

Odpoved avtomobilskega plašča

Automobile Tyre Failure

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Za aktivno varnost avtomobila je plašč eden od najpomembnejših sestavnih delov. Njegova navidezna konstrukcijska enovitost se pri analizi odpovedi pokaže kot varljiva. Ne le, da ga ne moremo definirati kot element, še več, obravnavati ga moramo celo kot kompleksni sistem. To dejstvo je v tem članku prikazano najprej s sistemsko analizo sistema PNEVMATIKA in nato z definicijo odpovedi elementa in celotnega sistema. Na koncu je za plašč kot kompleksni sistem analizirana še odpoved zaradi padca tlaka polnilnega zraka in obrabe.

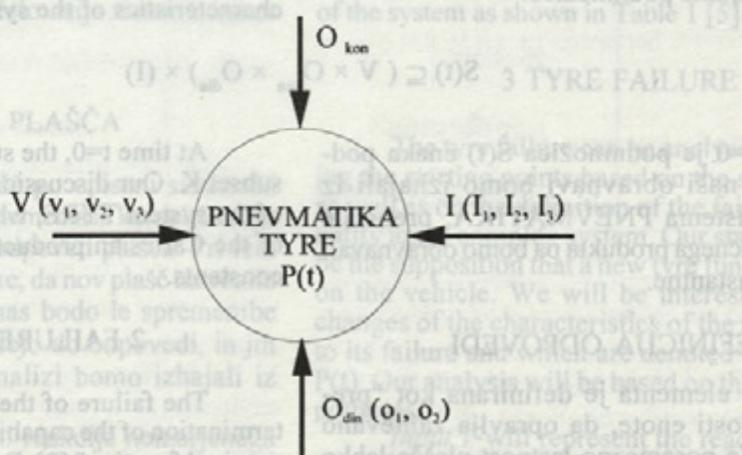
Ključne besede: plašči avtomobilski, analize sistemske, odpoved plašča, varnost aktivna

The pneumatic tyre is one of the most important parts of the car as far as the active car safety is concerned. According to the failure analysis, its apparent structural uniformity appears misleading. It is not only that the tyre cannot be defined as an entity, even more, it has to be dealt with as a complex system. All this is considered in this paper by means of the system analysis of the system TYRE as well as by the definition of the failure of both an entity and of a complex system. Failures due to the decrease of air pressure and tread wear are also analysed for the tyre as a complex system.

Key words: pneumatic tyre, system analysis, pneumatic tyre failure, active safety

1 SISTEMSKA ANALIZA

Avtomobilski plašč je kompleksen tehnični sistem, saj so razmerja med njegovimi elementi zapletena in elementov z vidika funkcionalnosti ne moremo natančno definirati [1]. Pri sistemski analizi odpovedi to niti ni potrebno, saj bomo uporabili vstopno-izstopni model. V sistemu PNEVMATIKA opravi preslikavo vstopa v izstop časovno spremenljivi operator $P(t)$. V sistem vstopajoči vstop sta množica V ter množici okolja O_{kon} in O_{din} . Iz sistema izstopajoči izstop pa je množica I , kakor je prikazano na sliki 1.



SI 1 Sistem PNEUMATIKA

Fig. 1. System TYRE.

Elementi vstopne množice V pomenijo aktivnosti voznika, ki so:

- v_1 - pospeševanje, v_2 - zaviranje,
- v_3 - upravljanje koles.

Vstopni množici O pomenita okolico. Pri tem je O_{kon} konstantna, nespremenljiva okolica, v katero za namen naše obravnave uvrstimo lastnosti avtomobila. O_{din} je dinamično spremenljiva okolica, katere podmnožici sta:

o_1 - klimatske razmere, o_2 - prometne razmere. Izhodna množica I vsebuje štiri podmnožice uporabnih lastnosti avtomobila:

- | | |
|------------------------|----------------------|
| I_1 - funkcionalnost | I_3 - ekonomičnost |
| I_2 - udobnost | I_4 - ekologijo. |

Vstope (VHOD) in izstope (IZHOD) lahko s kartezičnim produktom združimo v množico M [2]:

$$M = (VHOD) \times (IZHOD) = (V \times O_{kon} \times O_{din}) \times (I) \quad (1).$$

