© Strojniški vestnik (43) št. 7-8, str. 289-298, 1997
Tiskano v Sloveniji. Vse pravice pridržane.
UDK 621.43.013:621.432.4:621.43.06:621.564
© Journal of Mechanical Engineering (43) No. 7-8, pp. 289-298, 1997
Printed in Slovenia. All rights reserved.
SV:0039-2480(97)4-R2
UDC 621.43.013:621.432.4:621.43.06:621.564

Vpliv hlajenja delov površine glave na lastnosti motorja

Influence of the Cooling of the Cylinder Head Surface Parts on Engine Characteristics

FRANČIŠEK BIZJAN

Večina motorjev, posebej majhnih, nima do potankosti optimiranega hlajenja. To pomeni, da je mogoče s spremembami določenih delov hladilne površine vplivati na hladilne razmere in posredno na motor. V prikazani raziskavi smo ugotavljali vpliv majhnih delov hladilne površine na značilnosti motorja. Z meritvami toplotnega toka sta se oblikovali dve glavi motorja z različno obliko in velikostjo delov hladilne površine. Meritve na tako oblikovanih glavah naj bi dokazale predvsem povezavo med spremembami hladilne površine in emisijo ogljikovodikov v izpušnih plinih.

Rezultati raziskave kažejo na možnost vplivanja na nekatere značilnosti motorja s spreminjanjem hlajenja delov hladilne površine. Pri tem je treba omeniti točke, kjer gostota toplotnega toka močno odstopa od povprečne vrednosti. Podani so rezultati meritev, s katerimi je bilo mogoče ugotoviti vpliv sprememb na glavi motorja in vpliv na emisijo izpušnih plinov ter momenta oziroma moči. Hkrati je bilo tudi ugotovljeno, da lahko že razmeroma zelo majhni deli površine močno vplivajo na delovanje motorja. V povprečju imajo deli hladilne površine podoben vpliv na motor kakor nastavljanje motorja.

Ključne besede: motorji, hlajenje motorjev, hlajenje glav, vplivi hlajenja

In most engines, especially the small ones, cooling is not precisely optimised. This means that by changing certain parts of the cooling surface it is possible to influence the cooling conditions and, indirectly, the engine characteristics. The present research establishes the influence of small parts of the cooling surface on the engine characteristics. According to the results of the heat flux measuring, two different cylinder heads have been designed, of different shape and size of the cooling parts surface. Measurements on newly designed cylinder heads should prove, in particular, the connection between the changes of the cooling surface and the hydrocarbon emission in exhaust gases.

The results of this research indicate the possibility of influencing some engine characteristics by changing the cooling of some cooling surface parts. The points where the heat flux deviates strongly from average value are mentioned. The given results provide the possibility of establishing the influence of the changes on the cylinder head as well as on the exhaust gasses and the torque or power respectively. It has at the same time been proven that the relatively small parts of the surface strongly influence the engine operation. On the whole, the cooling surface parts have a similar effect on the engine as does its adjustment.

Keywords: engines, cooling of the engines, cooling of the cylinder head, influence of cooling

0 UVOD

Hlajenje motorja oziroma glave je potrebno, saj se tako odvede presežek toplote iz motorja. Naš cilj je najti način, kako in koliko toplote odvesti, da ne bi bil motor prevroč ali prehladen. Poleg tega se za odvajanje toplote jemlje še del dejanske moči motorja, to je za pogon ventilatorja, vodne črpalke, alternatorja itn. Vse to vpliva na značilnosti motorja, emisijo plinov v izpuhu, porabo goriva itn.

Preizkusi, ki naj bi prikazali, kolikšen je vpliv majhnih površin na glavi motorja, so bili narejeni na malem dvotaktnem motorju TOMOS UMO 080 s prostornino 80 cm^3 in močjo 2,4 kW pri 5500 min^{-1}. Hlajenje motorja je zračno s prisilnim obtokom zraka mimo valja in glave. Pri preizkušanju je ostal valj nespremenjen, le na glavi sta se spreminjali oblika in velikost hladilne površine. Spremembe na glavi so bile narejene glede na rezultate meritev toplotnega toka. Zaradi lažjega obvladovanja različnih temperaturnih stanj je bila glava pri nekaterih preizkusih hlajena z oljem [1].

0 INTRODUCTION

Cooling of the engine, or more precisely its cylinder head, is necessary in order to remove the surplus heat from the engine. The aim of this research is to find out how to extract heat - and how much - to ensure that the engine is neither too cool nor too hot. Furthermore actual engine power is used for heat extraction, i.e. operation of the fan, water pump, alternator etc. All the above factors influences the characteristics of the engine, gas emission in the exhaust, fuel consumption, etc.

Tests designed to demonstrate the influence of small two-stroke engine TOMOS UMO 080 with a capacity of 80 cm^3 and a power of 2.4 kW at 5500 min^{-1}. The engine was air-cooled by the forced circulation of air passing by the cylinder and the head. During the experiments the cylinder remained unchanged, only the size and shape of the head cooling surface was changed. The changes on the head were carried out in accordance with the results of the heat flux measurements. For easier controlling of different temperature conditions the head was oil cooled [1].

