VEHICLE TIRE PRESSURE MONITORING SYSTEMS

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Summary

Drivers very often disregard the condition of tires and the value of the prevailing pressure in them. Changes in the value of air pressure in a tire have a significant impact on driving comfort, fuel efficiency and road safety. The article presents selected pressure control systems used in automotive vehicles, based on a literature review and the authors' experience.

Keywords: diagnostic information, monitoring systems, road safety, tire.

SYSTEMY MONITORUJĄCE CIŚNIENIE W OPONACH POJAZDÓW

Streszczenie

Operatorzy pojazdów bardzo często lekceważą stan techniczny ogumienia oraz wartość ciśnienie panującego w oponach. Zmiany wartości ciśnienia powietrza w oponie mają istotny wpływ na komfort jazdy, zużycie paliwa oraz bezpieczeństwo w ruchu drogowym. W artykule w oparciu o przegląd literatury zagadnienia oraz doświadczenie autorów, przedstawiono wybrane układy kontroli wartości ciśnienia wykorzystywane w pojazdach samochodowych.

Słowa kluczowe: informacja diagnostyczna, systemy monitorowania, bezpieczeństwo ruchu drogowego, opony.

1. INTRODUCTION

Legal regulations of road safety require that each vehicle is equipped with active and passive safety systems such as ABS, ESP, AB, etc. Requirements for brake systems of cars were formulated in Regulations of 13 UN Economic Commission for Europe (ECE) [8]. These requirements relate to braking motion stability of the vehicle during braking and reliability of braking system. The braking performance is expressed by braking distance being influenced by technical condition of the braking system and by pressure in tires.

Tires provide the only contact of the vehicle with the substrate; whether a vehicle can maintain direction of motion, or whether it can stop before the barrier depend on them [5]. Drivers very often disregard the condition of tires and the value of the prevailing pressure in them. Changes in the value of air pressure in the tire have a significant influence on driving comfort, fuel efficiency and road safety (e.g. braking distance). The braking distance of a vehicle also depends on several factors having an impact on tire grip, such as weather conditions (rain, fog, lighting conditions), geographic (e.g. slope of the land), speed, quality and type of tire [4, 7]. The measurement of tire – road contact forces is the first step towards the development of new control systems for improving vehicle safety and performances [2]. Constructions of these systems are constantly being developed in terms of use of sensors [11], tire durability [9] and road safety [1, 2].

For monitoring and informing the driver about the state of tire pressure in different types of monitoring systems of pressure are used. In this paper, based on literature and experience of the authors, pressure control systems used in automotive vehicles are presented.

2. TIRE PRESSURE MONITORING SYSTEMS

The task of the tire pressure control systems is to warn against dangerous amendments, if the tire pressure is different from the pressure required. The influence of different pressure values in tire from the tire contact with the ground surface is shown in Figure 1.

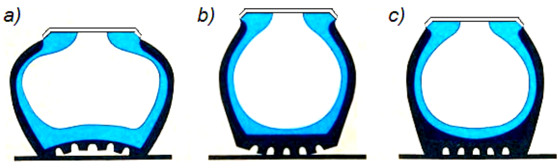

Fig. 1. Pressure values in the tire dependent on the contact surface: a) underinflation, b) overpressure, c) correct pressure [3]

Driving a vehicle with too low pressure in the tire (Fig. 1a) causes the tire to bulge upwards in the middle so that only its outer surface optimally transmits the force to the road. As a consequence, there is strong heating of the tire, and thus there is the danger of damage to its structure, which shortens the lifetime of the tire and the vehicle has a longer braking distance.

If you are driving with too high pressure in the tire the area of contact with the ground occurs only in the center (Fig. 1b). Driving such a vehicle results in irregular tread wear, reduction of tire lifetime and driving comfort.

In the tire with correct pressure value, the tire tread adjacent the whole width of the road (Fig. 1c). The tire tread wears evenly, it translates into greater durability tires and potentially longer distance of kilometers. In addition, the vehicle retains the minimum braking distance and cornering stability. The passengers experience better driving comfort.

The course of impact of pressure change in the tire on a distance which can be performed at the time of tire operation is shown in Figure 2. The axis A shows the change of pressure in the tire, while the axis B relates to distance change which can be covered by a given tire. Areas C and D indicate the tire pressure, too low – C and too high – D.

