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ISSN 0350-350X
GOMABN 39, 5, 273-294
Pregledni rad/Review
UDK 665.753.4.035 : 621.436.019.8 : 614.7 : 621.436.013.4/.068.3/.068.7 (497.13)(4-62)

GORIVO ZA DIZELOVE MOTORE "NOVI" ZAHTJEVI U PRIMJENI

Sažetak

Sve stroži zahtjevi za zaštitom okoliša odnose se svojim značajnim dijelom i na vozila pogonjena dizelovim motorima. U ovom dijelu oni obuhvaćaju zahtjeve za poboljšanjem:

- *ekonomičnosti potrošnje goriva,*
- *emisije ispuha,*
- *emisije buke.*

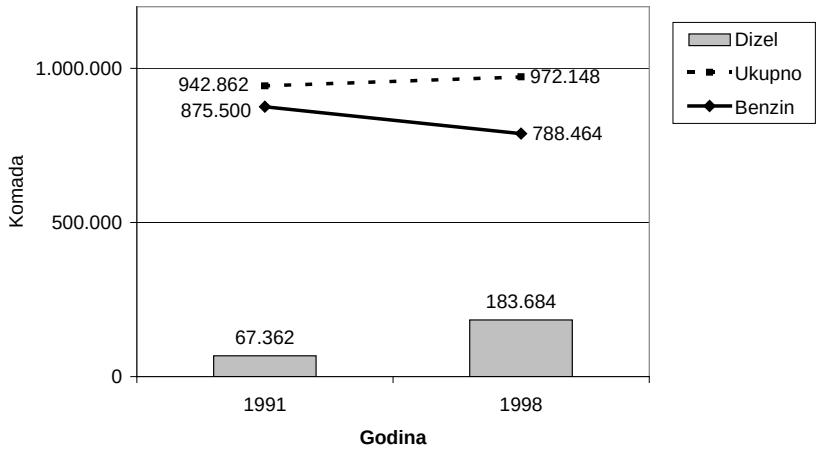
S obzirom na oštrinu ovih zahtjeva, kao i na sve kraće rokove u kojima ih treba zadovoljavati, jedino moguće rješenje je sinkronizirano poboljšavanje konstrukcije motora i vozila te kvalitete goriva. Stručnjaci koji se bave pronalaženjem zadovoljavajućih rješenja prepoznali su područja u kojima je moguće postići maksimalne učinke. Jedno od takvih područja svakako je sustav za upravljanje izgaranjem. Približavanje postavljenim zahtjevima ovim sustavom ostvaruje se ekstremnim podizanjem oštrine parametara odgovornih za pripremu smjese goriva i zraka. Sve ovo dovelo je do tehnoloških rješenja koja su osobito osjetljiva na fizički i kemijski utjecaj goriva na elemente sustava s kojima je ono u doticaju.

Određena iskustva u primjeni alarmiraju na nužnost prepoznavanja mogućih opasnosti. Namjera ovog rada je da uz kratki prikaz novih tehnoloških rješenja sustava za ubrizgavanje goriva kod dizelovih motora ukaže na moguće probleme. Osobita pažnja usmjerena je na one značajke kvalitete koje mogu biti odgovorne za sigurnost primjene dizelskog goriva u suvremenim visokozahtjevnim motorima.

UVOD

Iz godine u godinu raste udio osobnih motornih vozila pogonjenih dizelovim motorom. U razdoblju od 1991. do 1998. ostvareno je povećanje udjela dizelovih osobnih vozila sa 7 na 19% uz istovremeni blagi porast ukupnog broja vozila i pad onih koje pogoni benzinski motor (slika 1).

Slika1: Osobna vozila u Republici Hrvatskoj
Figure 1: Passenger vehicles in Croatia



Ukupno – Total Komada – Pieces Godina - Year

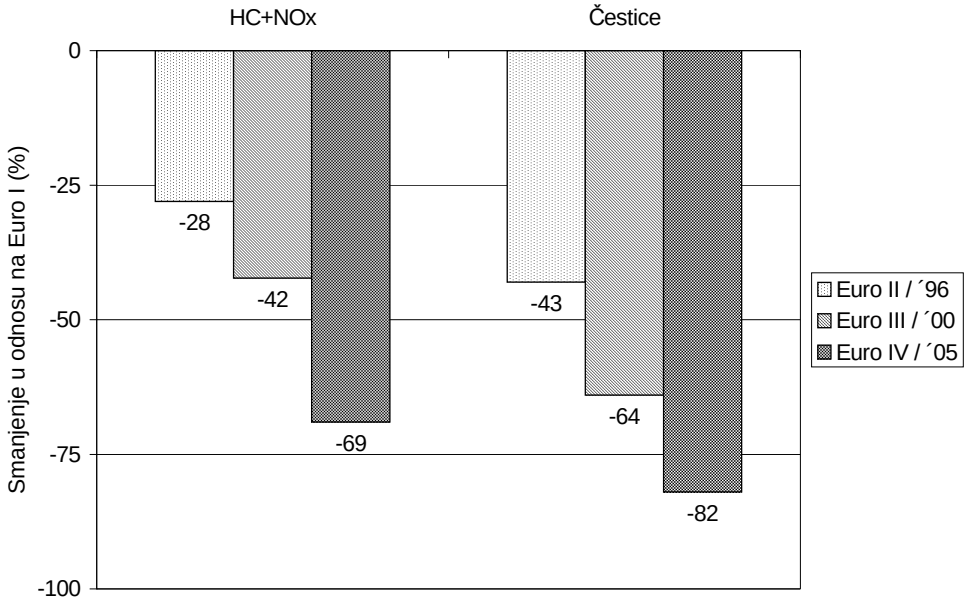
Glavni pokretači ovog porasta prednosti su koje u području potrošnje goriva ostvaruje dizelov motor u odnosu na benzinske motore. Ovu vrst prednosti dizelov motor ostvaruje poznatim elementima:

- veći omjer kompresije,
- manji gubici prigušenja,
- veća volumetrijska ogrjevna moć goriva,
- manja jedinična cijena goriva.