V tem primeru je bila hladilna površina glave razdeljena na tri dele ali prekate - komore, ločene med seboj, tako da jih je bilo mogoče neodvisno hladiti vsako posebej. Na ta način smo lahko nastavili želene temperature za vsak posamezni prekat. Omejitev oziroma začetno stanje pri meritvah je bila temperatura valja na kritičnem mestu; merjena v višini prvega batnega obročka nad izpušnim kanalom. Tako je bilo postavljeno izhodišče za osnovno oziroma primerjalno stanje.

Meritev toplotnega toka je pokazala, da so na glavi deli površin, ki razmeroma močno odstopajo glede na povprečni toplotni tok. S spreminjanjem toplotnega toka v teh točkah lahko opazimo največji mogoči vpliv odvedene toplote iz majhnih delov površin glave na značilnosti motorja.

Pričakovati je mogoče, da bo omejevanje ali pospeševanje toplotnega toka neposredno vplivalo na emisijo ogljikovodikov (CH). Dejansko se je to tudi pokazalo, ker so razlogi za nastanek CH v največji meri odvisni od temperature sten zgorevalnega prostora. Čim višja je temperatura sten in čim hitreje je ta temperatura dosežena, tem manjša je emisija CH. Po drugi strani je znano, da temperature, kjer se pretakata zmes ali zrak za zgorevanje ne smejo biti visoke. V primeru višjih temperatur pade namreč učinek polnitve valja s svežo zmesjo.

Primeren selektiven odvod toplote je mogoče doseči le z natančnim hlajenjem. Ker je določanje tega razmeroma zamudno in drago, je bila izbrana manj običajna pot, to je merjenje toplotnega toka skozi glavo motorja.

1 PRIPRAVA PREIZKUSA

V valj motorja so bili vgrajeni termoelementi v višini prvega batnega obročka zaradi preverjanja temperaturnega stanja. Bolj podrobno je bilo izmerjeno temperaturno stanje v glavi. Za merjenje toplotnega toka so bila izdelana zaznavala, ki so bila vgrajena - zalepljena v steno glave (sl.1) [2].

In this case, the cooling surface of the head was divided into three parts or chambers, so that each could be independently cooled. Thus, we were able to set the desired temperature in each separate chamber. The limit or the starting point of the measuring was the cylinder temperature at the critical point, measured at the height of the first piston ring above the exhaust port. The starting point for the basic or comparative state was defined in this way.

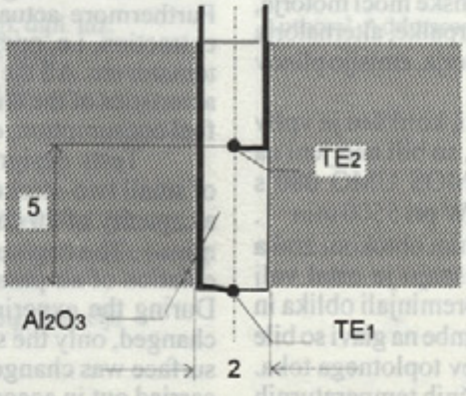
The measurements showed that the heat flux in some parts of the head surface differed considerably from an average heat flux. By changing the heat flux at these points it was possible to observe the greatest possible influence of the heat extracted from the small parts of the head surface on the characteristics of the engine.

It was to be expected that the limitation or acceleration of the heat flux would directly affect the hydrocarbon emission (CH). This actually turned out to be true, since the reasons for the formation of CH depended greatly on the temperature of the combustion chamber wall. The higher the temperature, and the sooner it was reached, the smaller was the CH emission. On the other hand, it is well known that temperatures should not be high in places where air, and a mixture of combustion air is flowing. In cases of high temperatures, the effect of the volumetric efficiency of the cylinder filled with fresh mixture drops is measured.

An appropriate selective heat extraction can be achieved only by precise cooling. Since this is a comparatively expensive and time - consuming method we have decided on an unusual approach, which is measuring of the heat flux through the engine head.

1 PREPARATION OF THE EXPERIMENT

Thermoelements were built into the engine cylinder at the height of the first piston ring in order to enable temperature control. The temperature on the head was measured with reasonable accurately. Special measuring heat flux sensors were built in, glued to the engine head [2] (Fig. 1).



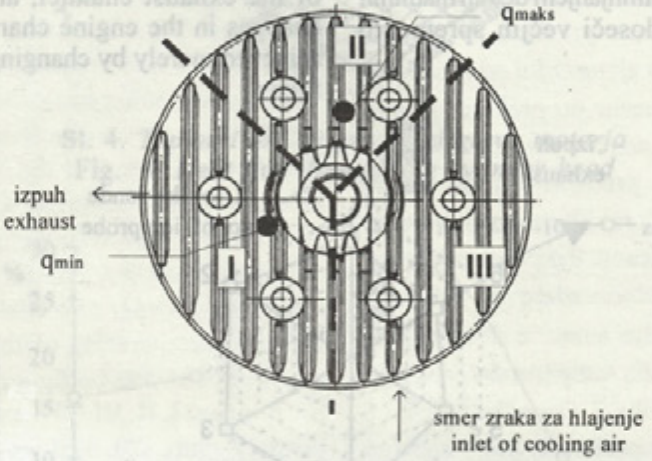
Sl. 1. *Zaznavalo toplotnega toka, zalepljeno v glavo*
Fig. 1. *Heat flux sensor, glued to the cylinder head*

