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EXPERIMENTAL DETERMINATION OF PNEUMATIC OPTIMAL PRESSURE IN PASSENGER MOTOR VEHICLE

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ABSTRACT
Safety of passenger road is a very complex category of society like ours, considering conditions on roads. High percent of traffic accidents that take lives and cause material damage demand more thorough cause analysis. Large number of traffic accidents, among other factors, happens as a result of low or large pneumatic pressure, which leads to destabilization of vehicle on roadway during the motion. Experiment was performed on motor passenger vehicle in brake state of all four wheels at different and constant pneumatic pressure. During the performance vehicle was partially loaded with passengers (1+0; 1+1; 1+2; 1+3; 1+4) in all phases, so that different positions of vehicle gravity center were taken into consideration.
Keywords: vehicle, brake system, pressure, pneumatic

1. INTRODUCTION
Everyday life has nowadays become inconceivable without transportation vehicles, particularly automobiles, regardless being passenger or freight vehicles. Improved traffic infrastructure, modern transport routes, main roads and highways, are one of the pillars of country's development and progress, whereby automobiles play a significant role. Modern automobiles are complex, built of mutually connected series of technical systems in order to achieve safe, reliable, and fast transport of people and goods. Rapid development of electronics, electronic components and computers, enabled large integrations in terms of vehicle-environment relations. However, besides extremely high-quality electro-mechanical components and accurate givers, existing ABS is not able to predict or prevent direct block of wheels, since they base their work on fast deflection of already blocked wheel. Having this in mind, certain studies have shown how vehicles with ABS have the same total accident percentage as vehicles without ABS. Also, their stopping path is equal to stopping path of vehicles without ABS. Modern vehicles are very complex, and consist of series of technical systems interconnected in order to achieve safe, reliable and fast transport of people and goods. In order to achieve above said all devices in vehicle need to be in working order.
One of the most important technical systems installed in the car is the system for car blocking, or braking system that presents combination of devices, whose main function is to enable progressive decrease of vehicle speed in motion, blocking, or maintaining vehicle in still condition if the vehicle is stopped. However, besides above mentioned elements that relate to braking process and vehicle stability in motion, one of important elements is wheel pneumatic.

2. VEHICLE PNEUMATIC

It has already been said that one of the most important elements for vehicle stability in motion are wheels. Wheel, as a single element of vehicle, presents combination of two parts, pneumatic and wheel rim. Pneumatic consists of tire and inner tube. In conventional vehicles, wheel rim constituted of tire and inner tube that was filled with air in order to obtain certain pressure in tire. In modern vehicles, however, inner tube was omitted, so that, besides wheel rim (mainly aluminum), only outer tire filled with air is used. Outer tire, in this case pneumatic (no inner tube), has tread layer – protector with patterns for wheel protection against skidding.

Basic pneumatic elements shown in Figure 1 are:

1. wheel rim
2. wire hoop
3. linen filter
4. interlayer
5. tread layer (protector)
6. rubber sealing layer
7. valve
8. wheel rim disk.

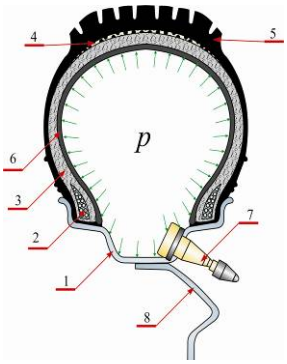


Figure 1: Vehicle wheel cross-section

3. WHEEL ROLLING (PNEUMATICS)

Vehicle driving mechanics is based on wheel rolling. Road deformations are negligibly small compared to wheel pneumatic deformations (Figure 2: Elastic wheel rolling on absolutely hard surface).

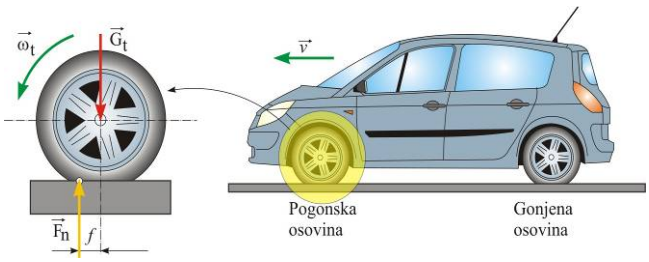


Figure 2: Vehicle wheel rolling on absolutely hard surface

Friction occurs due to pneumatic deformation during its exploitation, so that one part of vehicle's driving aggregate energy is weakened. Having in mind that pneumatic materials are not absolutely elastic, hysteresis phenomenon occurs. Pneumatic air pressure is greatly influencing resistance coefficient at rolling, depending upon basis hardness. As the tire is not absolutely elastic, or basis absolutely hard, basis type for each pneumatic can determine optimal air pressure where rolling resistance coefficient is the smallest. Rolling coefficient is also depending upon vehicle speed and air pressure, as shown in Figure 3.