Premda je ovaj porast, ponajprije zbog više cijene dizelovih motora te zbog određenih nedostataka vezanih za ugodnost vožnje, bio razmjerno uravnotežen,

ipak je s pozicije brige za okoliš, udio osobnih vozila pogonjenih dizelovim motorom postao značajno respektabilan. Propisi kojima se regulira dopuštena razina emisije ispuha dizelovog motora postaju sve stroži. Posebno ilustrativan je primjer ograničavanja razine koksnih čestica, dušikovih oksida i neizgorjelih ugljikovodika. U Europi postoje poznate norme Euro I, II, III i IV. Pored oštrine ovih propisa, za proizvođače vozila osobito je bila zabrinjavajuća brzina njihovih promjena. Slika 2 ilustrira i oštrinu i dinamiku promjena ovih Euro zahtjeva.

Slika 2: Emisija - Euro zahtjevi
Figure 2: Emission – the Euro requirements



Čestice – Particles Reduction with regard to Euro I (%)

Ilustracije radi, pretpostavimo li Euro I zahtjev polaznim zahtjevom, vidimo da sljedeći zahtjev koji je trebalo dostići za 4 godine traži smanjenje količine čestica u ispuhu za 43% uz istovremeno smanjenje količine HC i NO_x za 28%. Euro III je trenutačno važeći zahtjev i on je za isto razdoblje zahtijevao smanjenje čestica za 37,5% i HC+ NO_x za 20% u odnosu na Euro II. Ne tako daleka budućnost je Euro IV zahtjev zadovoljenjem kojega će se ostvariti

respektabilno smanjenje čestica za 82% i HC+ NO_x za 69% u odnosu na početni Euro I zahtjev.

IZVEDBENE PROMJENE

Ovako oštri zahtjevi maksimalno su mobilizirali razvojne resurse u automobilskoj industriji. Intenzivni razvoj rezultirao je revolucionarnim promjenama u izvedbi dizelovog motora čime je ostvareno:

- izravno ubrizgavanje goriva,
- povećavanje tlaka ubrizgavanja,
- računalno upravljanje ubrizgavanjem,
- povrat dijela ispušnih plinova i
- dodatna obradba ispušnih plinova.

Sva ova poboljšanja, osim što su omogućila dostizanje zadanih razina kvalitete ispušnih plinova, osigurala su i dodatno unapređenje ekonomičnosti potrošnje goriva i osobito značajno poboljšanje u području percepcije ugodnosti vožnje. Dizelov motor u osobnom vozilu postao je uz značajno manju potrošnju goriva po izlaznim performancama blizak benzinskom motoru. Tako se dogodilo da su nametnuti zahtjevi za kvalitetom ispuha rezultirali značajnim ubrzavanjem povećavanja udjela osobnih vozila s dizelovim motorom u ukupnom motornom fondu razvijenih tržišta.

Jedan od važnih elementa koji je omogućio značajno povećanje performanci novih dizelovih motora bilo je kombiniranje izravnog ubrizgavanja s ekstremno visokim tlakovima ubrizgavanja goriva. Razmjeri promjena u tlakovima ubrizgavanja pokazani su slikom 3.

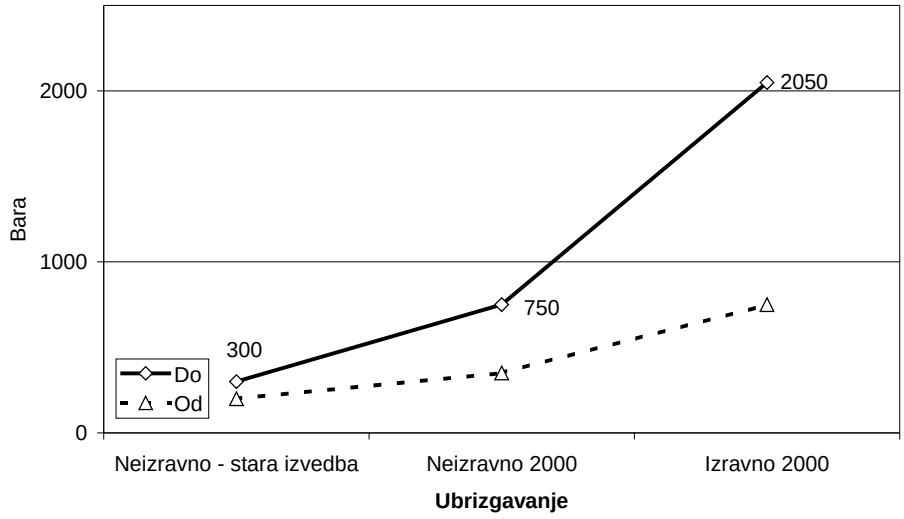
Slika 3 ilustrira raspone tlakova u sustavima za ubrizgavanje iz proizvodnog programa jednog od svjetski poznatih proizvođača namijenjenih za ugradnju u 2000. godini. U ovom slučaju rasponi tlakova kod neizravnog ubrizgavanja kretali su se od 350 do 700 bara, a kod izravnog ubrizgavanja od respektabilnih 750 do ekstremnih 2.050 bara. Kako bi se mogli ostvariti ovako visoki tlakovi, zračnost između pokretnih elemenata sustava smanjena je do ekstremnih granica. Isto tako razmjerno su smanjeni i promjeri sapnica brizgaljki. Sve ovo posljedično je uzrokovalo povećanje osjetljivosti sustava na:

- abraziju,
- koroziju i
- zaglavljivanje pokretnih elemenata.