V glavo je bilo vstavljenih 18 merilnikov, enakomerno porazdeljenih po površini. Glede na izmerjen toplotni tok se je pokazalo, da je mogoče razdeliti površino na tri dele s povprečnim toplotnim tokom in v dve točki z izrazitim odstopanjem od povprečne vrednosti (sl. 2). Temu primerno sta bili izbrani dve poti preizkušanja:

- delitev glave na tri dele - prekate, med seboj ločene in hlajene z oljem, tako da je bilo mogoče vsak prekat hladiti posebej,
- na mestih z izrazitim odstopanjem toplotnega toka (največji in najmanjši toplotni tok) so bili vgrajeni vložki, ki so imeli drugačno toplotno prevodnost od osnovnega materiala.

18 probes were installed all over the head surface. With regard to the measured heat flux it turned out that the surface could be divided into three parts with an average heat flux and two points with considerable deviation from the average value (Fig. 2). Consequently two ways of testing were chosen:

- the division of the head into three - part chambers, divided and oil cooled so that each chamber could be cooled separately.
- at the points of heat flux deviation (the largest and the smallest heat flux), elements of heat conductibility different from the basic material were inserted.



Sl. 2. *Delitev glave na tri dele - prekate in točki z najmanjšim oziroma največjim toplotnim tokom*
Fig. 2. *The division of the head into three parts - chambers and the points with smallest or largest heat flux*

V prvem primeru, torej pri oljnem hlajenju, sta bili narejeni dve vrsti meritev: meritve s približno enako temperaturo sten glave v vseh prekatih in meritve z različnimi temperaturami sten v posameznem prekatu. V obeh primerih se je temperatura sten spreminjala navzgor in navzdol glede na nastavljeno začetno temperaturo.

V drugem primeru so bili na mestih z največjim oziroma najmanjšim toplotnim tokom vgrajeni vložki valjaste oblike z različnimi premeri (5, 10 in 15 mm) in z manjšo oziroma večjo toplotno upornostjo glede na material glave.

Meritve z oljnim hlajenjem in z vložki z različnimi toplotnimi upornostmi so omogočile oblikovanje hladilnih površin dveh glav, ki se je razlikovalo po obliki in površini od serijske izvedbe. Pri oljnem hlajenju se je izkazalo, da tretjega prekata praktično ni treba hladiti. Zato je bila izvedena zračno hlajena glava brez hladilnih reber na tem delu (tretji prekat). Meritve z vložki so nakazale drugačno rešitev; to je v oblikovanju hladilne površine (višina reber) glede na gostoto toplotnega toka v posamezni točki na glavi.

In the first case of oil cooling, two kinds of measurements were made: measurements with approximately the same temperature of the head walls in the chambers and measurements with different temperature of the walls in each chamber. In both cases the temperature of the walls varied up and down relatively to the set starting temperature.

In the second case, we inserted pieces of cylindrical shape with different diameters (diameter 5, 10 and 15 mm) as well as heat resistance lower or higher to the resistence of the head material were built in the places of the largest or smallest heat flux respectively.

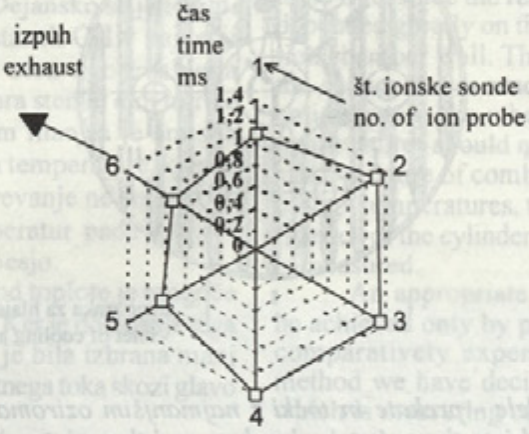
The results of the above measurements with oil cooling, as well as with inserted elements or with different heat resistances, have initiated the design of the cooling surfaces of two heads different in shape and surface from the mass production heads.In case of oil cooling it was established that the third chamber needs practically no cooling. That was why the air cooled head was made without the cooling ribs in this part (chamber III). But the measurements with the inserted elements indicated another solution; the cooling surface (the height of the ribs) was designed in relation to the heat flux at a certain point on the head.

Emisija izpušnih plinov (CO, CH, O_2, CO_2) je bila merjena z analizatorjem NDIR, medtem ko so bile druge vrednosti (vrtilna frekvenca, moment, temperatura, tlak) izmerjene in izračunane na že ustaljen način.

Kot pomoč pri ugotavljanju dogajanja v valju so bile izmerjene še hitrosti potovanja fronte plamena (sl. 3) z ionskimi sondami. Izmerjene vrednosti naj bi pokazale, ali obstaja smer širjenja fronte plamena, ki je bolj izrazita; to je, ali prispe do roba valja kasneje od nekega povprečja. Izkazalo se je, da se plamen širi v vse smeri razmeroma enakomerno, morda samo v smeri izpušnega kanala malo počasneje. To tudi pojasnjuje razmeroma majhen toplotni tok na strani izpušnega kanala in, da s spreminjanjem delnih hladilnih površin ni bilo mogoče doseči večjih sprememb značilnosti motorja.

