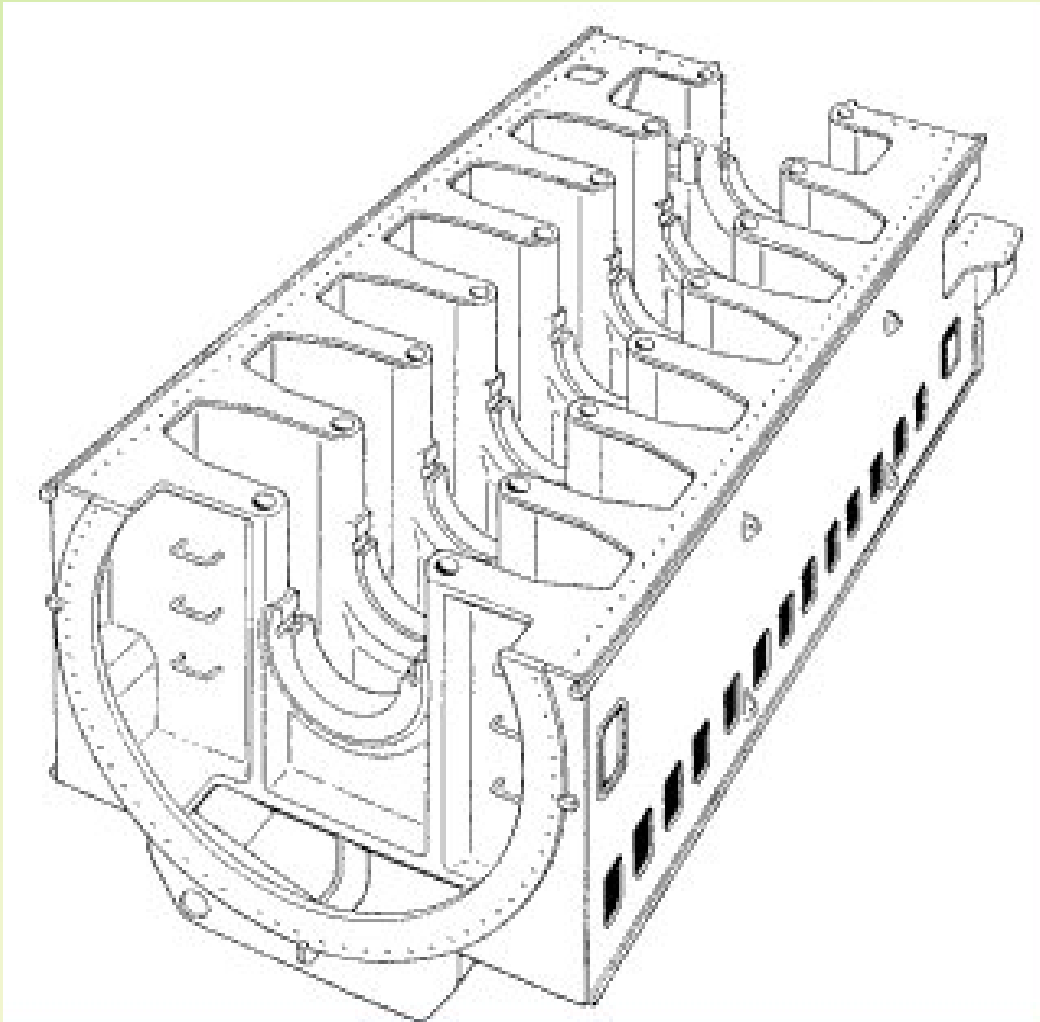


Brodski motori

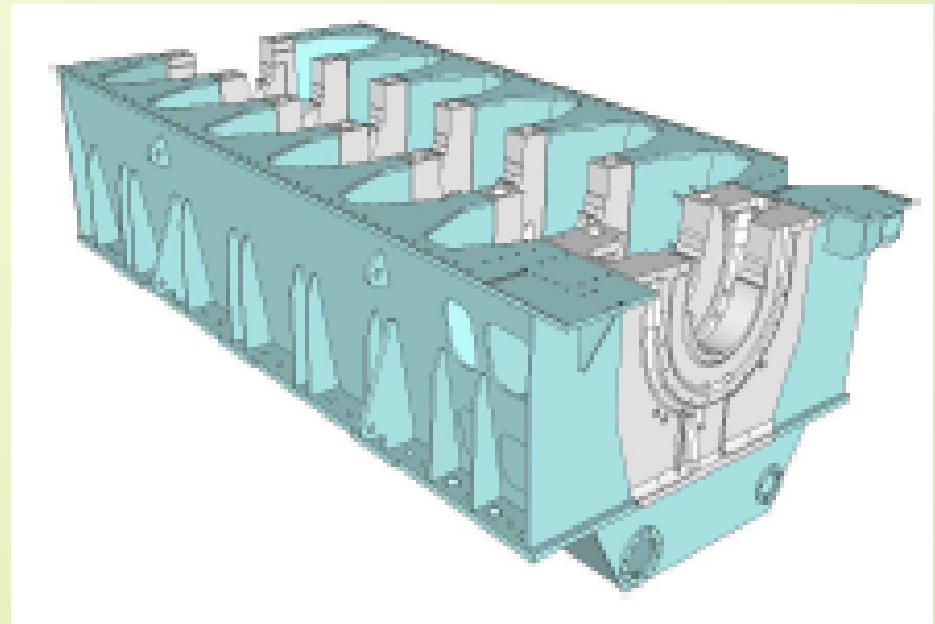
VII

Prof.dr.sc. Ivica Šegulja

TEMELJNA PLOČA



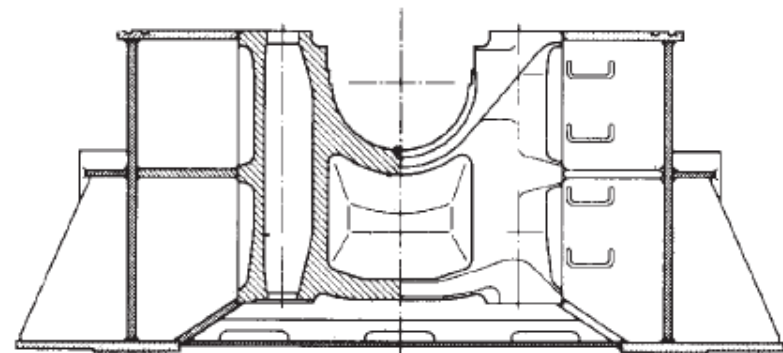
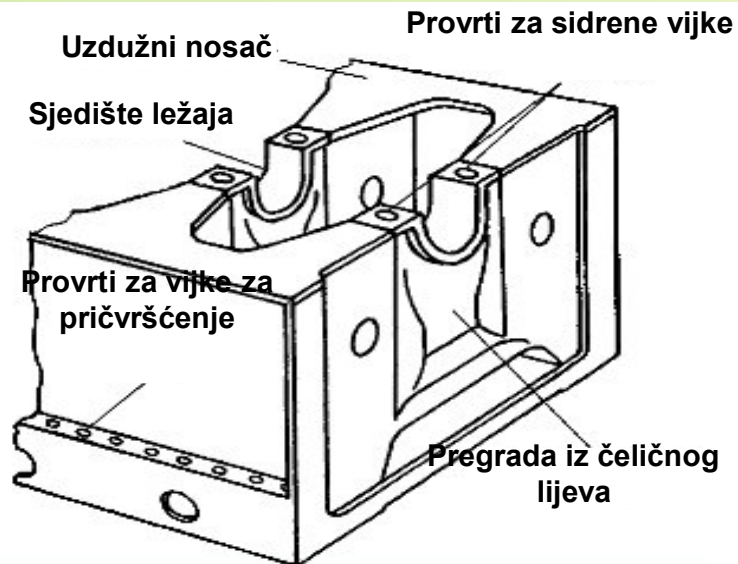
- - pričvršćuje motor na brodski temelj
- - podupire i nosi koljeničastu osovinu
- - podupire i nosi kućište motora
- Daje motoru (uz brodski trup) krutost.
- - lijevana izvedba
- -zavarena izvedba
- Na dnu zatvoren s TAVOM ULJA.

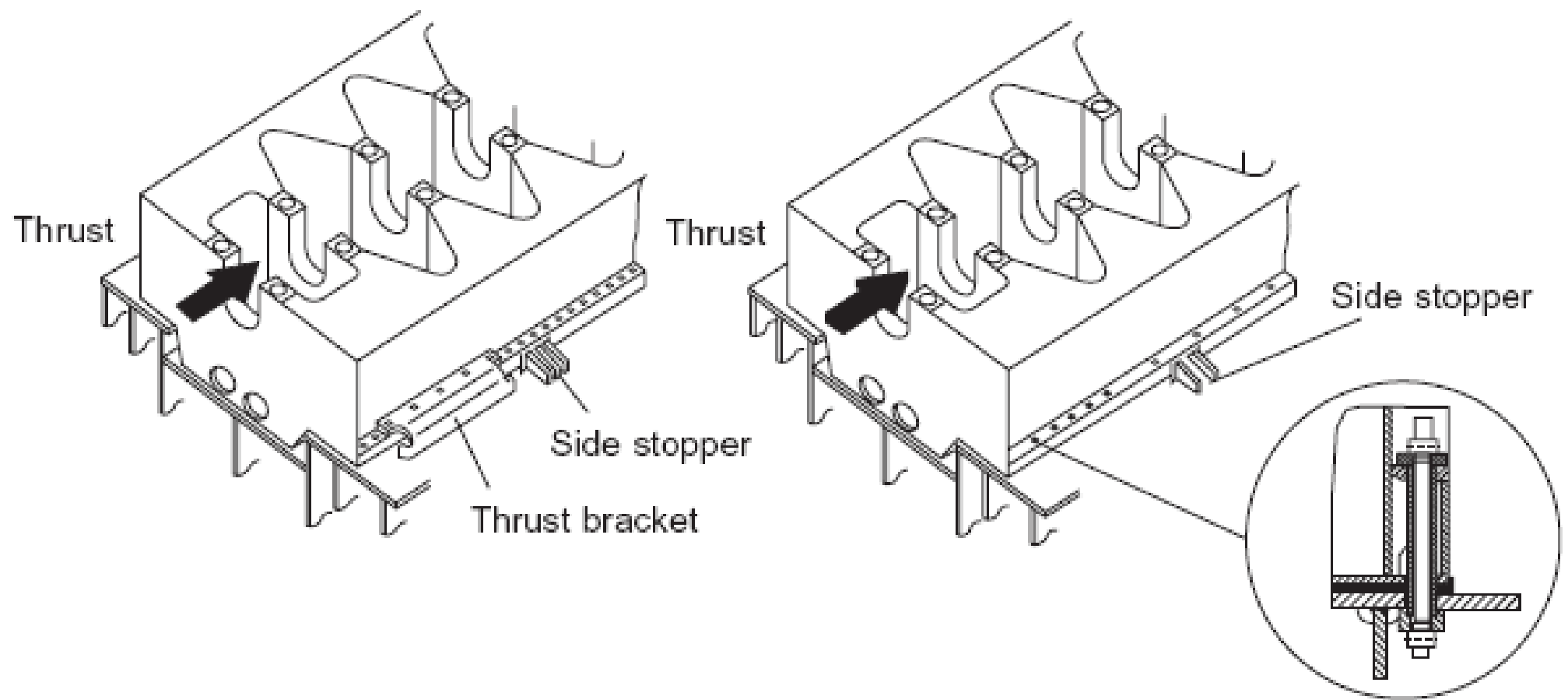


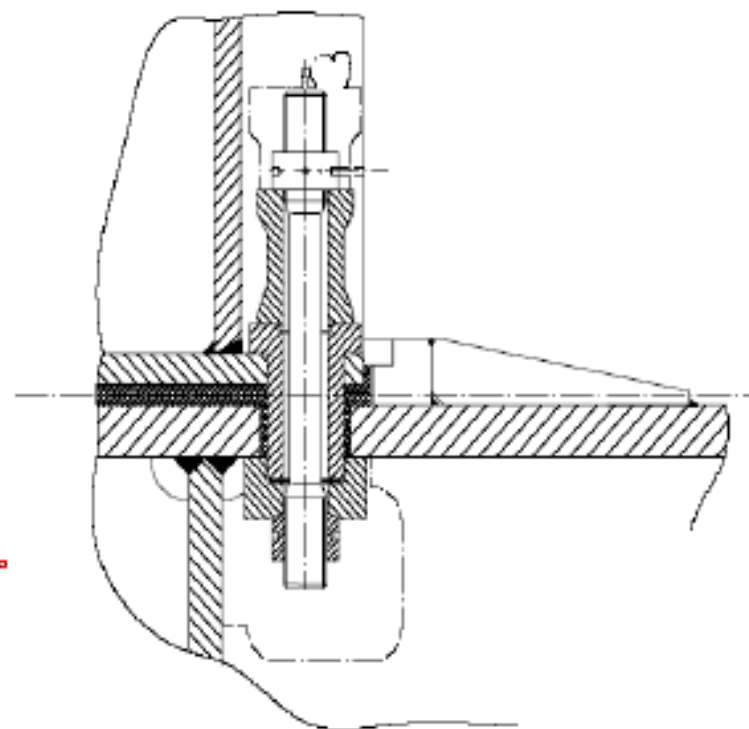
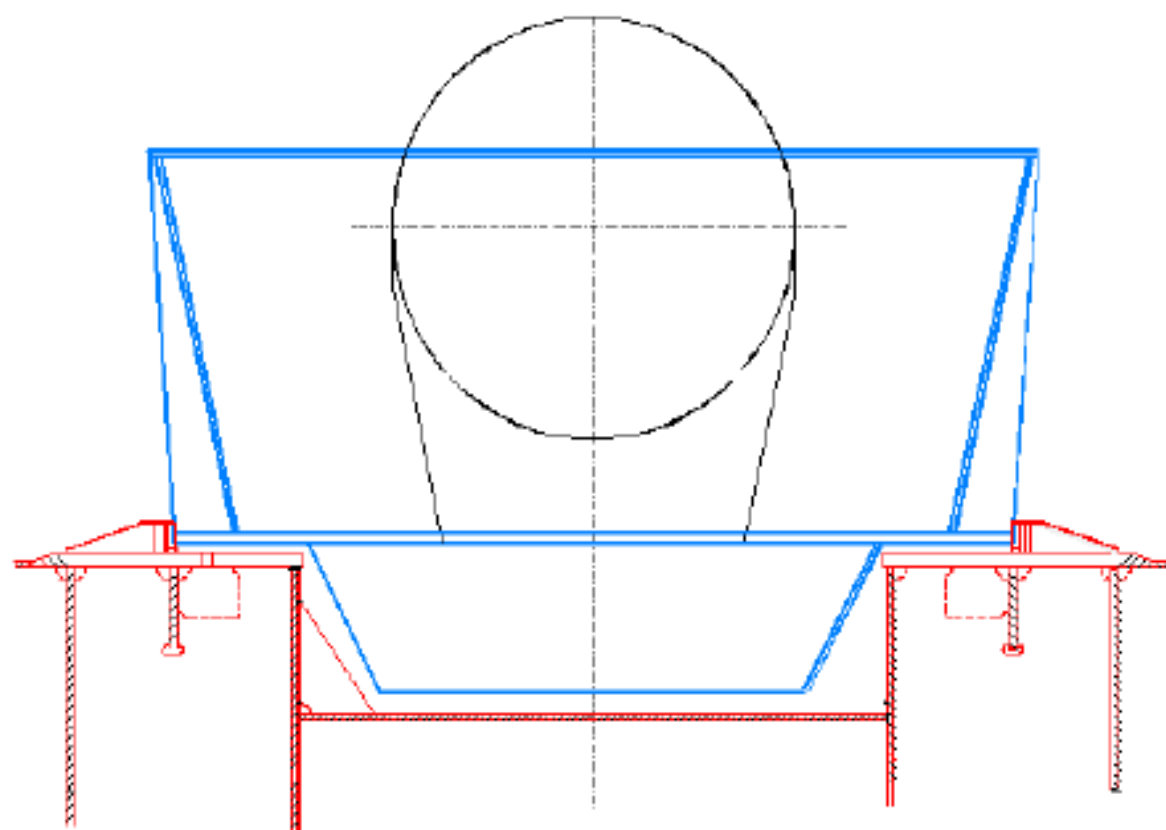
TEMELJNA PLOČA

Sastoji se od :

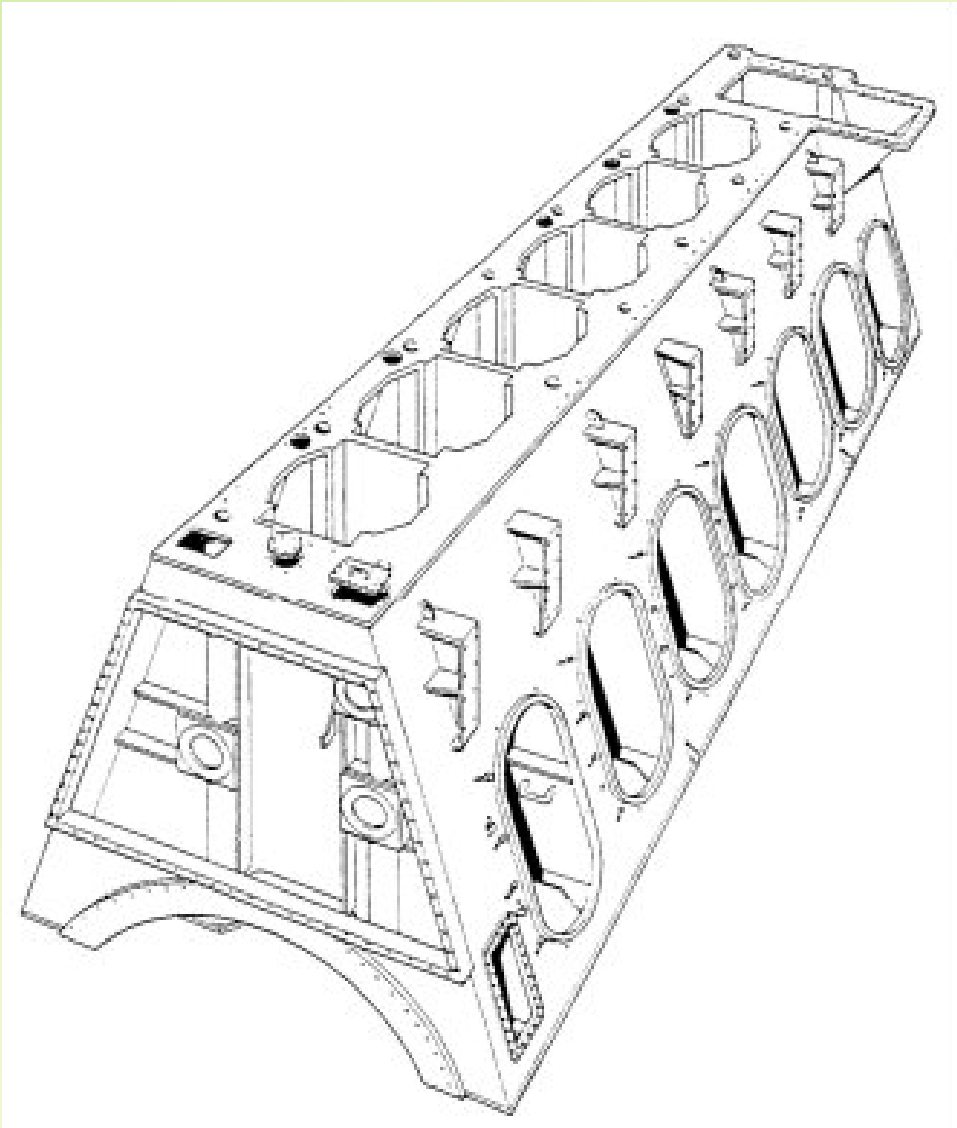
- uzdužnih nosača
- poprečnih nosača



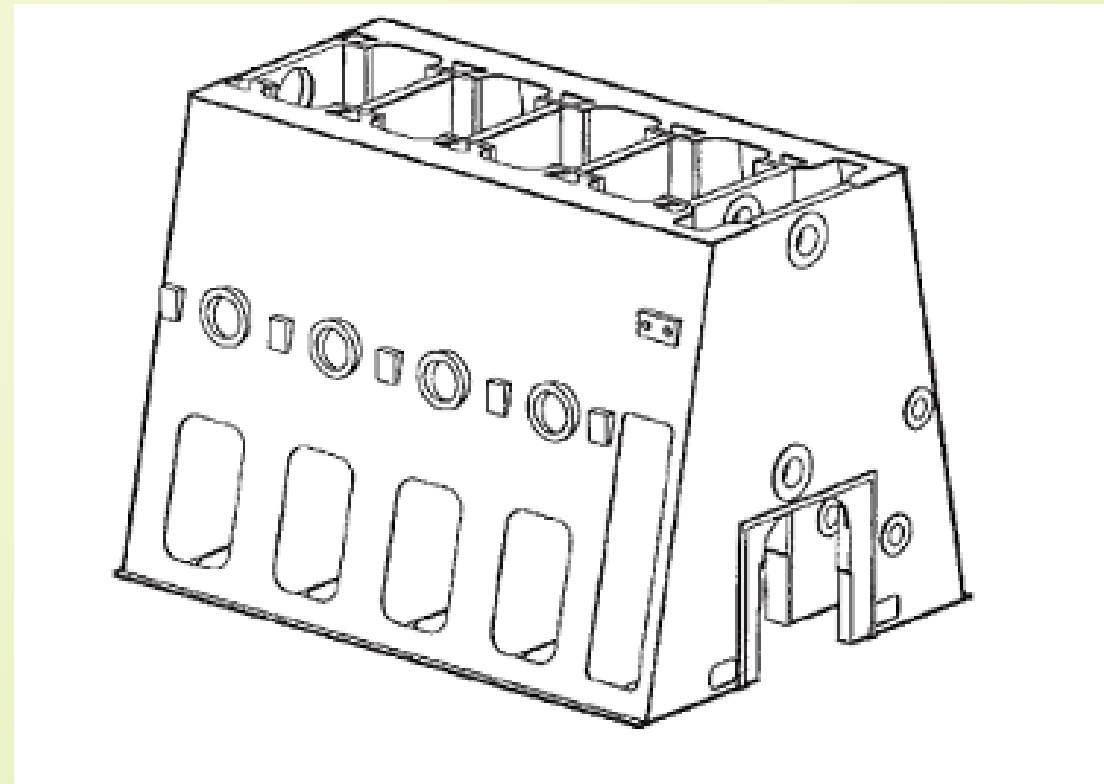




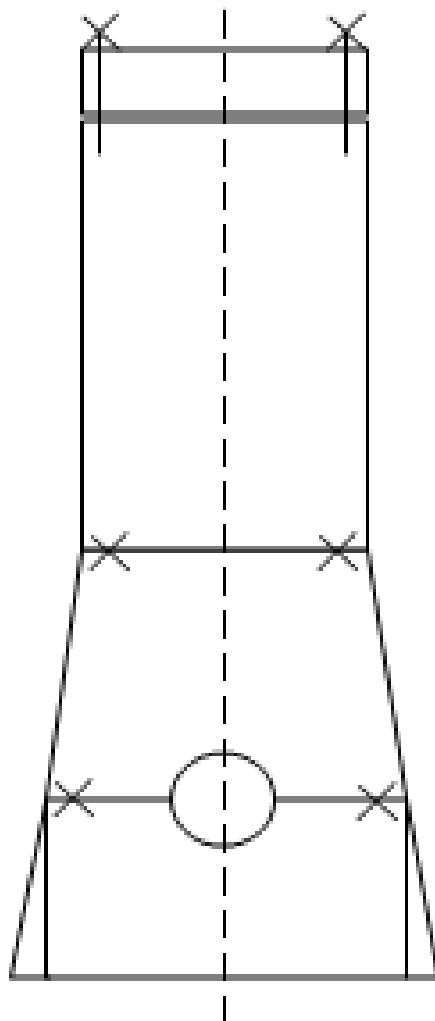
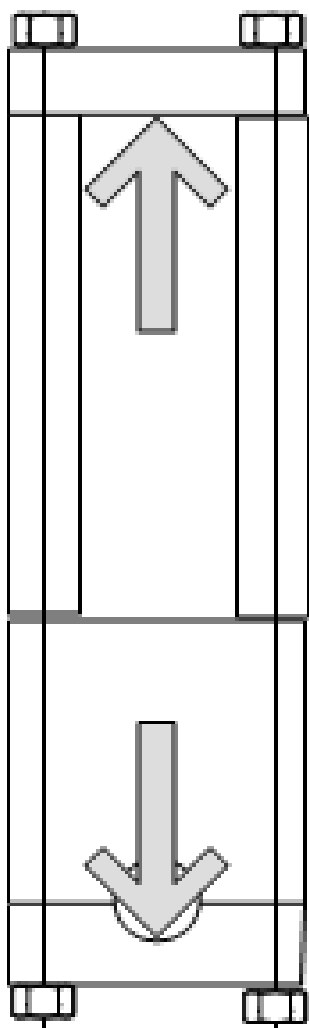
KUČIŠTE MOTORA