Drugi značajan element kojim su ostvarena poboljšanja performanci bio je element računalnog upravljanja izgaranjem. Kod ovih sustava namjenskim

mjernim osjetilima skupljaju se podaci o zahtjevima i odzivu rada motora. Ovi podaci se računalnom usporedbom s unaprijed mapiranim podacima za različite režime rada moduliraju u odzive postavnih elemenata izvršnih članova sustava za ubrizgavanje goriva. Elektroničko vođenje omogućilo je gotovo savršenu preciznost određivanja i postavljanja trenutka i trajanja ubrizgavanja što je u slučaju izravnog ubrizgavanja od iznimnog značenja za ostvarivanje zahtjevnih performanci. No svako degradiranje mjerenih signala, kao i blokiranje kretanja izvršnih članova, rezultira ozbiljnim pogoršanjima u radu motora. Budući da je većina elemenata odgovornih za funkcioniranje ovih sustava u izravnom doticaju s gorivom, i budući da je povećana osjetljivost na prije spomenute utjecaje, gorivo u takvim motorima postaje posebno odgovorno za njihovu zaštitu i siguran rad.

Slika 3: Tlak ubrizgavanja
Figure 3: Injection pressure



Indirect-old design Indirect 2000 Direct 2000

Osim spomenutih elemenata koji se odnose na upravljanje izgaranjem i kojima se izravno ostvaruju projektirane performance motora, u nova vozila ugrađuju se i sustavi čija je isključiva zadaća ostvarivanje zahtijevane kvalitete

emisije ispuha. Ovi sustavi, poput recirkulacije dijela ispušnih plinova, katalizatora izgaranja u ispuhu i hvatača neizgorjelih čestica, također za svoj učinkovit i dugotrajan rad zahtijevaju odgovarajuću kvalitetu goriva.

ZADOVOLJENJE ZAHTJEVA TROŠILA

Tržišni pristup nalaže zadovoljenje zahtjeva trošila. Zadovoljenje zahtjeva trošila ostvarivo je u tri osnovna pravca djelovanja:

1. Osiguranje zakonski regulirane kvalitete u spremniku kupca.
2. Briga o zakonski nereguliranim značajkama kvalitete.
3. Pravovremeno osiguranju dostupnosti kvalitete koja zadovoljava zahtjeve novih trošila.

Osiguranje zakonski regulirane kvalitete u spremniku kupca potpuno je određeno pravilima i slučajevi neostvarivanja postavljenih granica spadaju u ekscesne događaje.

Briga o zakonski nereguliranim značajkama kvalitete primjenska je kategorija i njezino ostvarivanje rezultira povećanom sigurnošću primjene goriva. Značajke koje motorna industrija ističe odgovornima za kvalitetan primjenski odziv dizelskog goriva su:

- ukupni sadržaj aromata,
- rast mikro organizama,
- sadržaj derivata biljnih estera,
- ukupni kiselinski broj,
- utjecaj na čistoću brizgaljki.

Promjene u regulativi za kvalitetom goriva posljedica su težnje za trajnim poboljšanjem čistoće okoliša i obveze prilagodbi novim izvedbenim rješenjima motora. Visoka tehnološka i ekonomska razvijenost generatori su postavljanja sve oštrijih granica. Manje razvijena područja u stalnoj su utrci dostizanja postavljenih ciljeva. Ove promjene očituju se u reguliranju do sada nereguliranih značajki, primjerice mazivosti i sadržaja policikličkih aromata, koje su ušle u najnoviju europsku normu za dizelska goriva, ili pak, što je češći slučaj, na pooštravanje već reguliranih značajki. U ovom području bilježi se ubrzano pooštravanje četiriju značajki:

1. sadržaja sumpora,
2. gustoće,
3. destilacije i
4. cetanskog broja.

Regulacijom ovih značajki ostvaruje se:

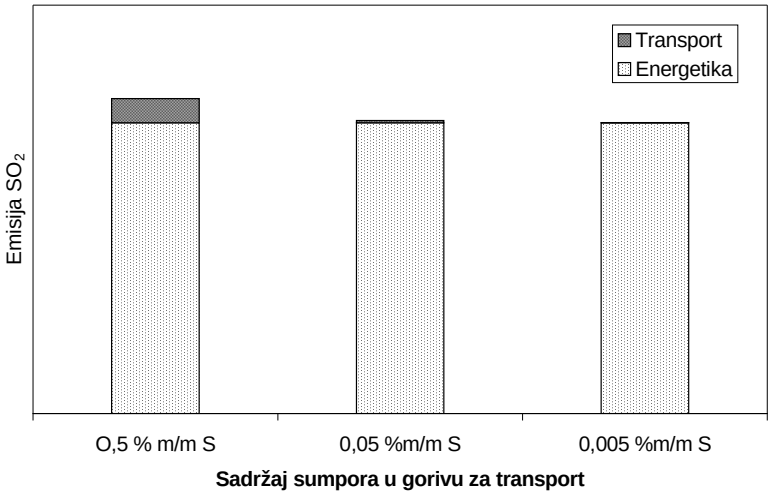
1. Izravno smanjivanje količine tvari u ispušnim plinovima koje štete okolišu reguliranjem dopuštene količine te tvari u gorivu, te poboljšanje gorivih osobina samog goriva.
2. Osiguravanje minimalnog utjecaja goriva na pogoršavanje ispravnog, sigurnog i dugotrajnog rada sustava za kontrolu izgaranja i smanjenje emisije ispuha.

Sadržaj sumpora izravno utječe na:

1. količinu SO_2 u ispuhu,
2. količinu koksnih čestica u ispuhu,
3. smanjenje učinkovitosti sustava za obradu ispušnih plinova.

Svi ovi utjecaji odgovorni su za onečišćenje okoliša, no značaj svakog od njih različit je s obzirom na ukupni učinak i moguća poboljšanja. Značaj emisije SO_2 iz ispuha dizelovog motora bitan je no, s obzirom na njezin udio u ukupnoj emisiji SO_2, ne i prioritetan čimbenik generiranja sve oštrijih zahtjeva za smanjenjem sadržaja sumpora u dizelskom gorivu.