Vendar je očitno, da vsi elementi kartezičnega produkta fizikalno niso dovoljeni. Kot primer si zamislimo kartezični produkt, ki ne zagotavlja varne vožnje:

$$[(VHOD) \times (IZHOD)]_1 = (\text{veliko goriva} \times \text{zavoj} \times \text{poledenelo vozišče} \times \text{velika hitrost}).$$

Zaradi tega je z načelom selektivnosti že konstrukter avtomobila naredil podmnožico kartezičnega produkta:

$$K \subseteq (V \times O_{kon} \times O_{din}) \times (I)$$

Elementi kartezičnega produkta določajo namenskost vozila. Tako imamo različne podmnožice za različna vozila: npr.: tovorna, poltovorna ali osebna vozila, vozila za vožnjo po cesti ali na neutrjenem terenu, športni avtomobili ali limuzine in podobno.

Zaradi spremnjanja lastnosti sistema PNEVMATIKA definiramo podmnožico:

$$S(t) \subseteq (V \times O_{kon} \times O_{din}) \times (I) \quad (3).$$

V času $t=0$ je podmnožica $S(t)$ enaka podmnožici K. V naši obravnavi bomo izhajali iz spremnjanja sistema PNEVMATIKA, preostale elemente kartezičnega produkta pa bomo obravnavali kot časovne konstantne.

2 DEFINICIJA ODPOVEDI

Odpoved elementa je definirana kot "prenehanje zmožnosti enote, da opravlja zahtevano funkcijo" [3]. Za posamezno lastnost plašča lahko odpoved definiramo kot prenehanje zmožnosti plašča, da za dane vstope (aktivnosti voznika) in dano okolico (lastnosti avtomobila, klimatske in

The elements of the input set V represent the driver's activities, such as:

- v_1 - acceleration, v_2 - braking,
- v_3 - wheels steering.

Input sets O represent the environment where O_{kon} represents the constant, unchangeable surroundings, which, for the purpose of our research, includes the characteristics of a vehicle. O_{din} is a dynamically variable environment with two subsets:

- o_1 - climatic conditions, o_2 - traffic conditions.

The output set I contains four subsets concerning the usage of a vehicle:

- | | |
|------------------------------------|------------------|
| I_1 - functional characteristics | I_3 - economy |
| I_2 - comfort | I_4 - ecology. |

Inputs (VHOD) and outputs (IZHOD) can be combined into the set M by means of a Cartesian product [2]:

However, it is obvious that not all the elements of the Cartesian product are physically allowed. As an example, let us consider a Cartesian product that does not ensure safe driving:

$$[(VHOD) \times (IZHOD)]_1 = (\text{A lot of fuel} \times \text{bend} \times \text{icy roadway} \times \text{high speed}).$$

Because of this, the designer of the car has already formed a subset of the Cartesian product by means of the principle of selectivity:

$$K \subseteq (V \times O_{kon} \times O_{din}) \times (I) \quad (2).$$

The elements of the Cartesian product determine the purpose of the vehicle. That is why there are different subsets for different types of vehicles such as trucks, vans, cars, vehicles for on - the - road or off - the - road driving, sports cars or limousines and the like.

The subset $S(t)$ is defined due to the changing characteristics of the system TYRE:

At time $t=0$, the subset $S(t)$ is identical to the subset K. Our discussion will be based on changes of the system TYRE, while the remaining elements of the Cartesian product will be dealt with as time constants.

2 FAILURE DEFINITION

The failure of the element is defined as "the termination of the capability of an entity to perform a required function" [3]. For each individual characteristic of a tyre the failure can be defined as the termination of the capability of a tyre to ensure the required outputs (behaviour of the car) for the

prometne razmere) zagotovi zahtevane izstope (obnašanje vozila). Nastanek odpovedi prikazuje slika 2.