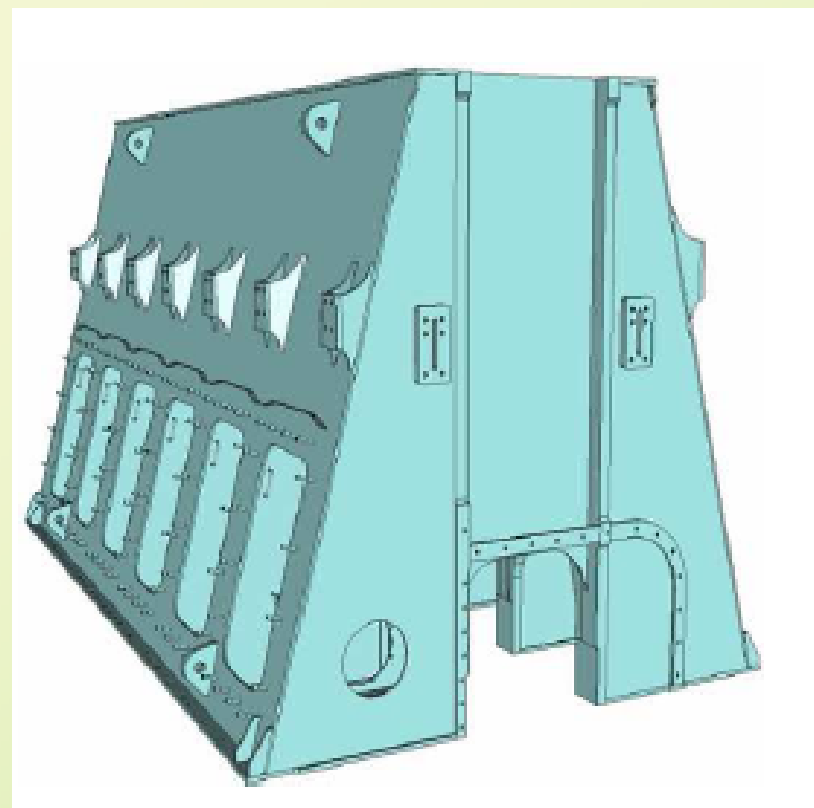
- Zatvara stapni mahanizam i spaja temeljnu ploču i kučište cilindara.
- Kod malih motora preuzima i funkciju TEMELJNE PLOČE.



KUČIŠTE MOTORA

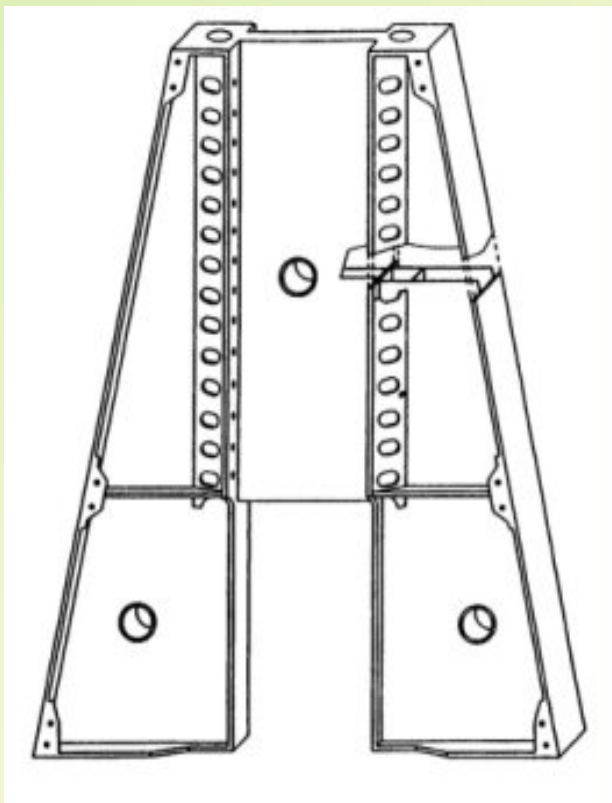


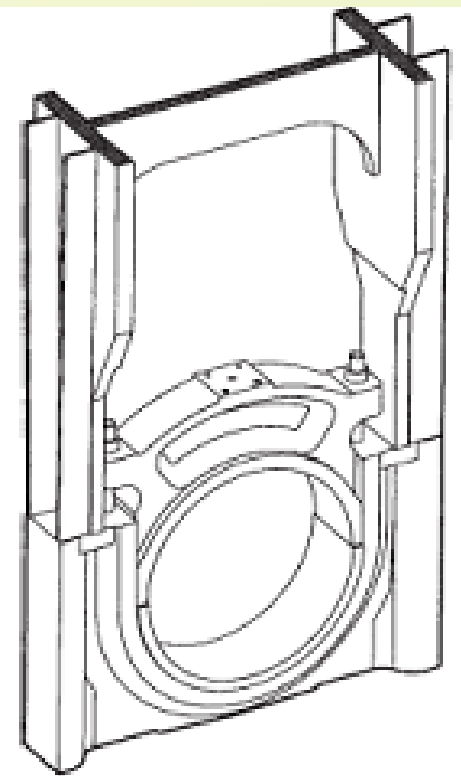
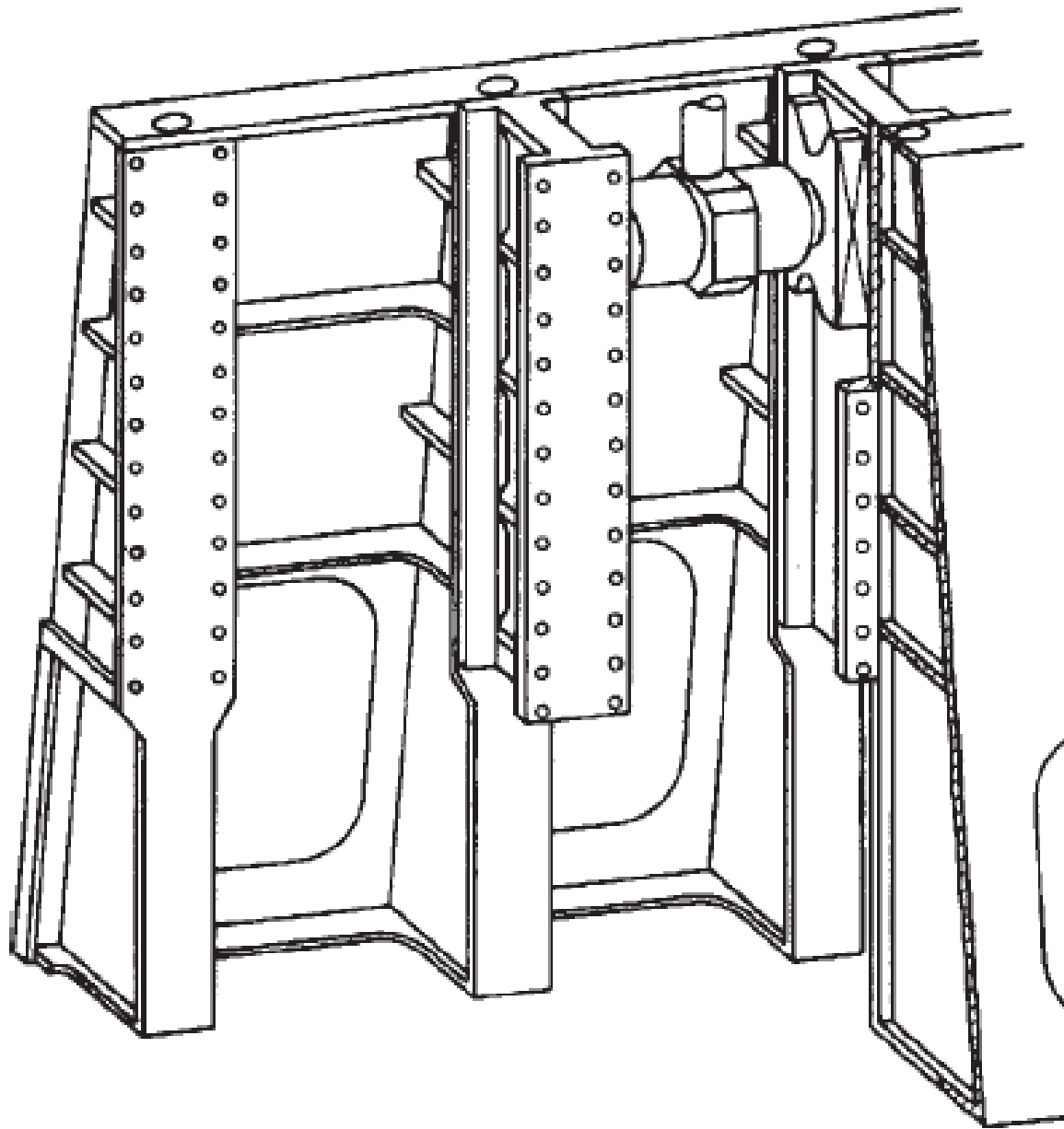
- Razlikujemo kučišta:
- - opterećena na vlak
- - neopterećana na vlak

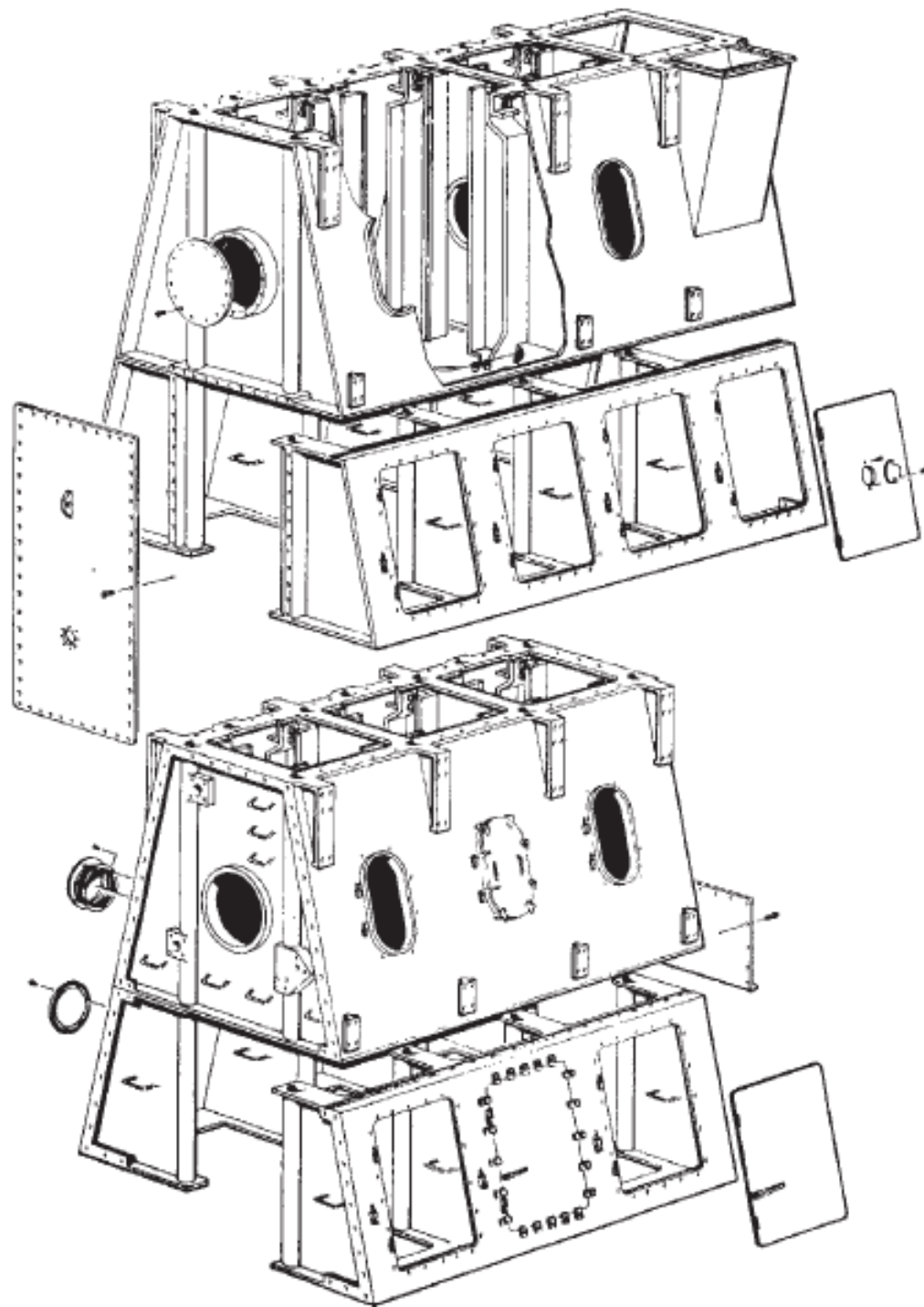


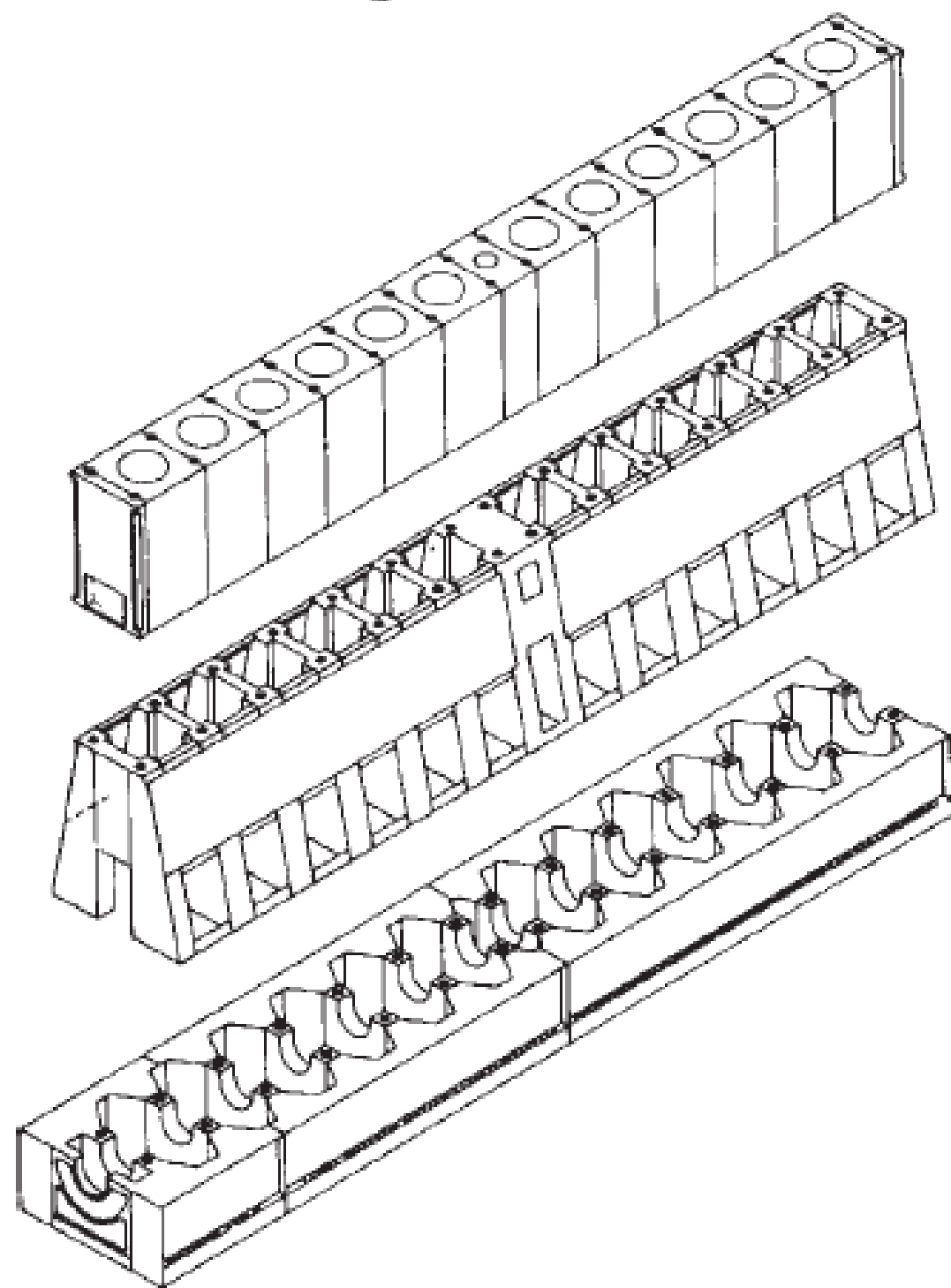
KUČIŠTE MOTORA

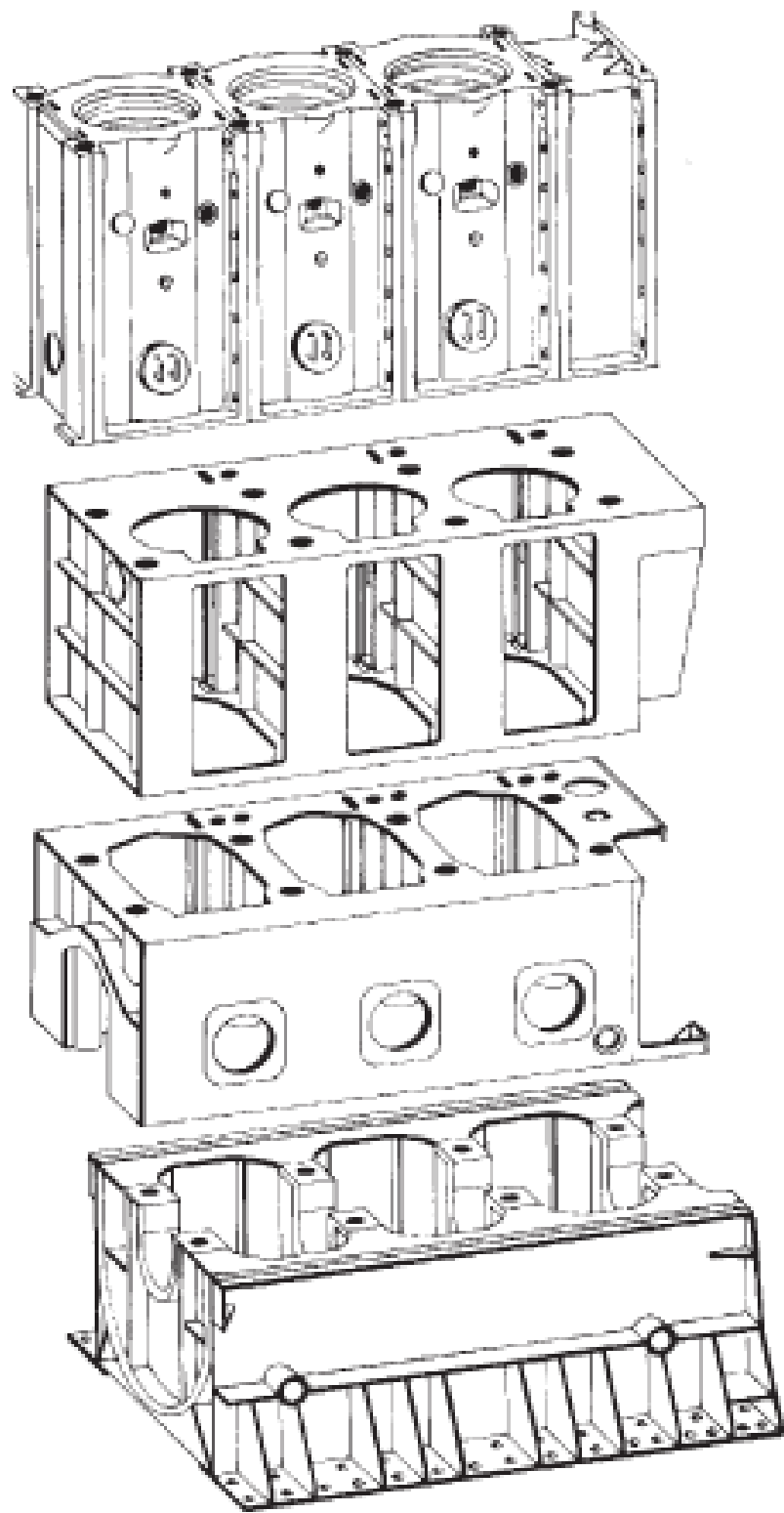
- Kod velikih motora se izgrađuje iz A STALAKA (na poprečne nosaće) povezanih pločama.