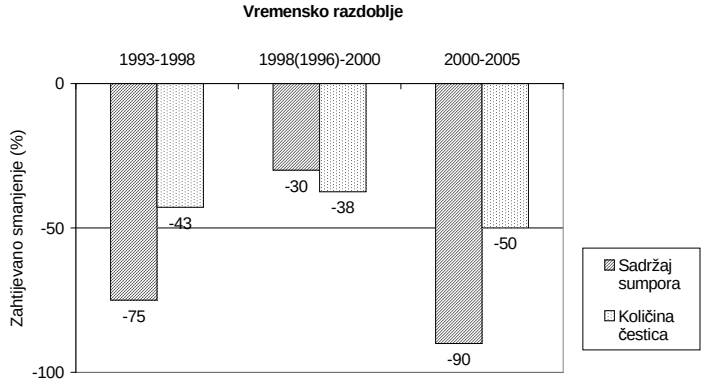
Slika 4: Projekcija emisije SO_2
Figure 4: SO_2 emission projection



Transportation fuel sulphur content

Iz slike 4 koja prikazuje projekciju udjela emisije SO_2 iz vozila s dizelovim motorom u ukupnoj emisiji SO_2 na području Republike Hrvatske, napravljenoj na temelju ukupno utrošenog goriva u energetici i transportu u prošloj godini te normiranih razina sadržaja sumpora, vidi se da bi se udio SO_2 iz vozila s dizelovim motorom prelaskom s dopuštenog sadržaja sumpora od sadašnjih 0,5% na ciljanih 0,05% smanjio za približno 7%. Iako i ova razina predstavlja doprinos brizi za okoliš, ona nije, s obzirom na veličinu i udio energije i emisije potrebne za ostvarivanje ekstremno niskog sadržaja sumpora u gorivu, prioritetan čimbenik pooštravanja zahtjeva. Primjer smanjivanja dopuštenog sadržaja sumpora s 0,05 na 0,005% koji već čvrsto ulazi u planove buduće kvalitete dizelskog goriva još izražajnije ilustrira prethodnu tvrdnju.

Slika 5: Regulacija sadržaja sumpora u gorivu i čestica u ispuhu
Figure 5: Regulation of the fuel sulphur content and the exhaust particle content



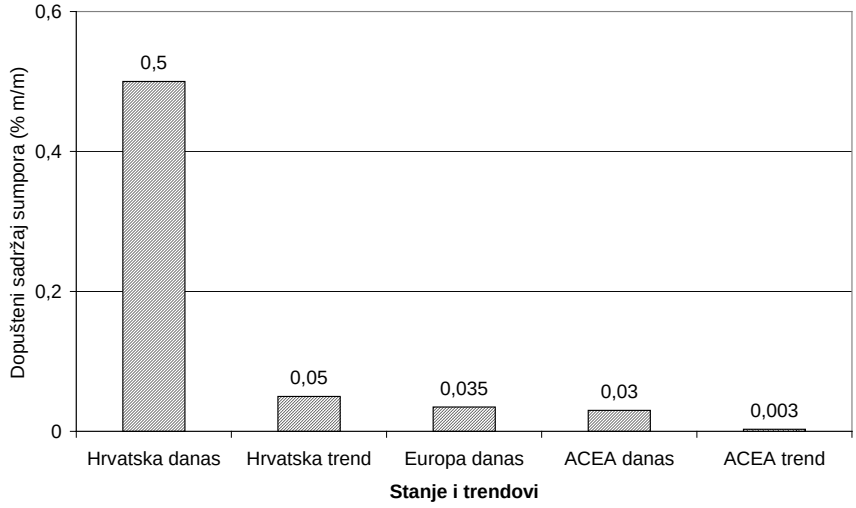
Zahtijevano smanjenje (%) - Required reduction (%)
Sulphur content Particle volume
Vremensko razdoblje - Interval

Smanjenje sadržaja sumpora u gorivu značajnije je zbog smanjenja neizgorjelih čestica u ispušnim plinovima, no i u ovom se slučaju bolji rezultati postižu konstrukcijskim promjenama u izvedbi samog motora. Naime, iako je sumpor katalizator stvaranja neizgorjelih čestica u ispuhu, promjenama

u konstrukcijskoj izvedbi motora, poput uvođenja sustava za precizno upravljanje izgaranjem pri izravnom ubrizgavanju te ugradnjom sustava za naknadnu obradbu ispušnih plinova postiže se osjetno veće smanjenje sadržaja sve strože reguliranih čestica.

Slika 5 prikazuje zahtijevana smanjenja sadržaja sumpora u dizelskom gorivu prema europskoj normi za određena vremenska razdoblja te zahtijevana smanjenja sadržaja čestica u ispušnim plinovima za ista razdoblja. Vidljiv je značajan nesrazmjer koji ukazuje da prioritet u smanjenju sadržaja čestica ima izvedbeno rješenje motora a ne sadržaj sumpora u gorivu.

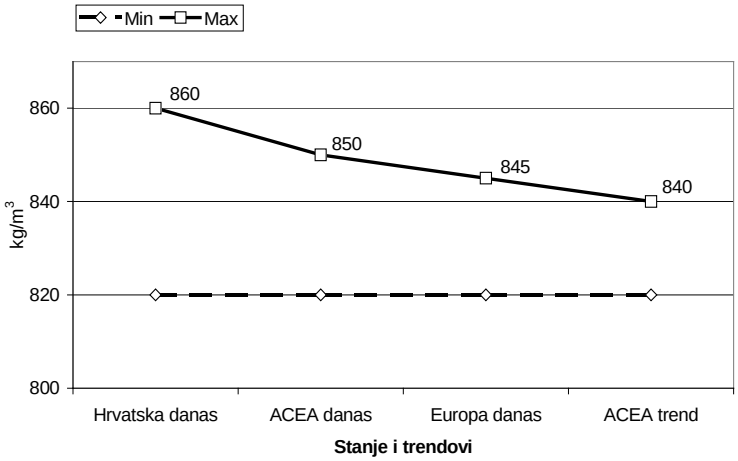
Slika 6: Sadržaj sumpora
Figure 6: Sulphur content



Permissible sulphur content (% m/m)
Croatia today Croatia-trend Europe today ACEA today ACEA-trend
Actual condition and trends