The emission of the exhaust gasses (CO, CH, O_2, CO_2) was measured with an NDIR analyzer, while the other values (engine speed, torque, temperature, pressure) were measured and calculated in the usual way.

The travelling speeds of the flame front were measured with ionic probes to help establish what was going on in the cylinder. The measured values were intended to show whether there existed an expressive direction of the flame front extension (Fig. 3) i.e. whether it reached the edge of the cylinder faster than average. It was proven that the flame spread comparatively symmetrically, perhaps a little slower in the direction of the exhaust channel. That also explained the comparatively low heat flux by the side of the exhaust channel, and showed that greater changes in the engine characteristics could not be achieved merely by changing the partial cooling surfaces.



Sl. 3. *Povprečni čas hitrosti fronte plamena od svečke (sredina) do roba valja*
Fig. 3. *The average time of flame front from the spark plug (center) to the edge of the cylinder*

2 REZULTATI IN ANALIZA

Temperaturno oziroma toplotno tokovno stanje je bilo izmerjeno po vsej krivulji največje moči. Slika 4 prikazuje porazdelitev toplotnega toka skozi glavo; uporabljena je bila tudi za določitev lege prekatov, kakor so označeni na sliki 2.

3 OLJNO HLAJENA GLAVA

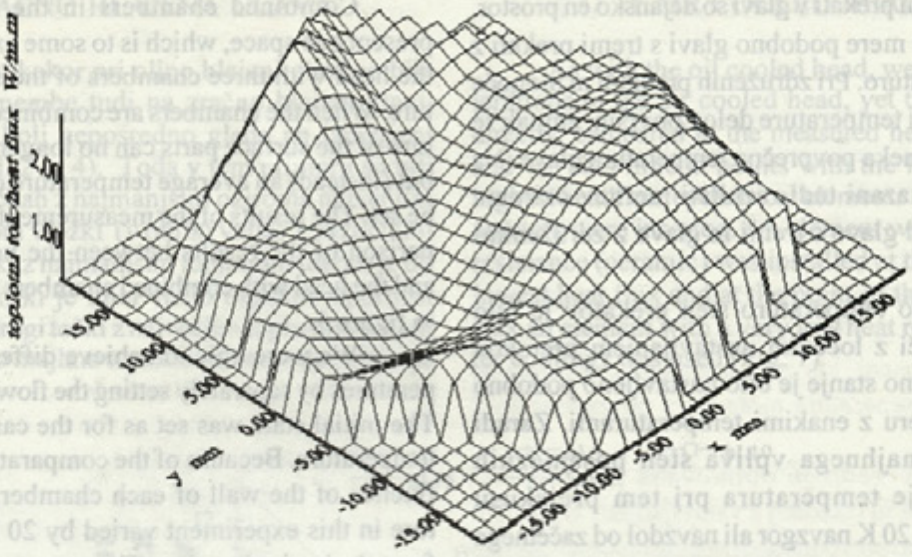
Enako temperaturo sten glave v prekatih je bilo mogoče dosegati s različnimi pretoki olja. Začetno stanje je bilo določeno, ko je vzpostavljeno enako ali podobno stanje temperatur na steni valja kakor pri serijski izvedbi, v prekatih na glavi pa so bile temperature sten enake. S primernim spreminjanjem pretokov hladila - olja, je bilo mogoče spreminjati temperaturo oziroma jo nastaviti na želeno vrednost. Izmerjena so bila stanja z začetno temperaturo (podobno kakor prvotni motor) z višjo (za + 10 K) in nižjo temperaturo (za - 10 K). Vpliv enakih temperatur prekatov na CH prikazuje slika 5; prikazane so spremembe emisije CH pri višji oziroma nižji temperaturi glede na začetno.

2 RESULTS AND ANALYSIS

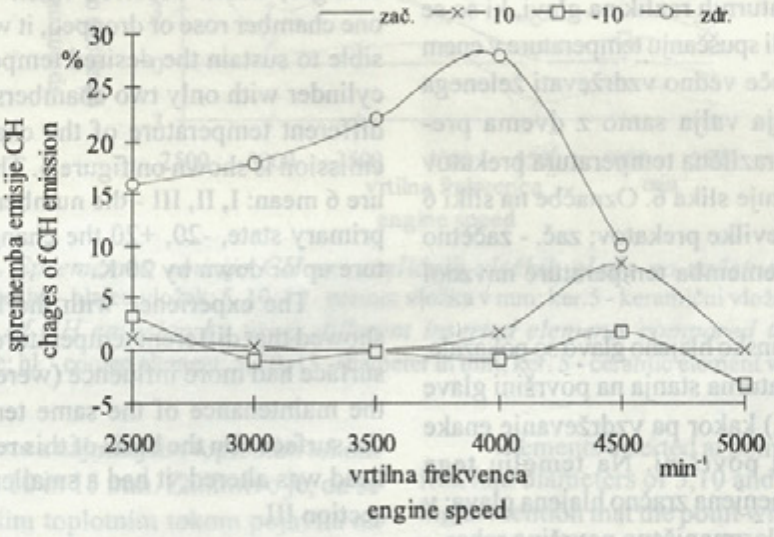
The temperature or heat flux state was measured through the whole curve of the maximum power. Figure 4 shows the distribution of the heat flux through the head; it was also used for the definition of the position of the chambers as marked in figure 2.