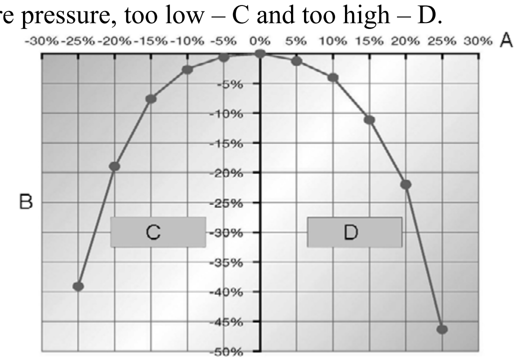

Fig. 2. Dependence of the air pressure in the tire to tire mileage [13]

It should be remembered that the value of the air pressure in a tire depends on the ambient temperature. Another factor is heat removal from the friction elements of the brake system and the deflection of the tire under the influence contact with the ground. The change of pressure in the tire under the influence of the ambient temperature is shown in Figure 3.

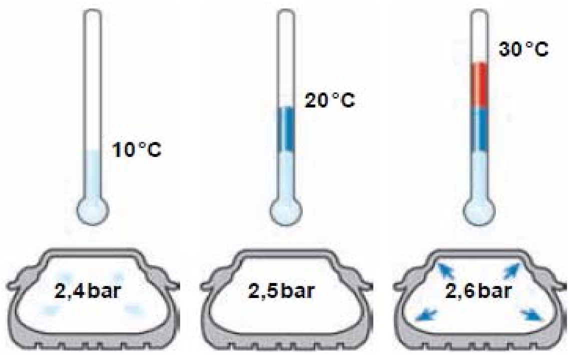

Fig. 3. Dependence of air pressure in the tire to change of ambient temperature [10]

From described above reasons, in vehicles are installed the tire pressure monitoring systems. And so in Volkswagen cars in order to monitor tire pressure are used three different types of systems [10]:

a) tire pressure gauge, as ordinary solution based on standard software (e.g. VW Polo and Golf),
b) tire pressure monitoring system (RDK) with recognition of the position of each wheel (e.g. VW Touareg and Phaeton, Fig. 4),
c) tire pressure control system without considering the position of each wheel (e.g. VW Passat).

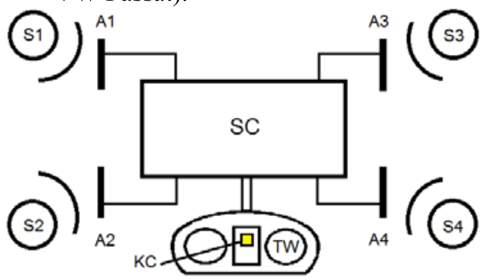

Fig. 4. The scheme of the vehicle tire pressure control system; S1, S2, S3, S4 – pressure sensors in the wheels, SC – control system, TW – control panel, KC – indicating lamp

RDK system (ger. Reifen Druck Sensoren) can operate on the basis of ABS sensors, or be equipped with additional pressure sensors. Schematic diagram of operation of the system based on pressure sensors at each wheel is shown in Figure 4. System consists of sensors located in the vehicle wheels, and antennas located in the wheel, which receive signals from these sensors. The data transmission from the sensors to antennas is done at regular intervals. In the normal mode, the sensors send suitable messages every 54 seconds, and in the fast mode - every 850 ms [10]. Fast mode is activated when the pressure drop in the wheel is faster than 0.2 bar / min [10]. In another variant of such a system the messages are sent every 15 or 30 seconds. Then, the signal shall be forwarded from the antenna to the controller by the CAN bus. In case of detecting changes in tire pressure controller sends a message notifying the driver by lighting a lamp, sending a message on the display, or via the audio signal. Depending on the vehicle equipment, system can inform driver, about change of air pressure of the tire or only informing driver of this fact. In the tire pressure monitoring system, the correct tire pressure must be set by the driver. The learning process of the system occurs after all the changes in tires, such as: a tire pressure correction (from partial to complete filling of tire), change of the one or all wheels, equipped with other electronic systems (e.g. winter wheels or replacement of a damaged wheel).

The learning process of system takes place only at the time when the vehicle is moving at a speed of about 25 km/h and can take up to 10 minutes. This process is accompanied by an adequate message on the display, or lightning of appropriate light indicator. This process includes the following options:

a) identifying the actual tire pressure,
b) the adoption of the actual pressure in the tire as correct pressure,
c) checking whether in the car are mounted the previous parts of electronic systems of wheels. If such exchange occurred, the system must be reprogrammed.
d) checking whether occurred the change of positions of wheel electronic systems. If so, the new position is stored.