<i>Pri klimatskih razmerah bomo upoštevali elemente podobne načinu na katerih je vključena vožnja na suhog, mokrem in vlažnem podlagi, zato bomo vključili v razmer, ki nastanejo po funkciji megu in ledi, razen pa v obdobju med počasnejšo vožnjo in večravnim vozilom. Ne bomo narediti, saj bi to zahtevalo boljši raziskave, zato ne bomo pogledovali na posledice načina vožnje na vozilu, ki je v sklopu razmer, ki so vplivali na vozilo. Vzroki za izstop v imenovanih razmerah bomo upoštevali le podobne razlike med različnimi vozili, in pri tem naslednje elemente:</i>	
<i>i - prenašanje nevrijemeljivosti na vozniških silah ii - premikanje po podlagi iii - prenašanje vzdržljivosti</i>	<i>f_a(t) - zgornja meja f_b(t) - spodnja meja</i>

Sl. 2. *Nastanek odpovedi*Fig. 2. *Origin of failure*

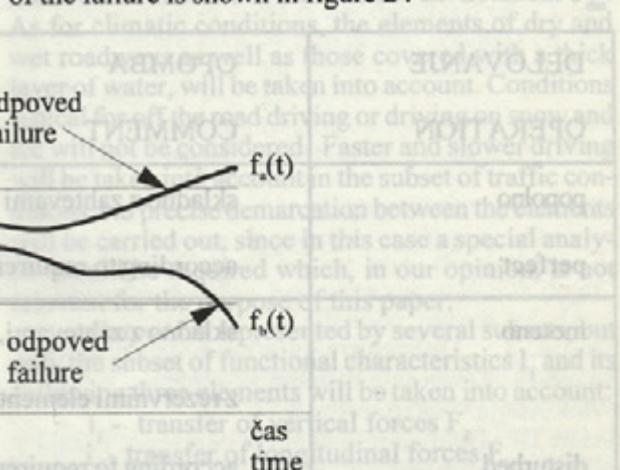
Funkciji $f_a(t)$ in $f_b(t)$ pomenita poljubni lastnosti plaščev. Prva funkcija po določenem času t doseže zgornjo mejo, druga pa spodnjo mejo. V obeh primerih pride do odpovedi plašča kot elementa, saj obe meji določata tolerančno območje funkcionalnosti plašča. Ker pa sistem PNEVMATIKA ni element, temveč kompleksen sistem, je določitev odpovedi nekoliko bolj zapletena. Pri kompleksnem sistemu nimamo več ene funkcije, kakor je to praviloma pri elementu in tudi preprostem sistemu. Zato njihovega stanja ne moremo več opisovati z zanesljivostjo, ki temelji na Boolean algebri. Stanje kompleksnih sistemov opisujemo s teorijo razpoložljivosti, ki temelji na Markovovem modelu. Tu se kljub odpovedi ene funkcije v nekaterih okoliščinah še vedno lahko odločimo za uporabo sistema [4]. V tem primeru imamo tako različna stanja delovanja sistema, kakor jih opisuje preglednica 1 [5].

3 ODPOVED PLAŠČA

S postavljivo izhodišč po opisani sistemski analizi in definiciji odpovedi elementa in kompleksnega sistema lahko analiziramo odpoved plašča. Pri tem bomo izhajali od predpostavke, da nov plašč na vozilu deluje popolno. Zanimale nas bodo le spremembe njegovih lastnosti, ki privedejo do odpovedi, in jih opisuje operator $P(t)$. V analizi bomo izhajali iz naslednjih predpostavk:

Vstop V bo prikazoval reakcije neizurjenega voznika, to je voznika z osnovnim znanjem vožnje, ki se v kritičnih situacijah odziva nagonsko. Takšnim voznikom avtomobilske tovarne tudi priredijo osnutek aktivne varnosti vozila.

given inputs (the driver's activity) as well as for the given environment (the car's characteristics, climatic conditions, traffic conditions). The origin of the failure is shown in figure 2.

Sl. 2. *Nastanek odpovedi*Fig. 2. *Origin of failure*

Functions $f_a(t)$ and $f_b(t)$ represent any tyre characteristics. The first function attains the upper limit in a certain time t , whereas the second one reaches the lower limit. In both cases there is a tyre failure as an entity, since both limits determine the tolerance range of the functional characteristics of the tyre. But, since the system TYRE is not an entity but a complex system, the failure assessment is somewhat more complicated. In a complex system we do not deal with one function only, as is the case with an entity and a simple system. That is why complex systems cannot be described in terms of reliability based on Boolean algebra; the theory of availability based on Markov's model is applied. Namely, this model still makes it possible to apply the system under certain conditions even though one function may fail [4]. In this case there are such different operating states of the system as shown in Table 1 [5].

