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Lega svečke v simetričnem zgorevalnem prostoru

Position of the Spark Plug in a Symetrical Combustion Chamber

Frančišek Bizjan

Svečka pri majhnih dvotaktnih motorjih leži pogosto v sredini glave motorja. Sredinska postavitev svečke je razmeroma ugodna glede na dogajanja v valju in na tehnološke rešitve. Meritve širjenja čela plamena v valju pa kažejo, da se plamen ne širi simetrično glede na lego svečke, ampak v odvisnosti od temperature in tokovnih razmer v valju. Preskusi so pokazali, da sredinska lega svečke ni vedno upravičena, še posebej z vidika sestave izpušnih plinov. Nadalje se je pokazalo, da se s spremembo lege ene svečke ali pa z dodajanjem druge svečke lahko doseže ugodnejša sestava plinov v izpuhu, ne da bi se pri tem spremenile druge značilnosti motorja. Pri preskusih je bil uporabljen tiristorski vžigalni sistem z dvojnim izhodom visoke napetosti z možnostjo brezstopenjskega spreminjanja predvžiga med obratovanjem motorja. Rezultati meritev kažejo, da je središčna lega svečke le cenovno ugodna rešitev, kar pa v današnjem času ni več vedno sprejemljivo.

(Ključne besede: motorji z notranjim zgorevanjem, motorji dvotaktni, prostor zgorevalni, svečke)

The spark plug in a small two stroke engine is often positioned in the middle of the cylinder head. The central position is comparatively favorable with respect to the activity in the cylinder, as well as from the technological point of view. Measurements of the flame front speed in a cylinder established that the flame does not spread symmetrically with respect to the spark plug position but depends on the temperature and current conditions in the cylinder. Experiments have shown that the central position of the spark plug is not always the best solution, especially not with respect to the composition of the exhaust gas. Further, it was established that the change of the spark plug's position, or the addition of a second spark plug, results in a more favorable composition of the exhaust gasses without changing the characteristics of the engine. A double outlet thyristor ignition system of high voltage with the possibility of adjusting the preignition during engine operation, was used. The results show that the central position of the spark plug is a low-priced solution which nowadays is not always acceptable.

(Keywords: internal combustion engines, two-stroke engines, combustion chamber, spark plugs)

0 UVOD

Sredinska postavitev svečke je pri simetričnem zgorevalnem prostoru običajna, kar velja posebej za majhne in cenene dvotaktne motorje. Taka izvedba pomeni v tehnološkem pomenu preprosto rešitev, pri tem pa je doseženo tudi razmeroma zanesljivo delovanje motorja. Zaradi spremenjenih pogledov, glede na lastnosti oziroma značilnosti motorja, je bil namen raziskave tudi preverjanje že ustaljenih rešitev.

Predstavljena raziskava se ukvarja z opazovanjem vplivov lege svečke (ene ali dveh, ki vžigata hkrati) na značilnosti motorja. Poudarek je v tem primeru predvsem na opazovanju vpliva pri spremembi lege svečke na sestavo izpušnih plinov pri pogoju, da ostane večina značilnosti motorja

0 INTRODUCTION

The central position of the spark plug in a symmetrical combustion chamber is usual in small and cheap two-stroke engines. Such a solution represents, in a technological sense, a simple solution. In addition, the operation of the engine is relatively reliable. Due to the change of views regarding the characteristics of the engine, the intention of this research is to verify the established solutions.

The paper deals with the effect of the spark plug (one or two that spark simultaneously) on the engine characteristics. The emphasis in this case, is first of all, on observing the influence of the spark plug position on the composition of the exhaust gasses, under the condition that the majority of the engine characteristics remain unchanged [1]. Of course

nespremenjenih [1]. Seveda so se uveljavila tudi druga pričakovanja, posebej še v primeru dveh svečk, saj mnogi primeri kažejo, da se lahko pri tem opazno spremeni tudi moč motorja.

Posebej pripravljene glave motorja so bile uporabljene za merjenje temperature stene zgorevalnega prostora in za merjenje hitrosti čela plamena. Poleg tega so bile prirejene še glave motorja z različnimi razporeditvami izvrtin za svečke. Zaradi razmeroma majhnih izmer glave so bile uporabljene manjše svečke, toda z enako toplotno vrednostjo, kakršna je predpisana. Ta sprememba je povzročila manjši padec moči oziroma moment motorja, glede na nespremenjen motor s predpisanimi deli. Preskusi pri različnih legah svečke oziroma svečk so pokazali, da se močneje spreminjata le dve značilnosti, in sicer temperatura glave motorja in sestava izpušnih plinov. Najbolj poudarjen učinek prestavitve svečke iz središča ali postavitve dveh svečk je bila v večini primerov višja temperatura glave. Pri tem je zanimivo, da kljub višji temperaturi glave motor ni kazal značilnih znakov pregrevanja. Prav tako sestava izpušnih plinov ni sledila pričakovanjem; višja temperatura, višja koncentracija NO_x, nižja koncetracija CH.