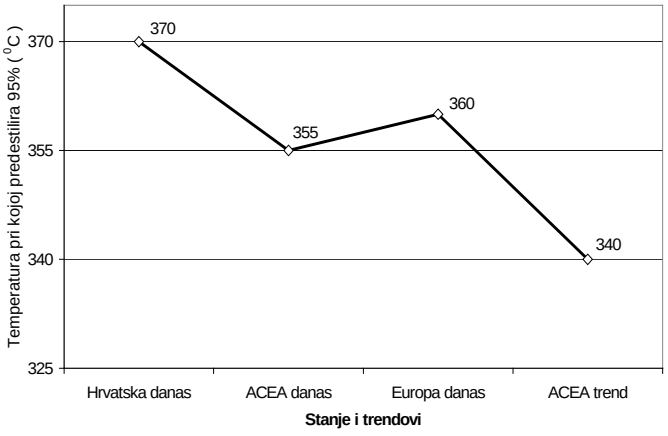
Ekstremno oštri zahtjevi za smanjenjem sadržaja sumpora u dizelskom gorivu posredno su pored ostalog vezani i za nastojanje dostizanja sve strožih normi čiji je cilj minimiziranje sadržaja nepoželjnih dušikovih oksida u ispušnim plinovima. Više nisu strane niti ideje o dovođenju sadržaja sumpora u dizelskom gorivu na razinu 0%. Dakako da ovakva ekstremna oštrina nije generirana odgovornošću sumpora za emisiju SO_2, već je najprije uzrokovana nastojanjem eliminiranja utjecaja sumpora na funkcionalnost sustava motora kojima se ostvaruje smanjivanje nepoželjnih spojeva u ispušnim plinovima.

Slika 7: Gustoća
Figure 7: Density



Croatia today ACEA today Europe today ACEA–trend
Actual condition and trends

Slika 8: Destilacija
Figure 8: Distillation



95% distillation temperature (^{0}C)
Croatia today ACEA today Europe today ACEA-trend
Actual condition and trends

Kod uređaja kojima se smanjuje emisija dušikovih oksida sumpor i njegovi spojevi odgovorni su za smanjenje njihova vijeka učinkovitog funkcioniranja.

Značajke gustoće i destilacije također su elementi prema kojima se postavljaju sve oštriji zahtjevi što ima posljedicu izravnog smanjivanja ekonomičnosti proizvodnje i uporabe goriva. Ovi zahtjevi također su usko vezani uz zahtjeve trošila a karakterizira ih sužavanje dopuštenih granica u smislu smanjivanja maksimalno dopuštenih razina (slika 7 i 8).

Ostvarivanjem ovih zahtjeva gorivo postaje lakše i primjerenije potrebama suvremenih sustava za upravljanje izgaranjem. Primjerice, sužavanjem dopuštenih granica za gustoću dizelskog goriva osigurava se preciznija regulacija sustava za recirkulaciju dijela ispušnih plinova kao i preciznije reguliranje potrebne količine ubrizganog goriva.

STRATEGIJA POOŠTRAVANJA ZAHTJEVA

Stalno pooštravanje zahtjeva prema kvaliteti dizelskog goriva globalno ima dva cilja:

1. Izravno smanjiti količinu tvari u gorivu koje onečišćuju okoliš.
2. Osigurati minimalan utjecaj goriva na pogoršavanje ispravnog, sigurnog i dugotrajnog rada sustava za kontrolu izgaranja i smanjenje emisije ispuha.

Budući da se veći rezultati u smanjenju emisije vozila postižu poboljšanjima na motoru, ovaj drugi cilj koji se odnosi na brigu o utjecaju goriva na funkciju dijelova motora prioritetni je generator ekstremno oštrih zahtjeva. Stoga svaka aktivnost definiranja vlastite kvalitete mora polaziti od zahtjeva cjelokupnog motornog fonda kome je namijenjeno dizelsko gorivo na određenom tržištu.

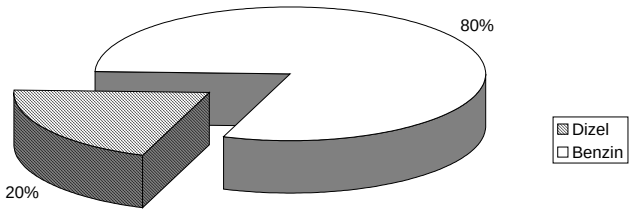
MOTORNI FOND REPUBLIKE HRVATSKE

Analiza motornog fonda na određenom tržišnom području, kao i trajno praćenje promjena njegovih zahtjeva, preduvjet je za pravovremeno osiguranje kvalitete koja zadovoljava zahtjeve novih trošila. Prema procjenama, ubrzanim rastom udjela osobnih vozila s dizelovim motorima, ostvareno je da 1/5 cjelokupnog fonda osobnih vozila u Hrvatskoj danas čine osobna vozila pogonjena dizelovim motorom.

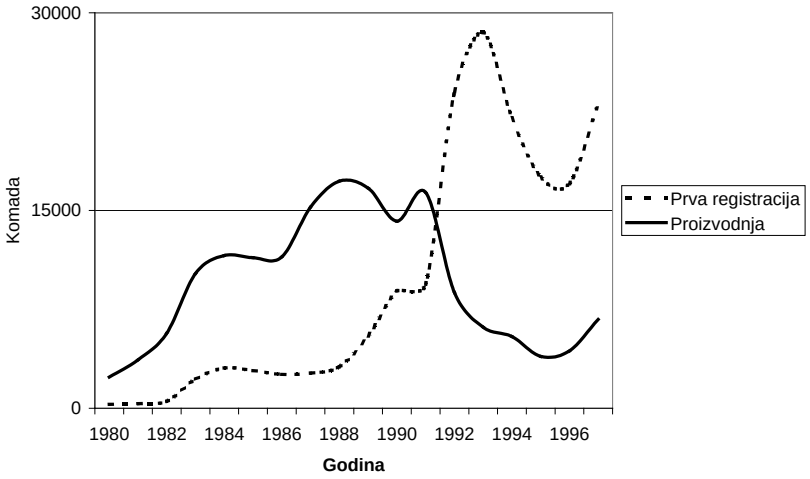
S obzirom na vremensku značajku uvođenja novih izvedbenih rješenja dizelovog motora, analiza starosne strukture osobnih vozila predstavlja

kvalitetno polazište za procjenu raspodjele i udjela zahtjevnosti pojedinih skupina vozila.

Slika 9: Osobna vozila registrirana u Hrvatskoj
Figure 9: Passenger vehicles registered in Croatia



Slika 10: Starosna struktura
Figure 10: Age structure



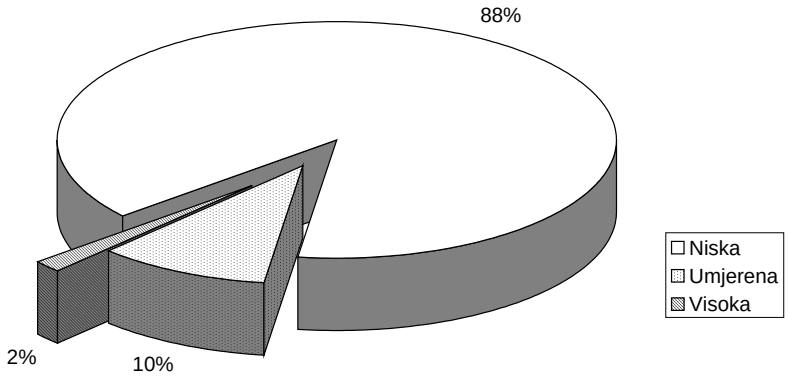
Komada – Pieces
Godina – Year
Prva registracija - First licencing
Proizvodnja – Production

Iz slike 10 koja predstavlja prikaz količina vozila prema godini proizvodnje (puna crta) te količina vozila prema godini prve registracije (isprekidana crta), jasno je da je iznimno visok porast udjela dizelovih osobnih vozila posljedica liberalizacije uvoza rabljenih vozila od 1992. godine. Na žalost, ovo pokazuje da dinamika popunjavanja dizelovog motornog fonda osobnih vozila Republie Hrvatske vozilima s novim izvedbenim rješenjima nije bila na razini razvijene Evrope. Što više, novi oštri zahtjevi za kvalitetom emisije dizelovih osobnih vozila u Europi, doprinijeli su bržem izvozu starih izvedbi u pravcu ekonomski slabijih područja.

Krajnja analiza zahtjevnosti (slika 11), temeljena na starosnoj strukturi dizelovog motornog fonda osobnih vozila te razdobljima i razinama Euro zahtjeva za emisijom, pokazuje da trenutačno u Hrvatskoj s obzirom na kvalitetu dizelskog goriva ima:

- 88% nisko zahtjevnih,
- 10% umjereno zahtjevnih i
- 2% visoko zahtjevnih vozila.

Slika 11: Zahtjevnost
Figure 11: Demanding rate



Low Moderate High

ZAKLJUČAK

- Nova izvedbena rješenja dizelovih motora i pripadajućih im sustava uspješno prate brzinu promjena u zahtjevima za zadovoljenjem kvalitete emisije.
- Ostvarena je sinergija između zadovoljenja zahtjeva za kvalitetom emisije i poboljšanja performanci vozila čime je ubrzano povećanje udjela osobnih vozila pogonjenih dizelovim motorom.
- Nova izvedbena rješenja, u uvjetima trajnog korištenja, osjetljivija su i stoga zahtjevnija prema kvaliteti goriva.
- Osiguravanje minimalnog utjecaja goriva na pogoršavanje ispravnog, sigurnog i dugotrajnog rada sustava za kontrolu izgaranja i smanjenje emisije ispuha, primarni je generator sve oštrijih zahtjeva za kvalitetom dizelskog goriva.
- Osnovni primjenski zahtjevi većinskog udjela dizelovog motornog fonda Republike Hrvatske zadovoljeni su važećim specifikacijama.
- **Osiguravanjem raspoloživosti dviju kvaliteta dizelskog goriva koje bi bile sukladne udjelima i zahtjevima starih nisko-zahtjevnih i novih visoko-zahtjevnih vozila, moguće je pravodobno zadovoljiti primjenske zahtjeve cjelokupnog dizelskog motornog fonda Republike Hrvatske te istovremeno postići pozitivne pomake u zaštiti okoliša.**

DIESEL FUEL - "NEW" APPLICATION REQUIREMENTS

Abstract

Increasingly stringent environmental protection requirements refer to a large extent also to diesel engine-powered vehicles. In this sense, they encompass requirements for improving:

- *fuel consumption cost effectiveness*
- *exhaust emission*
- *noise emission.*

Given the stringent character of the said requirements, as well as increasingly shorter deadlines within which they are to be met, the only possible solution is a synchronized improvement of vehicle

design and fuel quality. The experts engaged in finding satisfactory solutions have recognized the areas within which maximum effects may be achieved. One of such areas is definitely the combustion control system. Through this system, the set requirements are approached by extreme lifting of the parameters responsible for prepairing the fuel and air mixture. All this has led to technological solutions highly sensitive to the physical and chemical impact of fuels on the elements of the system it comes into contact with.

Certain experiences in application call for the need to appreciate possible threats. The purpose of this paper is to briefly present new technological solutions for the diesel engine fuel injection systems, while pointing to potential problems. Special attention has been given to the quality features that may be responsible for the safety of applying diesel fuel in higly demanding modern engines.

INTRODUCTION

The number of passenger vehicles powered by diesel engines has been increasing year in year out. In the 1991-1998 period, the share of diesel passenger vehicles went up from 7 to 19%, with a simultaneous mild increase of total vehicle number and decrease of those powered by gasoline engines (Figure 1).

The main causes of this increase are the advantages achieved by diesel engines in the fuel consumption area with regard to gasoline engines. These advantages are achieved by diesel engines through the following well-known features:

- higher compression ratio,
- lower throttling losses,
- higher volumetric fuel heating value,
- lower unit fuel price.

Although this increase has been relatively balanced due to the higher price of diesel engines, as well as to certain defficiencies associated with comfortable driving, from the point of environmental concern, the share of diesel engine-powered vehicles has become considerable. Regulations setting permissible exhaust emission level are growing increasingly stringent. Particularly striking is the example of limiting the level of carbon particles,

nitrogen oxides, and non-combusted hydrocarbons. In Europe, the well-known Euro I, II, III and IV standards are at force. Apart from the stringent character of these regulations, the rate at which they were changing was also particularly alarming. Figure 2 illustrates both the severity and the change dynamics of these Euro requirements.

For the purpose of illustration, if we consider Euro I to be the starting requirement, we may observe that the next requirement supposed to be complied with in 4 years requires reduction of the exhaust particulate volume by 43%, with a simultaneous reduction of HC and NO_x by 28%. Euro III, being the currently valid requirement, has demanded, over the same period, the reduction of particles by 37.5% and that of HC + NO_x by 20% with regard to Euro II. The Euro IV requirement constitutes a not so distant future. Compliance with it shall achieve an impressive reduction of particles by 82% and that of HC + NO_x by 69% with regard to the initial Euro I requirement.

CHANGES IN DESIGN

Such stringent requirements have engaged the automobile industry developmental resources to the fullest. Intense development has resulted in revolutionary changes in the design of diesel engines achieving:

- direct fuel injection,
- increased injection pressure,
- computer-controlled injection,
- exhaust gas recirculation, and
- additional exhaust gas treatment.

Apart from enabling the meeting of the set exhaust gas quality level, all these improvements have ensured additional advancement of the fuel consumption cost effectiveness, and a particularly considerable improvement of the comfortable driving perception. Passenger vehicle diesel engines have approached those gasoline in terms of output performances, with considerably lower fuel consumption. The requirements set for exhaust quality have thus resulted in a considerably faster increase of the diesel engine-powered passenger vehicles' share in total vehicle pool of the modern markets.

One among the important elements enabling a considerable performance increase of the new diesel engines was the combining of direct injection with extremely high fuel injection pressure. The extent of change referring to injection pressures is shown in Figure 3.

Figure 3 illustrates the extent of pressure in injection systems from the production programme of a world-known manufacturer for 2000. In this case the extent of pressure at indirect injection ranged from 350-700 bar, and, at direct injection, from the respectable 750 to the extreme 2,050 bar. In order to be able to achieve such high pressure, the clearance among the moving elements of the system had to be reduced to the lowest possible level. The injector nozzles' diameters were reduced accordingly. All this has caused the system to be more sensitive to:

- abrasion,
- corrosion, and
- sticking of the moving elements.

Another significant element enabling improved performances was computer-controlled combustion. In these systems, special measuring sensors collect data on the engine operation requirements and response. Through a computer-made comparison with the previously mapped data for various operating regimes, the data collected are turned into the response of the fuel injection system operating elements.

Electronic control has enabled an almost perfect precision in setting the exact injection timing and duration. In the case of direct injection, this is of extreme importance for achieving the highly demanding performances. However, any of the measurement signal degradation, as well as blocking of the executive members' movement, results in serious worsening of engine operation.

Since most elements responsible for the functioning of this systems come into direct contact with the fuel, and given the increased sensitivity to the aforementioned influences, the fuel in such engines becomes especially responsible for their protection and safe operation.

Apart from the aforementioned elements referring to injection control, directly realizing designed engine performances, the new vehicles include also the systems whose sole task it is to achieve the set exhaust emission quality. These systems, such as partial recirculation of exhaust gas, exhaust combustion catalyst, and non-combusted particle trap also require appropriate fuel quality for their efficient and lasting operation.

MEETING REQUIREMENTS OF THE CONSUMING DEVICES

Market approach calls for meeting the requirements of consuming devices. This may be achieved in the following three ways:

1. By ensuring legally regulated quality in the buyer's reservoir.
2. Through concern about the legally unregulated quality properties.
3. By timely making available the quality meeting requirements of the new consuming devices.

Ensurance of the legally regulated quality in the buyer's reservoir is entirely set by regulations. Cases of not achieving the limits set fall under the category of excess events.

Concern of the legally unregulated quality properties is an application category whose implementation results in increased fuel application safety. The properties singled out by the automobile industry as responsible for a good quality application response of the diesel fuel are as follows:

- total aromatic content,
- microbial growth,
- vegetable ester derivatives content,
- total acid number,
- impact on the cleanliness of injectors.

Changes in fuel quality regulations result from a permanent desire for environmental advancement, as well as from the need to adapt to new engine design solutions. High technological and economic development is setting more and more stringent limits. Less developed areas are constantly fighting to reach the objectives set. These changes result in the regulation of the yet unregulated properties - such as lubricity and polycyclic aromatic content - which have entered into the latest European diesel fuel standard, or, which is more often the case, in the already regulated properties becoming even more stringent. In this area, we have recorded a speedy increase in the stringent character of the following four properties:

- sulphur content,
- density,
- distillation, and
- cetane number.

The following is achieved through the regulation of the said properties:

1. Direct reduction of environmentally harmful substances in the exhaust gases through the regulation of their permissible fuel content and through the improvement of the fuel's combustive properies.
2. Ensuring minimal fuel impact on impairing correct, safe, and lasting operation of the combustion control and exhaust emission reduction systems.

Sulphur content has a direct impact on the following:

1. SO_2 exhaust content,
2. Coke particles exhaust content,
3. Lowered efficiency of the exhaust gases treatment system.

All these impacts are responsible for environmental pollution. However, their significance is different in terms of total effect and possible improvements. The significance of diesel engines SO_2 exhaust emission is considerable, but - viewing its share in total SO_2 emission - not a priority factor in elaborating growingly stringent requirements for reducing the diesel fuel sulphur content.