3 TYRE FAILURE

The tyre failure can be analysed by determining the starting points based on the system analysis as well as on the definition of the failure of both the entity and a complex system. Our starting point will be the supposition that a new tyre functions perfectly on the vehicle. We will be interested only in the changes of the characteristics of the tyre which lead to its failure and which are denoted by the operator $P(t)$. Our analysis will be based on the following hypotheses:

Input V will represent the reactions of an untrained driver, i.e. a driver with only a basic knowledge of driving, who, when confronted with critical situations, reacts instinctively. The car designer adapts the concept of active car safety to such drivers.

Preglednica 1: *Vrste delovanja kompleksnega sistema*

Table 1: *Types of functioning of a complex system*

DELOVANJE OPERATION	OPOMBA COMMENT	PRIMER: PLAŠČ EXAMPLE: TYRE
popolno perfect	skladno z zahtevami according to requirements	skladno z zahtevami according to requirements
moteno disturbed	skladno z zahtevami, z rezervnimi elementi according to requirements, with spare elements	skladno z zahtevami z rezervnim plaščem according to requirements, with a spare tyre
okrnjeno limited	brez nekaterih funkcij without certain functions	poletni plašč pozimi summer tyre in the winter
zasilno provisional	le z glavnimi funkcijami with main functions only	obrabljeni plašč worn out tyre
zastoj stop	ustavitev brez nevarnosti za okolico stop without any danger for the surroundings	počasni izpust zraka slow air outlet
kritično critical	ustavitev z nevarnostjo za okolico stop dangerous for the surroundings	hitri izpust zraka fast air outlet

Okolico O prikazujeta konstantna okolica O_{kon} in dinamično spremenljiva okolica O_{din} . V konstantno okolico O_{kon} bomo pri obravnavi plašča uvrstili celoten avtomobil, za katerega bomo predpostavili, da je opremljen v skladu z zahtevami izdelovalca in ima zato vse lastnosti v tolerančnem območju.

Zanemarili bomo njihovo časovno spremjanje, izjema so seveda plasči. V dinamično okolico O_{din} pa sta uvrščeni podmnožici klimatske in prometne razmere. Pri klimatskih razmerah bomo upoštevali elemente suhega, mokrega in z visoko vodo prekritega vozišča. Razmer, ki nastanejo pri terenski vožnji ali vožnji po snegu in ledu, ne bomo upoštevali. Pri podmnožici prometne razmere pa bomo upoštevali hitrejšo in počasnejšo vožnjo. Natančne razmejitve med elementi ne bomo naredili, saj bi to zahtevalo posebno analizo, poleg tega pa menimo, da za namen tega prispevka to ni potrebno.

Izstop I pomeni več podmnožic, od katerih bomo upoštevali le podmnožico funkcionalnih lastnosti I_1 , in pri njej naslednje elemente:

i_1 - prenašanje navpičnih sil F_z

i_2 - prenašanje vzdolžnih sil F_x

i_3 - prenašanje bočnih sil F_y

Za vse tri elemente bomo postavili pogoj, da lastnost, ki jo ima posamezen element, ne sme izstopiti iz tolerančnega področja, ki še zagotavlja aktivno varnost. Za novo vozilo je to področje implicitno določil izdelovalec vozila, pri starem vozilu pa bomo upoštevali le vpliv plasčev.

Vstopne in izstopne veličine bo povezoval operator $P(t)$, ki upošteva časovno spremjanje plasčev: $I = P(t) \cdot V$

Najpomembnejši časovni spremembi plasčev sta spremjanje tlaka polnilnega zraka in zmanjševanje globine kanalov. Zanj bomo naredili kakovostno analizo, v kateri bomo povezali različne elemente klimatskih in prometnih razmer s pogojem, da bo izhod zagotavljal aktivno varnost za neizurjenega voznika.