3 OIL COOLED HEAD

It was possible to reach the same temperature of the head walls at different flows of oil. The starting state was defined when a state equal or similar to that of the cylinder wall temperature as during mass production was restored, and the temperatures of the walls in the head chambers were the same. With an appropriate changing of the cooler - oil flow it was possible either to change the temperature or set it to the desired value. The states with higher (by + 10 K) and lower (by - 10 K) starting temperature (similar to the original engine) were measured. The influence of the same temperatures of the chambers on the CH emission is shown in figure 5. The changes shown are the changes of the CH emission at temperatures higher or lower than the initial temperatures.



Sl. 4. *Toplotni tok, ki gre skozi glavo motorja*
Fig. 4. *Heat flux through the cylinder head*



Sl. 5. *Sprememba emisije CH (NDIR) pri enakih temperaturah sten glave glede na začetno stanje, pri višji in nižji temperaturi* (zač. - začetna temperatura glave s tremi prekati; +10 za 10 K višja temperatura; -10 za 10 K nižja temperatura; zdr. - glava z združenimi prekati)

Fig. 5. *The change of CH emission (NDIR) at the head wall temperature similar to the starting state and at higher and lower temperatures* (zač. - the starting temperature of the head with three chambers; +10 for 10 K higher temperature; -10 for 10 K lower temperature; zdr. - the head with united chambers)

Slika 4 prikazuje, da enaka temperatura sten glave vpliva na značilnosti motorja. Meritve kažejo, da se v povprečju emisija in poraba goriva povečata, moč pa zmanjša. Od celotne količine toplote, ki se odvede z oljem odpade na prvi prekat približno 41 odstotkov in na drugi prekat 59 odstotkov, medtem ko tretji prekat ni bilo treba hladiti. Že najmanjši mogoči pretok skozi tretji prekat je povzročil občuten padec temperature (40 K ali več), kar se je dogajalo pri vseh vrtilnih frekvencah.

Figure 4 shows that uniform head wall temperature influences the characteristics of the engine. The measurements show that, on the average, the emission and consumption of the fuel increases, while the power decreases. From the entire quantity of the heat extracted with oil, 41% of it goes to chamber I, 59% to chamber II, from chamber III needed no cooling. Even the smallest possible flow through the chamber III resulted in a substantial fall in temperature (40 K or more), and that occurred at all engine speeds.

Združeni prekati v glavi so dejansko en prostor, kar je do neke mere podobno glavi s tremi prekati z enako temperaturo. Pri združenih prekatih ni mogoče več uravnavati temperature delov površin, ampak se lahko nastavi neka povprečna temperatura glave. Na sliki 5 so prikazani tudi rezultati meritev oziroma primerjav med glavo s tremi in glavo z združenimi prekati.

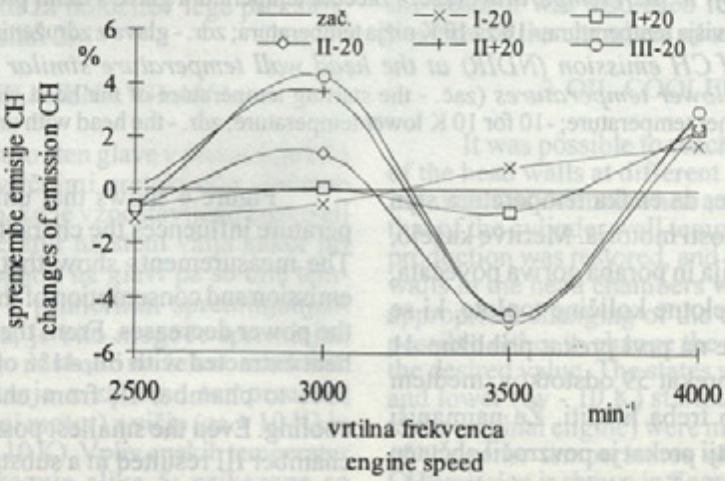
Različno temperaturo sten prekatov je bilo mogoče doseči z ločenim nastavljanjem pretokov hladiva. Začetno stanje je bilo nastavljeno podobno kakor v primeru z enakimi temperaturami. Zaradi razmeroma majhnega vpliva sten posameznih prekatov se je temperatura pri tem preizkusu spreminjala za 20 K navzgor ali navzdol od začetnega stanja. Nastavljanje temperatur po prekatih je bilo ločeno, kar pomeni, da se je samo v izbranem prekatu uravnavala temperatura v preostalih dveh pa ne. Zaradi večjih temperaturnih razlik na glavi, ki so se pojavile pri dviganju ali spuščanju temperature v enem prekatu, ni bilo mogoče vedno vzdrževati želenega temperaturnega stanja valja samo z dvema prekatoma. Kako vpliva različna temperatura prekatov na emisijo CH, prikazuje slika 6. Označbe na sliki 6 pomenijo: I, II, III: številke prekatov; zač. - začetno stanje; -20, +20 - sprememba temperature navzdol ali navzgor za 20 K.