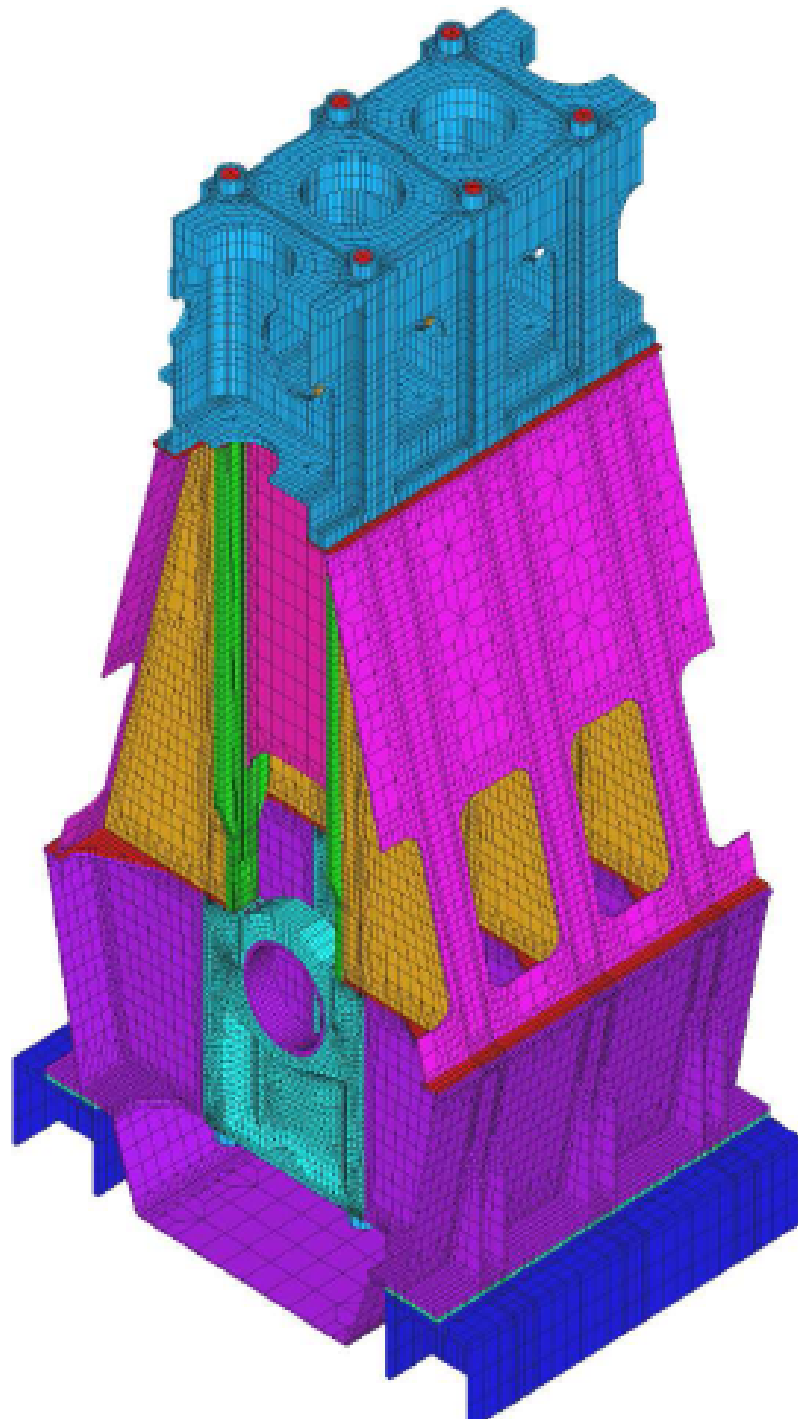






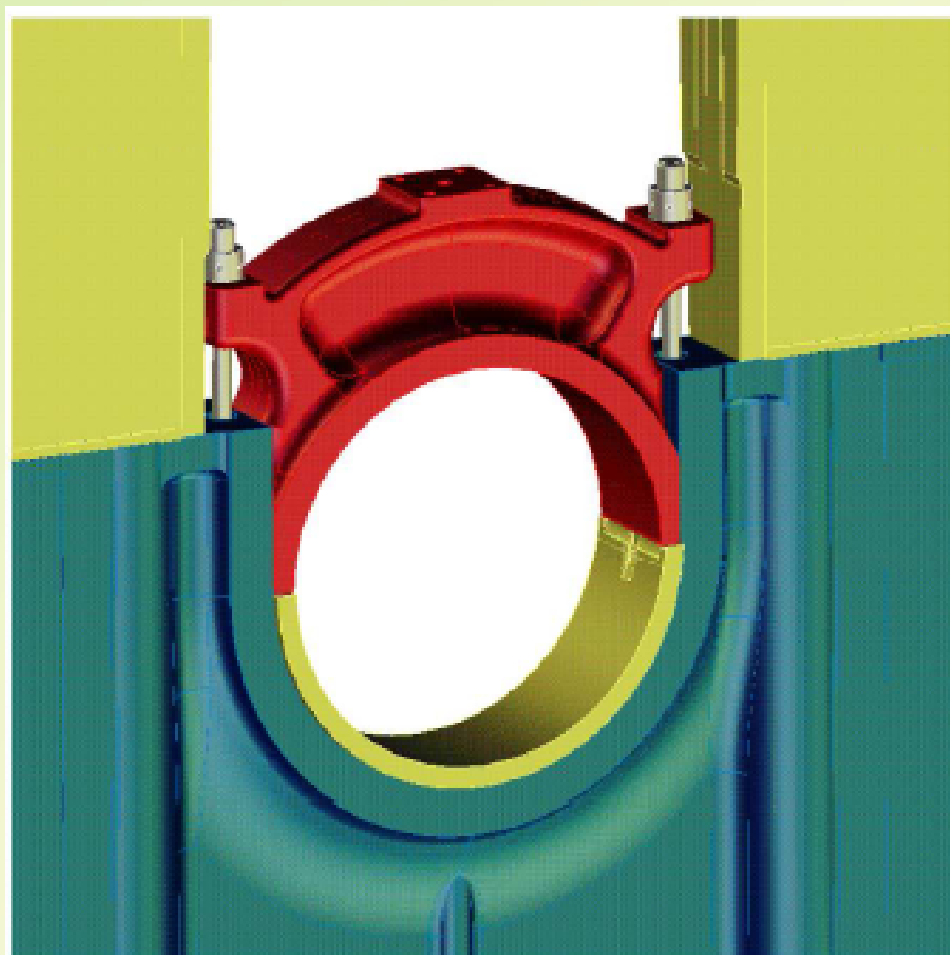






TEMELJNI LEŽAJI

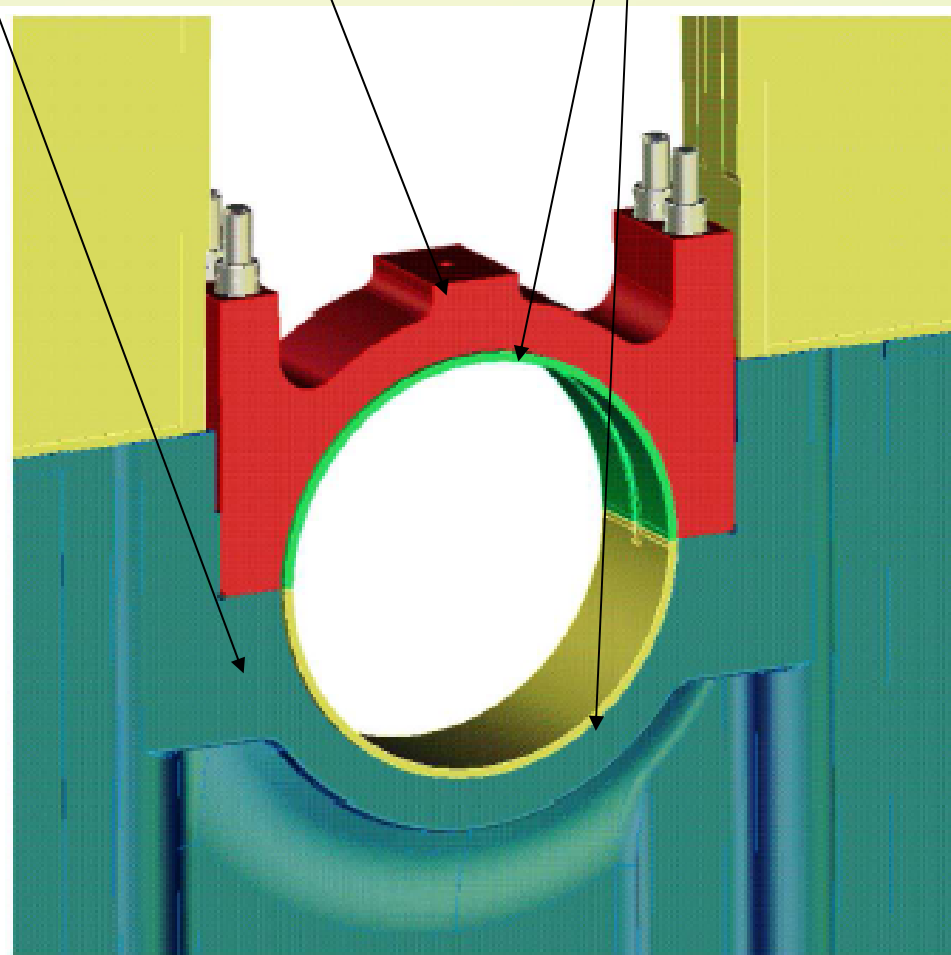
- Pruža oslonac koljeničastoj osovini



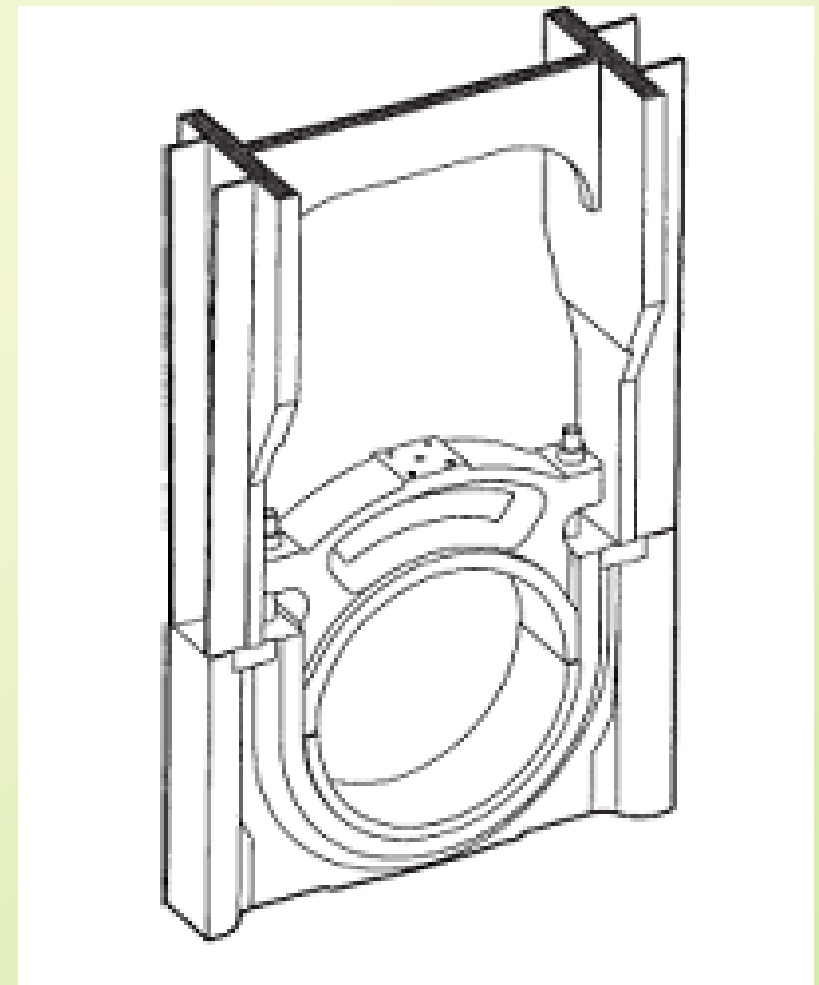
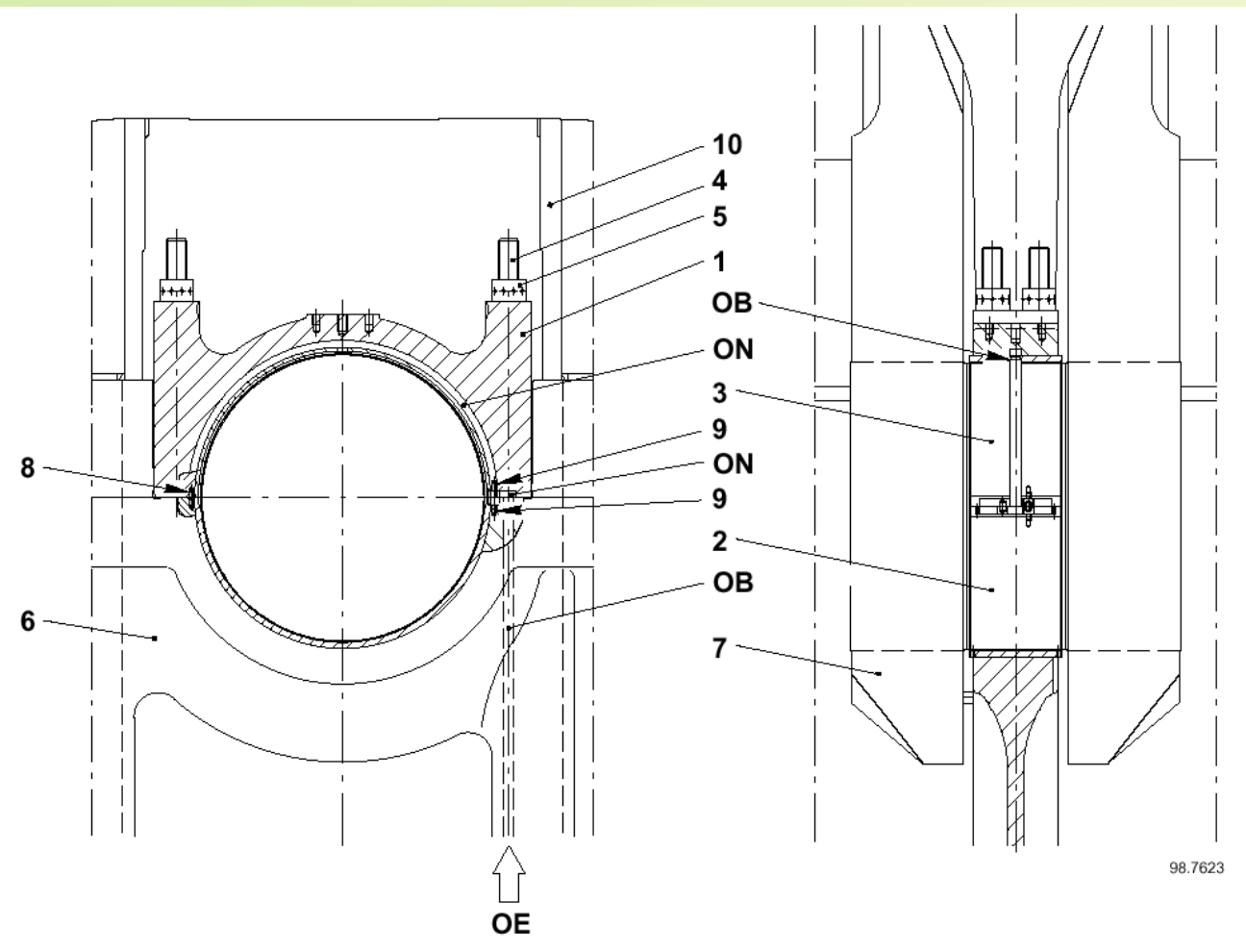
Kučište ležaja

Poklopac ležaja

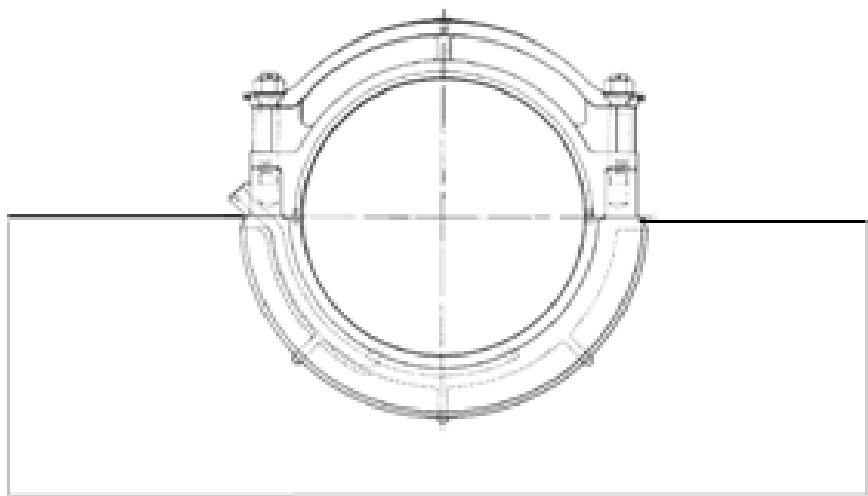
blazinice



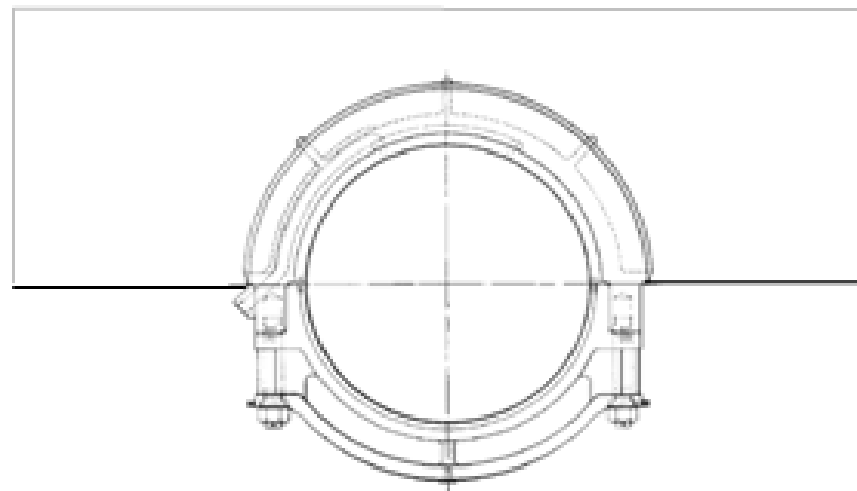
TEMELJNI LEŽAJI



TEMELJNI LEŽAJI



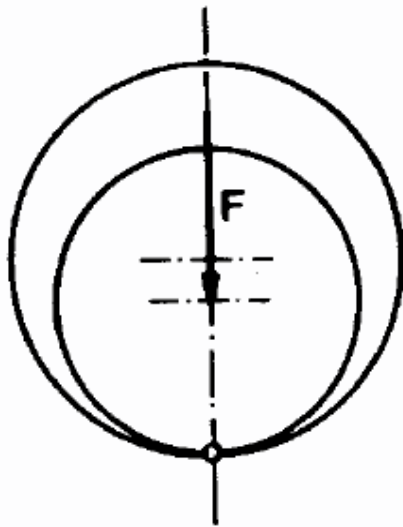
stojeći



viseći

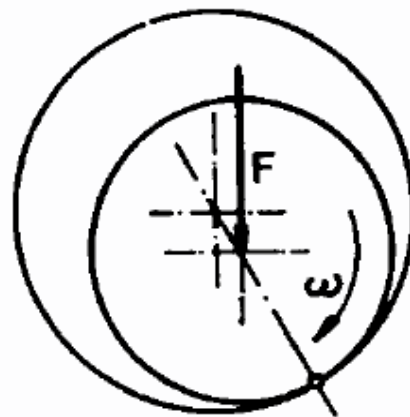
TEMELJNI LEŽAJI

Faze rada kliznog ležaja



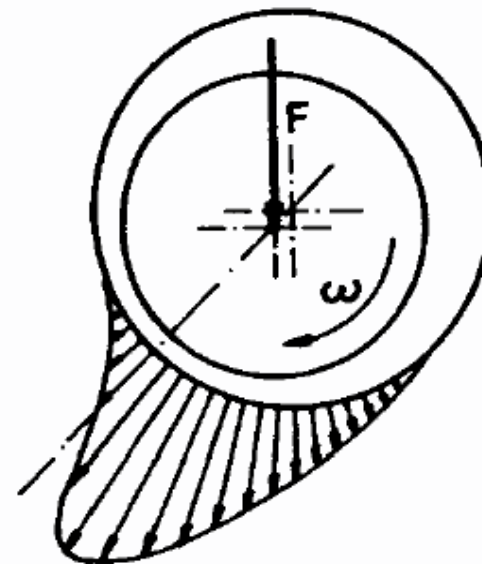
(a)