3.1 Spreminjanje tlaka polnilnega zraka

Polnilni zrak z ustreznim tlakom neposredno sodeluje pri prenašanju navpičnih sil F_z z vozila na cestišče. Posredno pa, z ojačevanjem lupine, ki jo predstavlja avtomobilski plasč, omogoča prenašanje sil pospeševanja in zaviranja F_x ter bočnih sil F_y , ki omogočajo vožnjo v krivinah. Ker pa guma, iz katere je izdelan avtomobilski plasč, ni absolutno tesna, pride s časom do zmanjševanja tlaka polnilnega zraka. To povzroči različna stanja delovanja sistema, kar prikazuje slika 3.

Their changes which occur over a period of time will be neglected, the only exception being the tyres. Furthermore, the subsets of climatic and traffic conditions will be included in the dynamic environment O_{din} . As for climatic conditions, the elements of dry and wet roadways as well as those covered with a thick layer of water, will be taken into account. Conditions typical for off the road driving or driving on snow and ice will not be considered. Faster and slower driving will be taken into account in the subset of traffic conditions. No precise demarcation between the elements will be carried out, since in this case a special analysis would be required which, in our opinion, is not relevant for the purpose of this paper.

Output I is represented by several subsets, but only the subset of functional characteristics I_1 , and its following three elements will be taken into account:

i_1 - transfer of vertical forces F_z

i_2 - transfer of longitudinal forces F_x

i_3 - transfer of lateral forces F_y

For all three elements we make it a condition that the characteristic represented by an individual element must be within the tolerance range which still ensures active car safety. For a new vehicle this tolerance is implicitly determined by the manufacturer, whereas for an old one only the influence of tyres will be considered.

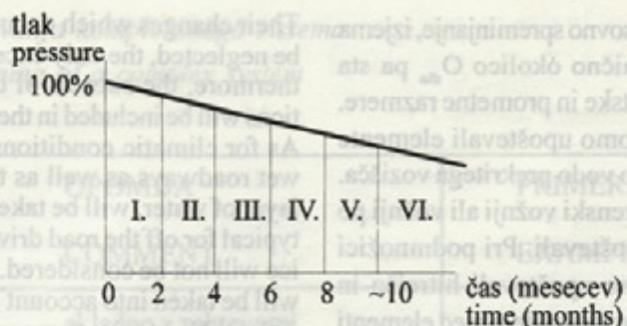
Input and output quantities will be connected by an operator $P(t)$ that takes into account the changing of tyres over a period of time:

$$I = P(t) \cdot V \quad (4)$$

The most important changes in tyres which occur over a period of time are changes of air pressure and the depth of tread grooves. Therefore, a qualitative analysis will be carried out in order to combine different elements of climatic and traffic conditions, with the condition that the output would ensure active safety for an untrained driver.

3.1 Air pressure changes

Adequate air pressure directly affects the transfer of vertical forces F_z from the vehicle to the roadway. Indirectly, by strengthening the shell, represented by the tyre, it enables the transfer of acceleration and braking forces F_x as well as of lateral forces F_y which enable driving around bends. Because the rubber of which the tyre is made is not absolutely tight, a decrease of air pressure occurs. This causes different operating states of the system as shown in figure 3.



Sl. 3: Zmanjševanje tlaka zraka v pnevmatiki

Fig. 3: Decrease of air pressure in tyre

Stanje I.: Delovanje sistema je popolno.

Stanje II.: Delovanje sistema je moteno; vožnja v ovinkih terja večjo pozornost.

Stanje III.: Delovanje sistema je okrnjeno; vožnja v ovinkih terja zmanjšano hitrost.

Stanje IV.: Delovanje sistema je zasilno; vožnja je mogoča le ob zmanjšani hitrosti.

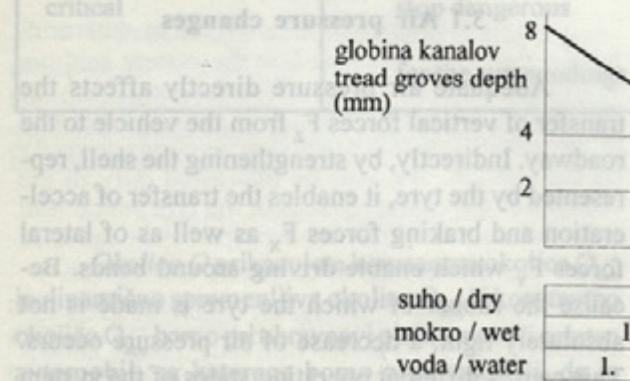
Stanje V.: Delovanje sistema zahteva zastoj; vozilo moramo ustaviti.