It may be observed from Figure 4 - showing estimated SO_2 emission share from diesel-powered vehicles in total SO_2 emission on the territory of Croatia based on total fuel consumption in energy supply and transport in the past year and on standardized sulphur content levels - that, by passing from the present sulphur content of 0.5% to the target one of 0.05%, the SO_2 share from diesel-powered vehicles would go down by approximately 7%. Although the said level also constitutes a contribution to environmental protection, given the amount and share of energy and emission necessary for achieving the extremely low fuel sulphur content, it is not a priority factor of the growingly stringent requirements. The example of reducing permissible sulphur content from 0.05 to 0.005%, already safely incorporated into the future diesel fuel quality plans, illustrates this claim even better.

The reduction of the fuel sulphur content is much more significant due to the reduction of non-combusted particles in the exhaust gases. However, even in this case, much more is achieved by change in design of the engine itself. Namely, although sulphur is the catalyst in creating non-combusted exhaust particles, changes in engine design - such as introduction of the precision combustion management system at direct injection, and the installation of the system for exhaust gas treatment, a much greater reduction is achieved of the particle content set by growingly stringent regulations.

Figure 5 shows the required diesel fuel sulphur content reduction in compliance with the European standard for specific intervals, as well as the required exhaust particle content for the same intervals. We may observe a considerable disproportion showing that it is the engine design, and not the fuel sulphur content, that has a priority impact on particle content reduction.

Extremely stringent requirements for diesel fuel sulphur content reduction are indirectly associated, among other things, also with the desire to comply with increasingly stringent standards the purpose of which is to minimize the

content of undesirable nitrogen oxides in exhaust gases. There have even been some ideas to reduce the diesel fuel sulphur content to zero level (0%). Such stringent requirements are, of course, not motivated by the fact that sulphur is responsible for SO_2 emission, but rather primarily by the tendency to eliminate sulphur impact on the functioning of engine systems enabling reduction of undesirable compounds in exhaust gases. Namely, when it comes to devices reducing the emission of nitrogen oxides, sulphur and its compounds are responsible for shortening their efficient service life.

Density and distillation properties are also the targets of growingly stringent requirements, resulting in direct lowering of the fuel production and use cost effectiveness. These requirements are also closely associated with the demands of the consuming devices, characterized by the lowering of permissible limits in the sense of reducing the maximum permissible levels, Figures 7 and 8.

By meeting these requirements, the fuel becomes lighter and more suitable for the needs of the modern combustion management systems. For instance, by lowering permissible limits for diesel fuel density, more precise regulation of the partial exhaust gas recirculation is ensured, as well as a more precise regulation of the necessary injected fuel amount.

THE STRATEGY UNDERLINING GROWINGLY STRINGENT REQUIREMENTS

The fact that the diesel fuel quality requirements are constantly growing more stringent may be explained by the following two goals:

1. Direct reduction of pollutants in the fuel.
2. Ensurance of a minimal fuel impact on impairing correct, safe, and lasting operation of the combustion control and exhaust emission reduction sistems.

Since greater results in vehicle emission reduction are achieved by engine improvements, the second objective, referring to the concern of fuel impact on the functioning of the engine parts is primarily responsible for the growingly stringent requirements. That is why any activity in defining one's own quality must begin by taking into account the entire vehicle pool for which diesel fuel on a given market is intended.

CROATIA'S VEHICLE POOL

The analysis of the vehicle pool on a given market, as well as permanent monitoring of the changes in its requirements ensures timely achievement of

the quality meeting the new consuming devices' requirements. According to estimations, a rapid growth in the share of passenger vehicles powered by diesel engines has caused them to reach 1/5 of Croatia's entire passenger vehicle pool.

Given the temporal element associated with introducing new diesel engine designs, the analysis of passenger vehicle age constitutes a good basis for estimating the distribution and requirements of individual vehicle groups.

Figure 10, presenting the number of vehicles per year of production (full line), as well as number of vehicles per year of the first licencing (dotted line) shows that the extremely high increase of the diesel passenger vehicles' share resulted from the possibility to import used vehicles introduced in 1992. This, unfortunately, shows that the dynamics of completing Croatia's diesel passenger vehicle pool by newly designed vehicles has not been at European level. Moreover, the new European stringent requirements for diesel passenger vehicles emission have contributed to the export of old vehicles to the economically less developed parts of Europe.

The final demand analysis (Figure 11), based on the age of the diesel passenger vehicle pool, as well as on the dates and levels of European emission requirements, has shown that - with regard to diesel fuel quality - Croatia at the moment has:

- 88% of low demanding,
- 10% of moderately demanding, and
- 2% of highly demanding vehicles.

CONCLUSION

- New designs of diesel engines and of their corresponding systems have successfully been following fast changes in the emission quality requirements.
- Synergy has been achieved between the meeting of emission quality requirements and the improvement of vehicle performances, resulting in an increased share of diesel engine-powered passenger vehicles.
- Under conditions of permanent use, new designs are more sensitive and hence more demanding when it comes to fuel quality.
- Ensuring minimal fuel impact on impairing correct, safe, and lasting operation of the combustion control and exhaust emission reduction systems is the primary reason for growingly stringent diesel fuel quality requirements.

- The basic application requirements of the vehicles with the largest share in Croatia's vehicle pool have been met by valid specifications.
- **By ensuring the availability of two diesel fuel qualities - matching the shares and requirements of old, low demanding and new, high demanding vehicles respectively, it is possible to timely meet the application requirements of the entire Croatia's diesel vehicle pool, while at the same time achieving certain environmental protection advancements.**

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Ključne riječi:	Key words:
665.753.4 dizelsko gorivo	diesel fuel
665.75.035 primjenska svojstva naftnih produkata	petroleum products application properties
621.436.019.8 zahtjevi kvalitete dizelskih motora	diesel engine quality requirements
614.7 zahtjevi zaštite okoliša	environment protection requirements
621.436 013.4 ubrizgavanje goriva	fuel injection
621.436.068.3 povrat ispušnih plinova	exhaust gas recirculation
621.436.068.7 katalitička konverzija ispušnih plinova	exhaust gas catalytic conversion

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Primljeno/Received:

08.11.2000.