Mirovanje



(b)

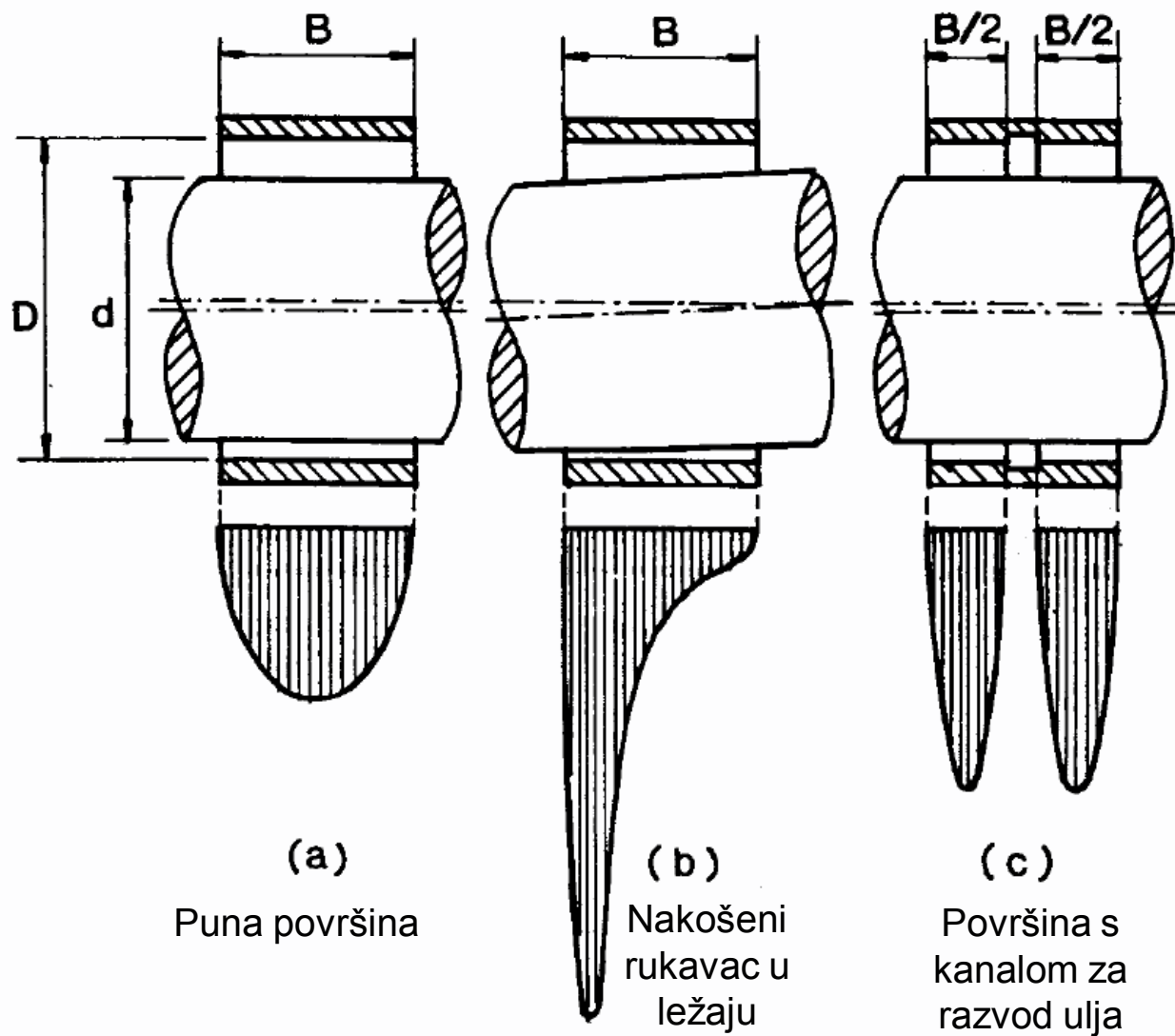
Prijelazno trenje



(c)

Hidrodinamičko klizanje

TEMELJNI LEŽAJI



Uzdužna razdioba tlaka u kliznom ležaju

TEMELJNI LEŽAJI

Materijal blazinica:

- sposobnost uhodavanja (plastičnost)
- dovoljno mekan (zabijanje otk.čestica)
- prijanjanje ulja
- minimalna klizna svojstva
- otporan na koroziju
- visoku temperaturu taljenja
- dobru toplinsku vodljivost
- mali koeficijent rastezanja

TEMELJNI LEŽAJI

Materijali :

Bijela kovina : legura kositra, antimona, bakra i olova.

+ uhodavanje, min. klizna svojstva

- osjetljiva na udarna opterećenja, niska temperatura
(100°C)

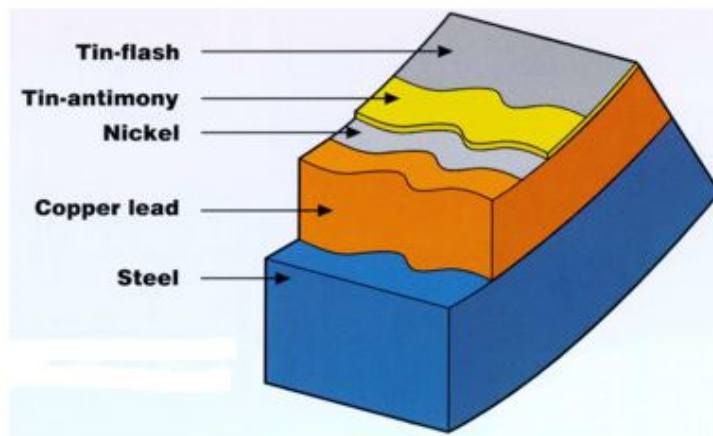
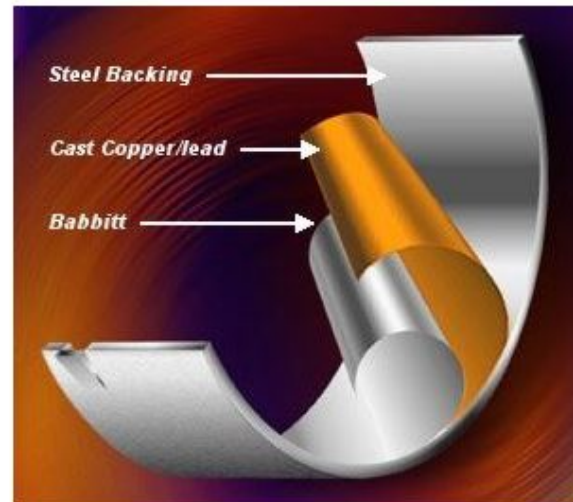
Bronce (kositrena, silicijeva, aluminijske i olovne)

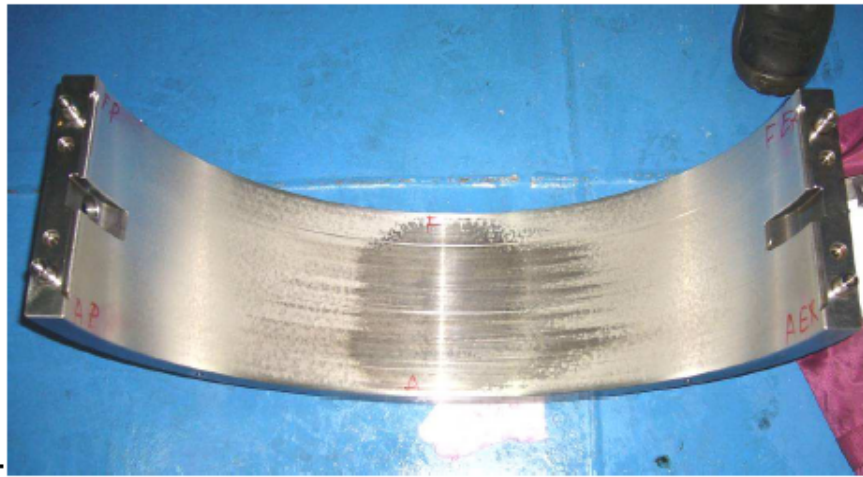
Aluminijske bronce :

+ visoka topl. vodljivost, mala težina, otporni na koroziju,
obradivost, visoka opterećenja

- slaba minimalna klizna svojstva

SUSTAV PODMAZIVANJA !!!

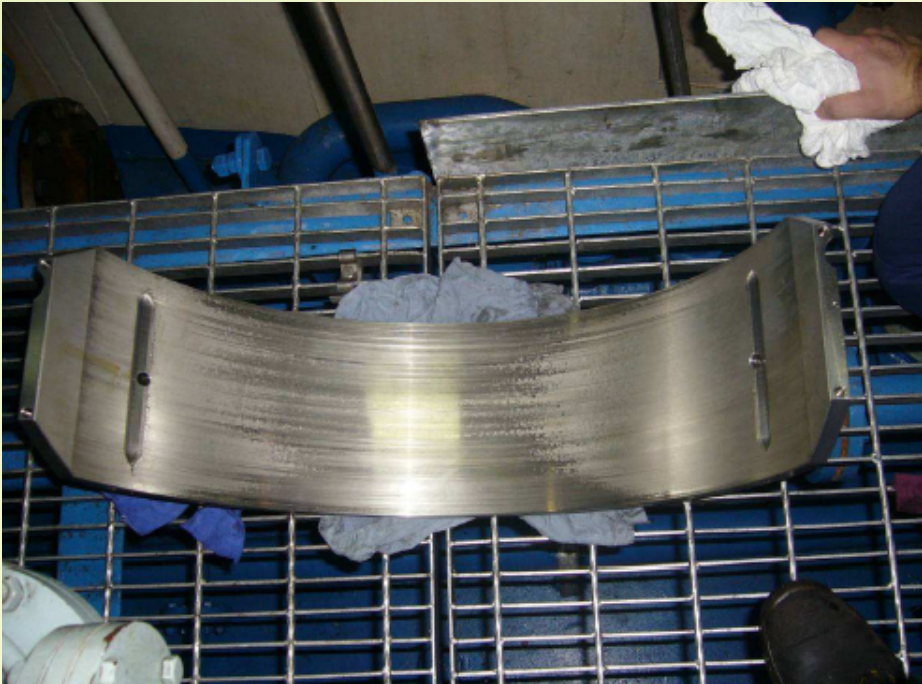


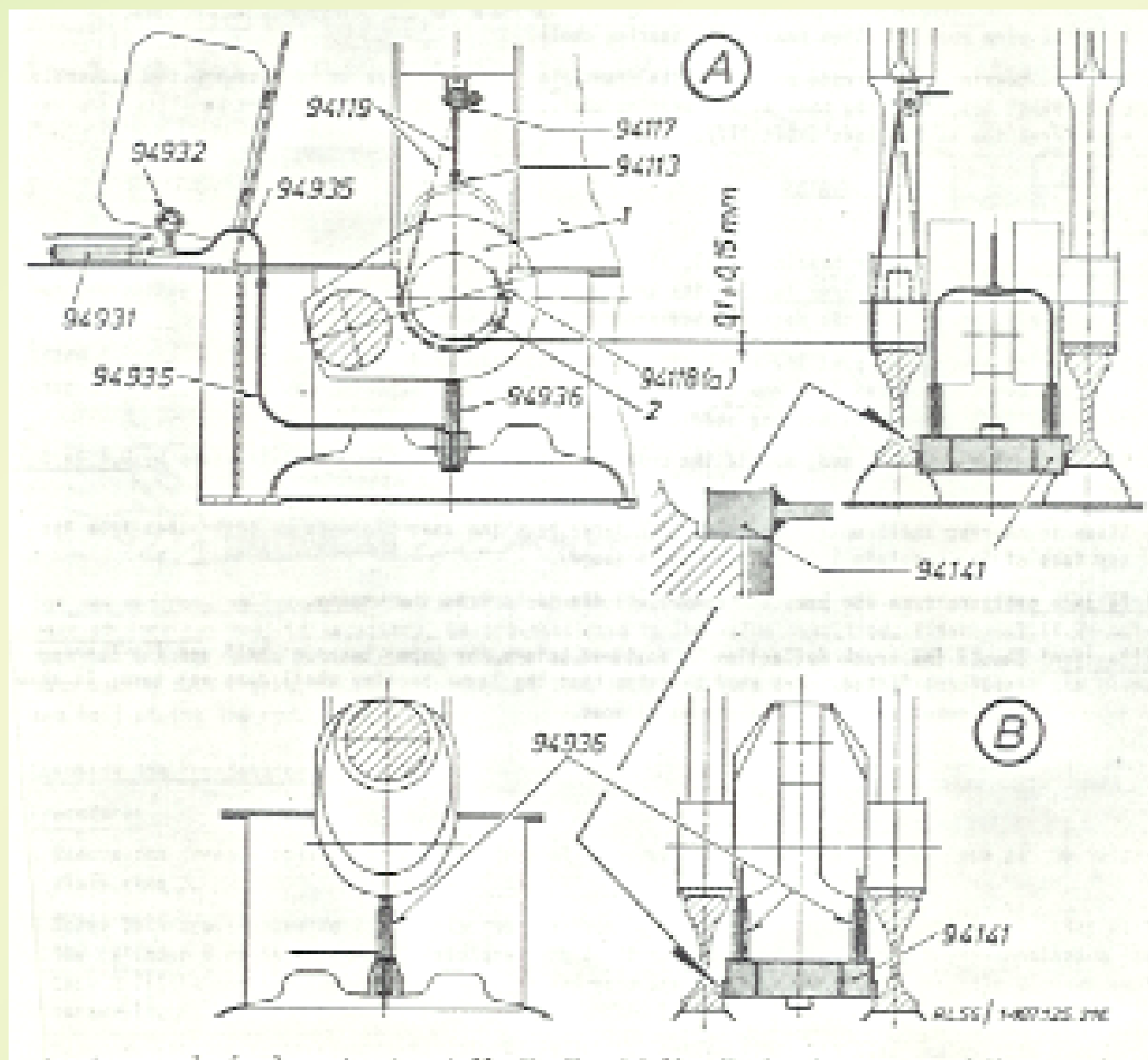
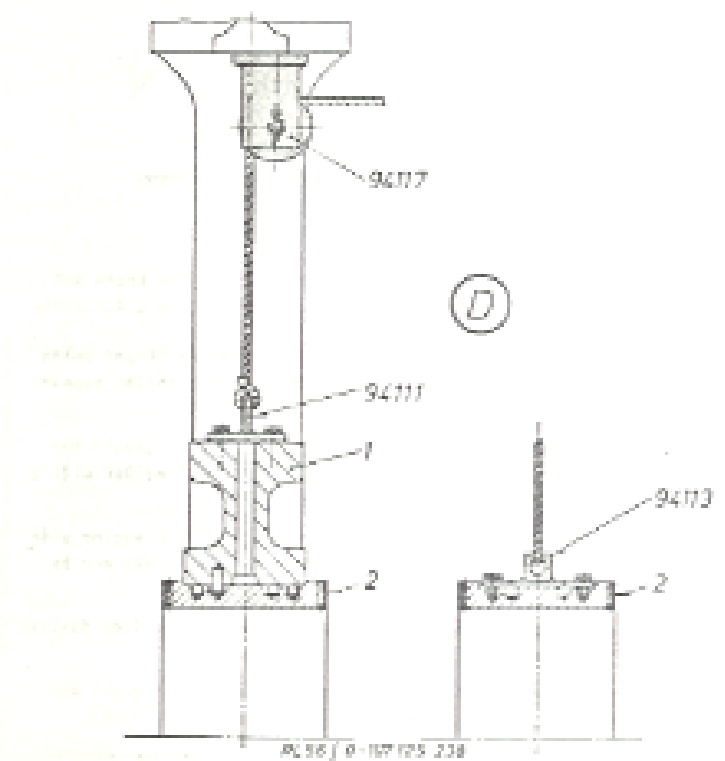
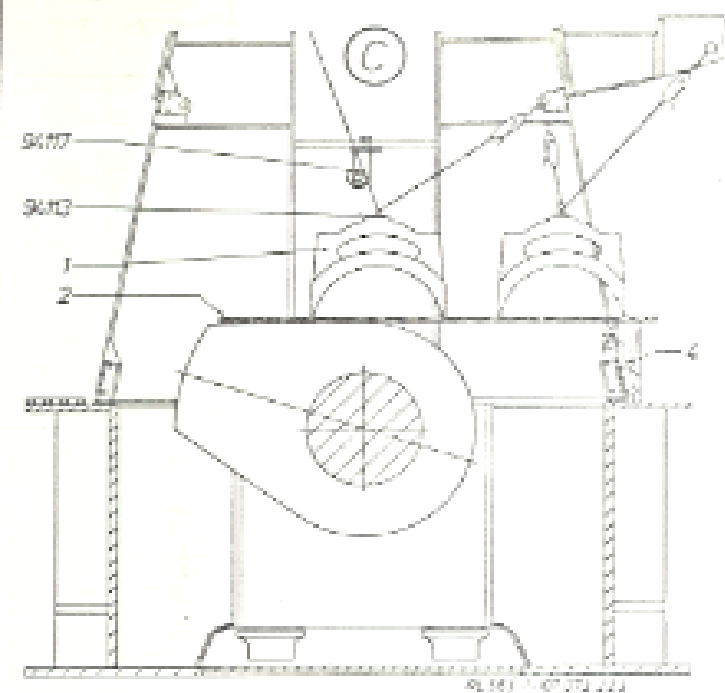