Stanje VI.: Delovanje sistema je kritično; nadaljnja vožnja postane nevarna.

Za opisana stanja je odpoved pnevmatike postopna in delna, v zadnjem stanju pa popolna. V primeru nasilne porušitve strukture avtomobilskega plašča, ko pride do trenutnega padca tlaka zraka, pa je odpoved nenasilna in popolna, zaradi tega pa tudi katastrofalna.

3.2 Zmanjševanje globine kanalov

Globina kanalov ima pomembno vlogo pri prenašanju vzdolžnih (F_x) in bočnih (F_y) sil z avtomobila na vozišče, na katerem je voda. Glede na količino vode razlikujemo dve vrsti vozišč [6]. Ko voda vozišče le omoči in ne presega višine 2 mm, govorimo o mokrem vozišču. Če pa je na vozišču več ko 2 mm vode in glede na vozne razmere obstaja nevarnost splavanja, govorimo o vodi na cesti. Delovanje plaščev in s tem različna stanja delovanja sistema PNEVMATIKA prikazuje slika 4.



Sl. 3: Zmanjševanje zraka v plašču

Fig. 3: Decrease of air pressure in tyre

State I: The operation of the system is perfect.

State II: The operation of the system is disturbed; driving around bends requires more attention.

State III: The operation of the system is limited; driving around bends requires lower speed.

State IV: The operation of the system is provisional; driving is possible only at reduced speed.

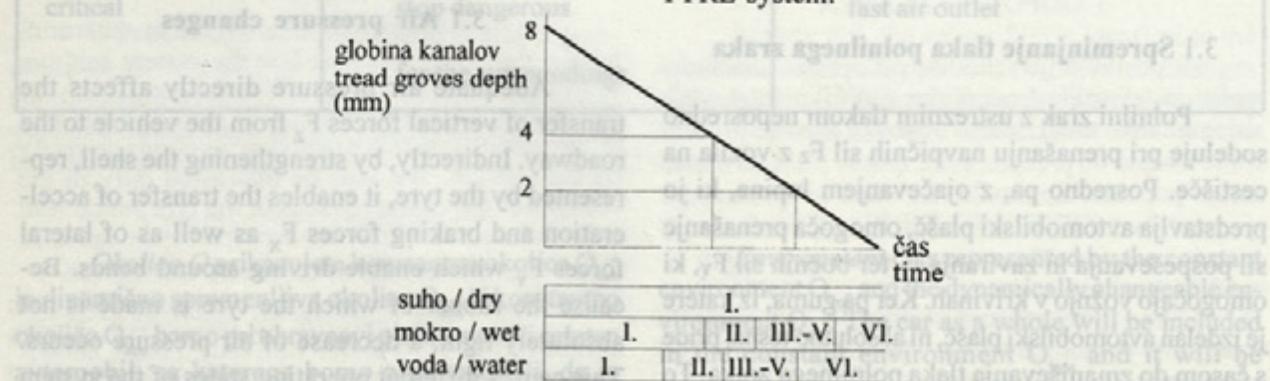
State V: The operation of the system requires stopping; driving has to be stopped.

State VI: The operation of the system is critical; any further driving becomes dangerous.

The tyre failure is gradual and partial for the above-mentioned states, except for the last one where, it is complete. In the case of violent braking of the tyre structure - and thus an instantaneous decrease of air pressure - the failure is sudden and complete, and therefore catastrophic.

3.2 Tread wear

Tread pattern has an important role in transferring longitudinal (F_x) and lateral forces (F_y) from the car to the roadway covered in water. We distinguish two different types of roadways as to the thickness of water layer on the roadway [6]. When water only moistens the roadway and the thickness of its layer does not exceed 2 mm, we can speak about a wet roadway. If there is more than 2 mm of surface water and a danger of aquaplaning, we can speak of water on the road. Figure 4 shows the functioning of tyres, and, accordingly, the different states of the TYRE system.