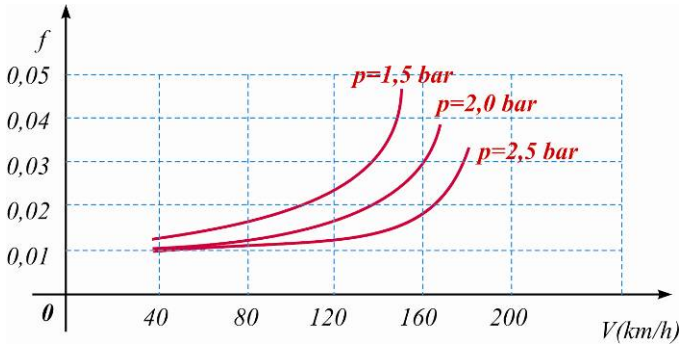
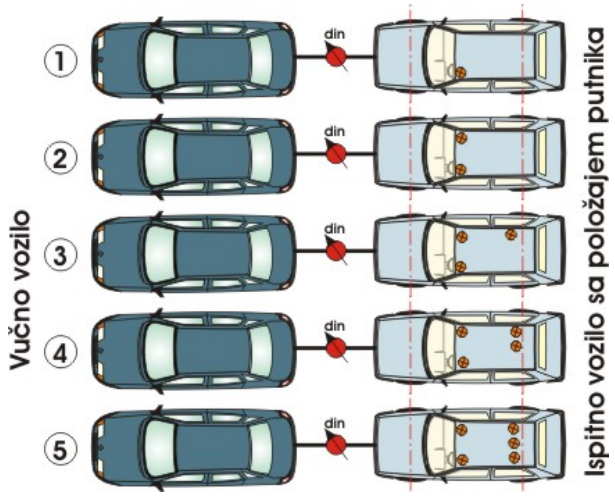


Figure 3: Change of rolling coefficent in function of speed and pneumatic pressure

4. PNEUMATIC OPTIMUM PRESSURE

Above stated elements clearly show that air pressure in pneumatic has a major role in vehicle stability during motion, as is the case with vehicle motion and braking process, whereat the driver is trying to stop the vehicle in the middle of dangerous traffic situation, which is often case with panic braking. Due to abrupt braking, vehicles demonstrate their instability in terms of maneuverability. Frequent reason of traffic accidents is low pressure in some pneumatics, which can cause swift vehicle rotation. Having in mind that passenger motor vehicle with limousine style body can take up maximum five (5) passengers, their positions inside the vehicle greatly affects vehicle stability during sudden braking process. Pneumatic friction force measurement during braking (blocking) of wheels was performed as shown in Figure 4, where each experiment was performed at $p_1 = 1{,}5\,bar$ to $p_5 = 2{,}5\,bar$ with increment $\Delta p = 0{,}25\,bar$.,



Exp.1. driver
Exp.2. driver + co-driver
Exp.3. driver + co-driver + passenger
Exp.4. driver + co-driver + 2 passengers
Exp.5. driver + co-driver + 3 passengers

Figure 4: Passenger positions in tested vehicle

Experiment was performed by means of dinamometer DPU 2-2 type, whose capacity is up to 2000 kg. Dinamometer was positioned in between wrecker and experimental vehicle. Connection between the two was established with steel cable, in order to set up a complete traction balance. During traction process of experimental vehicle, all four wheels block was implemented. Figure 5 shows experiment results with distinctive skidding force deviations when $p = 2\,bar$ pressure is in pneumatics (all four with same pressure). In majority of experiments, the curve at given pressure shows local extreme, i.e. local minimum and maximum, which can be demonstrated as optimum pressure at which vehicle brake characteristics are optimal, having in mind all elements connected to vehicle stability and maneuverability in motion and intensive braking process. Figure 3 shows central curve at $p = 2\,bar$, at which rolling coefficient *f is* moving in $f = 0{,}01 \div 0{,}04$ margins at $40 \div 160\,\text{km/h}$.

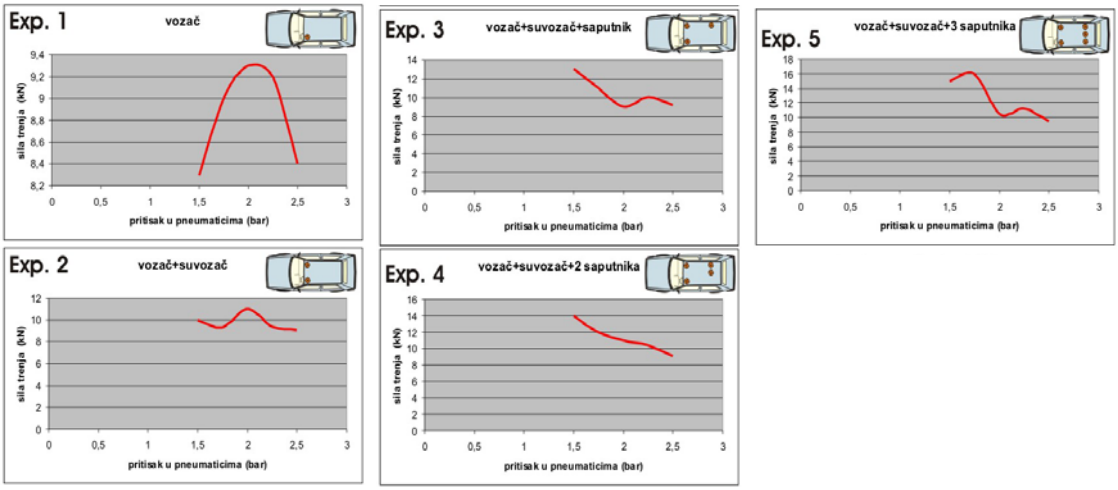


Figure 5: Experimental optimum pressure determination during braking process

4. CONCLUSION

The starting point of traffic accident studies is the fact that they are caused by numerous correlating factors. In order to understand the causes of accidents, it is necessary to detect these factors and their interactive relation. Besides human factor, as the most important one, poor pneumatics (worn-out tread layer – protector, pressure) is frequent cause of traffic accidents. Too low pressure on one of pneumatics at intensive braking can cause horizontal rotation of vehicle, while too high pressure reduces adherence coefficient and thus increases vehicle stagnation braking point and its vertical stability. This experiment, in which vehicle center of gravity was constantly changing, has shown that 2 bar pressure in passenger vehicle is optimal in terms of above mentioned factors.

5. REFERENCES

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