Izkušnje s tekočinsko hlajeno glavo so pokazale, da so različna temperaturna stanja na površini glave bolj vplivna (koristna) kakor pa vzdrževanje enake temperature po vsej površini. Na temelju tega dognanja je bila spremenjena zračno hlajena glava; v tretjem prekatu je imela zmanjšano površino reber.

Combined chambers in the head actually present one space, which is to some extent similar to the head with three chambers of the same temperature. When the chambers are combined, the temperature of the surface parts can no longer be controlled, but (instead) an average temperature of the head can be set. The results of the measurements and the comparison of the results between the head with three and the head with combined chambers are also shown in figure 5.

We were able to achieve different wall temperatures by separately setting the flows of the cooler. The initial state was set as for the case of the same temperature. Because of the comparatively small influence of the wall of each chamber, the temperature in this experiment varied by 20 K up or down from the beginning state. The temperature was regulated only in the chosen chamber, but not also in the other two. Because of the higher head temperature changes, which occurred when the temperature in one chamber rose or dropped, it was not always possible to sustain the desired temperature state of the cylinder with only two chambers. The effect of the different temperature of the chambers on the CH emission is shown on figure 6. The indicators in figure 6 mean: I, II, III - the numbers of the chambers; primary state, -20, +20 the change of the temperature up or down by 20 K.

The experience with the liquid cooled head showed that different temperature states on the head surface had more influence (were more useful) than the maintenance of the same temperature all over the surface. On the basis of this result, the air cooled head was altered; it had a smaller rib-surface in the section III.



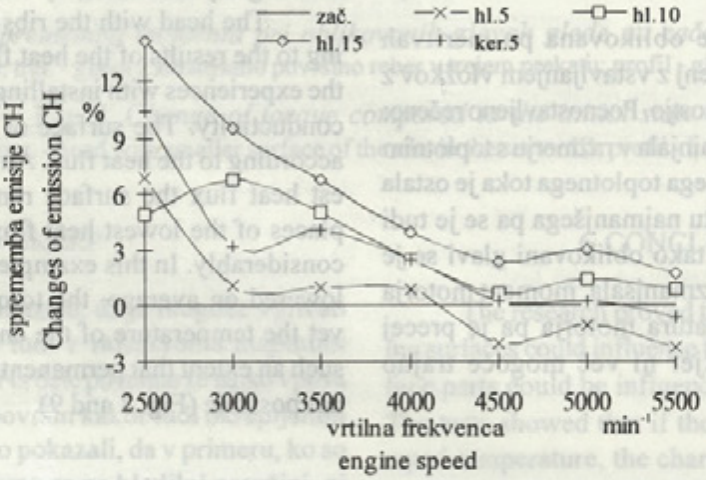
Sl. 6. *Sprememba emisije CH pri spreminjanju temperature prekatov*
Fig. 6. *Change of the CH emission by changing the temperature of the chambers*

4 ZRAČNO HLAJENA GLAVA

Podobno kakor pri oljno hlajeni glavi so bile narejene spremembe tudi na zračno hlajeni glavi, vendar tokrat bolj neposredno glede na izmerjeni toplotni tok (sl. 2 in 4). Toda v tem primeru so bili vstavljeni v točkah z najmanjšim oziroma največjim toplotnim tokom vložki (v obliki valja) z različnimi premeri. V točki z najmanjšim toplotnim tokom je bil narejen vložek, ki je imel večjo toplotno upornost (keramika), v drugi točki z največjim toplotnim tokom pa vložek z zelo majhno toplotno upornostjo (hlajenje z vodo) (sl. 7).

4 AIR COOLED HEAD

As with the oil cooled head, we also made alterations to the air cooled head, yet this time more directly, compared to the measured heat flux (Fig. 2 and 4). This time at points with the lowest and the highest heat flux, cylindrical elements of different diameters were inserted. An element with higher heat resistance (ceramic) was installed at the point of the lowest heat flux and at the point of the highest heat flux an element with a very low heat resistance (water cooling) was used (Fig. 7).



Sl. 7. *Sprememba emisije CH pri različnih vložkih glede na začetno stanje*
(zač. - začetno stanje; hl. - hlajen vložek; 5, 10, 15 - premer vložka v mm; ker.5 - keramični vložek s premerom 5 mm)
Fig. 7. *Change of CH emission by using different inserted elements compared to the initial state*
(zač. - initial state; hl. - cooled element; 5, 10, 15 - diameter in mm; ker. 5 - ceramic element with 5 mm diameter)

Vložki na mestu z najmanjšim toplotnim tokom so imeli premere 5, 10 in 15 mm. Zanimivo je, da se je točka z najmanjšim toplotnim tokom pojavila na izpušni strani. S podrobnejšo analizo je mogoče ta pojav pojasniti z žepom plinov, sestavljenim deloma iz zaostalih plinov in deloma iz sveže zmesi, ki se pojavlja prav na tem mestu. Morda je bolj zanimivo, da motor ni deloval, ko je dosegel delovno temperaturo, ker sta bila vstavljena 10 in 15 mm debela vložka. Tako je bilo izmerjeno samo stanje pri vložku s premerom 5 mm, medtem ko je za obnašanje motorja pri večjih dveh vložkih težko dati preprosto pojasnilo brez dodatnih preverjanj.