Stanje I.: Delovanje sistema je popolno, na suhem vozišču do popolne obrabe plasča, saj kanali ne vplivajo na oprijem. Na mokrem vozišču je delovanje plasčev nemoteno le do okoli 4 mm in na vodi do okoli 5 mm globine kanalov.

Stanje II.: Delovanje sistema je moteno in zahteva dodatno pozornost voznika.

Stanje III. do V.: Delovanje sistema postane okrnjeno oz. zahteva celo zastoj. Na mokrem vozišču se to prične pri okoli 3 mm in na vodi že pri 4 mm globine kanalov. Voznik mora močno povečati pozornost, zmanjšati hitrost in se izogibati vsakim sunkovitim reakcijam.

Stanje VI.: Delovanje sistema postane kritično. Na mokrem vozišču je to pri globini kanalov pod 1,6 mm in na vodi pod 2 mm. Vožnja s takšnimi plasči postane nevarna.

4 SKLEP

Povsem razumljivo je, da so za različne lastnosti plasča definirana različna tolerančna območja. Težava pa se pojavi pri definiranju velikosti posameznega področja. Na to težavo kaže že definicija odpovedi plasča, kjer je odpoved odvisna tudi od klimatskih razmer. To praktično pomeni, da bo plasč s premajhno globino kanalov v stanju delovanja na suhem vozišču in v stanju odpovedi na mokrem vozišču. Vso to zapletenost danes rešujejo trije subjekti: izdelovalec vozila, zakonodaja in uporabnik vozila.

Izdelovalec vozila ima že pri samem razvoju določen sistem tolerančnih območij za posamezne lastnosti. Praktično to pomeni, da vozila ne sprosti za izdelavo, dokler ne ugotovi, da so vse njegove lastnosti v skladu z njegovimi lastnimi zahtevami in tudi z zahtevami tehnične zakonodaje držav, kamor namerava vozilo prodajati. Tako lahko predpostavimo, da je delovanje novega vozila popolno in v celoti v skladu z zahtevami izdelovalca in zakonodaje. Različne kakovosti vozil ne zanikajo te predpostavke, pomenijo le, da imajo različni izdelovalci pač različna tolerančna območja v skladu z namenom uporabe vozila, svojimi razvojnimi in izdelovalnimi možnostmi in ugledom znamke vozila, ki ga želijo na tržišču. Praktično so tolerančna območja izdelovalca vozila definirana v posredni obliki v homologacijski dokumentaciji vozila. V njej so določeni vsi elementi, ki so potrebni za delovanje vozila. Povzetek teh elementov vsebuje Izjava o ustreznosti vozila, ki jo mora imeti vsako novo vozilo. Odpoved, ki je posledica nespoštovanja tehničnih zahtev izdelovalca vozila, izraženih v homologacijskem dokumentu, ugotovijo pregledniki na tehničnem pregledu vozila. Takšno odpoved zato lahko imenujemo homologacijska odpoved.

State I: The functioning of the system is perfect on dry roadways up to the point when the tyre is completely worn out, which is due to the fact that tread grooves do not influence the grip. On wet roadways the functioning of tyres is not disturbed only when the grooves are about 4 mm depth, whereas on water it holds true for the depth of grooves equal to about 5 mm.

State II : The functioning of the system is disturbed and requires additional attention on the part of the driver.

State III to V : The functioning of the system becomes limited or it requires stopping. On wet roadways this process begins when the grooves are at about 3 mm depth, and on water at 4 mm depth. The driver has to pay full attention, reduce speed and avoid sudden and abrupt reactions.

State VI : The functioning of the system becomes critical. On wet roadways it occurs when the grooves are at a depth of 1.6 mm, on water when they are at the depth of less than 2 mm. Driving with such tyres becomes dangerous.

4 CONCLUSION

It is quite understandable that for different tyre characteristics different tolerances are defined. However, it is difficult to define each tolerance range, as is evident from the definition of the tyre failure which states that the failure depends on climatic conditions, as well. This practically means that a tyre with an inadequate tread pattern (grooves are not deep enough) can function on dry roadways but fails on wet roadways. Nowadays, there are three main factors which are involved in solving this complicated situation: the manufacturer of the vehicle, legislation and the user of the vehicle.