Pri teh spremembah karakteristik je imela druga svečka močan vpliv tako na sestavo plinov kakor tudi na vrtilni moment in deloma na porabo goriva. Prav tako je zanimivo, da se je osnovni vzorec časov preleta čela plamena do roba valja ohranil (glede na lego svečke v sredini) tudi v primeru dveh delujočih svečk.

Preskušanje je nazadnje tudi dokazalo, da je mogoče kljub nekaterim nepričakovanim rezultatom postaviti dve svečki pri razmeroma majhnem premeru valja. Pri tem se je pokazalo, da ni mogoče doseči bistvenih sprememb značilnosti motorja, če sta svečki zelo blizu skupaj ali zelo oddaljeni. V teh primerih je mogoče pričakovati le zanesljivejši vžig, nihanje najvišjega tlaka v valju pa se praktično ne spremeni.

1 PRIPRAVA PREIZKUSA

Za raziskavo je bil uporabljen majhen dvotaktni motor s prostornino 80 cm^3 (premer bata 48 mm, gib bata 42 mm). Zaradi omejenega prostora na glavi so bile uporabljene svečke z manjšim premerom glede na izhodiščno svečko, vendar z ustrezno toplotno vrednostjo.

Izvrtine v glavah motorja za svečke so bile postavljene v smeri vstop - izstop hladilnega zraka in sesanje - izpuh (sl. 1). Vseh izvrtin oziroma leg za svečke je bilo 21, na sliki 1 so prikazane le lege, kjer so bile izmerjenje značilnosti motorja dobre ali še sprejemljive. V vseh legah, ki jih prikazuje slika 1 so bile narejene meritve s kombinacijami ene ali druge svečke ali obeh hkrati.

there were also other expectations, particularly in the case of two spark plugs, since many examples have shown that the engine power can be considerably changed.

Specially prepared cylinder heads were used to measure the temperature of the combustion chamber walls as well as the speed of the flame front. Cylinder heads with different arrangements of borings for spark plugs were used. Due to the relatively small dimensions of the cylinder head, smaller spark plugs were used, but with the prescribed heat values. This change caused a small fall in engine power and torque with respect to the unchanged engine with the prescribed parts. Experiments with different spark plug positions show that only two characteristics of the engine changed: the temperature of the engine head and the composition of the exhaust gasses. The most significant effect of spark plug transfer from the central position or the use of two spark plugs, proved to be an increase in cylinder head temperature. It was interesting that in spite of higher temperatures, the engine did not show signs of overheating. The composition of the exhaust gasses was not as expected, higher temperatures did not result in a higher concentration of No_x and a lower concentration of CH.

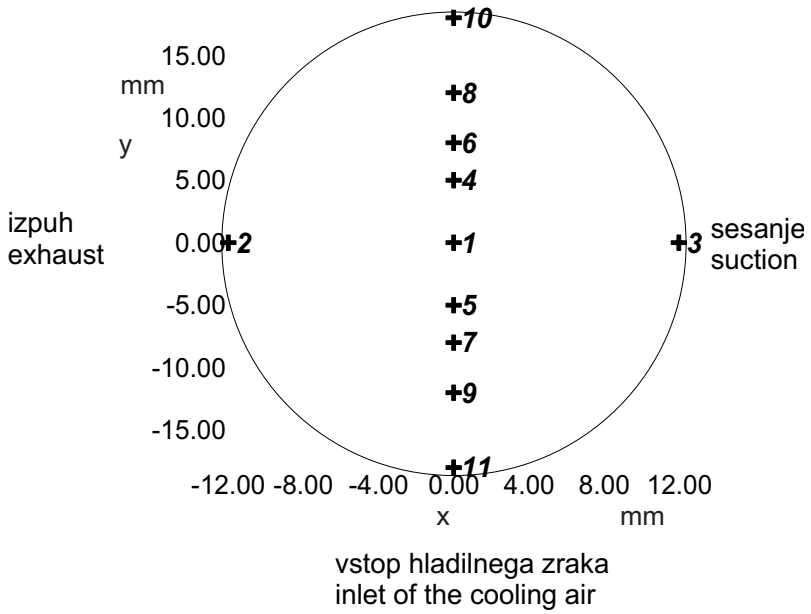
The second spark plug had a strong influence on the gas composition as well as on the torque and to some extent on the fuel consumption. It is also interesting that the basic time pattern of the flame front travel to the cylinder edge was preserved (with respect to the spark plug central position) also in the case of two active spark plugs.

