AERODYNAMIC ATTRACT OF VEHICLES IN REAL TRAFFIC

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1. INTRODUCTION

Motor vehicle, as technical means for mass transport has forever attracted attention and been an object of interest but also a subject of research of many researchers.

In the base, a vehicle has its functional and work capability that should be constantly and imperatively upgraded during its development from many reasons and mostly from safety, ergonomic, technical, technological, finance and energy reasons. Stability and driving of motor vehicles under real traffic conditions are also very important.

Personal road experience, quantitative, qualitative and cumulative, being reached contemplatitively under real traffic conditions as an active participant in it, pointed out the existence of phenomenon which is presented as a change of behavior of a motor vehicle at passing by or passing with another motor vehicle from opposite direction under real traffic conditions. Practically, three characteristic phases in process of passing by or passing with other motor vehicle from opposite direction are identified as follows:

- Phase of slowing a driven motor vehicle down, in the moment at approach of a motor vehicle that is passing by or coming from opposite direction;
- Phase of side attract of a driven motor vehicle, at parallel motion with another motor vehicle that is passed by or come from opposite direction;
- Phase of acceleration of a driven motor vehicle in the moment with ended parallel motion with another motor vehicle being passed by or come from opposite direction.

It is also noticed that these phases as per duration and intensity, besides others, depend on the following: type, shape and size of motor vehicles; mutual side distance, during their parallel motion; speed of motor vehicles; and besides others, if it is on parallel or from different directions passing by of motor vehicles. From such information and experience, the starting theoretical researches are initiated that are subject to this paper.

2. MOTOR VEHICLE

Any motor vehicle that may be legally present in real traffic is to be registered and it means it must be under standard qualification of road motor vehicles, being attested, having known origin and technically regular.

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For this accepted problem, the type, shape and size of a vehicle are very important. Using basic principle of modeling it is possible to show simply the motor vehicles by geometric primitive shape of parallelepiped from where all characteristic types of motor vehicles come from being important for this subject research (Figure 1).

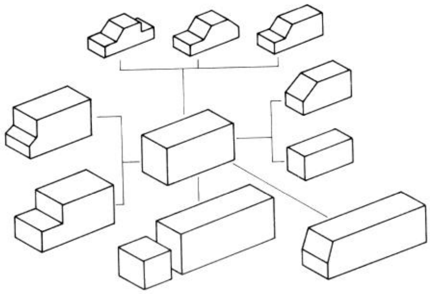

Figure 1: *Simplified view of a motor vehicle [5]*

From the aeromechanic point of view, a motor vehicle, at its motion through air, is flown by air. Around the motor vehicle, the current flow of air is formed with fricatives of defined shapes along with appropriate fields of speed and pressure on motor vehicle body surfaces. Simplified view of flowing of motor vehicle characteristic type is presented in the Figure 2, with assumption that the motor vehicles are alone in the flow of air, air is with no motion and there are no outside initiations that may disturb symmetric air flow of the motor vehicle.

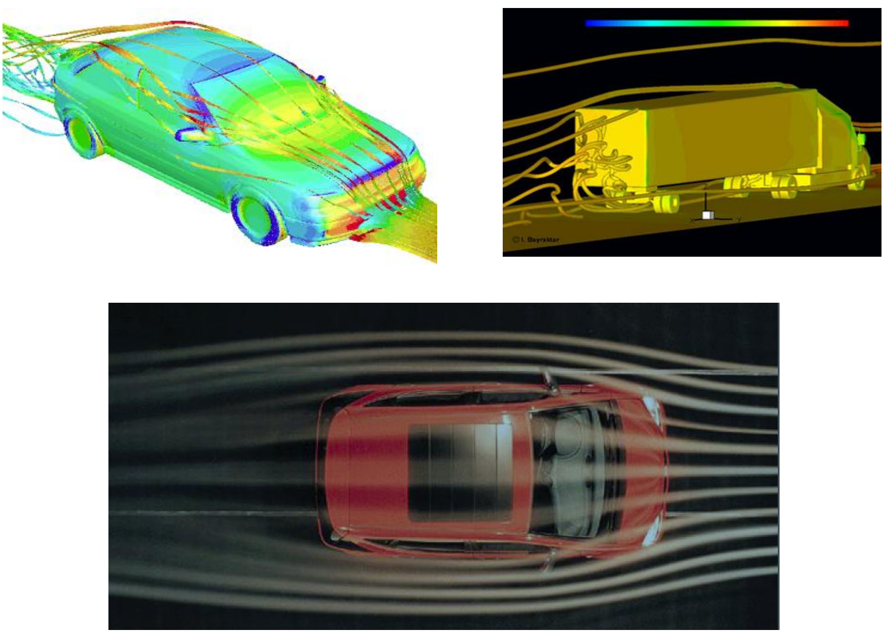

Figure 2: *Schematic view of air flow of some motor vehicle types*

Because of conditional assumptions in the process of air flow the following is noticed:

- Symmetrically longitudinal air flow of subject motor vehicle;
- Equalized field of speed on both sides of subject motor vehicle;
- Equalized field of pressure on both sides of subject motor vehicle;
- With no side forces that, due to pressure differences, may affect the subject motor vehicle.

It is important to note that also frontal surfaces of some motor vehicles are mutually different as presented in the schematic view in the Figure 3.

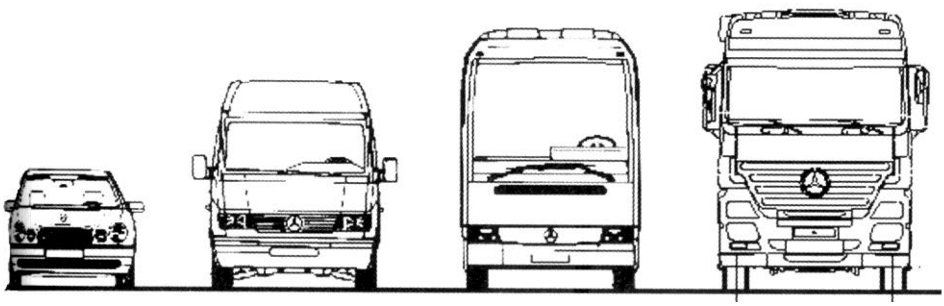

Figure 3: *Schematic view of some vehicle frontal surface [4]*

3. VENTURI'S TUBE

As known, the link between pressure and speed of fluid flow, in subject fluid flow of uncompressible and not viscous fluid, is done by Bernuli's equation.

$$p + \frac{1}{2}\rho v^2 + \rho g h = const. \qquad (1)$$

Where is:

- p – Absolute pressure in fluid
- ρ – Density of fluid
- v – Fluid speed in fricative
- g – Acceleration of earth's gravitation
- h – Fricative height relating to referent level

For noticed path of fluid part and two points on it and between them, there is no size change of noticed fluid parts, the Bernuli's equitation for the subject fluid flow may be written.

$$p_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = p_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2 = const. \tag{2}$$

If Venturi's tube is considered, set horizontally relating to horizontal level (Figure 4), and if the fluid flow of uncompressible and not viscous fluid is in it, then using manometer of U-tube type one may measure the pressure difference in characteristic points of Venturi's tube.

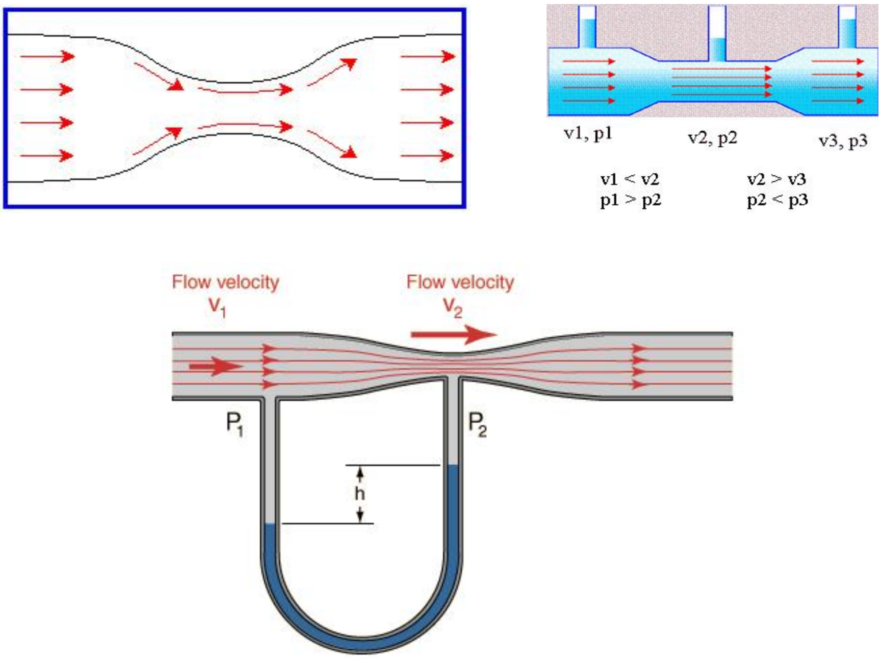

Figure 4: *Venturi's tube with manometer of U-tube type*

Appropriate equations for subject fluid flow:

- Equation of continuation,

$$\rho v_1 A_1 = \rho v_2 A_2 = \rho v_3 A_3 = const. \tag{3}$$

$$v_1 A_1 = v_2 A_2 = v_3 A_3 = const. \tag{4}$$

- Bernuli's equation,

$$p_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = p_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2 = const. \tag{5}$$

$$h_1 = h_2 = h_3 \tag{6}$$

$$\rho = const. \tag{7}$$

$$\rho g h_1 = \rho g h_2 \tag{8}$$

$$p_1 + \frac{1}{2}\rho v_1^2 = p_2 + \frac{1}{2}\rho v_2^2 \tag{9}$$

$$(p_1 - p_2) = \frac{1}{2}\rho\left(v_1^2 - v_2^2\right) \tag{10}$$

$$\Delta p = p_1 - p_2 \tag{11}$$

Manometer shows as follows, $\Delta p = \rho_o g h$ (12)

namely, $p_1 - p_2 = \rho_o g h$ (13)

Namely, it is

$$p_1 > p_2 \tag{14}$$

If the subject fluid flow through Venturi's tube is idealized and virtualized completely, the pressure change in the Venturi's tube (Figure 5) may also be conditionally shown.

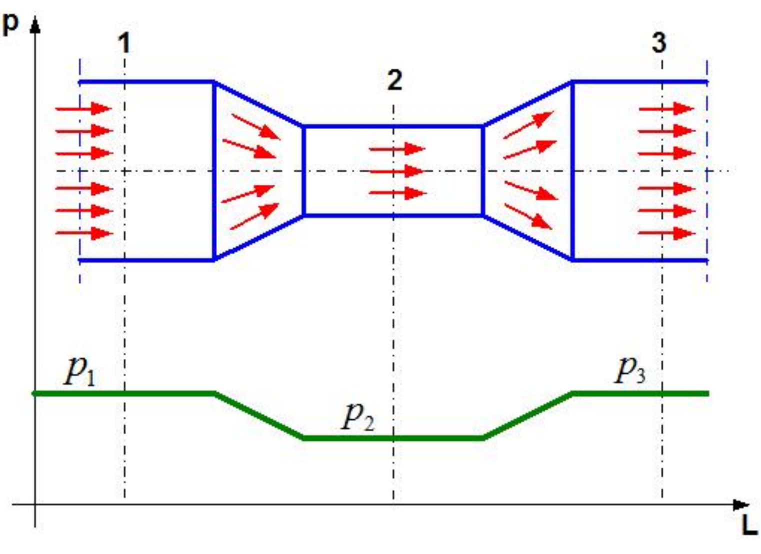

***Figure 5:** Pressure change in Venturi's tube*

4. PHENOMENA OF AERODYNAMIC ATTRACT

A motor vehicle in real traffic conditions is used within its purposes and in accepted work regime, adapting to stable and driven road conditions, climate and methereologic conditions, static, kinematics and dynamic environment.

Still considering the accepted problem, two characteristic cases will be noticed as follows:

- Motor vehicle-1, passes another vehicle-2, Figure 6;
- Motor vehicle-1, passes another vehicle from opposite direction-2, Figure 8.

To show motor vehicles in appropriate combination, the simplified model of motor car, so called the geometric primitive parallelepiped shape, will be used. It will be supposed that air in a motor vehicle environment is in no motion, the road is flat and straight, no outside initiations disturbing the subject state and mutual interaction of subject motor vehicle.

Mutual side distance between motor vehicles is geometric value (a), which is always positive but higher than zero, to perform passing physically, namely passing of motor cars from different directions, and among others it depends on the following: road width; position of motor vehicle-2; position of motor vehicle-1; and motor vehicle width.

The subject motor vehicle's-1, speed is

$$(v_{MV})_1 \neq 0 \tag{15}$$

and motor vehicle's-2, speed is

$$(v_{MV})_2 \neq 0 \tag{16}$$

and both adapted to allowed speed on subject road part.