When designing a vehicle, the manufacturer takes into consideration a certain system of tolerance ranges. That means that the vehicle is not released for manufacture unless it complies with the manufacturer's own technical specifications and the requirements regarding technical regulations of the countries to which it is to be exported. It can thus be assumed that a new car functions perfectly and that it is completely in accordance with the requirements of both the manufacturer and the legislation. This assumption cannot be negated even by the fact that cars differ in their quality. Namely, different manufacturers determine different tolerance ranges for various reasons, one being the purpose of the car, the other their own possibilities in the field of car development and manufacturing, and finally also the reputation they would like to acquire for certain car brands on the market. Tolerance ranges are indirectly defined by the manufacturer in the homological documentation of the vehicle which determines all the elements required for the intended functioning of the vehicle. A condensed list of these elements is included in the Safety Compliance Certification which has to be attached to each car. Any failure which is due to the neglect of the manufacturer's technical specifications given in the homological document is determined during a periodic overhaul of the vehicle. Such failure can thus be called a homological failure.

Zakonodaja sprejme kot izhodišče predpostavko, da je delovanje novega vozila popolno. Zato prepoveduje spremembe, ki bi povzročile drugačno vozilo, kakor ga je odobril njegov izdelovalec. Predpisuje pa tudi, kakšne so lahko spremembe učinkovitosti zavor, sestave izpušnih plinov, obrabljenosti elementov obes in stanja plaščev. To vrsto odpovedi ugotovi preglednik na tehničnem pregledu z upoštevanjem predpisov, zato jo lahko imenujemo normativna odpoved.

Uporabnik vozila se odloča o zamenjavi plaščev glede na lastno znanje in odgovornost, to pomeni, da sam določa tolerančno območje in trenutek odpovedi. Poleg globine kanalov, ki je tudi zakonsko predpisana in jo mora upoštevati, ocenjuje tudi splošno stanje plaščev, še zlasti poškodbe. Če njegove ocene niso ustrezne, lahko pride do dejanske odpovedi plašča, na primer nenaden izpust zraka. V obeh primerih, ko uporabnik to oceni ali ko pride do dejanske odpovedi, mora plašč na vozilu zamenjati, zato to vrsto odpovedi imenujemo dejansko odpoved.

Dandanes določamo, kakorkoli že, le lastnosti, ki vplivajo na aktivno varnost vozila. Pa še pri tem je zanemarjen vpliv tlaka polnilnega zraka, ki nima na aktivno varnost vozila nič manjšega vpliva kakor na primer globina kanalov. Povsem pa so neupoštevane ekološke lastnosti in ekonomičnost plaščev. Tako kakor sta ekonomičnost in ekologija že močno posegli v razvoj motorja, lahko pričakujemo, da bosta v bližnji prihodnosti posegli tudi v razvoj plaščev.

The legislation assumes that the functioning of a new car is perfect. Therefore, it prohibits any modifications that would bring about vehicle changes which are not in accordance with the manufacturer's homological documents. At the same time the legislation prescribes any permissible changing of braking efficiency, the composition of exhaust gases, suspension wear and tyre conditions. This type of failure is determined during period overhauls, which have to be carried out according to the regulations, and it is therefore called a standardised failure.

The user of the vehicle decides whether to replace tyres or not according to his/her knowledge and sense of responsibility, i.e. he/she determines the tolerance range as well as the instance of failure. He/she has to take into account not only the depth of tread grooves, which are legally sanctioned and thus have to be taken into consideration, but also the general state of the tyre, especially damages. If his/her assessments are not adequate, a tyre failure, such as a sudden outlet of air, can take place. In both instances, i.e. in case of the user's assessment or an actual failure, the tyre has to be replaced. That is why such failure is called an actual failure.

Nowadays, only those characteristics which influence the active safety of the vehicle are determined in different ways. The influence of air pressure is neglected although it affects the active safety no less than, for example, the tread pattern. It can be expected that, in the near future, the economical and ecological factors will play an active role in the development of tyres, just as much as they already have in the development of car engines.

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