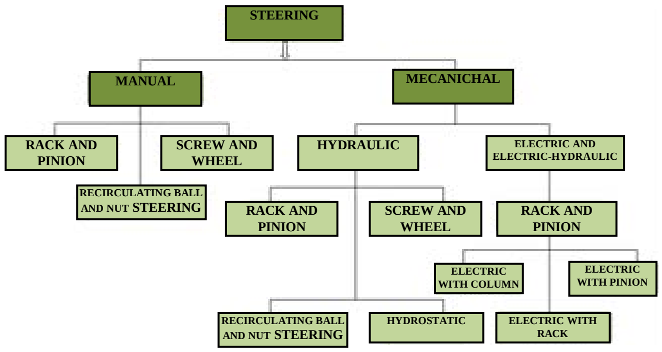


Fig.21

Rock and pinion *Screw and wheel* *Recirculating ball and nut steering*

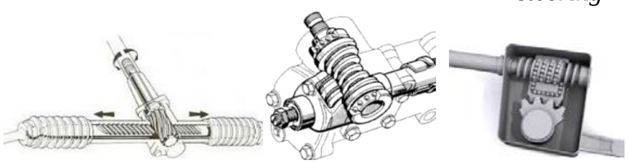


Fig.22 The manual steering system

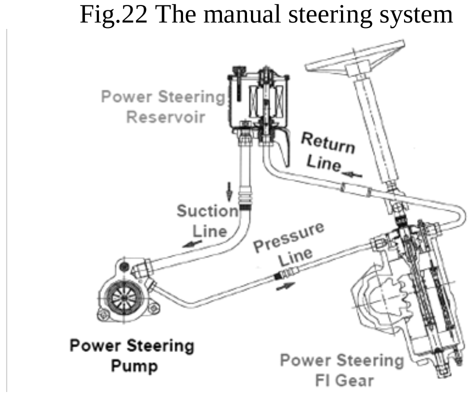


Fig.23 Hydraulic power steering

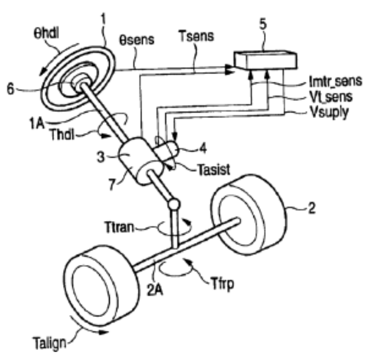


Fig.24 Electric power steering

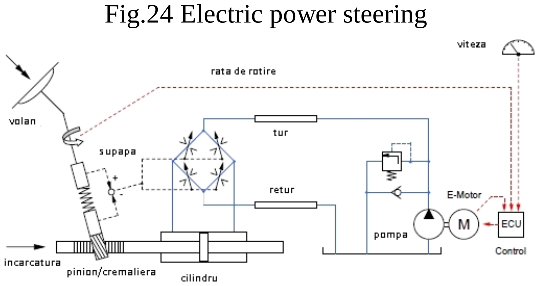


Fig.25 Electric hydraulic power steering

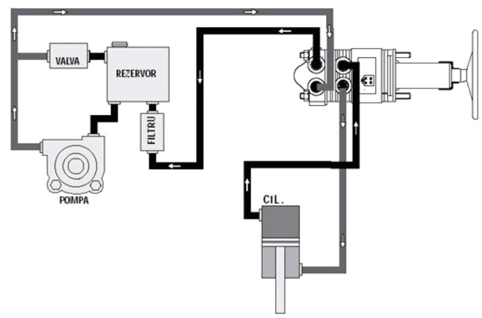


Fig.26 Hydraulic steering

Hydrostatic steering: For the hydrostatic steering there is no mechanical connection between the steering column and the steering wheels. Alternatively, there are hydraulic pipes and hoses between the steering unit and the steering cylinder. When the wheel is span, the steering unit measures the quantity out of an oil volume proportional with the spinning wheel rate. This volume is directed towards the corresponding part of the steering cylinder, while the oil is directed towards the tank. In the systems with open centres the steering unit is powered with oil from a separate pump with fixed displacement.

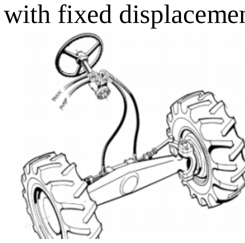


Fig.27 Hydrostatic steering system with open centre

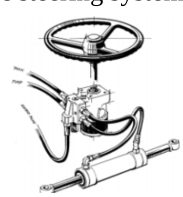


Fig.28 Hydrostatic steering system with loading sensor


Fig.29 Hydrostatic steering system with loading sensor and flow amplifier

In the load sensing systems, a pump can provide oil to the steering system and to the hydraulics. A priority valve ensures that the steering always has priority.

Flow amplifiers: For large vehicles and ships, for the steering units can be used flow amplifiers that amplify the flow of the oil to the steering cylinders.

Hydraulic steering is a technology used for decades that has been greatly improved lately. Previously, it had no reaction response dependent on the speed of the car but with the advent of new technologies it has become sensitive to speed. Electric power steering is a relatively new technology with construction and mechanism less complicated and occupies less space and it is more durable. Electric power steering sensor detects the speed of the vehicle and generates different answers needed by the steering at different speeds. Some of the main differences for the hydraulic steering in contrast with the electric power steering power are as follows:

1. The hydraulic power steering is complicated compared to electric power steering.
2. Hydraulic power steering usually weights more than the electric power steering.
3. Hydraulic power steering uses hydraulic fluids to operate while there is no such fluid needed for the electric power steering that needs much less maintenance.
4. The electric power steering gives better response at different speeds in regard to hydraulic power steering.
5. The electric power steerings are less prone to problems and defects, and they are more durable.
6. The hydraulic steering extracts energy from the engine, so it makes a contribution to engine fuel. The electric power steering uses energy from the battery so the engine consumes less power. Conclusion: the electric steering is more efficient than the hydraulic power steering.

3. PERFORMANCE SYMPTOMS, FAULTS AND CONTROLS

3.1 The symptoms of an improper alignment of the steering system for a truck are:

- Heavy steering – The wheel is handled with difficulty even when the truck does not carry weight. Furthermore, the vibrations are one of the most common signs of wheel misalignment.
- Truck pulls to one side - If the wheel has a tendency to pull either left or right when driving on a paved road, this is a sign of poor wheel alignment.
- Excessive over steering or understeering. The steering wheel does not respond or responds faster than normal.

3.2 Technical Control RAR (Romanian Auto Register) of the steering system

It is performed in traffic (CTT) and in the ITP or RAR stations dependent on the frequency of the undergoing periodic technical inspections. The control carried out by the RAR specialized service takes into account the rear and front axle:

- State, fixing: steering wheel, steering column, steering mechanism;
- Games: steering wheel, steering column, joints, levers, rods;
- State, fixing, performance, tightness: power steering.

4 THE STEERING DIAGNOSIS, PRACTICAL MEASURES

The technical condition of the steering system is particularly important for road safety. It contributes significantly to ensure performance of manageability and stability of the vehicle and influences the tire wear intensity. The state changing of the steering system consists of:

- Processes of wear in the steering mechanism, in the lever joints, in guiding the steering column bearings and couplings between these and the steering gear;
- Galling in the steering gear and in the levers articulations;
- Weaken or damage of the steering catching chassis;
- Deformation of the steering levers;
- Deformation of the deck components that determines the geometry of the steering wheels.

The diagnostic parameters of the steering system are:

- The free play of the steering wheel;
- The operating force of the steering wheel;
- The play in steering joints and in the axle arms;
- The lateral force on the tyre contact area with the ground;
- Angles that define the geometry of the steering wheel

4.1 The diagnosis after the play angle and the steering effort

The free play of the steering wheel is a parameter of global assessment of the degree of wear and of tightening the steering components.

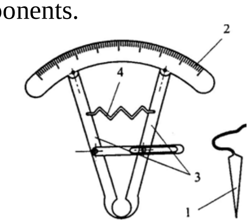


Fig.30

The measurement is done with a device like the one in Figure 30. The indicating arrow 1 attaches to the steering wheel rim and the goniometer on the fixed envelope of the steering column that are tight by bow 4. The steering wheel rotates alternately in both directions until an observer in front of the car observes the beginning of the steering wheel movement. The game steering wheel must not exceed 15 °. The causes of an increased game can be: wear joints (which increases the game with 2-4°); the loosening of the fixation of the steering gear box (which contributes with 10-20°); the wear of the knuckle pivot and its bushings (3-4°).

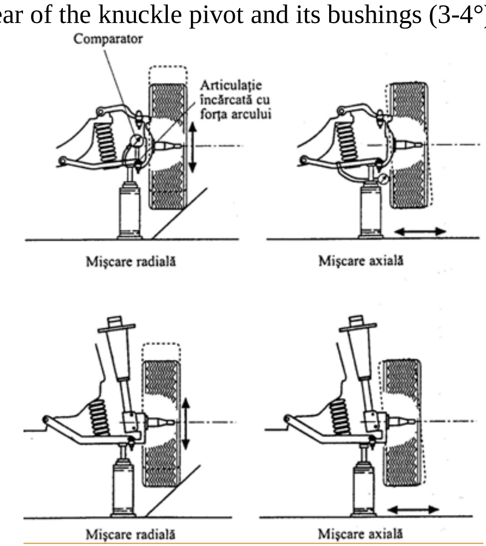


Fig.31

To locate the games, with the help of a jack, each steering wheel is suspended one by one. Catching the wheel with both hands to the tyre, the energy oscillates vertically, examining the development of the joints, Figure 31. In order to verify the ball joints, they must be unloaded by the elastic force of the spring suspension that may result into the masking of the game by pressing the ambit of the carcase.

If the bow rests on the lower bridge, the jack will be placed under this arm, thus relieving the lower joint. If the bow is supported on the upper arm, a device that pushes up the upper arm will be used. These checks can be made using a plate stand as well. The automobile is brought with the wheels on the two plates of the stand. The brake pedal is maintained in a straight position. The plates are actuated by a hydraulic system so that it slides horizontally in the longitudinal direction and in the transverse direction as well. A technician who stays under the automobile, in the canal below the two plates, will visually locate the areas with games.

The effort required for the wheel spinning depends on the friction from the articulations, from the gearing of the steering gear box and from the bearings, the deformation of the levers or the wrong placing of the steering gear box to the chassis. For the measurement of the wheel drive, the vehicle is placed on a flat concrete or dry asphalt and the parking brake is operated. The dynamometer is gripped to the outermost part of the spokes of the steering wheel and the steering wheel is spun to the end position. The value should exceed the permissible value (between 3 ... 8 daN, depending on the system).

The checking of the wheel alignment must be preceded by the following operations:

- Checking and adjusting the nominal pressure in the tyres;
- Checking games in the articulations of the articulated rod and of the connecting rods;
- Placing the car on the chassis of diagnosis (the deviation from horizontality of the land on which it is located, must be less than 1%);
- Loading the vehicle in accordance with manufacturer's requirements;
- Rocking the vehicle several times, through pushing, to relax the suspension;
- Operating the parking brake
- Bringing the steered wheels in straight ahead position

Reading the tyre wear

The careful examination of the tyres provides a state indication of the alignment direction of the vehicle and prepares it for possible problems. If the tyres provide long life and are worn evenly across the tread, there are good chances that the alignment would require little or no correction. On the other hand, the misalignment or other problems can cause characteristic wear models on the tyres, and by recognizing them the problem can be identified. The examination of the tyres in this way is called the reading of the tyres.

The wear on the inside or outside - Increased wear in the inside or outside of the tread may be an indication of incorrect camber or the angle of convergence, or both. A negative camber causes wear on the inside tread. The left convergence will also determine wear inside the tread wear, but the wear will be the same for both front wheels. An excessive positive camber or right convergence will cause wear on the outside tread in the same way. In general, the wear caused by the angle of camber tends to be located near the end of the tread, or to the tyre shoulders, but it is not always the case as there are other combinations.

The angle of camber

The feathered edges - the type of wear caused by excessive camber, positive or negative. With the feathered edge wear, one side of each rolling ridge is high and "sharp", while the other side of the ridge is smaller and rounded. You can feel these edges by running your hand on the tread from side to side. When the hand stops sharp edges while moving out and glides smoothly, as soon as it is moved towards the inside, this is the positive indication convergence angle. It can also verify the existence of the uneven wear inside or outside of the front tyre. A wear feathered model usually indicate a convergence angle well beyond the normal specifications. These feathered edges indicate positive convergence angle. This condition will cause the outside tread wear on both wheels.

The wear on both edges – the wear both inside and outside edges of a tyre can indicate low pressure of the tyres. Low pressure of the tyres is the most common cause of rapid tyre wear. A tyre with low pressure declines too much to the sidewalls and has poor contact with the road surface in the centre of the tread. This can also cause overheating of the tread, the tire suddenly cracking and failure. Wear on both edges can be determined by aggressive veerings too.

The centre wear- may indicate too much pressure. This model has become less frequent in the case of radial tyres, but with nowadays wider rims and inferior sectional tyres, this might appear.

Too high tyre pressure

The diagonally wear – occasionally, a diagonal wear pattern appears on the rear tyres of the vehicle with front wheel drive. This is an indication that the convergence angle is outside the specifications. Because of the curves the wear convergence angle is distributed uniformly around the circumference of the tyre. Since the rear wheels carry less weight and do not rotate, excessive convergence angle makes the tyre have the tendency to shoot and then roll, the appearance of this wear model causing noise and vibration.

Irregular wear - may have several causes, although rarely due to alignment settings. Mufflers torn or broken can cause a wear laced tyre model. Damaged suspension parts can cause this type of wear, also other irregularities such as portions removed due to an unbalanced wheel, a wheel or damaged tyre.

The diagnosing of the steering servo mechanism (actuator):

The first step in the diagnosing of a steering servo mechanism steering is a careful visual inspection. The following are checked: the state of wear and the tyre pressure; the servo pump drive belt of the servo mechanism; the condition of the pipelines; the state of the steering levers and joints; the wheel alignment. If the belt is in good technical condition, it is measured its extent using a special machine, positioned on the belt midway between the pulleys. The possible drive operational fluid leaks and the operational fluid level in the tank drive will be checked. After the visual inspection, it will proceed to test the road conditions to find any abnormalities in the functioning of the actuator.

In some cases it is necessary to conduct additional tests: measuring the wheel drive force; the measurement of the required effort to the spindle lever movement; the checking of the system pressure; the checking of the pump; the checking of the actuator and of the control valve.

The machines used for the checking of the steering wheel alignment can be: mechanical; with telescopic rod (for checking the convergence); with spirit level (for the verification of the angle of camber and of longitudinal / transversal inclination of the pivot); optical, the most used because of their high accuracy.

Fig.32

In the past few years verification systems of the steering wheel alignment computer-assisted have appeared. These systems include wheel position sensors based on different operating principles (optical - infrared laser ray or gravitational). The signals from these sensors are processed by a system provided with microprocessor. The latter controls the entire technologic process, sending detailed instructions to the technician to perform various operations on the test, Figure 32.

Finally, such a system offers the diagnostic bulletin stating that based on the data bank that it has, what adjustments are needed and sometimes displaying a diagram monitor steering and suspension parts indicating on which to act.

Stand Cormach WR328 characteristics, Figure 33, used to check the steering system (trucks, buses, touring cars):

Fig.33

• 4 measuring heads, with 8 CCD high precision cameras with which the system can measure all angles of the front and rear rolling and that does not use any kind of cable in between.

• Data transmission system of measuring heads (front + rear) directly to the cabinet through the multi frequency communication (2.4 GHz) - without cables

• The measuring heads are provided with keyboard for selecting directly from the workstation.

• Electronic level for all measuring heads. The Romanian language software manages a database of touring cars and trucks with over 20,000 models; with the possibility of introducing an own database of 1000 models.

• Quick and simple graphical interface for selecting and displaying the measured data available.

• The working procedure with custom configuration options depending on the user’s requirements.

• The "help" function available on screen at any stage of the program.

• 40 GB hard disk drive PC (Windows), DVD optical drive, colour monitor, keyboard and colour A4 printer.

• Wheel locking device; Locking brake pedal; mechanical rotating platters, capac.3000kg, Ø 370mm

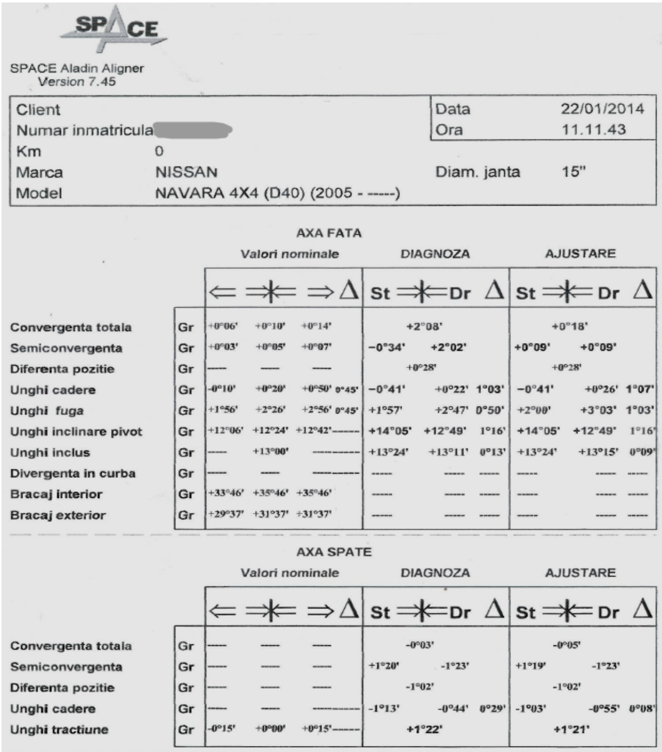
• 4 sensors with self-centring mounting brackets in 4 mounting points, with extensions for trucks and adapters for utility

4.2 Practical Measurements

The measurements of the steering system were made in a car service within a week. The collected values are represented in table 1.

Table 1

	FRONT AXLE									REAR AXLE								
	Nominal values			*Diagnosis*			*Adjustment*			*Nominal values*			*Diagnosis*			*Adjustment*		
	←	→	Δ	St	Dr	Δ	St	Dr	Δ	←	→	Δ	St	Dr	Δ	St	Dr	Δ
		→←			→←			→←			→←			→←			→←	
M1 vehicle , 4x2 traction; diam. 15'' rim; Dacia Logan																		
Semi convergence	-0°10'	+0°00'		+0°19'	+0°25'		-0°05'	-0°05'		+0°15'	+0°30'		+0°09'	-0°03'		+0°09'	-0°03'	
Angle of camber	-0°40'	+0°20'	1°00'	-0°13'	-0°43'	0°30'	-0°10'	-0°52'	0°42'	-1°06'	-0°36'		-1°58'	-1°29'	0°29'	-1°58'	-1°29'	0°29'
Caster angle	+2°12'	+3°12'	1°00'	+2°33'	+2°52'	0°19'	+2°08'	+2°47'	0°39'									
Angle of steering – knuckle pivot	-19°50'	+40°10'		+13°02'	+10°19'	2°43'	+13°02'	+10°19'	2°43'									
M1 vehicle , 4x2 traction; diam. 13'' rim; Dacia Logan																		
Semi convergence	-0°10'	+0°00'		-0°55'	-0°23'		-0°05'	-0°04'		-0°08'	+0°08'		+0°04'	-0°16'		+0°04'	-0°16'	
Angle of camber	-0°30'	+0°30'		-0°12'	-0°40'	0°28'	-0°15'	-0°38'	0°23'	-0°30'	+0°30'		-1°18'	-0°34'	0°44'	-1°18'	-0°34'	0°44'
Caster angle	+1°30'	+2°30'		+0°58'	+0°56'	0°02'	+1°05'	+1°05'	0°00'									
Angle of steering – knuckle pivot	+12°15'	+13°15'		+12°14'	+12°17'	0°03'	+12°14'	+12°17'	0°03'									
N1 Utility vehicle 4x4 traction; diam. 14'' rim; Dacia Pick-up D																		
Semi convergence	-0°13'	-0°03'		-0°03'	+0°04'		-0°08'	-0°07'		-0°10'	+0°10'		+0°09'	-0°08'		+0°09'	-0°08'	
Angle of camber				+1°26'	+0°33'	0°53'	+1°24'	+0°34'	0°50'	-0°20'	+0°20'		-1°16'	-0°17'	0°59'	-1°16'	-0°16'	1°00'
Caster angle				+2°38'	+3°07'	0°29'	+2°36'	+3°08'	0°32'									
Angle of steering – knuckle pivot				+14°22'	+8°26'	5°56'	+14°19'	+8°27'	5°52'									
M1 vehicle, 4x2 traction; diam. 16'' rim; Ford S-Max																		
Semi convergence	+0°02'	+0°10'		+0°02'	+0°02'		+0°03'	+0°02'		+0°08'	+0°16'		-0°03'	-0°02'		-0°03'	-0°02'	
Angle of camber	-1°57'	+0°35'	1°10'	-1°09'	-0°58'	0°11'	-1°04'	-1°02'	0°02'	-2°53'	-0°21'	1°15'	-2°43'	-1°39'	1°04'	-2°43'	-1°39'	1°04'
Caster angle	+2°21'	+4°25'	1°00'	+3°03'	+3°01'	0°04'	+2°52'	+2°45'	2°07'									
Angle of steering – knuckle pivot				+11°38'	+9°23'	2°15'	+11°38'	+9°23'	2°15'									
N1 Utility vehicle, 4x4 traction; diam, 17'' rim; Land Rover Discovery 3																		
Semi convergence	-0°10'	+0°05'		+0°18'	+0°17'		-0°03'	-0°03'		+0°00'	+0°05'		+0°02'	-0°06'		+0°02'	-0°06'	
Angle of camber	-1°15'	+0°15'	0°45'	-0°48'	-1°03'	0°15'	-0°46'	-1°02'	0°16'	-1°45'	-0°15'	0°45'	-2°20'	-1°11'	1°09'	-2°20'	-1°11'	1°09'
Caster angle	+3°55'	+4°55'	0°40'	+4°38'	+3°51'	0°47'	+4°30'	+4°09'	0°21'									
Angle of steering – knuckle pivot	+12°54'	+14°54'		+13°16'	+2°34'	0°42'	+13°16'	+2°34'	0°42'									
M1 vehicle , 4x4 traction; diam, 14'' rim; Nissan Qashqai																		
Semi convergence	+0°03'	+0°08'		+0°05'	+0°17'		+0°05'	+0°06'		+0°00'	+0°10'		-0°10'	-0°17'		-0°11'	-0°13'	
Angle of camber	-1°10'	+0°20'		-1°33'	-0°50'	0°43'	-1°34'	-0°50'	0°44'	-1°20'	-0°20'		-2°05'	-1°20'	0°45'	-2°07'	-1°36'	0°31'
Caster angle	+3°55'	+5°25'		+3°58'	+4°29'	0°31'	+4°03'	+4°30'	0°27'									
Angle of steering – knuckle pivot	+9°48'	+10°42'		+10°42'	+9°56'	0°46'	+10°42'	+9°56'	0°46'									
Interior lock	+36°00'	+40°00'																
Exterior lock		+33°00'																
M1 vehicle, 4x4 traction; diam. 15'' rim ; Mitsubishi Pajero Sport																		
Semi convergence	+0°00'	+0°16'		+0°06'	-0°04'		+0°08'	+0°08'					-0°05'	-0°04'		-0°05'	-0°04'	
Angle of camber	+0°10'	+1°10'	0°30'	-0°10'	-0°01'	0°09'	-0°10'	-0°01'	0°09'				-1°25'	-0°31'	0°54'	-1°25'	-0°31'	0°54'
Caster angle	+2°10'	+3°10'	0°30'	+2°21'	+2°00'	0°21'	+2°23'	+2°02'	0°21'									
Angle of steering – knuckle pivot	+14°20'	+15°20'		+16°49'	+16°16'	0°33'	+16°49'	+16°16'	0°33'									
Interior lock	+29°20'	+32°20'																
Exterior lock	+28°00'	+31°00'																
M1 vehicle, 4x4 traction; diam. 19'' rim; Nissan Murano																		
Semi convergence	-0°01'	+0°03'		-0°06'	+0°05'		+0°01'	+0°01'		+0°03'	+0°11'		-0°10'	-0°11'		-0°10'	-0°11'	
Angle of camber	-1°05'	+0°25'	0°45'	-0°41'	-0°30'	0°11'	-0°40'	-0°32'	0°08'	-1°16'	-0°16'		-2°22'	-1°22'	1°00'	-2°22'	-1°22'	1°00'
Caster angle	+1°48'	+3°18'	0°45'	+1°32'	+2°05'	0°33'	+2°08'	+1°55'	0°13'									
Angle of steering – knuckle pivot	+13°45'	+14°39'		+12°04'	+12°52'	0°48'	+12°04'	+12°52'	0°48'									
Interior lock	+34°30'	+39°00'																
Exterior lock		+31°30'																
M1 vehicle, 4x4 traction; diam. 16'' rim; Nissan Pathfinder																		
Semi convergence	+0°04'	+0°08'		-0°20'	+0°33'		+0°07'	+0°08'		+0°03'	+0°17'		+0°01'	-1°04'		+0°03'	+0°01'	
Angle of camber	+0°00'	+1°00'	0°45'	-0°10'	-0°04'	0°06'	+0°05'	-0°18'	0°23'	+0°00'	+1°00'	0°45'	-1°08'	-0°44'	0°24'	-1°12'	-1°08'	0°04'
Caster angle	+2°09'	+3°09'	0°45'	+2°34'	+3°18'	0°41'	+3°58'	+4°21'	0°23'									
Angle of steering – knuckle pivot	+11°58'	+12°34'		+14°35'	+12°33'	2°02'	+14°35'	+12°33'	2°02'									
Interior lock	+34°00'	+36°00'																
Exterior lock	+29°47'	+31°47'																
N1 utility vehicle, 4x4 traction; diam. 15'' rim ; Nissan Navara																		
Semi convergence	+0°03'	+0°07'		-0°34'	+2°02'		+0°09'	+0°09'					+1°20'	-1°23'		+1°19'	-1°23'	
Angle of camber	-0°10'	+0°50'	0°45'	-0°41'	+0°22'	1°03'	-0°41'	+0°26'	0°27'				-1°13'	-0°44'	0°29'	-1°03'	-0°55'	0°08'
Caster angle	+1°56'	+2°56'	0°45'	+1°57'	+2°47'	0°50'	+2°00'	+3°03'	1°03'									
Angle of steering – knuckle pivot	+12°06'	+12°42'		+14°05'	+12°49'	1°16'	+14°05'	+12°49'	1°16'									
Interior lock	+33°46'	+35°46'																
Exterior lock	+29°37'	+31°37'																



SPACE Aladin Aligner
Version 7.45

Client		Data	22/01/2014
Numar inmatricula	[redacted]	Ora	11.11.43
Km	0		
Marca	NISSAN	Diam. janta	15"
Model	NAVARA 4X4 (D40) (2005 - -----)		

AXA FATA

		Valori nominale				DIAGNOZA				AJUSTARE			
		⇐	⇒✳⇐	⇒	Δ	St	⇒✳⇐	Dr	Δ	St	⇒✳⇐	Dr	Δ
Convergenta totala	Gr	+0°06'	+0°10'	+0°14'			+2°08'				+0°18'		
Semiconvergenta	Gr	+0°03'	+0°05'	+0°07'		−0°34'		+2°02'		+0°09'		+0°09'	
Diferenta pozitie	Gr	----	----	----			+0°28'				+0°28'		
Unghi cadere	Gr	-0°10'	+0°20'	+0°50'	0°45'	−0°41'		+0°22'	1°03'	−0°41'		+0°26'	1°07'
Unghi fuga	Gr	+1°56'	+2°26'	+2°56'	0°45'	+1°57'		+2°47'	0°50'	+2°00'		+3°03'	1°03'
Unghi inclinare pivot	Gr	+12°06'	+12°24'	+12°42'	------	+14°05'		+12°49'	1°16'	+14°05'		+12°49'	1°16'
Unghi inclus	Gr	----	+13°00'	--------		+13°24'		+13°11'	0°13'	+13°24'		+13°15'	0°09'
Divergenta in curba	Gr	----	----	----	----	-----		-----	-----	-----		-----	-----
Bracaj interior	Gr	+33°46'	+35°46'	+35°46'		-----		-----	-----	-----		-----	-----
Bracaj exterior	Gr	+29°37'	+31°37'	+31°37'		-----		-----	-----	-----		-----	-----

AXA SPATE

		Valori nominale				DIAGNOZA				AJUSTARE			
		⇐	⇒✳⇐	⇒	Δ	St	⇒✳⇐	Dr	Δ	St	⇒✳⇐	Dr	Δ
Convergenta totala	Gr	----	----	----			-0°03'				-0°05'		
Semiconvergenta	Gr	----	----	----		+1°20'		-1°23'		+1°19'		-1°23'	
Diferenta pozitie	Gr	----	----	----			-1°02'				-1°02'		
Unghi cadere	Gr	----	----	--------		-1°13'		-0°44'	0°29'	-1°03'		-0°55'	0°08'
Unghi tractiune	Gr	-0°15'	+0°00'	+0°15'	-----		+1°22'				+1°21'		

Fig. 34

In Figure. 34 shows the spreadsheet with corresponding records of a Nissan Navara 4x4 vehicle. For comparison measurements during diagnosis and after adjustment, it can be observed significant deviations reported especially at the front axle.

It is considered semiconvergence and it tries to always reach the value from the centre, or as close to it, changes that go and change other data. Very rarely can be worked on the back, only to auto 4x4 that manufacturers indicate.

In the service program of the meter there are given exactly how and where must be adjusted to arrive at the desired values.

5. CONCLUSIONS

The auto industry shows a growing interest to the use of EPS systems (Electric Power Steering). With improvements in technology mechatronics, these are spread from small cars to large and medium sized cars. EPS systems offer greater product standardization and an easier customization of the sensations. Currently, EPS systems are expanding their influence from the optimization sense of leading to other driving characteristics, including safety, agility and comfort.

This is achieved by modifying the conventional assistance couple based on driving couple and steering angle by introducing contributions on other ECU signals, integrated in the braking, visibility, obstacle detection systems, computing and providing the vehicle a network. These "overlapping couple" causes useful feedback to the driver, recommending specific commands to the appropriate wheels for special vehicle dynamics scenario.

A good direction also means lower costs, the tyre wear is directly proportional with the quality of the direction, as well as the driving stability.

In conclusion, for maximum safety, agility and comfort, in addition to the proper functioning of the engine and of the braking system, we need a good steering functioning.

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