WM layer of lower shell MB#5



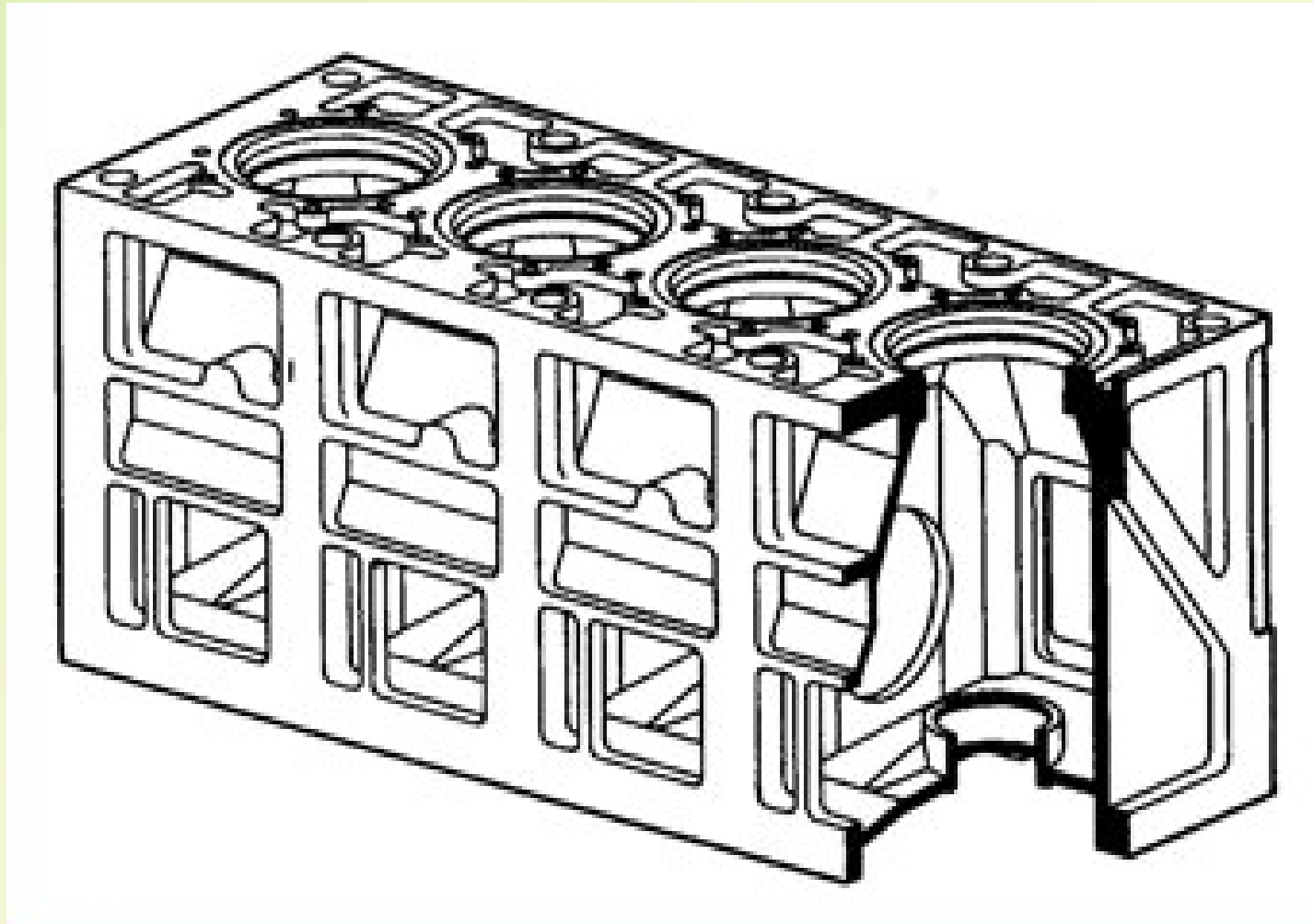
Back side of lower shell MR#5



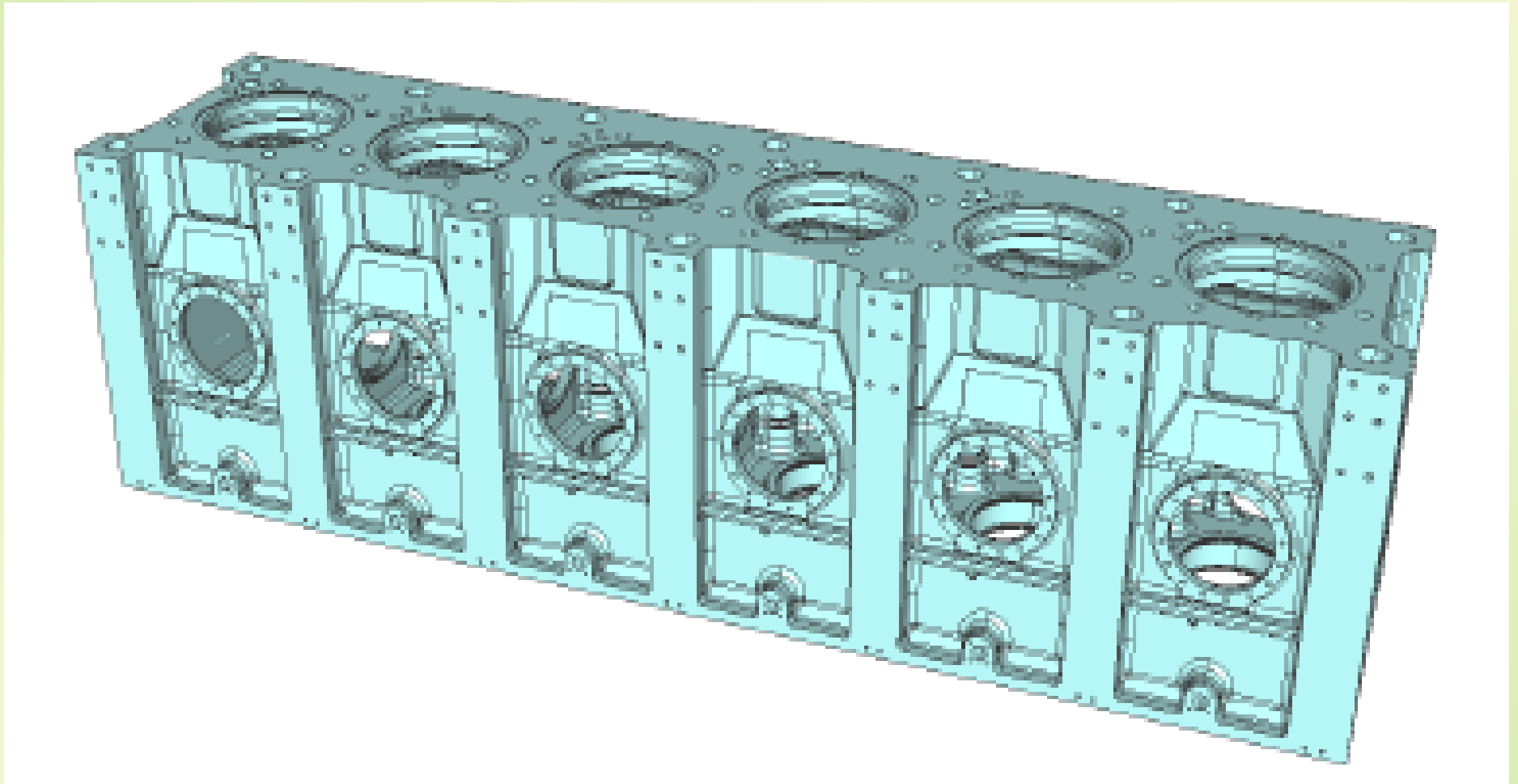


KUČIŠTE CILINDARA

Pružá oslonac cilindarskim košuljicama.



KUČIŠTE CILINDARA



KUČIŠTE CILINDARA

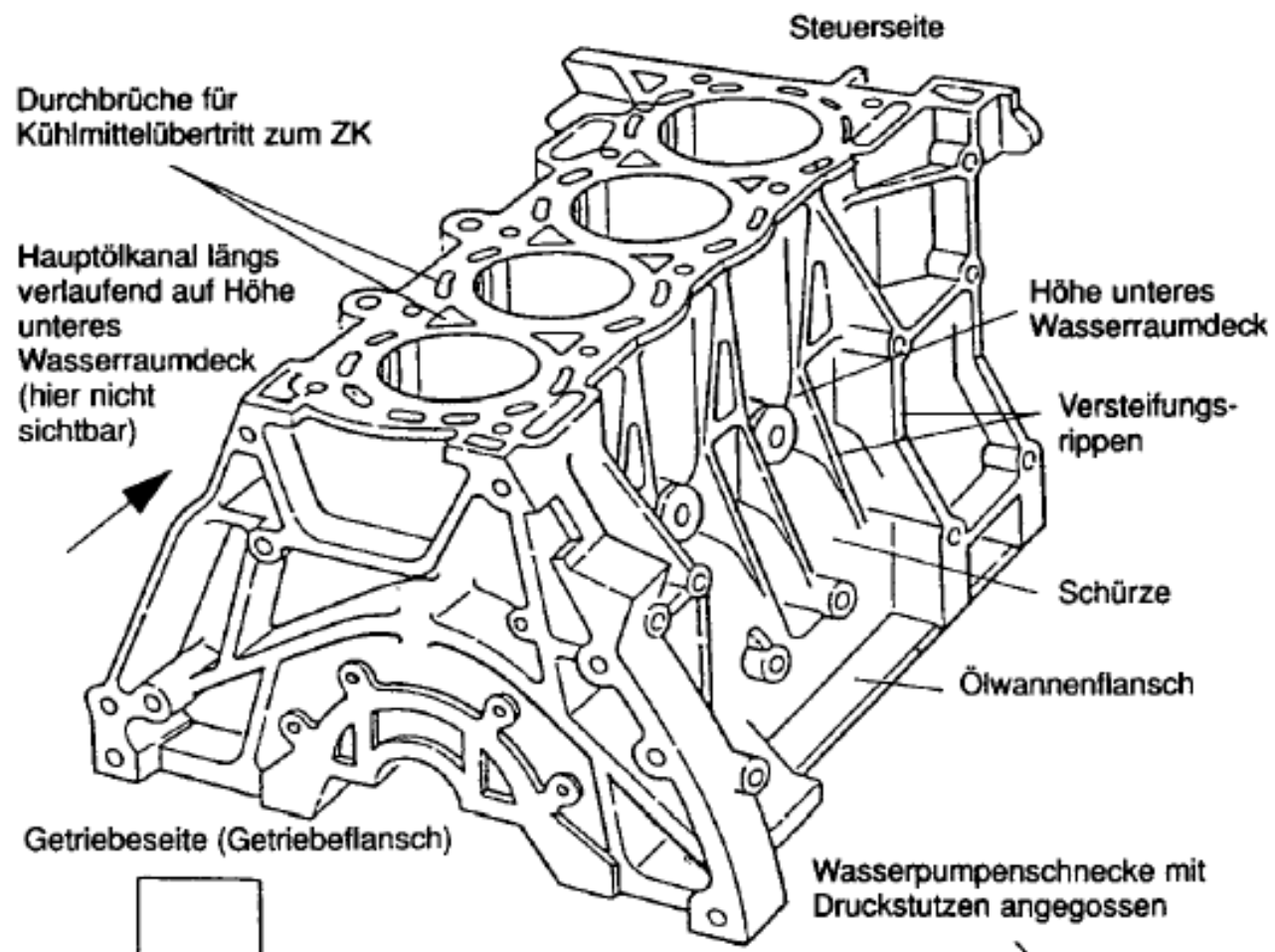
Sastoji se od :

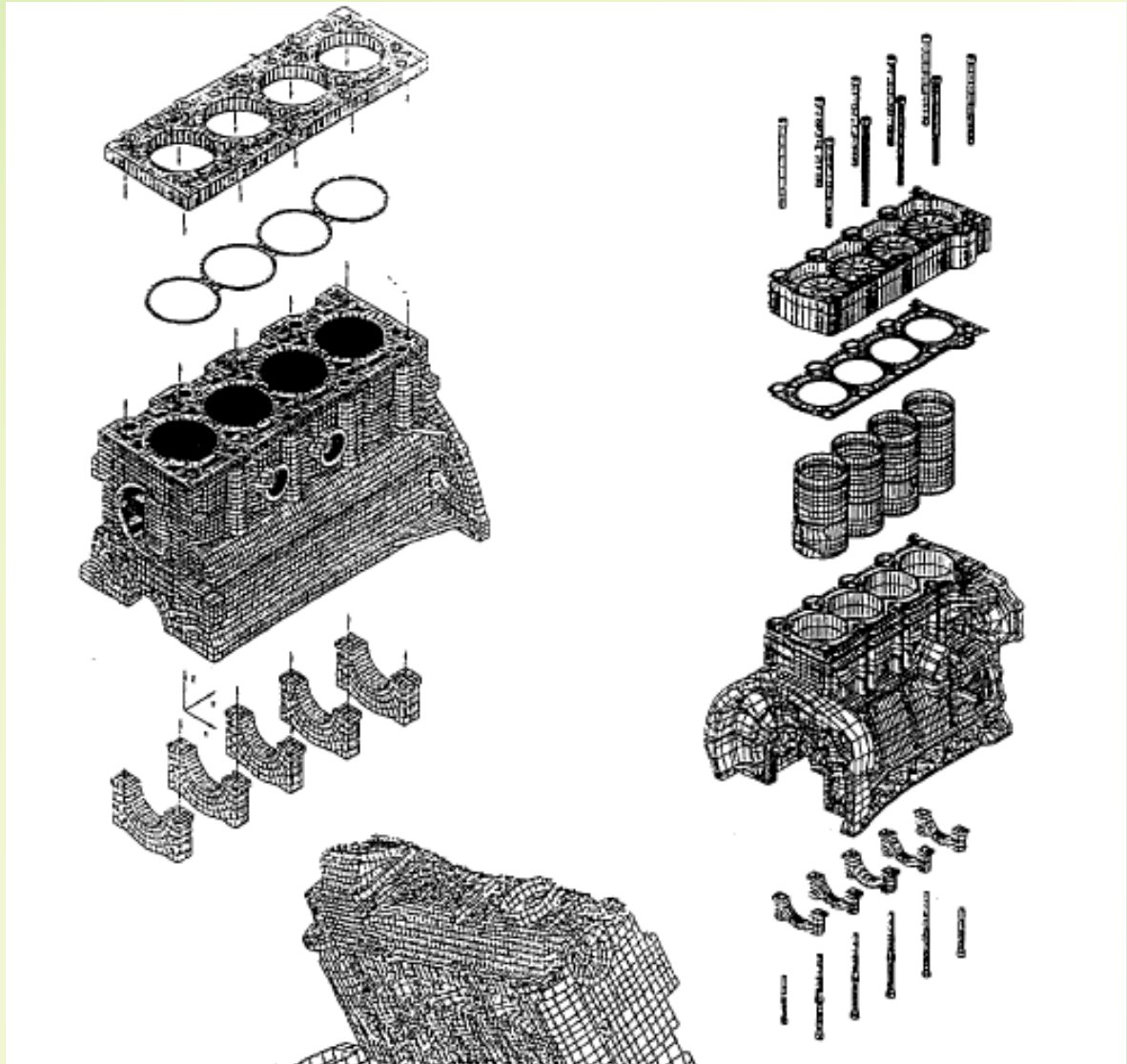
- plašta cilindra (ispirno okućje)
- košuljice cilindra
- rashladno okućje

Kod malih motora preuzima funkciju i temeljne ploče, kućišta motora i kućišta cilindra.

Kućište može biti za svaki cilindar posebno ili za više njih zajedno.

Sivi lijev, čelični lijev, Al legure





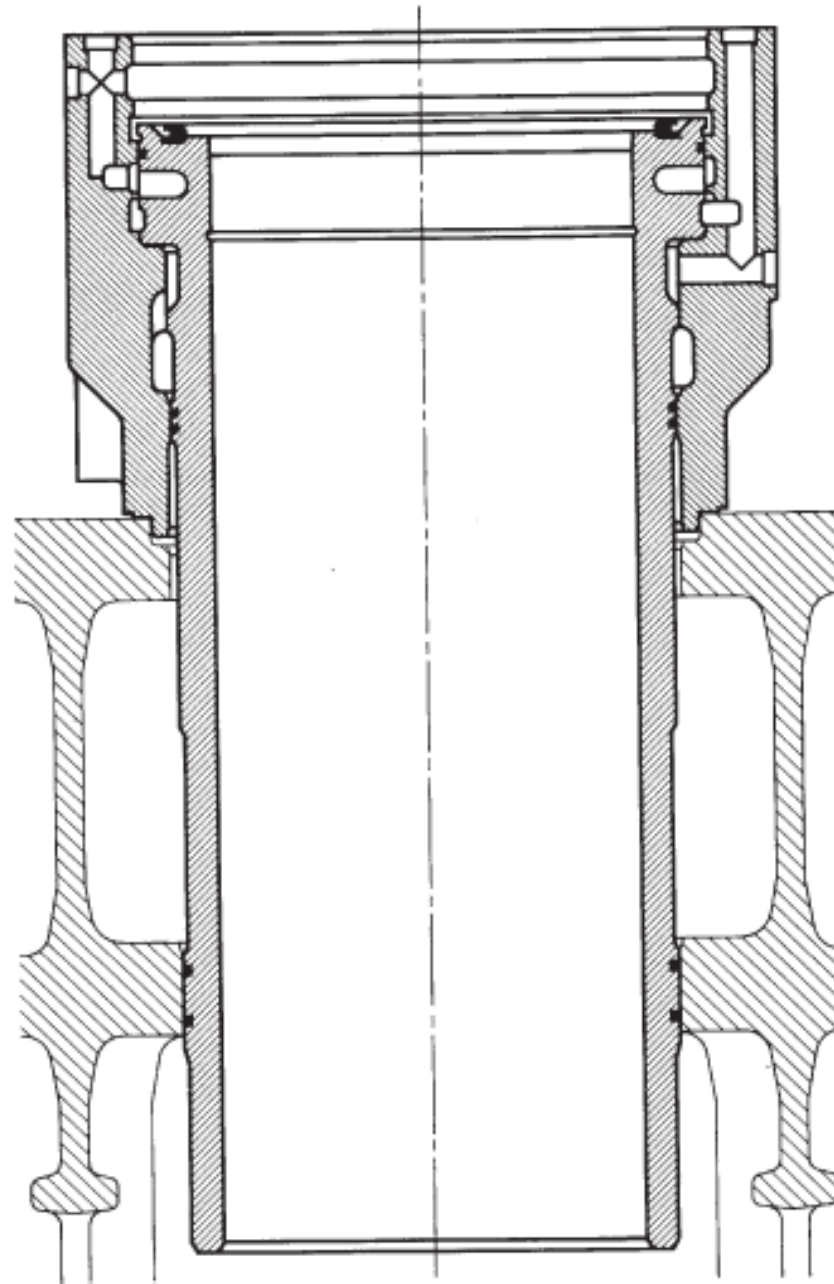
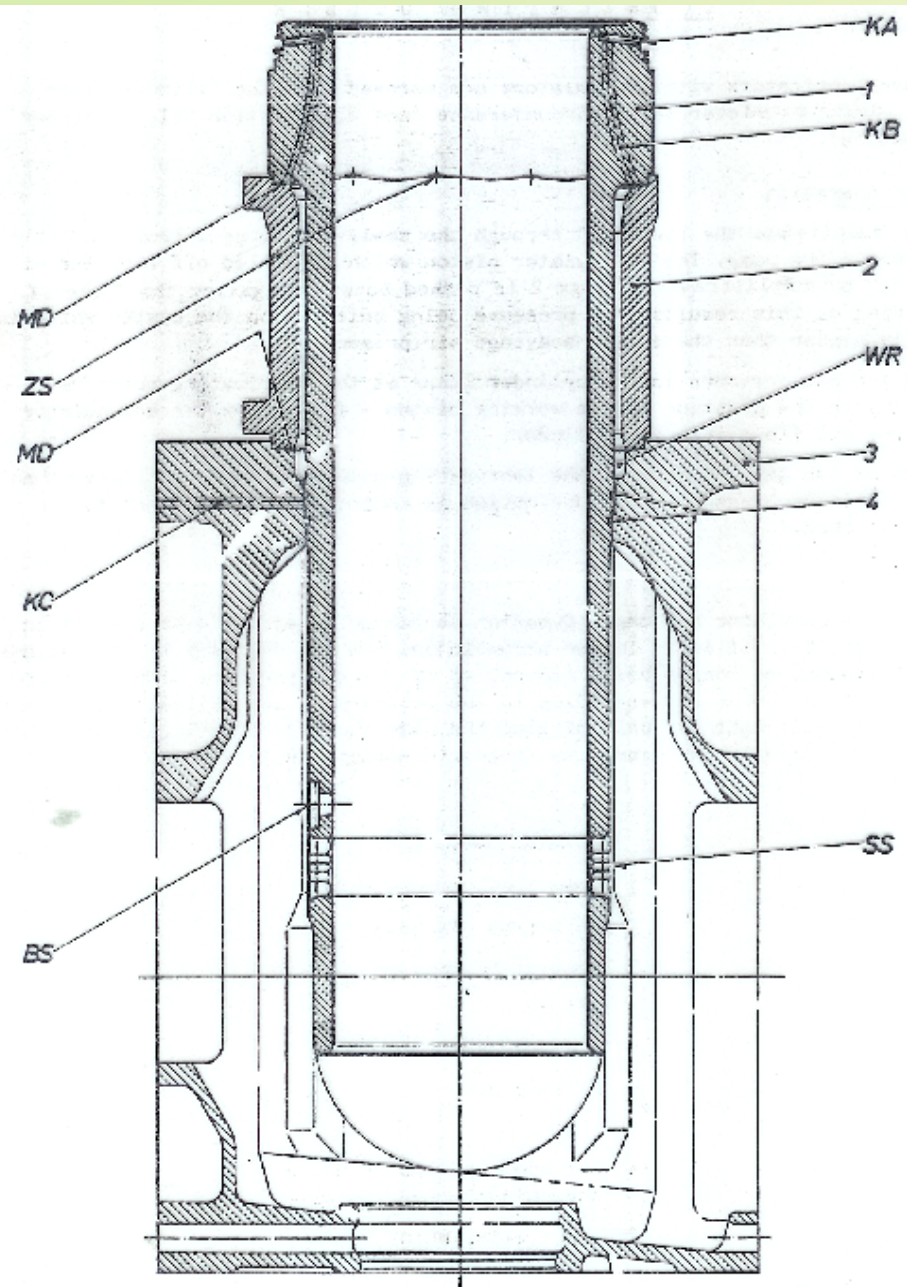
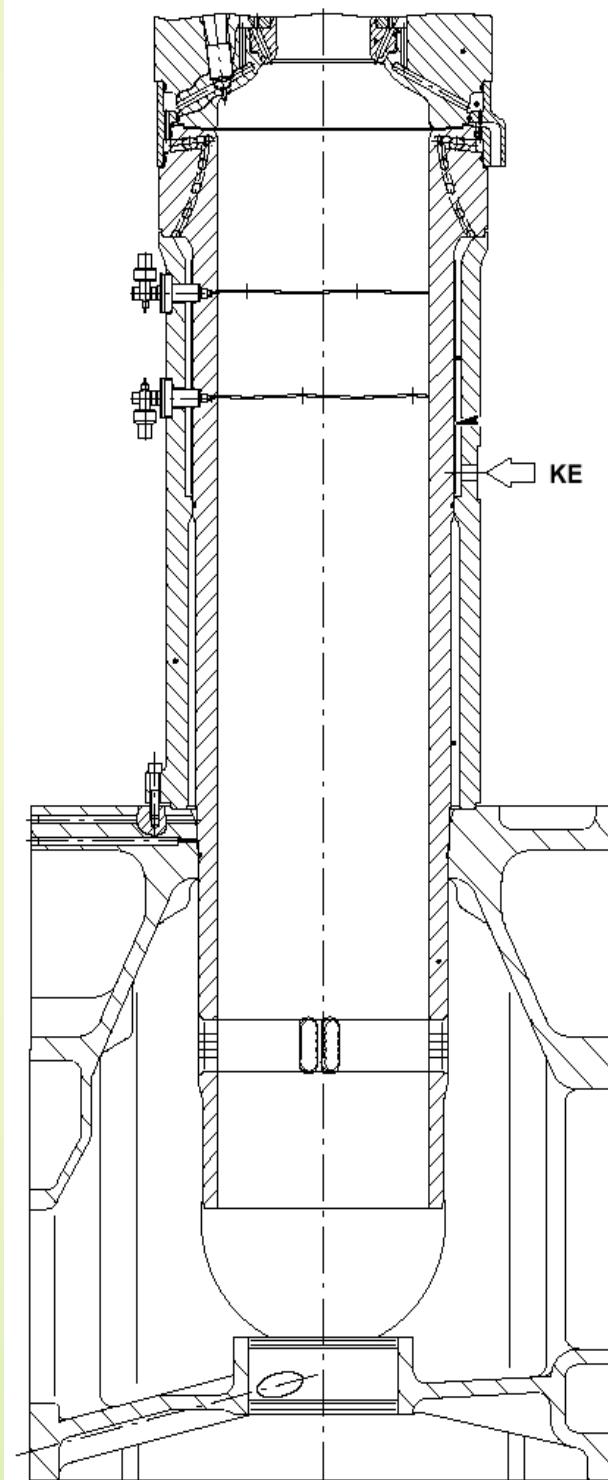
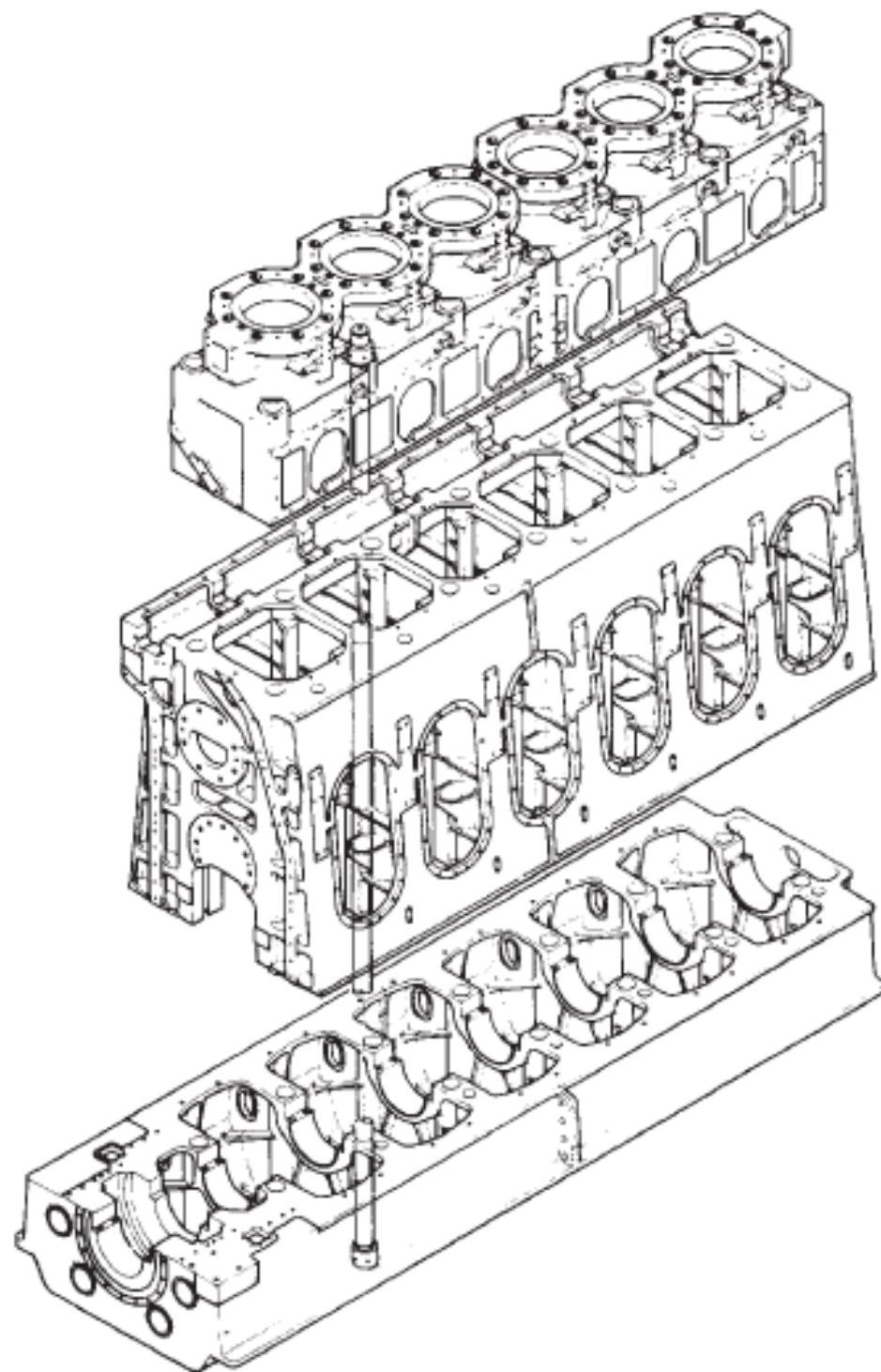


Figure 22.7 Cylinder liner of original L58/64 engine. A flame ring was specified in later models (see Figure 22.20)

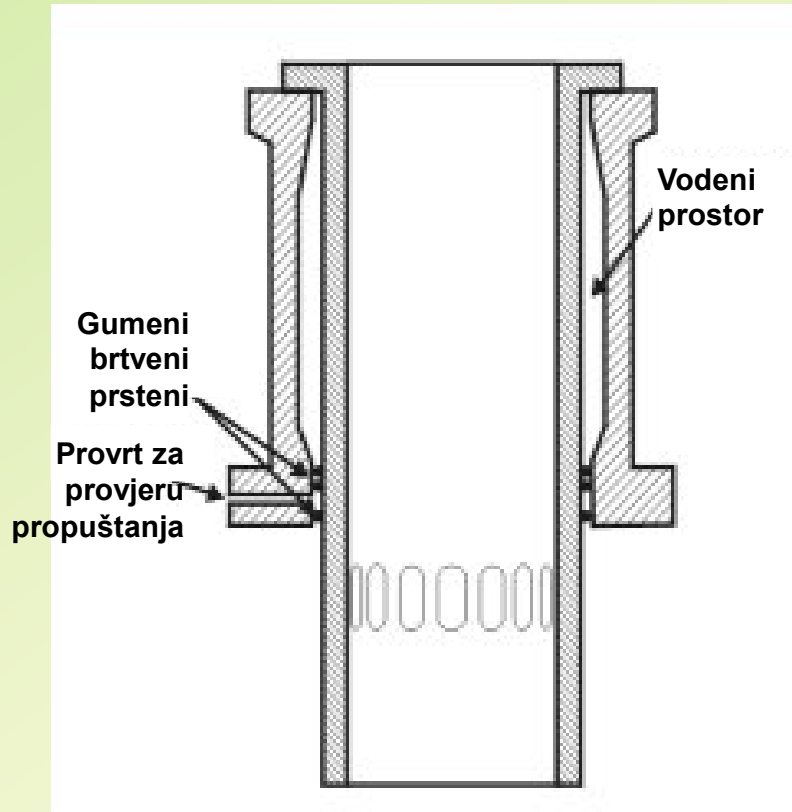


3-107.215.296





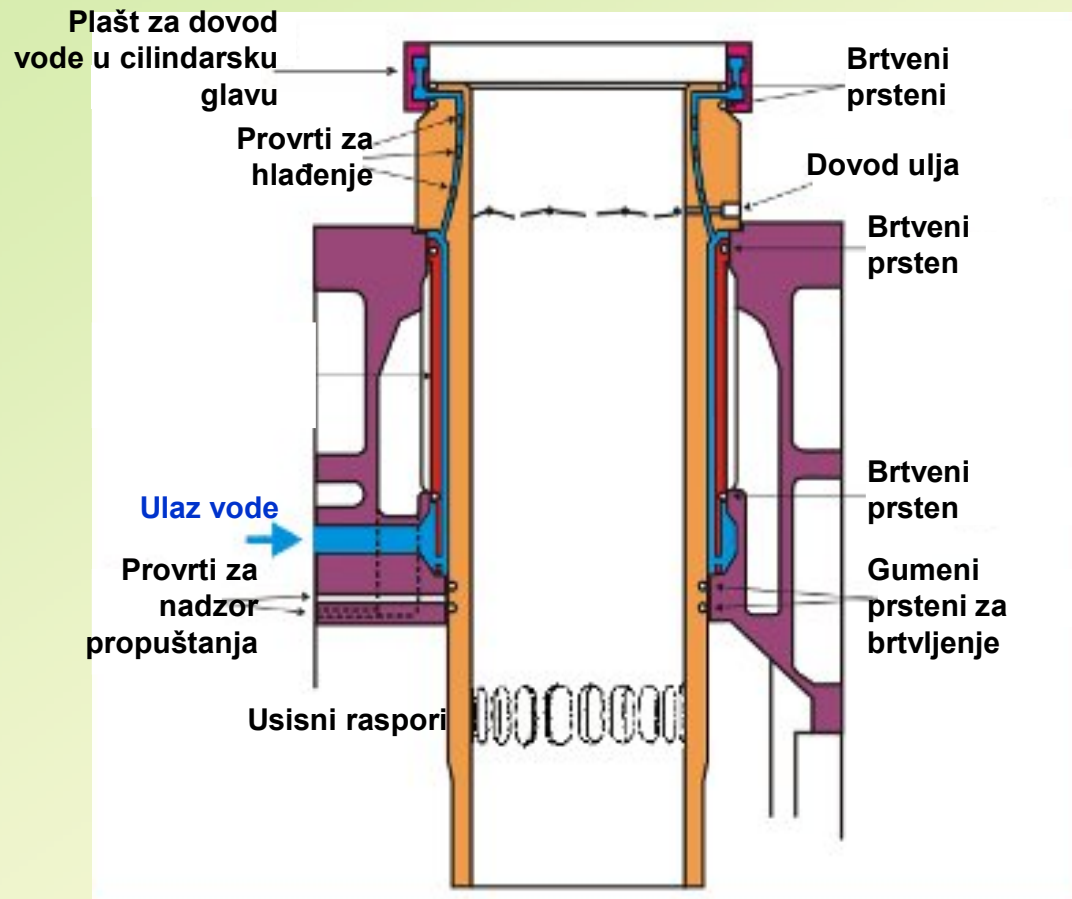
CILINDARSKA KOŠULJICA



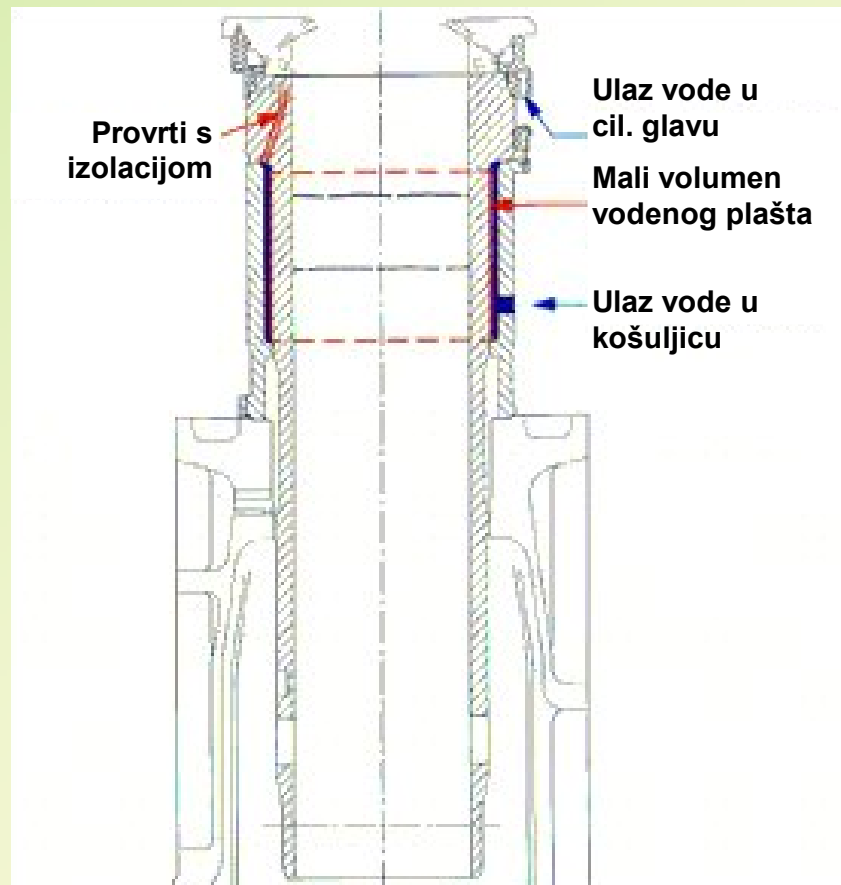
- vodi klip u linearnom kretanju.
- zatvara prostor za izgaranje
- kod 2T ima raspore za ispiranje
- gornjim prstenom naslonjena na plašt (okućje) , a donji slobodan
- otvori za podmazivanje

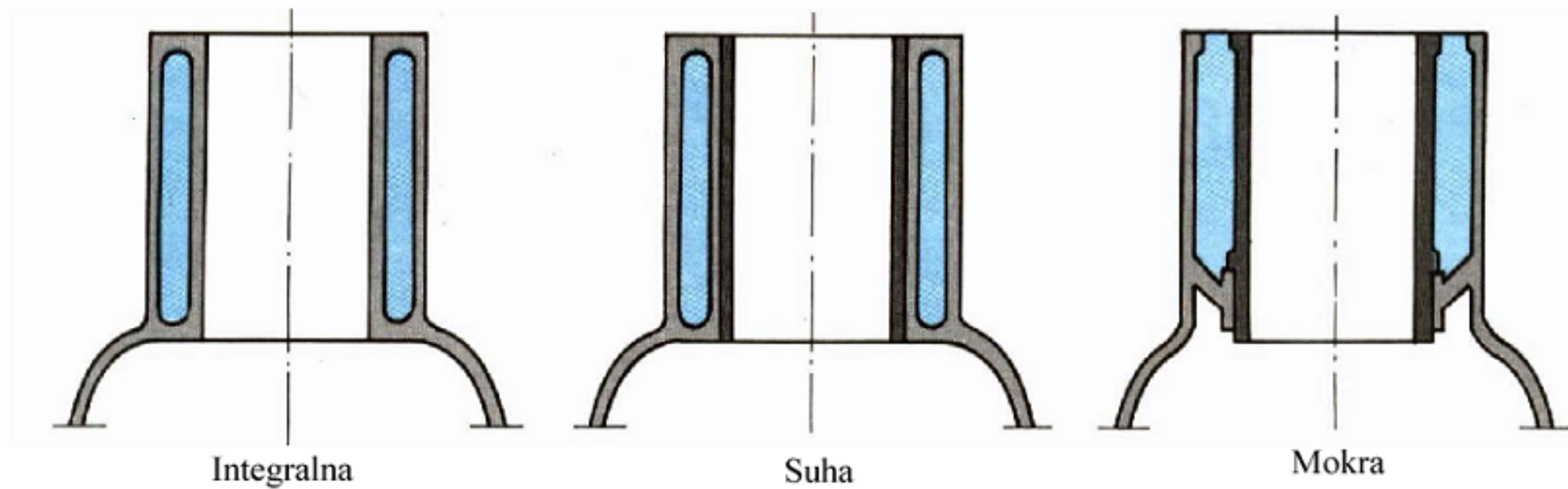
Izrađuju se ljevanjem iz sivog lijeva legiranog kromom, vanadijem i molibdenom (radi povećanja otpornosti na koroziju i habanje). Površinski sloj može biti : tvrdo kromiran ili nanesen sloj tvrdog materijala (NIKASIL).

Cilindarska košuljica

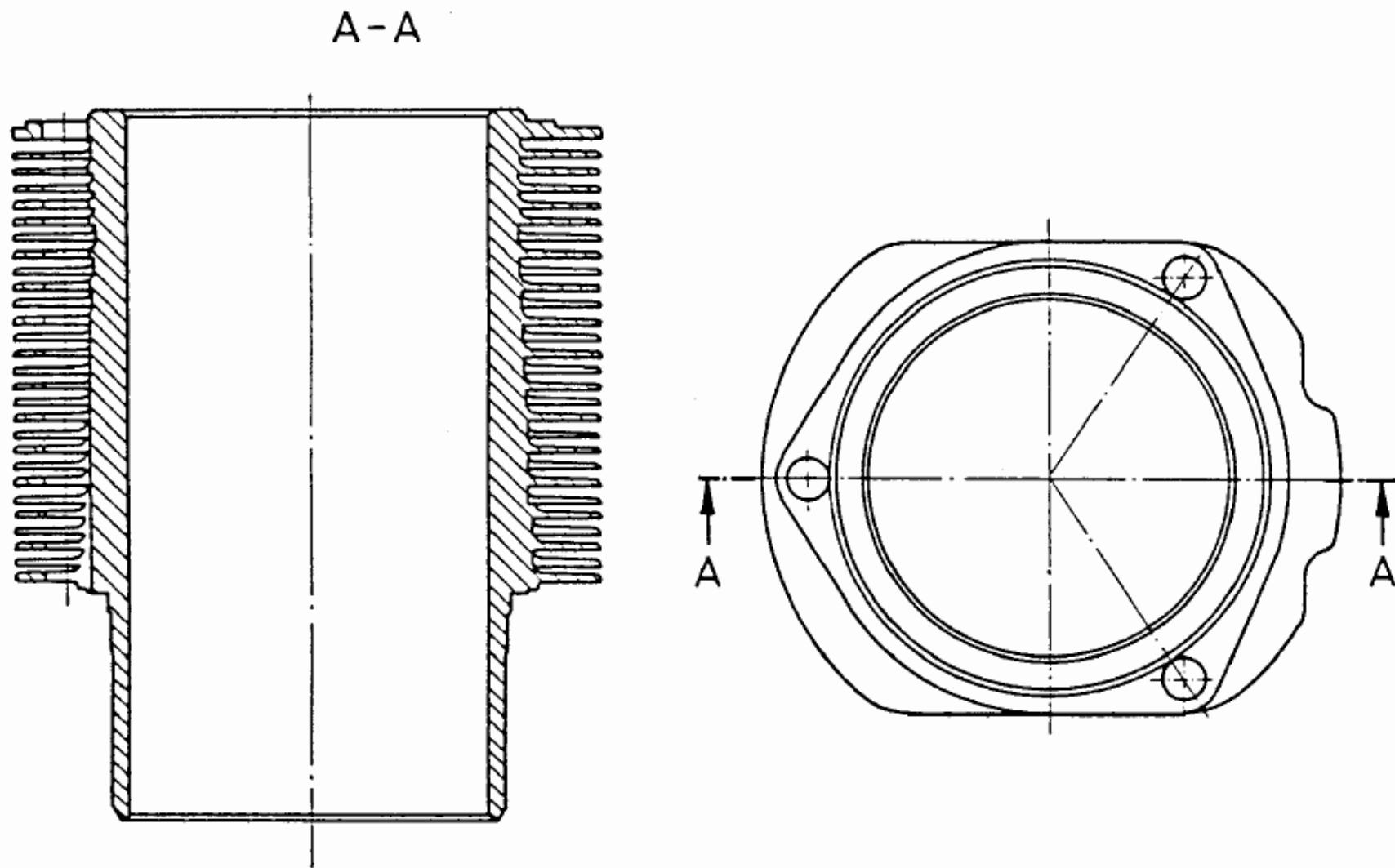


Cilindarska košuljica

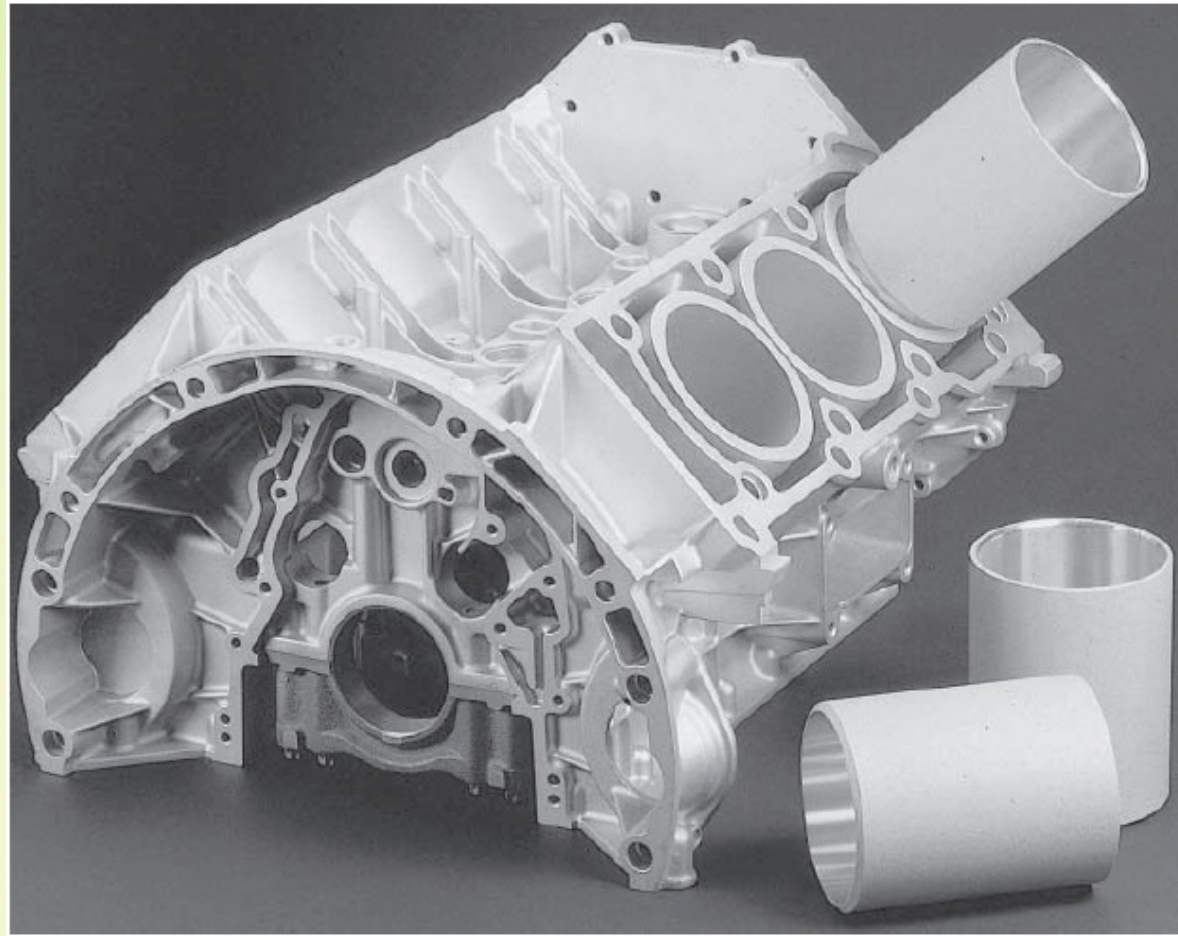




Izvedbe cilindarskih košuljica motora



Cilindarska košuljica zrakom hlađenog motora



TROŠENJE KOŠULJICA CILINDRA

Glavni parametar TBO (time between overhaul)

Mehanizmi istrošenja:

1. Korozivno istrošenje :

uzrok : sumporna kiselina

pogoduje: više S, veći tlakovi

2. Adhezivno istrošenje

uzrok : probijanje uljnog filma između prstena i košuljice

pogoduje : visoke temperature

3. Abrzivno istrošenje

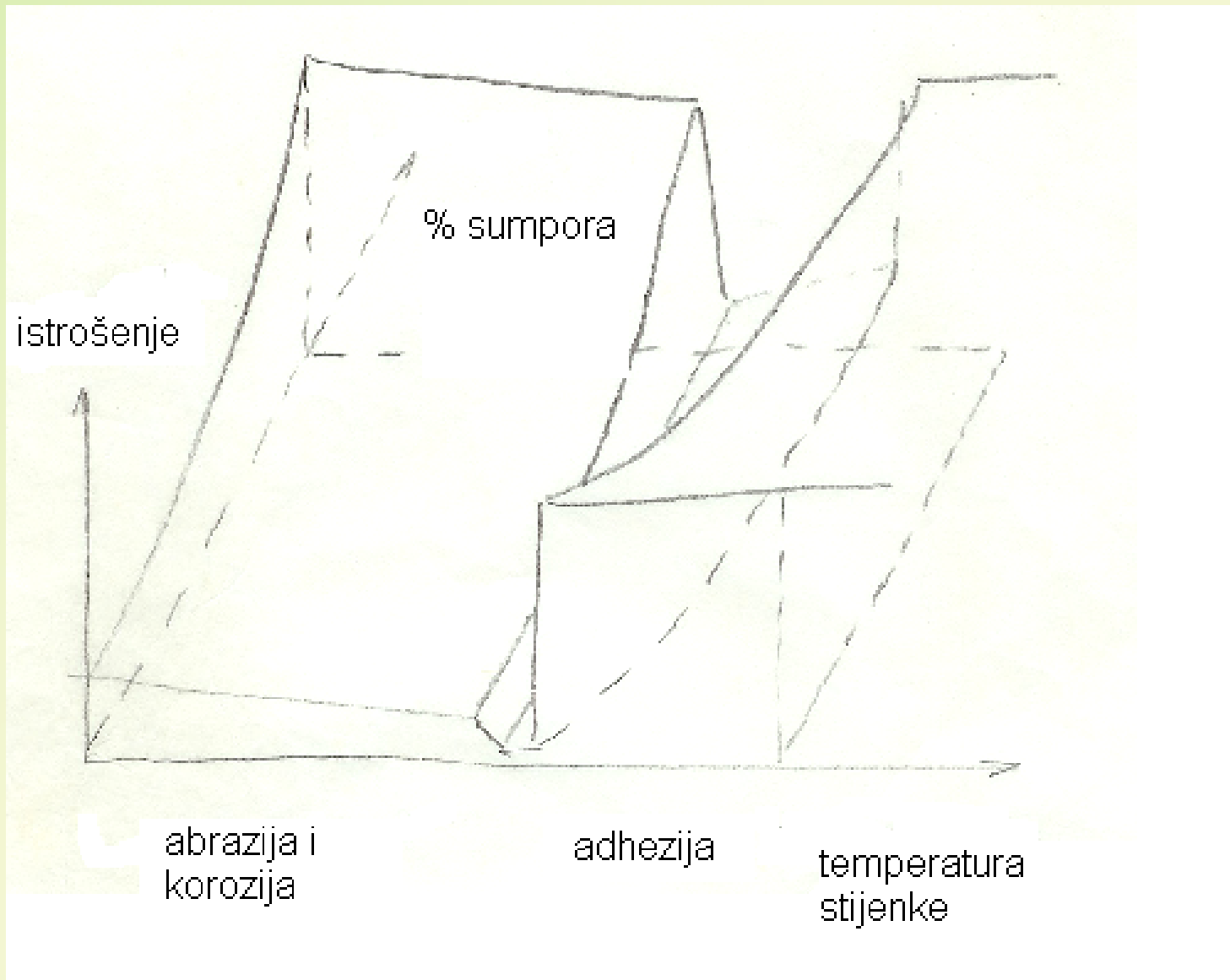
uzrok : abrazija čestica između prstena, klipa i košuljice

pogoduje : posljedica korozivnog i adhezivnog

4. Kavitaciono istrošenje

TROŠENJE KOŠULJICA CILINDRA

Prostorni dijagram istrošenja

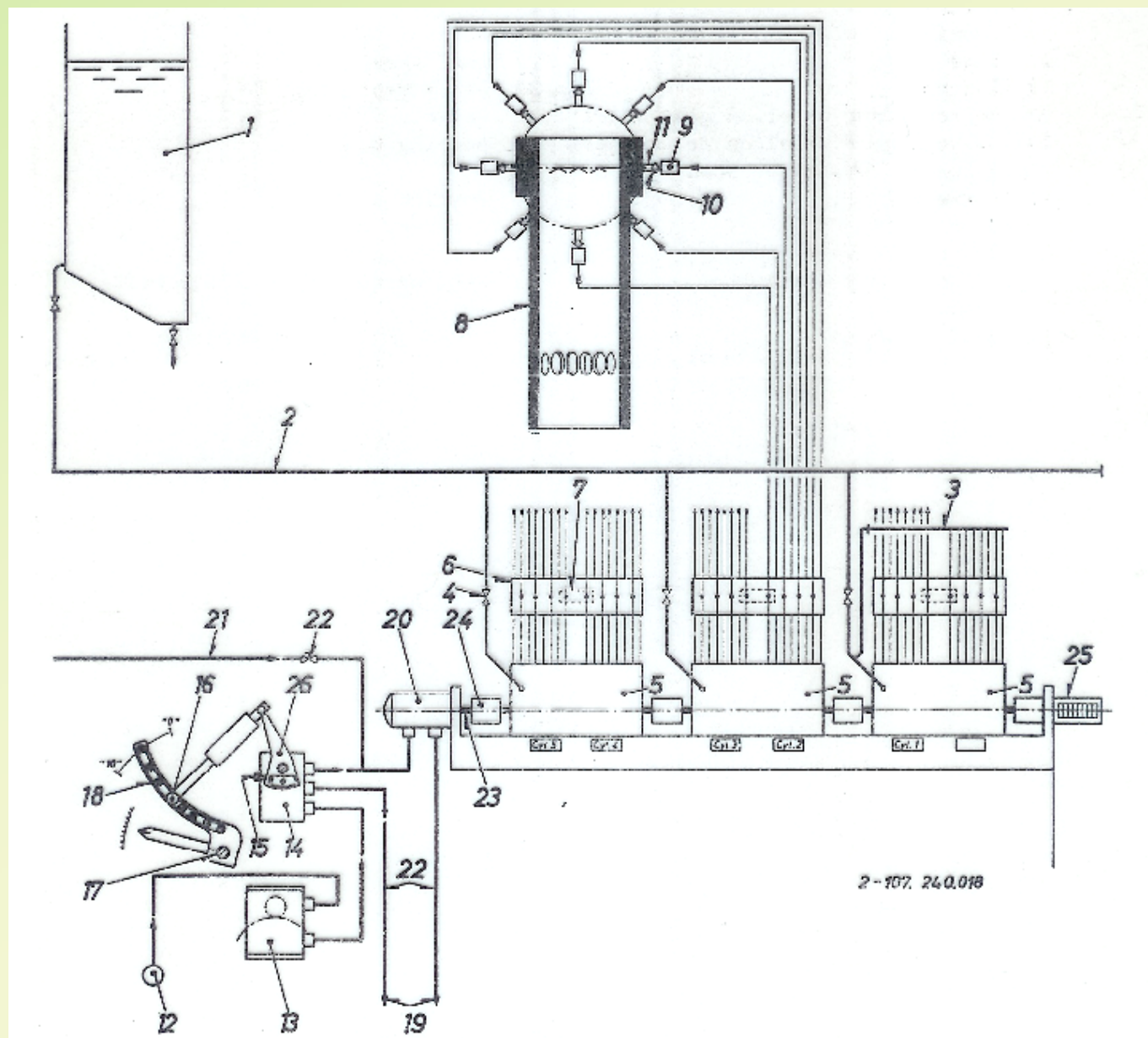


TROŠENJE KOŠULJICA CILINDRA

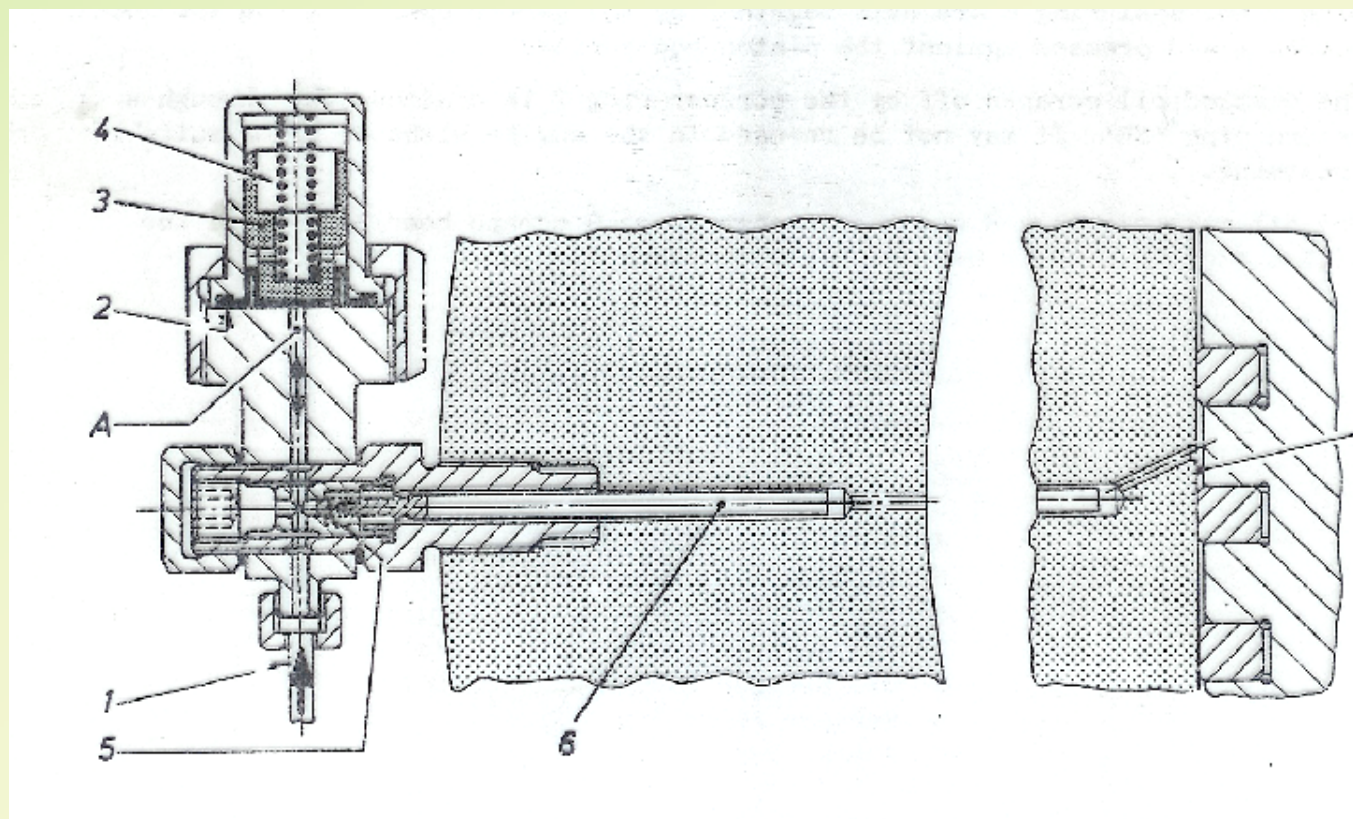
Sprečavanje trošenja :

- otporni materijal košuljica
- raspored temperature po visini košuljice
- dobro podmazivanje
- izbjegavanje propuštanja prstena
- propisna priprema smjese (ispiranje košuljice)
- filteri zraka
- gorivo bez SUMPORA
- dodavanje LUŽINA (TBN)

SUSTAVI PODMAZIVANJA KOŠULJICA CILINDRA

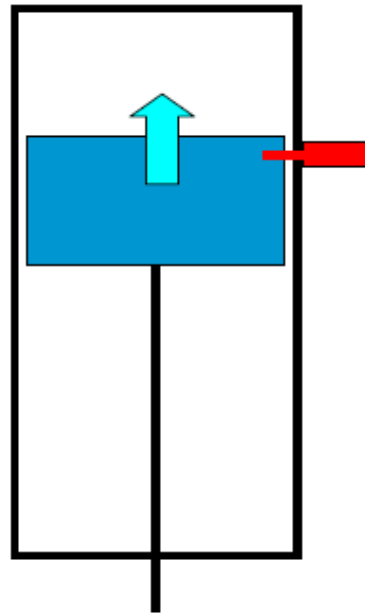


SUSTAVI PODMAZIVANJA KOŠULJICA CILINDRA

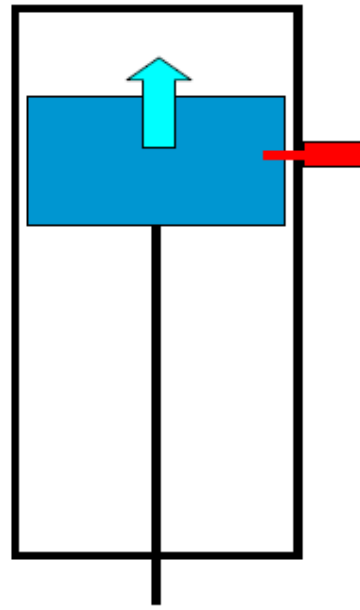


Pulse Lubricating System

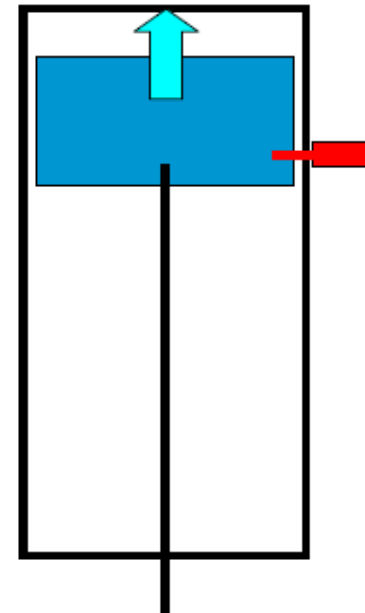
Electronically Controlled Flexible Timing of Lube Oil Injection



Lube oil distribution to piston top to lubricate **upper** part of liner



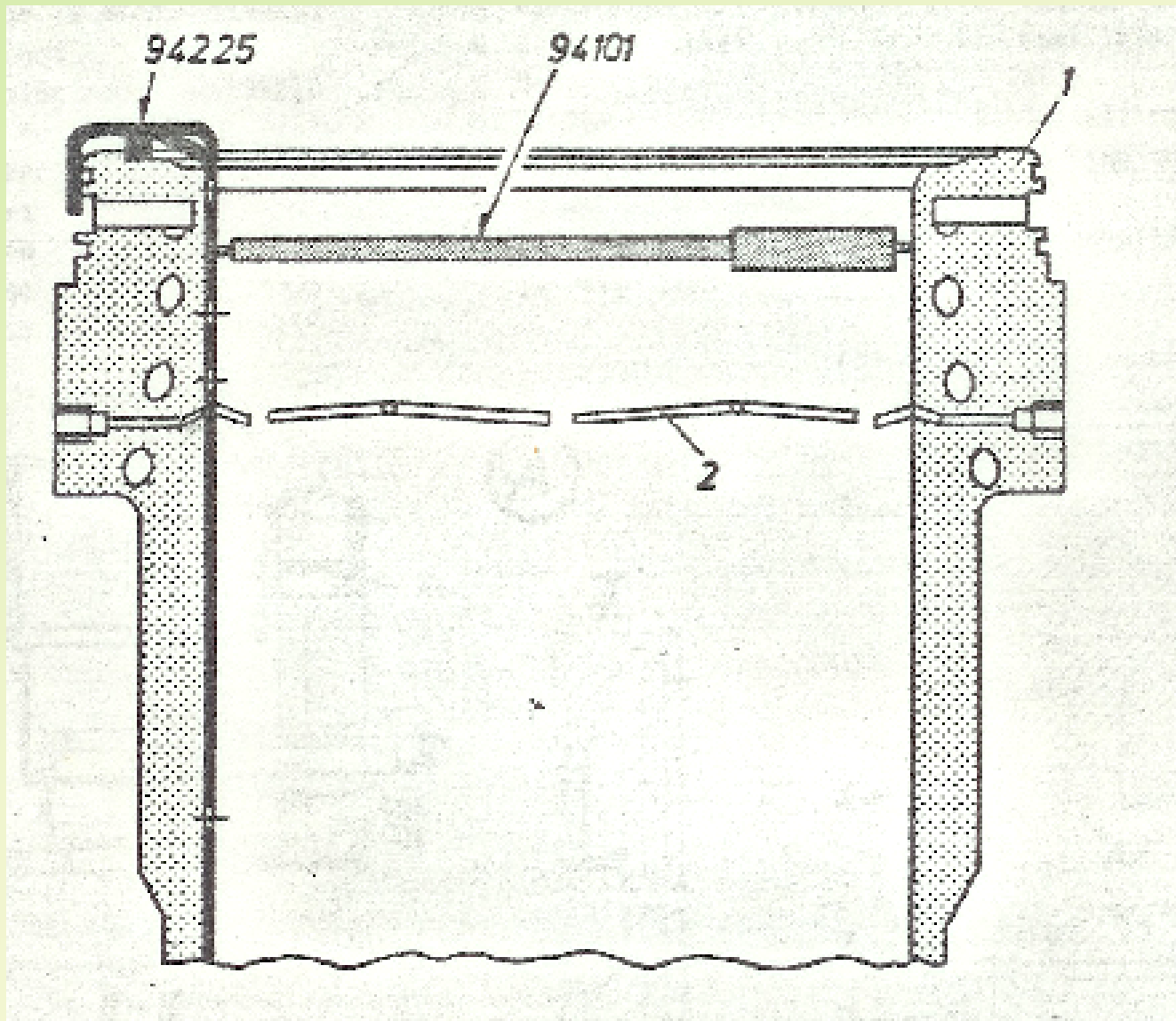
Lube oil distribution into **piston ring pack** to lubricate piston rings



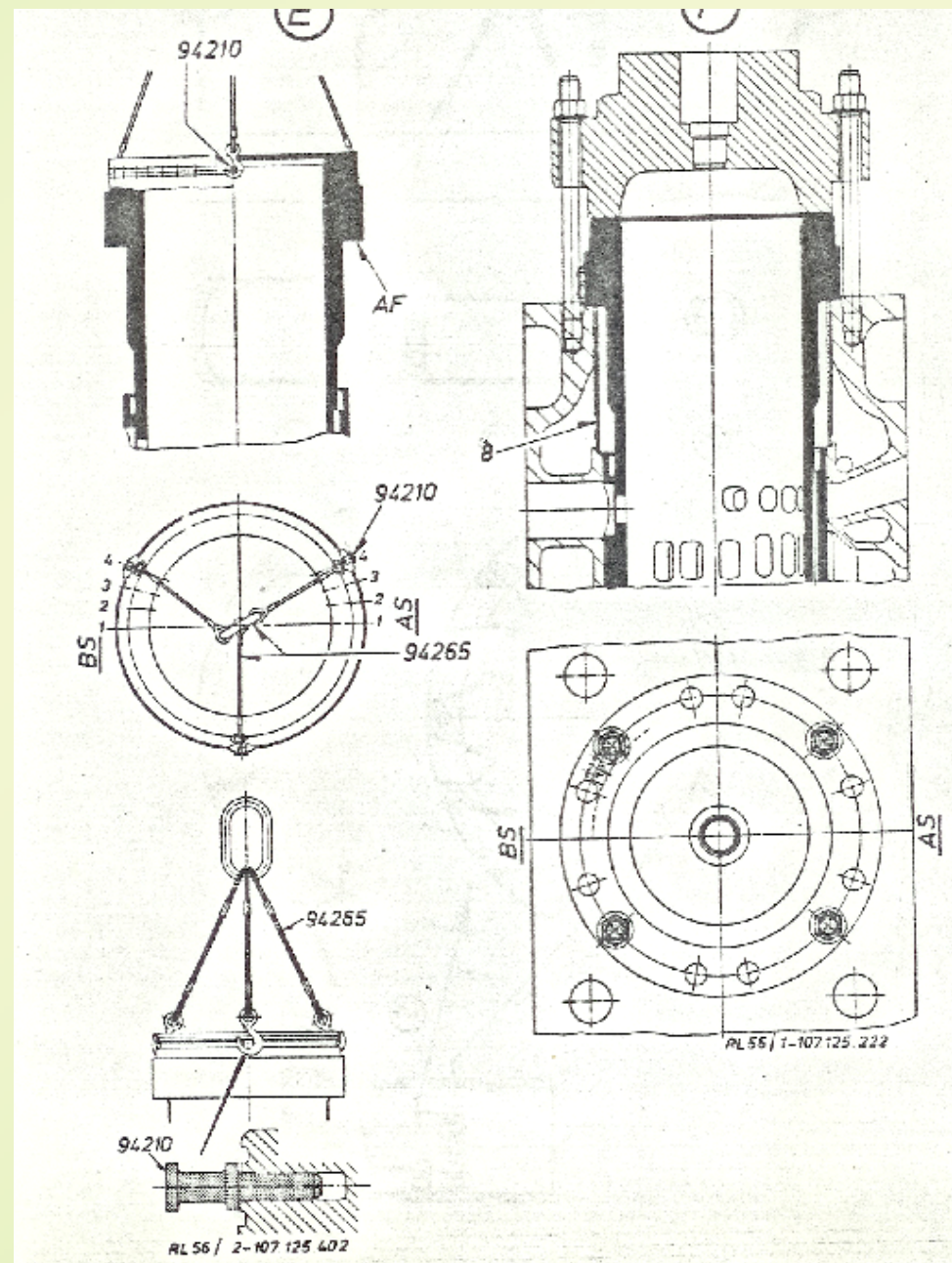
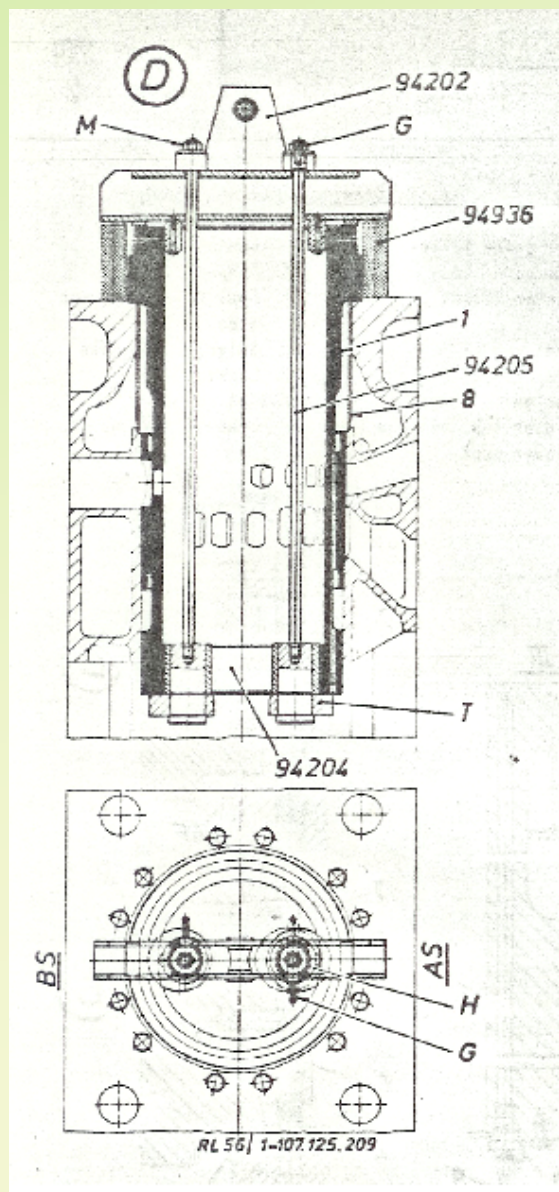
Lube oil distribution to piston skirt to lubricate **lower** part of liner

Lubrication during compression stroke only, not at every engine revolution!