Vložki na mestu z največjim toplotnim tokom so imeli enako obliko (valj) in enake premere, le da so bili hlajeni z vodo. V teh primerih so izmerjene vrednosti popolnoma v skladu z znanimi dejstvi. Gre za to, da se je v zgorevalnem prostoru pojavil del stene s precej nižjo temperaturo; zaradi tega je emisija CH večja.

Elements inserted at points with the lowest heat flux had diameters of 5,10 and 15 mm. It is interesting to mention that the point with the lowest heat flux appeared on the exhaust side. By detailed analysis the phenomenon could be explained by the pocket of gasses, consisting partly of the residual gases and partly of the fresh mixture which appeared at this particular point. It might be more interesting that the engine did not work after reaching the working temperature when 10 and 15 mm elements were inserted. Only the condition with 5 mm inserted elements could have been measured, and it was not possible to give any comment on the engine operation when bigger elements were inserted. Additional tests should be carried out.

Elements inserted at points of the highest heat flux had the same cylindrical form and same diameters, only they were water cooled. In all these cases the measured conditions corresponded to the known facts. In the combustion chamber there appeared a section with a considerably lower temperature; the consequence was higher CH emission.

5 HLADILNA POVRŠINA GLAVE

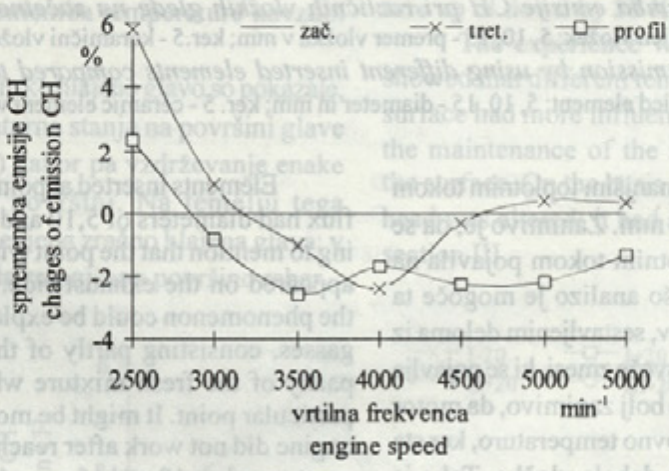
Glava brez hladilne površine v tretjem prekatu je oblikovana na podlagi meritev z oljem. Oblika, to je odstranitev reber, na področju tretjega prekata izhaja neposredno iz rezultatov meritev, pri katerih se je izkazalo, da je bilo hlajenje v tem prekatu odveč. Pri tako oblikovani glavi se je pokazalo, da se emisija v izpuhu, posebej še CH, bistveno ne spremeni, opazno se poveča moment, kar za 5 odstotkov, rahlo pa se dvigne tudi temperatura motorja, v povprečju do 5 odstotkov.

Glava z rebri je oblikovana po meritvah toplotnega toka in izkušenj z vstavljanjem vložkov z različno toplotno prevodnostjo. Poenostavljeno rečeno: površina reber se je spreminjala v razmerju s toplotnim tokom; na mestu največjega toplotnega toka je ostala nespremenjena, na mestu najmanjšega pa se je tudi najbolj spremenila. Pri tako oblikovani glavi se je emisija CH v povprečju zmanjšala, moment motorja se je zmanjšal, temperatura motorja pa je precej narasla, do območja kjer ni več mogoče trajno obratovanje (sl. 8 in 9).

5 HEAD COOLING SURFACE

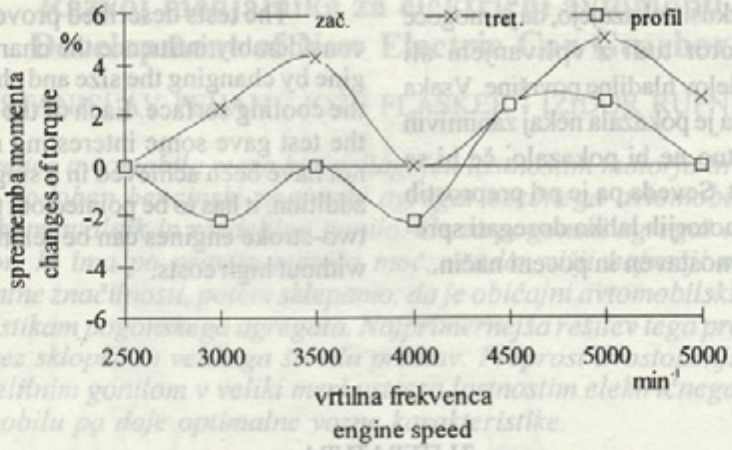
The head without the cooling surface in sector III is designed according to the results of the oil cooling. The shape - i.e. from removal on the ribs in the sector III - was the direct consequence of the measuring results, which showed that this sector did not need any cooling. The designed head proved that the emission in the exhaust, especially of the CH, did not essentially change; the torque was considerably increased, by 5 %, and the temperature of the engine was slightly increased, by 5 % on the average.

The head with the ribs was designed according to the results of the heat flux measurements and the experiences with installing parts of different heat conductivity. The surface of the ribs was changed according to the heat flux. An the points of the highest heat flux the surface remained unchanged; at places of the lowest heat flux the surface changed considerably. In this example the CH emission was lowered on average, the torque was also lowered, yet the temperature of the engine was increased to such an extent that permanent, lasting operation was not possible (Fig. 8 and 9).