Experiments proved that in spite of some unexpected results it was possible to place two spark plugs in a relatively small cylinder diameter. It is to a large extent true that no essential changes in the engine characteristics were observed when two spark plugs were mounted very near to each other or very far apart. In such cases it is possible to expect reliable ignition while the oscillation of the highest pressure remains practically unchanged.

1 PREPARATION OF THE EXPERIMENT

A small two stroke engine with the capacity of 80 cm^3 (cylinder diameter 48 mm, stroke 42 mm) was used for the research. Due to restricted space in the cylinder head , spark plugs with smaller diameters compared to the initial ones were used. These smaller spark plugs were, however, of the appropriate heat value.

Borings in the cylinder heads were made in the direction inlet – outlet of the cooling air and suction - exhaust ; Figure 1. Altogether there were 21 borings for spark plugs. Figure 1 shows only the positions where the measured characteristics of the engine were either good or at least still acceptable. All the measurements shown in figure 1 were carried out in combinations with either one spark plug or both of them.



Sl. 1. *Označene lege izvrtin za svečke na glavi motorja (št. 1 - izhodiščna lega)*
Fig. 1. *Marked positions of the spark plug borings in the cylinder head (no.1 – initial position)*

Izbrani vžigalni sistem [2] je imel proženje toka na primarni strani z uporabo tuljave in tiristorja (kondenzatorski vžig), ker se je pri primerjavi z drugimi sistemi pokazal kot razmeroma najbolj učinkovit. Sistem je imel možnost nastavljanja brezstopenjskega prvega vžiga v območju ± 30^0 zavrtitve ročične gredi glede na statično nastavitev kota. S tem je bilo mogoče nastavljati vedno največji moment, ki ga je motor zmogel pri določeni obratovalni točki. To pomeni, da je bilo edino pravilo pri nastavljanju motorja največji doseženi oziroma mogoč moment motorja ne glede na preostale značilnosti.

Čas preleta čela plamena od svečke na sredini do stene valja pri izhodiščnem motorju prikazuje slika 2. Prikazane vrednosti na sliki kažejo, da čas, potreben od svečke do stene valja, ni v vseh smereh enak, kljub temu, da leži svečka na sredini zgorevalnega prostora. Časi so daljši v smereh, kjer se pojavlja višja temperatura glave (izpuh, izstop hladilnega zraka) in nasprotno, krajši časi so v smeri hladnejših delov glave oziroma prostora. Vzrok tega je področje, bogato z zgorelimi izpušnimi plini, ki se pri izpiranju le deloma razredči.

Podobni časi se pojavljajo tudi na strani izstopa hladilnega zraka, kar pomeni, da je v tem predelu zmes slabše vnetljiva zaradi prebogate zmesi, ki pride v valj. Zmes je v tem delu bogatejša zaradi višje temperature valja in še posebej obtočnega kanala, poleg tega pa je lahko vzrok še daljši čas dogorevanja zmesi, kar povzroča tudi višjo temperaturo. Nasprotno so časi preleta čela plamena na hladnejši strani valja krajši; to je na vstopu hladilnega zraka in na strani sesalnega kanala. Iz prikazane slike je deloma že mogoče določiti

The chosen ignition system [2] had the current trigger on the primary side by means of a coil and thyristor (condensed ignition) since, in comparison with other systems, it has proved to be the most effective. The system had the possibility of adjusting the setting of the pre-ignition in the range of ± 30^o of the lever shaft with respect to the static setting of the angle. It was therefore always possible to set the highest torque of which the engine was capable at any particular operation point. This implies that the assessment was based on the highest achievable engine torque, regardless of the other characteristics of the engine.

The time for the flame front to travel from the centrally located spark plug to the cylinder wall in the case of the initial engine is shown in figure 2. The values show that the required time is not equal in all directions in spite of the fact that the spark plug is fixed in the middle of the combustion chamber. Times are longer in directions where the temperature of the cylinder head is higher (exhaust, outlet of the cooling air) and times are shorter in the direction of the cooler parts of the cylinder head or chamber. This is due to an area rich in combusted exhaust gasses where scavenging can only be partly diluted.