In a system named TPMS (Tire Pressure Monitoring System), there are two types of the control process: direct and indirect. In the direct system, information is transmitted by radio the computer on the basis of the measurements from the sensors placed on the inner side of the vehicle wheel rim. Direct system allows you to accurately measure the tire pressure. During seasonal tire replacements driver must inform the service technician about such a system, so as not to expose the client to the additional costs associated with the replacement of the sensor connections and reconfiguration of TPMS. When mounting the wheel without electronic pressure sensor it is advisable to turn off the tire pressure monitoring system.

Indirect system does not require additional sensors because it receives information from the sensors of ESP and ABS. Wheel with less air pressure in the tire has a smaller radius and spins faster which is detected by sensors measuring the rotation of the wheels of the ABS. In this way, the system recognizes a wheel with a low pressure and informs the driver about it. The system uses data from the ABS system and thanks to it is cheap and efficient. The disadvantage of the indirect system is not detecting pressure loss when all tires lose pressure equally.

The vehicle tire pressure monitoring system can operate when the vehicle is driving and is stationary. In regular intervals the electronic system of sensor measures tire pressure and air temperature in the wheel. The tire pressure monitoring systems can perform functions such as:

- continuously informing about the pressure of the tire,
- slow losses of pressure in the wheel,
- rapid pressure drop in the wheel,
- large loss of tire pressure when vehicle is stationary.

Another variation of the tire pressure monitoring system is Integrated Vehicle Tire Pressure Monitoring System (IVTM). Schematic diagram of the integrated vehicle tire pressure monitoring system in trucks is shown in Figure 5.

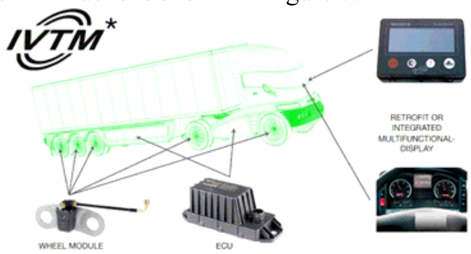

Fig. 5. The schematic diagram of the IVTM system in a truck [13]

System IVTM is intended for users of trucks and buses. This system helps prevent the bursting of tires, accidents and damage to other road users. A special sensor in the wheel module checks the tire pressure and sends the information wirelessly for the control unit (ECU) in a truck or bus, and trailer. The ECU identifies too low or too high pressure, and changing the tire pressure. The system can distinguish whether the falling pressure is caused by tire leak or normal pressure variations [13]. IVTM helps preventing tire blow-outs by timely informing the truck driver of a leak before the tire goes flat and is destroyed. In combination with TrailerGUARD telematics, IVTM also reports the tire pressures to a web portal and warns the fleet manager or dispatcher via SMS or e-mail [13]. The use of this system in practice also helps to prevent the explosion of the tire during inflation.

In vehicle maintenance practice, are possible situations of malfunctioning warning of the tire pressure loss. Incorrect warning can occur when there are several of the following situations [13]:

a) various road condition (for example, ice on the one side of the road),
b) unilateral loading of the car,
c) uneven tire wear of one axis (for example, one of the tires is worn out)
d) non-uniform heating of the wheels on one side of the car (e.g., due to strong solar radiation).

In situations such as driving on uneven and the uncured roads, during braking, driving on hills or road declines and the dynamic sporting driving, data evaluation system pressure control is interrupted. It is not possible to detect the pressure loss under these conditions of the movement of the car. However, in the case of normal driving conditions warning about tire pressure may be delayed.

3. CONCLUSIONS

Thanks to early detection of a fault in a vehicle it is possible to prevent a failure and to improve of road safety [6]. Pressure control systems are among the groups of electronic devices and systems to support the driver. Currently this systems are used as an additional equipment in vehicles. However, vehicles equipped with the self-supporting tires always are equipped with tire pressure sensor. When the vehicle have self-supporting tires, driver almost does not feel diminishing pressure, for this reason tire pressure control system is recommended here [10].

Thanks to the control system, it is possible to continuously maintain the optimum tire pressure. The advantage of using these systems is less tire wear and fuel. The tire pressure monitoring system relieves the driver, but it does not relieve the driver from responsibility for regular control of the tire pressure. The disadvantage of such systems is recalibration of the system after changing the wheels, because the system does not perform this function automatically.

The integrated vehicle tire pressure monitoring system are used in the truck vehicles as an additional equipment. This system may be used as an additional complementary function for the control system and technical state control of the owned fleet in the transportation company. As shown in this article, the maintenance of the correct tire pressure increases the life time of tire and reduces fuel cost. The use of such systems in the transport company allows you to optimize maintenance processes of vehicles.

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