Sl. 8. *Učinek predelave glave na emisijo CH*
(zač. - začetno stanje; tret. - glava z zmanjšano površino reber v trejem prekatu; profil - glava z obdelanimi rebri)

Fig. 8. *Effect of head modificationon on the CH emission*
(zač. - initial state; tret. - head with smaller surface of the ribs in the sector III; profil - head with profiled ribs)



Sl. 9. *Sprememba momenta pri oblikovanih glavah glede na začetno stanje*
(zač. - začetno stanje; tret. - glava z zmanjšano površino reber v trejem prekatu; profil - glava z obdelanimi rebri)

Fig. 9. *Change of torque compared to the initial state*
(zač. - initial state; tret. - head with smaller surface of the ribs in the sector III; profil - head with profiled ribs)

6 SKLEP

Raziskava je pokazala, da je mogoče vplivati na delovanje motorja tudi z razmeroma majhnimi hladilnimi površinami. Na dele površine se lahko vpliva tako z oblikovanjem površin kakor tudi okrepljenim hlajenjem. Preizkusi so pokazali, da v primeru, ko so dosežene enake temperature na hladilni površini, ni doseženo tudi izboljšanje značilnosti motorja. Izkaže se, da mora biti temperatura sten različna, ugotoviti pa je treba mesta, kjer je tako stanje koristno. Na tak način lahko posredno vplivamo na značilnosti motorja. Moč vplivov hlajenja delov površine lahko primerjamo približno z nastalo razliko med slabo in dobro nastavljenim motorjem.

Pokazalo se je, da je ugotavljanje velikosti hladilnih površin pri zračno hlajenem motorju razmeroma uspešno, če se motor najprej predela v tekočinsko hlajenega. S tekočinskim hlajenjem se je zelo nazorno pokazala potreba po bolj ali manj intenzivnem hlajenju v posameznem prekatu. Tako je bilo tudi ugotovljeno, da je površina hladilnih reber v tretjem prekatu večja kakor bi bilo potrebno. Pri preizkusu z zmanjšano površino je bil dosežen premik pri emisiji izpušnih plinov, momenta in temperature motorja.

Vpliv hlajenja z uporabo vložkov z različnmi toplotnimi upornostmi je pokazal nekoliko drugačne odstopke pri značilnostih motorja. V tem primeru se je izboljšala emisija CH, moment je upadel, precej pa se je povišala temperatura motorja. Pri meritvah se je pokazalo, da že del površine glave v velikosti 10 odstotkov lahko odločilno vpliva na delovanje motorja.

6 CONCLUSION

The research proved that relatively small cooling surfaces could influence the engine operation. Surface parts could be influenced by cooling intensity. The tests showed that if the cooling surface was of equal temperature, the characteristics of the engine could not be improved. The temperature of the walls should be of different temperatures and the points where such a condition is of benefit should be detected and defined. In such a way the characteristics of the engine could be indirectly influenced. The intensity of the influence of surface cooling parts influence could be compared approximately to a difference between well and a badly adjusted engine.

It emerged that the identification of the size of the cooling surfaces with an air cooled engine was relatively successful if the engine was modified to a liquid cooled engine. In cases of liquid engine cooling it proved necessary to cool separate sections. It was also noted that the surface of cooling ribs in section III was greater than necessary. Tests with smaller cooling surfaces showed changes of exhaust gas emission, torque and engine temperature.

The influence of cooling by means of inserted elements of different heat resistance demonstrated the different influences on the engine characteristics. In the case of the CH, emission was improved - the torque dropped, and the engine temperature was considerably increased. The tests showed that a 10% part of the head surface can decisively influence the engine operation.

Predstavljeni preizkusi dokazujejo, da je mogoče opazno vplivati na motor tudi z vplivanjem ali spreminjanjem manjših delov hladilne površine. Vsaka od izbranih poti preizkusa je pokazala nekaj zanimivih rezultatov, kar se verjetno ne bi pokazalo, če bi se odločili samo za eno pot. Seveda pa je pri preprostih in majhnih dvotaktnih motorjih lahko dosegati spremembe na razmeroma enostaven in poceni način.

The tests described prove that it is possible to considerably influence the characteristics of the engine by changing the size and shape of small parts of the cooling surface. Each of the chosen variations of the test gave some interesting results, which could not have been achieved in a single way approach. In addition, it has to be pointed out that simple and small two-stroke engines can be relatively easily changed without high costs.

7 LITERATURA
7 REFERENCES

[1] Bizjan, F., M. Zgonik, R. Vičič: Hladjenje motora za putnička vozila uljem. JUMV-NMV, Kragujevac, 1990.
[2] Ricolfi, T., J. Scholz: Thermal Sensors - Volume 4. VCH Verlagsgesellschaft mbH, D-6940 Weizheim, 1990.

Avtorjev naslov: dr. Frančišek Bizjan, dipl. inž.
Fakulteta za strojništvo
Univerza v Ljubljani
Aškerčeva 6
1000 Ljubljana

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

Prejeto: 17.4.1997
Received:

Sprejeto: 29.8.1997
Accepted: