ues, and also wheels vertical displacements difference at steering wheel turn.

4. It Is established, that the essential displacement difference from king pin inclination angles originates already on small steering wheel turn angles - 10-15 degrees.

5. King pin cross inclination angle change within its possible adjustment limits (+ - 2 degrees) doesn’t make visible effect on the kart front wheels vertical displacement. Such displacement on small steering wheels turn is particularly absent.

6. Caster change within its possible adjustment limits (+/- 2 degrees) is visible only at big angles of steering wheel turn. It is insignificant on small steering wheel turn angles.

7. Kart front wheels vertical displacement difference make a skew of its support points on a track surface on the concerning frame. Their installation in one plane results lifting of rear inside wheel and it’s hung out at absolutely rigid kart frame.

Steered Wheels Turning & Frame Twist Angle

Kart front wheels support points displacement from steering wheel turn researches has shown that a frame skew appears. It leads to uplifting of rear inside wheel at corner. This skew provides the kart moving in turn on three wheels. Therefore it is used at kart handling setup and is one of the major parameters. That’s why it is necessary to know what effect value will be rendered on displacement (uplifting) of inside rear wheel depending on front end setup parameters.

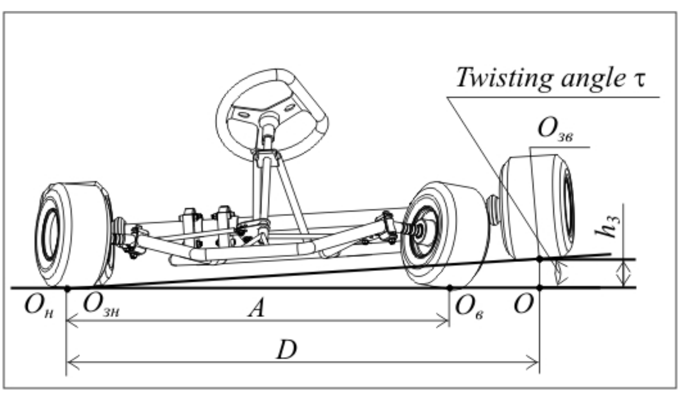

Fig. 42. Kart frame twisting angle appearance

We shall observe how we can describe rear inside wheel displacement through kart front wheels displacement from steering wheel turn (fig.42).

We have already known that at steering wheel turn inside wheel spindle center Cв is hauled down, and outside wheel spindle center Cн will rise. Accordingly support points of these wheels Oв and Oн haul down and rise.

If we draw a line through these support points so between this line and the line parallel to ground plan, appears the angle τ which we shall name a kart frame twisting angle.

Its clear, that this angle will depend on kart geometric parameters (front end track width, wheel spindle lengths, wheels turn angles) and wheel support points displacement differences at their turning. Wheels displacement difference depends on kart front end setup parameters - king pin inclination angles and wheel spindle lengths.

*****It's necessary to note, that there is an influence on frame twisting angle from wheel inclination which appears at steering wheel turn and the result is physical contact spot moving more close to the wheel on its forming. It leads to kart frame displacement altitude increase concerning track surface. However, this altitude value increment in big extent is defined by wheel rigidness. Wheel rigidness depends on tire properties, air pressure and tire width. It is not possible to illustrate functionally this effect yet.*

At the present research stage it is assumed, that wheel contact spot with track surface displacement from the tire center closer to its side face will reduce the contact area. Hence it leads to greater tire wrinkle. The tire sag also will increase, that partially compensates moving increase due to wheel inclination. Thus wheel inclination effect at steering wheel turn was not considered.

Here is this angle – a frame plane turning around the longitudinal axis - interests us as an angle of the kinematic twisting. Why is the concept of the "kinematic" used?

The frame actually is not absolutely rigid. Under affecting of the applied forces, it can be twisted so, that the rear wheel will not rise on a designed quantity, and in some cases will not rise at all. In the further, at the kart dynamics research, frame rigidness and its effect on handling would be studied.

Magnitude of twisting angle is defined by follows.

If we know front wheels support points displacement (total moving) Δhn, then relation of Δhn to the magnitude A will be a tangent of required angle τ (look fig. 42), and τ angle value will be defined by:

$$\tau = \text{arc tg } \Delta hn/A \tag{20}$$

Value of magnitude *A,* as distances between each wheels support at their turn, is defined by following (fig. 43):

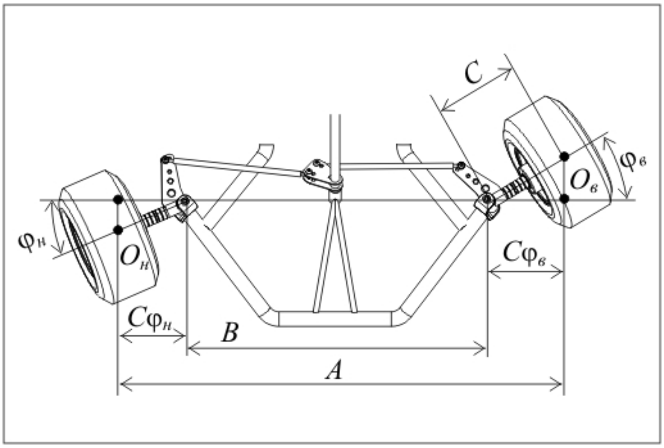

Fig. 43. The scheme of kart frame twisting angle definition

Considering, that A distance depends on wheels turn angles, it can be defined by following dependence:

$A = B + C\varphi в + C\varphi н$ (21)

Where:

B – distance between king pins of kart front axis;

$C\varphi$ - projection of wheel spindle *C* length. It is defined as leg of rectangular triangle with a hypotenuse *C*:

- for inside wheel $C\varphi в = C \cos\varphi в;$
- for outside wheel $C\varphi н = C \cos\varphi н.$

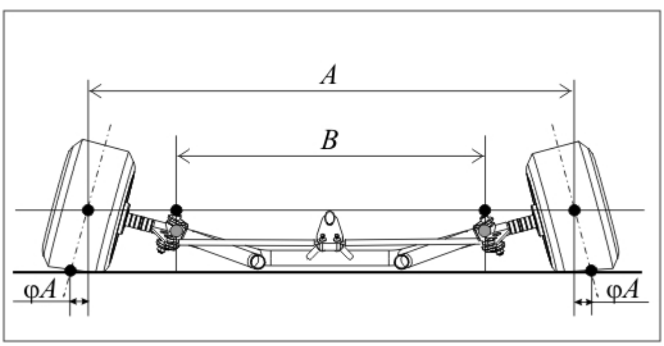

Fig. 44. Camber effect on front end width

Speaking exactly, wheels spinning centers and contact spots centers at positive and negative camber don't align (fig. 44).

In some cases ΔA can reach 2-3 mm, however it is established, that their effect on kart characteristics research does not render essential effect on a characteristics connection and does not exceed distortion from tire, frame, an axis, deformation etc.

Then, having defined value *A*, it is possible to define twisting angle value:

$$\tau = arc\ tg\ \Delta hn/A = arc\ tg\ \Delta hn/(B + C\,(\cos\varphi в + \cos\varphi н)) \quad (22)$$

In other words, twisting angle is on angle on which the plane of absolutely rigid kart frame rotates concerning support area at steering wheel turn on the set angle ψ, provided that front wheels will be in contact with track bearing area. If we represent this condition, when both front wheels are in contact with track bearing area than rear wheels in case of absolutely rigid frame would be turned on the same twisting angle - τ (look fig. 45)

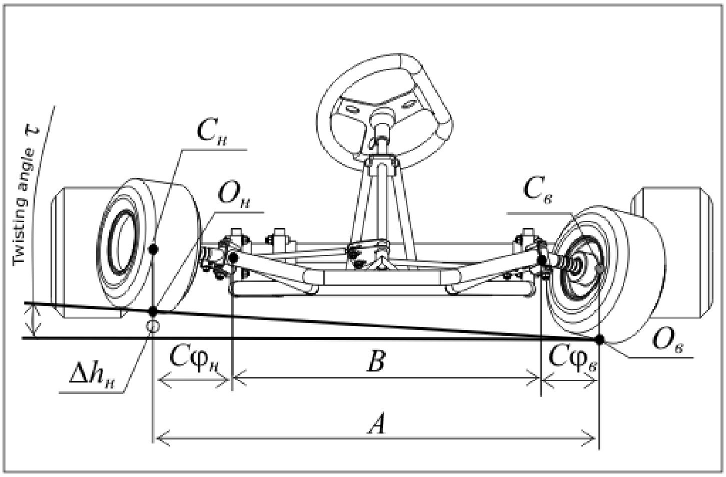

Fig. 45. Rear inside wheel uplifting at frame twisting

For presentation, support points of front and rear outside wheels are combined with front inside wheel support point and form plane which coincides with kart wheels support plane.

Now, when we know quantitative value of twisting angle τ, it is simply enough to define the main required kart frame setup parameter – rear inside wheel kinematic raising altitude value at steering wheel turn - hз.

It is obvious from fig. 45 that the required parameter *hз* is a leg of triangle *O Oзв Oн* and can be defined through a tangent of twisting angle τ and rear wheels track which is marked out by *D*.

$$h_з = D\, tg\ \tau \tag{23}$$

Thus, the kinematic (without taking into account kart frame rigidness) rear inside to turn wheel rising altitude depends on rear wheels track - *D* and an frame twisting angle - τ .Also twisting angle depends on the distance between king pins *B* and kart front end setup parameters – king pin axis inclination angles β *and* γ and front end width *A*. Thus kart front wheels spindle length C is entered to equation (21) as a component which defines front end width. It is included also into the equation defining scrub radius through which front wheels vertical displacements are defined at steering wheel turn.

Resume:

1. Front wheels support points at steering wheel turn can be quantitatively sized up by kart frame twisting angle.

2. Its value can be defined through frame geometrical parameters, including distance between king pins, wheel spindle length, king pins inclination, and steered wheels turning angles. These parameters depend on steering trapezoid parameters and steering wheel turn angle.

3. At twisting angle definition the camber of wheels can not be considered because of its insignificant effect.

4. Using frame twisting angle and value of rear end width it is possible to define quantitative value of the inside rear wheel kinematic uplifting altitude at steering wheel turn. Thus the assumption is accepted, that kart frame is absolutely rigid.

The Rear Inside Wheel Hung Out At Cornering

We shall observe vertical kinematic moving of rear inside wheel in more detail. This moving directly proportional to the tangent of frame twisting angle (see the formula 23). In its turn, the frame twisting angle depends on difference of front axis wheels displacement difference - $\Delta h\text{н}$ which is defined by certain adjusting parameters. Let’s observe their effect.

We shall set up the value of angle τ in the formula (23) for definition of rear wheel moving altitude. This value is defined through the front wheels displacement difference Δhn *(22)*. Then we shall gain the following dependence reflecting relation of front and rear wheels vertical diplacement:

$$h\ \text{з} = D\ tg\ (arc\ tg\ \Delta hn/A) = D\ \Delta hn/A = \Delta hn\ D/and \qquad (24)$$

Or

$$h\ \text{з} = \Delta hn\ D\ /\ (In + With\ (cos\text{в}\ \varphi + cos\text{н}\ \varphi)) \qquad (25)$$

From the formula (25) and also from the formulas defining total displacement of front wheels (19) follows that in parameters which influence on rear wheel vertical displacement at steering wheel turn, are:

- caster - β;