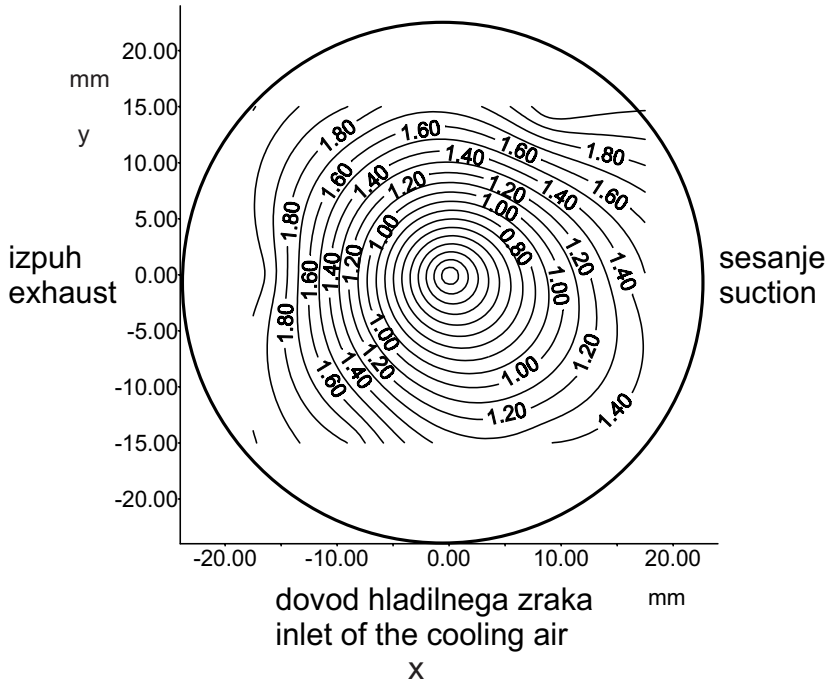
Similar times appear at the cooling air outlet, which means that due to the rich mixture that enters the cylinder the mixture is less inflammable. The mixture in this section is richer due to higher cylinder temperatures and especially the circulation canal temperature, besides the possible cause at longer combustion times, and accordingly higher temperaturs. In contrast, the speed of the flame front travel faster on the cooler side of the cylinder, that is on the cooling air inlet side of the suction canal. An area suitable for the mounting of the spark plug can

območje, ki je primerno za postavitev svečk. To območje zajema neko srednjo temperaturo stene zgorevalnega prostora v glavi motorja.

Pri dvotaktnem motorju se pojavljajo v razmeroma velikih količinah ogljikovodiki (CH), kar je posledica nepopolnega zgorevanja zaradi prevelike količine zaostalih plinov, pobega zmesi zaradi kratkostičnega izpiranja in običajno prevelikih količin mazalnega olja (v primeru mešanice goriva in olja). Razmeroma laže rešljiv problem je koncentracija ogljikovega monoksida (CO), saj je v največji meri odvisna od razmernika zraka. Tudi dušikovih oksidov (NO_x) je razmeroma malo zaradi vpliva zaostalih plinov, prav zato pa se nadaljnje zmanjšanje koncetracije precej teže doseže.

be roughly defined from the figure itself. The area covers the average temperature of the combustion chamber wall in the cylinder head.

Two stroke engines produce hydrocarbons (CH) in relatively large quantities. This is the result of incomplete combustion due to large quantities of lagged gasses, escape of the mixture due to the short cut scavenging and significant amounts of lubricating oil (in the case of fuel and oil mixture). It is comparatively easy to solve problems related to the concentration of carbon monoxide (CO) which is very dependent on the air to fuel ratio. Because of the small influence of the remaining gasses there are few nitrogen oxides (NOx), and that is the reason why further concentration can hardly be achieved.



Sl. 2. *Čas v ms, ki ga potrebuje čelo plamena do določene točke zgorevalnega prostora*
Fig. 2. *The time in ms of flame front travel to the certain points of a combustion chamber*

Poleg strupenih komponent sta bila izmerjena še kisik in ogljikov dioksid, kar je omogočilo neposreden izračun razmernika zraka, ki pa v tem primeru nima takšnega pomena kakor pri štiritaktnem motorju. Koncentracije CH, CO in CO_2 so bile izmerjene po metodi NDIR, medtem ko sta bili koncentraciji NO_x in O_2 izmerjeni po kemični metodi.

Časi preleta čela plamena so bili izmerjeni z ionskimi sondami, ki zaznajo tok v trenutku, ko pride čelo plamena do elektrod. Izrabljeno je dejstvo, da sta električno neprevodni tako zmes goriva in zraka kakor tudi zgoreli plini.

In addition to the toxic components, the oxygen and carbon dioxide were also measured, which enabled direct calculation of the air to the fuel ratio, however, this is not so important as in the case of the four stroke engines. The concentrations of CH, CO, and CO_2 were measured according to the NDIR method and the concentrations of NOx and O_2 according to the chemical method.

The flame front travel times were measured by means of ionic probes, which detect current at the moment when the flame front reaches the electrode. The fact that the mixture of fuel and air as well as the exhaust gasses are electrically nonconductive can be exploited.

2 REZULTATI MERITEV

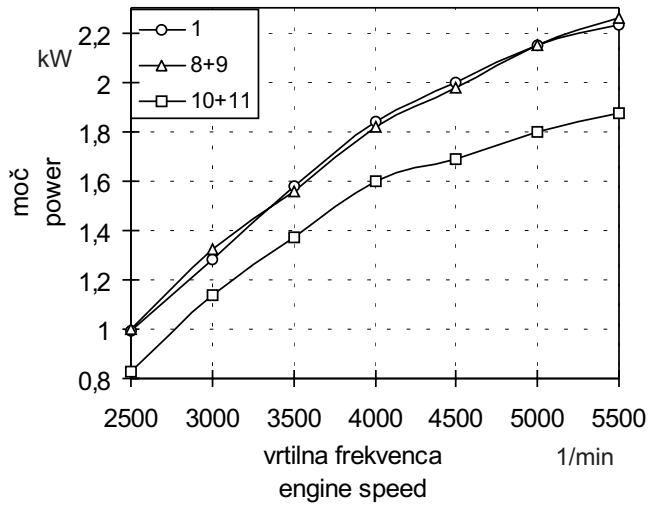
Zunanje značilnosti: spremenjena lega ene svečke lahko vpliva v nekaterih primerih opazno na

2 RESULTS OF THE MEASUREMENTS

External characteristics: Changing the position of one spark plug can, in some cases, result

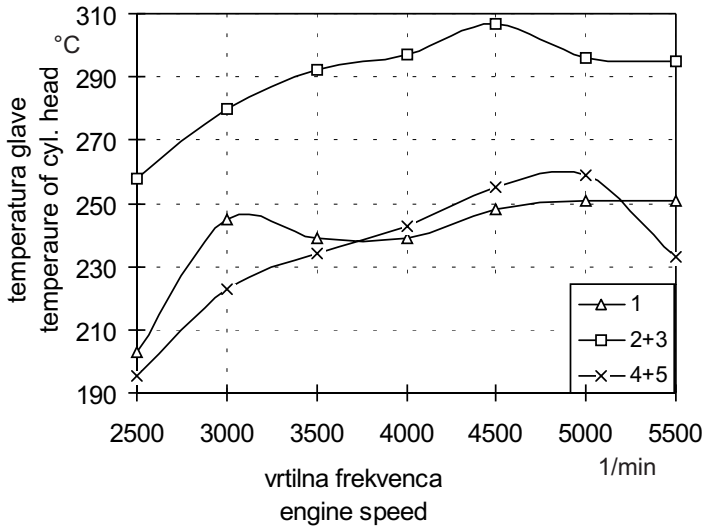
manjšo moč motorja, kar pa se da do določene mere uravnovesiti s postavitvijo druge svečke. Razlike v moči motorja, če delujeta dve svečki, prikazuje slika 3. Slika prikazuje skrajnosti, ki so bile dosežene pri preskusih glede na izhodiščno stanje. Posledica spreminjanja lege svečke je bila pogosto tudi višja temperatura glave in deloma valja. Vzrok tega sta lega svečke oziroma zgorevanje zmesi na mestih, ki so že toplotno bolj obremenjena ali razmeroma dolgo dogorevanje zmesi pri ekspanziji ali razmeroma daljše poti plamena glede na pogoje vnetljivosti zmesi ali pa kombinacija omenjenih pojavov.

in a reduction in engine power, which can, in some cases, be offset by the addition of a second spark plug. The difference in power, in cases where two spark plugs are used, is shown in figure 3. The figure shows the extreme situations reached compared to the initial situation. The consequence of spark plug position is often also a higher cylinder head temperature and to some extent the cylinder temperature. The reason is the spark plug position , the combustion of the mixture in places which are thermally heavily charged or relatively long combustion of the mixture at the expansion or longer flame paths with regards to the inflammability of the mixture or the combination of the above phenomena.



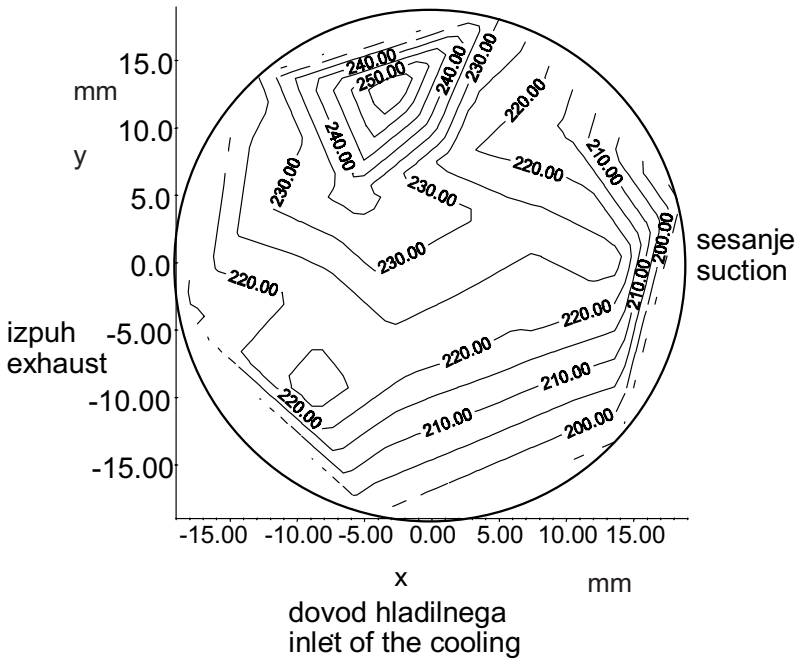
Sl. 3. *Značilnica moči pri legah svečke 1 (izhodišče), 8, 9 (obe svečki delujoči) in 10, 11 (obe svečki delujoči)*

Fig. 3. *Power characteristics at spark plug position 1 (initial position), 8,9,(both spark plugs active) and 10,11 (both spark plugs active)*



Sl. 4. *Temperatura glave motorja pri različnih postavitvah svečke; 1 (izhodiščna lega), 2, 3 (obe svečki delujoči) in 4, 5 (obe svečki delujoči)*

Fig. 4. *Cylinder head temperature at different spark plug positions ; 1 (initial position), 2,3, (both spark plugs active) and 4,5 (both spark plugs active)*



Sl. 5. *Temperaturno polje stene zgorevalnega prostora v glavi valja*
Fig. 5. *Temperature field of the combustion chamber wall in the cylinder head*

Prav zaradi različnih pojavov v valju motorja, ki postanejo bolj izraziti pri uporabi dveh svečk, se temperatura glave lahko močno spreminja glede na različno lego svečk, kar prikazuje slika 4.

Z izmerjenimi temperaturami glave motorja se prikažejo, podobno kakor na sliki 2, mesta, ki so oziroma niso primerna za postavitev svečke. Slika 5 prikazuje temperaturo glave motorja tik pod površino na strani zgorevalne komore v primeru izhodiščne lege svečke. Pri podrobnejšem pregledu lahko to sliko deloma primerjamo s sliko 2.

Izkazalo se je, da obstaja povezava med visoko temperaturo in daljšim časom potovanja čela plamena in nasprotno. S temi in še drugimi rezultati je mogoče določiti približno smer ali območje, kjer je primerno postavljati svečko. Približno območje leg svečk, kjer se dosegajo dobri rezultati, je narisano na sliki 5 - črtkana črta.

Emisija CH in NO_x: Skoraj pri vseh postavitvah svečke se pojavlja padec koncentracije obeh komponent, kar je presenetljivo predvsem za NO_x. Zaradi nekoliko višje temperature glave (zgorevalnega prostora) je sicer pričakovana nižja emisija CH, kar v nekaterih primerih pomeni tudi 10 odstotkov in več. Seveda je glede na metodo (NDIR) merjenja spekter različnih CH ožji, toda kljub temu so spremembe očitne, kar prikazuje slika 6.

Emisija NO_x se je znižala tudi za 50 odstotkov ali več. Tako dogajanje je težko pojasniti, posebno še, ker je bil motor razmeroma vroč. Razumljivo pojasnilo bi bilo, da se je hitrost čela plamena povečala zaradi vpliva dveh svečk. S tem se je čas zgorevanja skrajšal in tudi čas, ki

Because of different events taking place in the cylinder, which become more distinctive with the use of two spark plugs, the head temperature can vary considerably with respect to different positions of the spark plugs, see figure 4.

As a result of measuring cylinder head temperatures it becomes clear that there are places (similar to figure 2) which are more or less suitable for the mounting of the spark plug. Figure 5 shows the cylinder head temperature immediately under the surface on the side of the combustion chamber with the initial position of the spark plug. With accurate analyses it can be compared to figure 2.

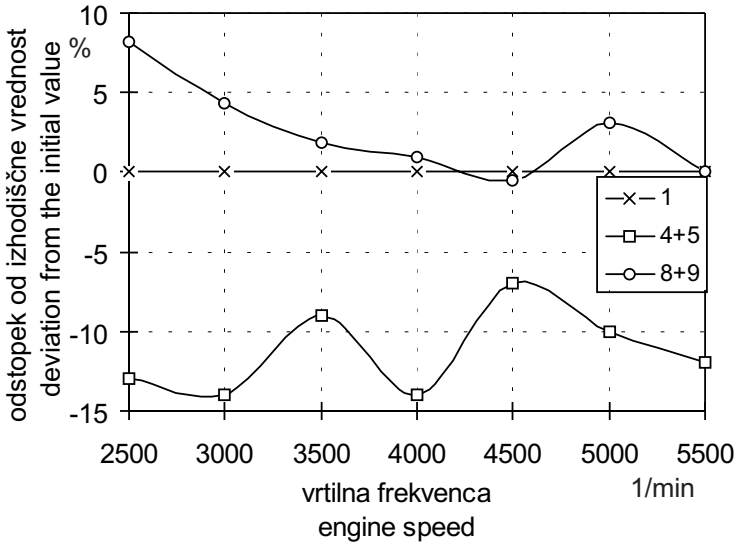
It is clear that there is a link between the high temperature and longer times of the flame front travel. In combination with other results this helps to establish the approximate direction or area where it is reasonable to place the spark plug . The approximate spark plug positions, where the results are favorable, are shown in figure 5 - dotted line.

Emission of CH and NO_x: With nearly all the spark plug positions there appears a reduction in the concentration of CH and NO_x. This is rather surprising, especially for NO_x. Due to the higher temperature of the cylinder head (combustion chamber) a lower CH emission is expected , which in some cases means 10 or more percent. The scope for different CH is narrower due to the measuring method (NDIR). Nevertheless the changes are clear, as it can be seen in figure 6.

The emission of NO_x fell by 50 percent or more. This phenomenon is difficult to explain, especially because the engine was comparatively hot. It is conceivable that the speed of the flame front increased because there were two spark plugs; the

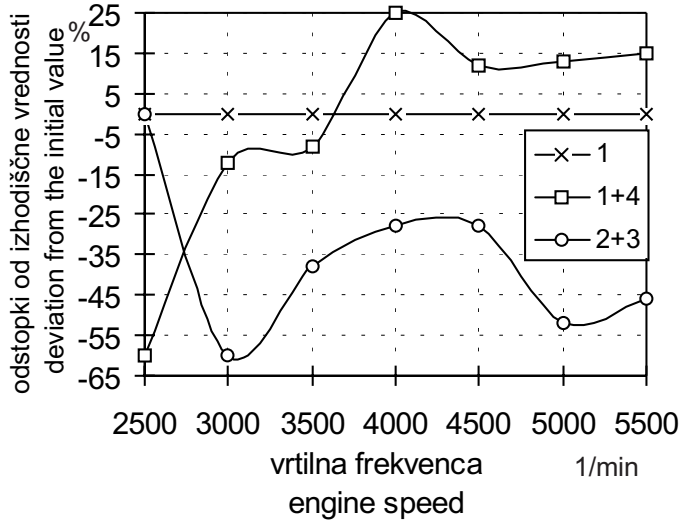
je potreben za nastanek NO_x, je bil krajši. Posredna posledica hitrejšega zgorevanja je lahko tudi nižja temperatura izpušnih plinov, kar pa predvsem pomeni, da je krajše tudi dogorevanje zmesi pri ekspanziji. Seveda je mogoča tudi kombinacija omenjenih vzrokov, ki posredno ali neposredno vplivajo na nastanek emisije NO_x. Na sliki 7 so prikazane karakteristike oziroma odstopki emisije NO_x glede na izhodiščno stanje (0 %). V obeh primerih emisij, to je na slikah 6 in 7, je prikazano razmerje med največjimi in najmanjšimi doseženimi odstopki v emisiji pri določeni legi svečk.

combustion time was shorter for this reason as well as the time necessary for the formation of NO_x. The indirect consequence of quicker combustion can also be a lower temperature of the exhaust gasses, which means that the combustion of the mixture at the expansion is shorter. Of course a combination of the mentioned causes is possible , which directly or indirectly influences the formation of the NO_x emission. Figure 7 shows the characteristics and deviations of the NO_x emission compared to the initial conditions. In the case of both emissions, figures 6 and 7, the ratio of the highest and the lowest achieved deviations of emission for certain spark plug positions is shown.



Sl. 6. *Odstopki emisije CH (NDIR) od izhodiščne lege svečke (1), lega 4 in 5 (svečki sta skupaj in obe delujoči) in lega 8 in 9 (obe svečki sta delujoči)*

Fig. 6. *Deviations of CH emission (NDIR) from the initial spark plug position (1), position 4 and 5 (both spark plugs are near to each other and active, and position 8 and 9 (both spark plugs are active)*



Sl. 7. *Odstopki emisije NO_x glede na izhodiščno vrednost (1), lega 1, 4 (obe svečki delujoči) in lega 2, 3 (obe svečki delujoči)*

Fig. 7. *Deviations of the NO_x emission from the initial position (1), position 1,4 (both spark plugs are active) and position 2,3, (both spark plugs are active).*

3 SKLEP

Raziskava različnih postavitev svečk v glavi motorja je pokazala, da različna postavitev svečk v simetričnem zgorevalnem prostoru lahko močno vpliva na sestavo izpušnih plinov. V primeru, da se ohrani samo ena svečka, je področje lege svečke močno omejeno na bližino izhodiščne lege. Druga možnost je vključitev dodatne svečke, tako da sta obe svečki delujoči. V tem primeru se področje postavitve svečk poveča (sl. 5). Na podlagi temperaturnega polja v glavi motorja in časovnega polja preleta čela plamena je mogoče zanesljivo določiti področje, primerno za postavitev svečke. Z nadaljnjimi preskusi je potem mogoče določiti končno postavitev. V primeru, da ostane sistem zamenjave snovi nespremenjen, se tudi moč motorja opazno ne spremeni. To je po eni strani razumljivo, saj se količina zaostalih plinov ne spreminja, po drugi strani pa se nekoliko spremeni hitrost zgorevanja. Toda izkušnje kažejo, da tudi pri drugih dvotaktnih motorjih z večjo prostornino in ob podobnih predpostavkah ne dosežemo občutne spremembe moči. Zato lahko predpostavimo, da je motor z dvema svečkama in nespremenjenim sistemom zamenjave snovi bolj zanesljiv glede vžiganja oziroma uporabe.

Drugi pomembnejši vidik vgradnje para svečk je opazno zmanjšanje emisije škodljivih plinov v izpuhu. S tega vidika je upravičeno tudi vprašanje o stroških, ki so lahko razmeroma majhni v primerjavi z doseženim rezultatom. Sprememba emisije CH je deloma predvidljiva glede na pričakovana dogajanja v valju. Povprečno zmanjšanje za 10 odstotkov je bilo doseženo samo z uporabo dodatne svečke.

Sprememba emisije NO_x je bolj opazna, saj se zmanjša za polovico. Za tako dogajanje je težko dati enopomensko pojasnilo, ker se pojavljajo nasprotujoči si dejavniki. Tako se kljub približno enaki temperaturi, kakršna je izhodiščna, ali celo nekoliko višji, emisija zmanjša. Glede na izmerjene podatke je za tako stanje razumljiva razlaga le razmeroma krajši čas zgorevanja zmesi.

Iz doseženih rezultatov se je pokazala upravičenost vgradnje dveh svečk pri majhnem dvotaktnem motorju, predvsem z vidika emisije, deloma pa, glede na uporabo, tudi zaradi zanesljivosti obratovanja. Pričakovanega povečanja moči motorja pa pri tako majhnih prostorninah ni mogoče doseči samo z dodano svečko. To je mogoče doseči z dodatno svečko šele pri večjih prostorninah (opazno šele pri 200 cm^3 in več) in pa zanesljivo v primeru, če se spremeni kakovost zamenjane zmesi.

3 CONCLUSION

The investigations of different spark plug positions in the cylinder head have shown that different positions in a symmetrical combustion chamber can strongly influence the composition of the exhaust gasses. In the case of one spark plug, the area of the spark plug position is strongly restricted to the vicinity of the initial position. The second possibility is the use of a second spark plug , so that both are active. In this case, the area of the spark plug position is widened (see figure 5). On the basis of the temperature field in the cylinder head and the time span for the travelling flame front, it is possible to reliably define the area suitable for the placing of a spark plug. With further experiments it is possible to establish the final position. In case the system of the substance replacement remains unchanged, the power of the engine does not change considerably. This can be understood since the quantity of the remaining gasses does not change, but on the other hand the combustion speed is slightly changed. Experience has shown that other two stroke engines with larger capacities and under similar conditions do not exhibit a considerable change in power. For this reason, we can presume that an engine with two spark plugs and an unchanged system of substance exchange is more reliable from the viewpoint of ignition and use.

The second important point of introducing another park plug is the reduced emission of harmful gasses in the exhaust. Here, the question of expense is also justifiable, the expenses are low compared to the achieved results. The change of CH emission can partly be foreseen with respect to the activity in the cylinder. An average cut of 10% was achieved, only by means of a second spark plug.

The change of NO_x emission is more obvious, since it dropped as much as by half. It is difficult to give a uniform explanation, since there appear to be opposing factors. In spite of the temperature being similar to that of the initial case or even a bit higher, the emissions are observed to decrease. A reasonable explanation is the comparatively short time for mixture combustion.

The achieved results justify the use of two spark plugs in small two stroke engines, first of all from the viewpoint of emission, and partly because of reliable operation. The expected increase in the engine power can not be achieved only by adding one spark plug for such a small volume. This is possible only for greater capacities (200 cm^3 and above) and under conditions where the quality of the mixture exchange is changed.

4 LITERATURA
4 REFERENCES

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Avtorjev naslov: dr. Frančišek Bizjan
Fakulteta za strojništvo
Univerze v Ljubljani
Aškerčeva 6
1000 Ljubljana

Author's Address: Dr. Frančišek Bizjan
Faculty of Mechanical Eng.
University of Ljubljana
Aškerčeva 6
1000 Ljubljana, Slovenia

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