4.1. Motor vehicle-1 passes another motor vehicle-2

$$(v_{MV})_1 > (v_{MV})_2 \tag{17}$$

It is indisputable that,

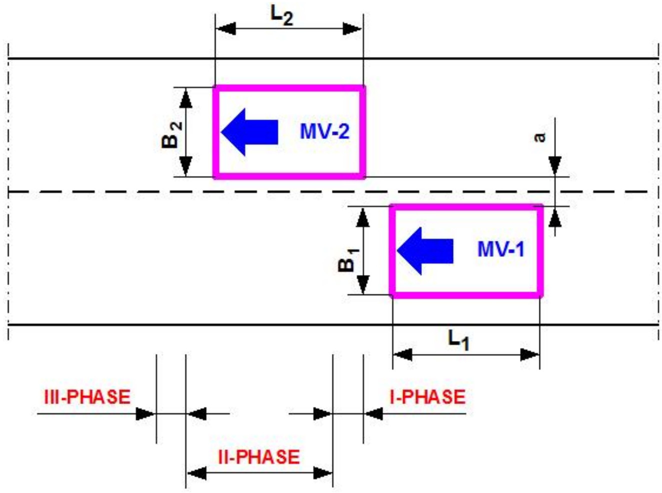

Figure 6: *Motor vehicle-1 passes the motor vehicle-2*

In the process of passing of motor vehicles, but in the phase two, the motor vehicles reach parallel position forming the virtual Venturi's tube (Figure 7).

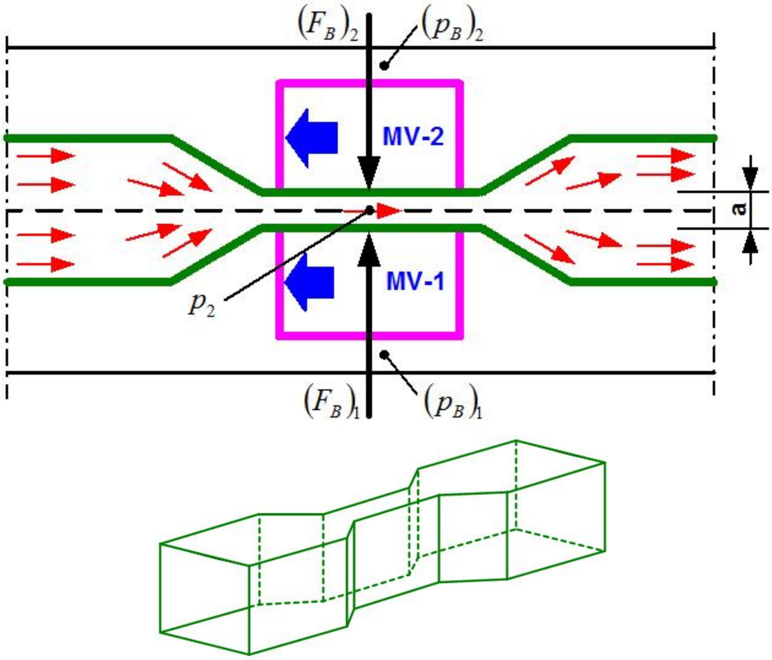

Figure 7: *Virtual Venturi's tube being formed by motor vehicles in passing*

Relative possible speed of air in area between subject motor vehicles is conditionally as follows:

$$v_2 = (v_{MV})_1 - (v_{MV})_2 \tag{18}$$

Side attract forces on subject motor vehicles,

$$(F_B)_1 = [(p_B)_1 - p_2](A_{MV})_{B1} \tag{19}$$

$$(F_B)_2 = [(p_B)_2 - p_2](A_{MV})_{B2} \tag{20}$$

where is:

$(p_B)_1$	–	Pressure in side free zone of the motor vehicle-1
$(p_B)_2$	–	Pressure in side free zone of the motor vehicle-2
p_2	–	Pressure in the zone between subject motor vehicles
$(A_{MV})_{B1}$	–	Side surface of the motor vehicle-1
$(A_{MV})_{B2}$	–	Side surface of the motor vehicle-2

4.2. Motor vehicle-1 passes the motor vehicle-2 from opposite direction

It is indisputable that,

$$(v_{MV})_1 \neq 0 \;;\; (v_{MV})_2 \neq 0 \;;\; (v_{MV})_1 > / = / < (v_{MV})_2 \tag{21}$$

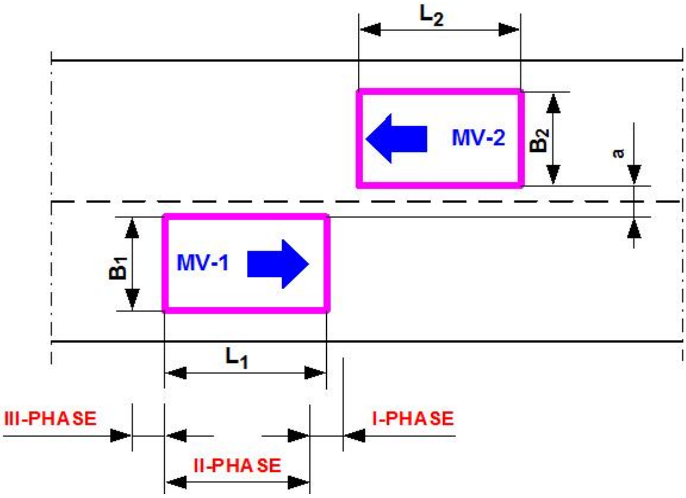

Figure 8: *Motor vehicles pass from different directions*

In the process of passing of motor vehicles from different directions in the phase two, the motor vehicles reach parallel position keeping it for some time, forming virtual Venturi's tube (Figure 9).

Relative possible speed of air in area between subject motor vehicles is conditionally as follows:

$$v_2 = (v_{MV})_1 + (v_{MV})_2 \tag{22}$$

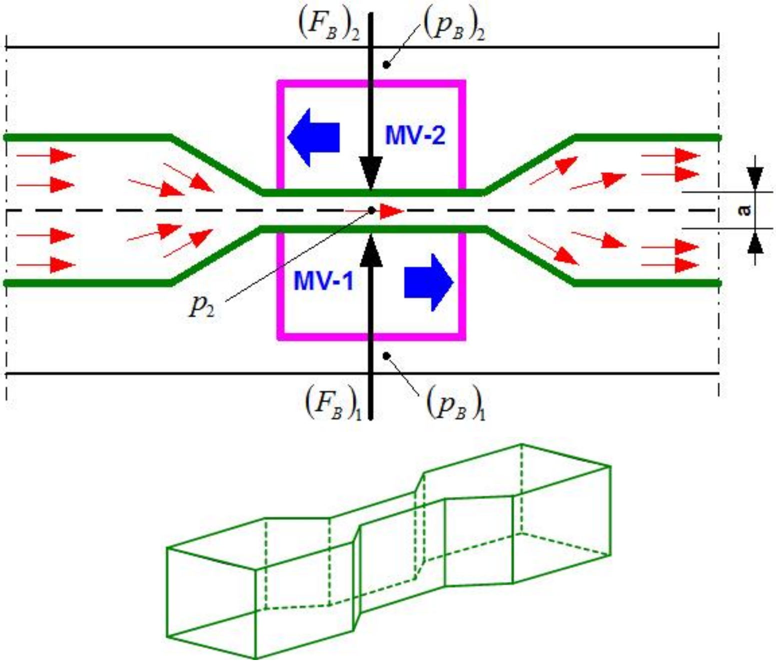

Figure 9: *Virtual Venturi's tube formed by motor vehicles in passing of motor vehicless from different directions*

In this case, side attract forces on subject motor vehicles are calculated by the same expressions as in previously described characteristic case, but with changed appropriate values only.

5. CONCLUSION

It is indisputable proved that the side attract forces also really exist between motor vehicles that pass by or pass from different directions during the process second phase when the subject motor vehicles are in parallel position but in real traffic. Considering their nature, it is justified to name these side attract forces the aerodynamically attracted forces since they are indeed. Their direction is known, but their intensity is changeable between limit values, i.e. between zero and the maximal value.

Existing of side aerodynamic attract forces indisputable influences the stability and driving of motor vehicles when they are in dangerous situations.

The traffic accidents are known where the participating motor cars come to side contacts, from "unknown reasons", and afterwards the unwanted circumstances occurred.

In existing domestic and foreign professional literature, being available to this paper author, no description on accepted problem was noticed.

An imperative obligation comes out from above presented and thus, in analyses on stability and driving of motor vehicles, the aerodynamically attracted forces must be also included equally, and a reason more for that it is surely a fact that in real traffic there are more and more motor vehicles having large side surfaces (long motor vehicles).

The presented problem should be firstly accepted as a contribution to upgrade the theory and practice of motor vehicles along with implementation of aeromechanics, but also as positive initiation and stimulus to further theoretic and practice research. It is to expect that this should be happened after publishing of the paper.

6. REFERENCES

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