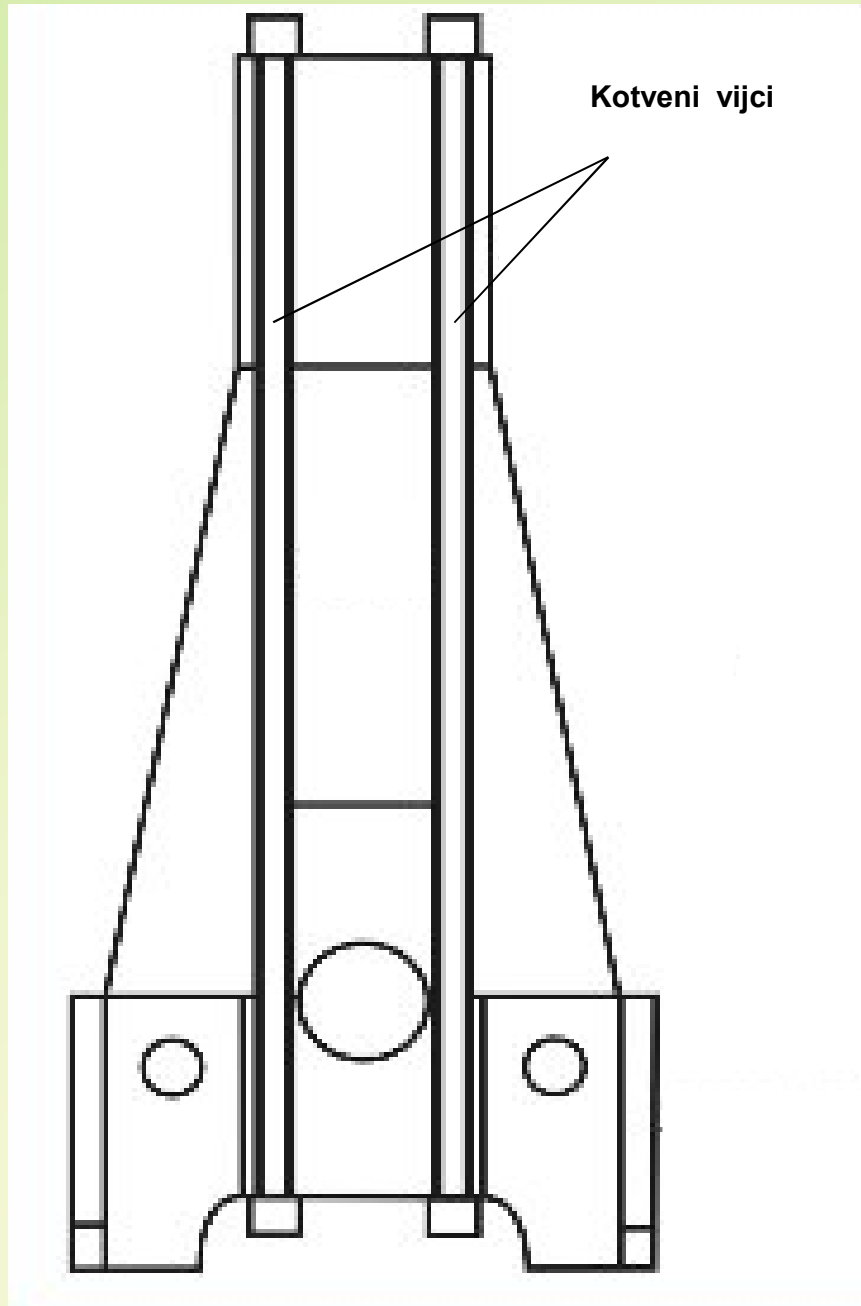
MJERENJE ISTROŠENJA KOŠULJICA



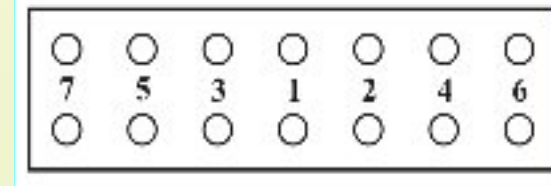
IZMJENA KOŠULJICA

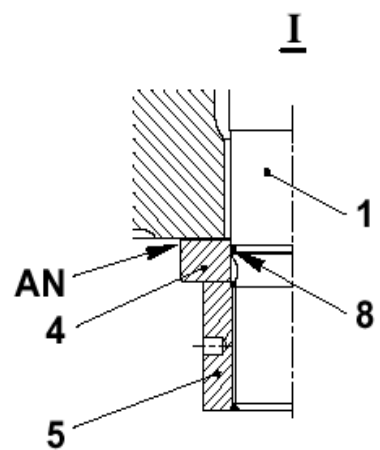
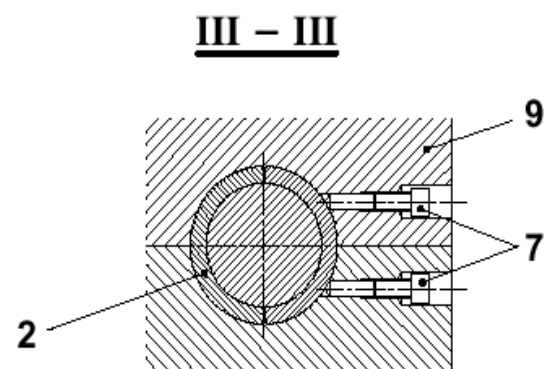
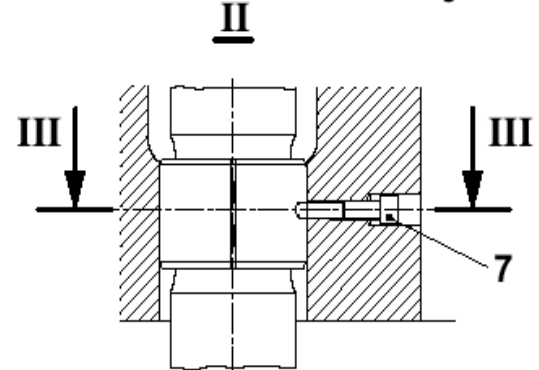
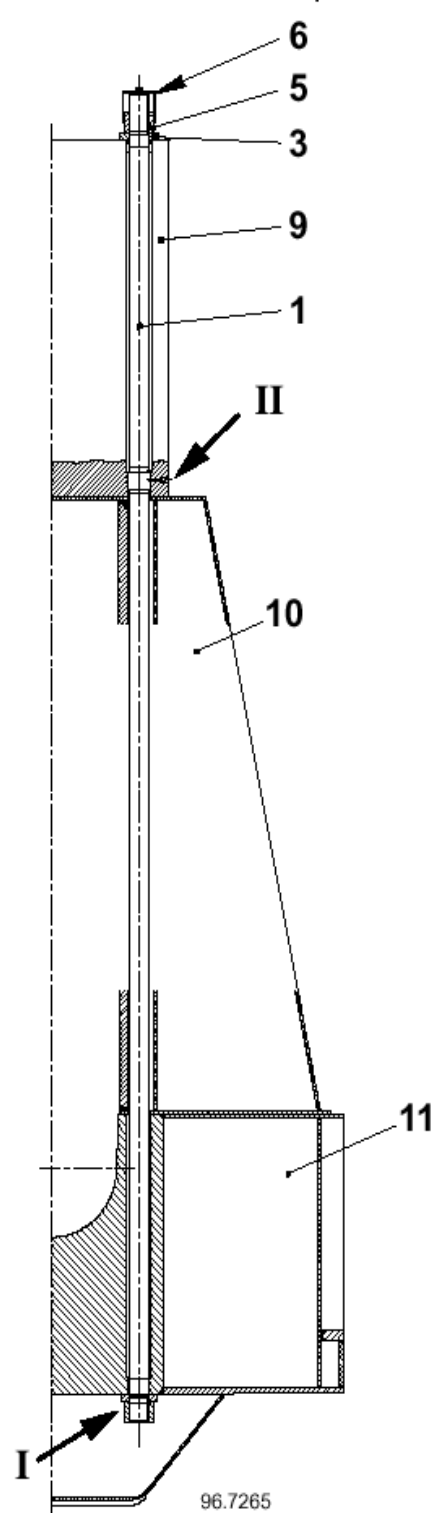


KOTVENI VIJCI

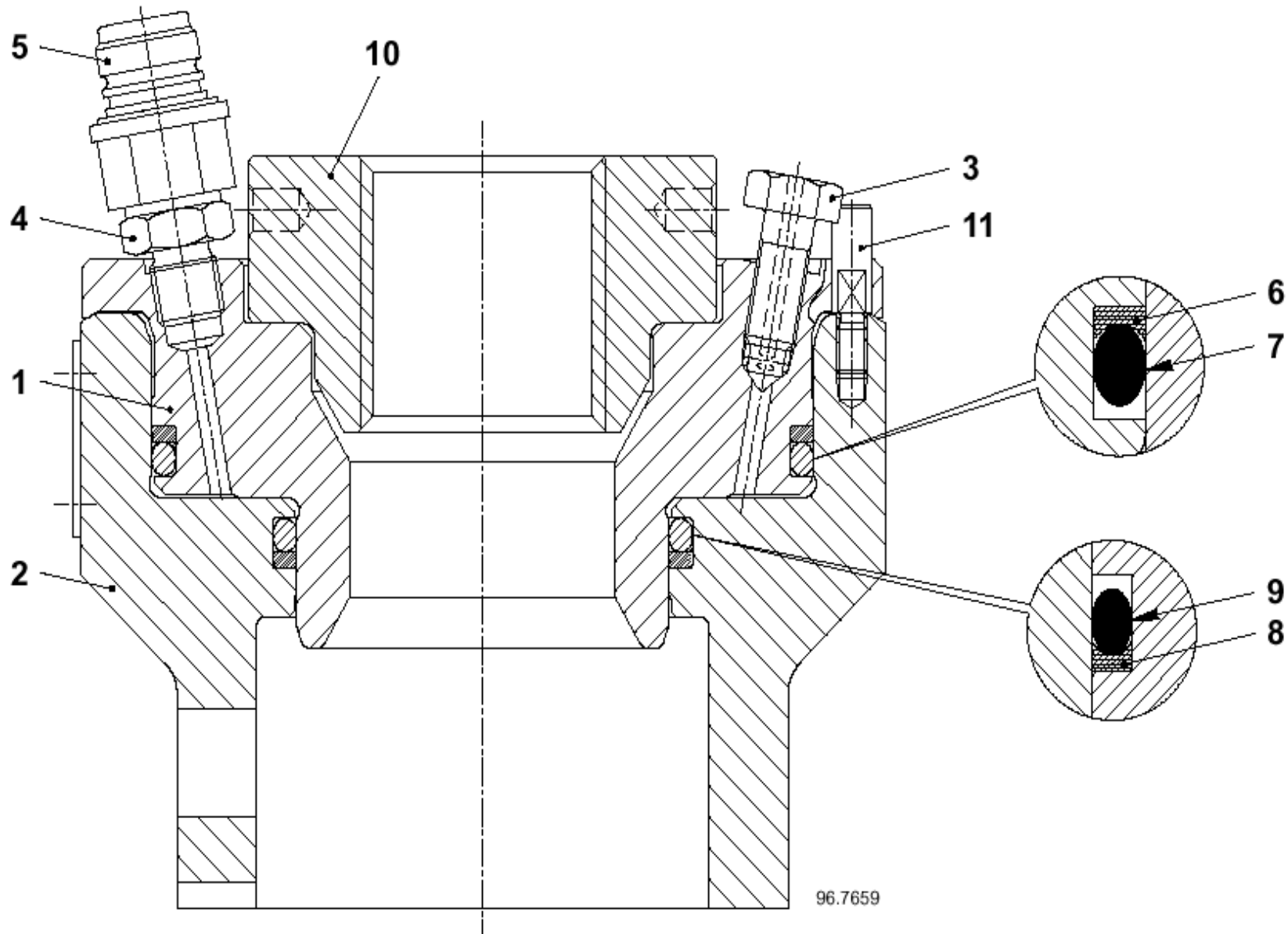


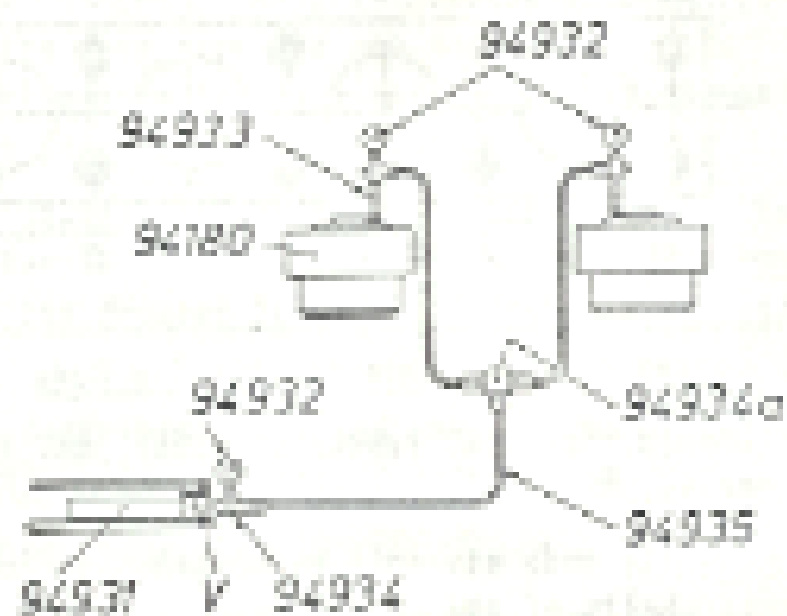
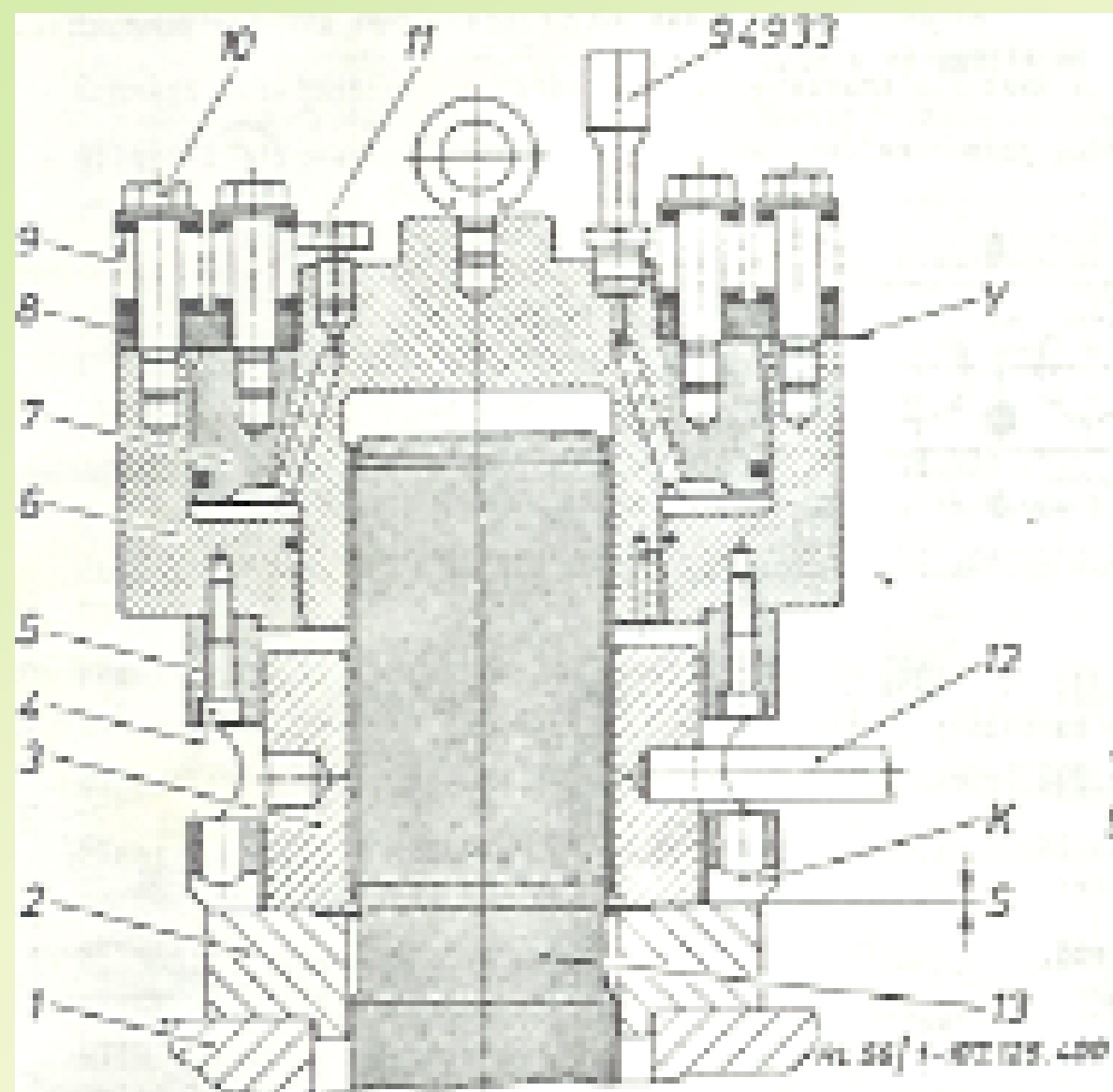
- Povezuju temeljnu ploču, stalke i plašteve cilindara
- preuzimaju na sebe vlačne sile





UREĐAJ ZA HIDRAULIČKO PRITEZANJE VIJAKA

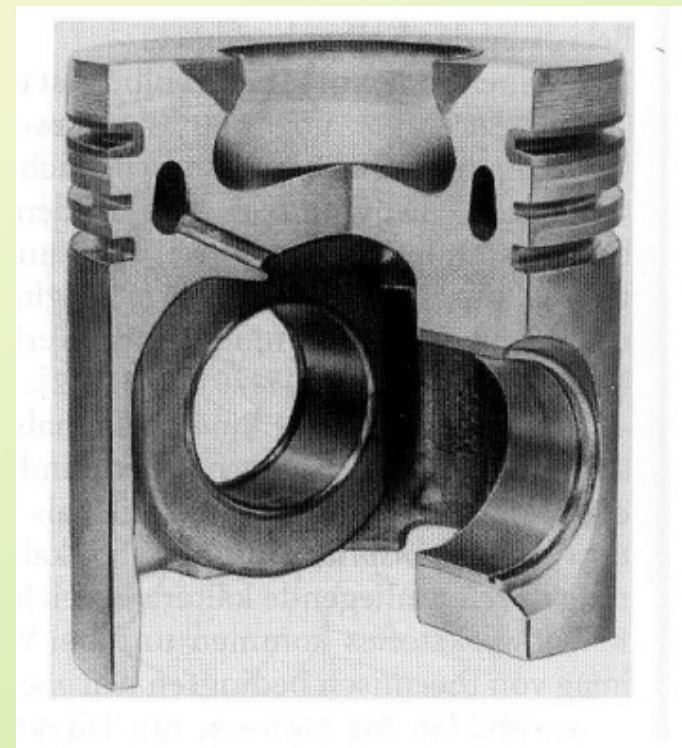
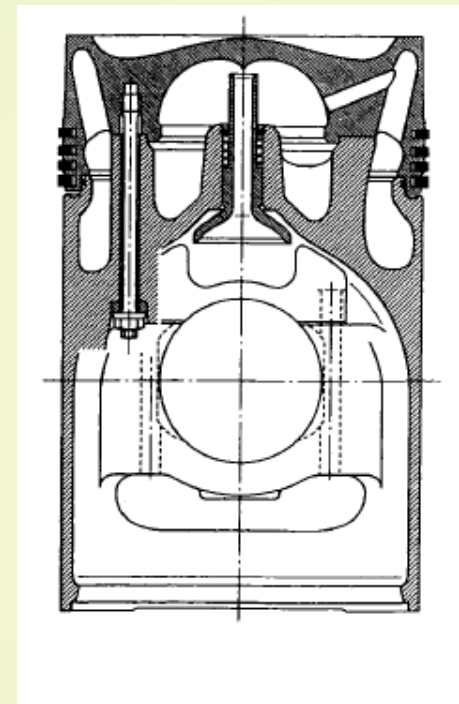
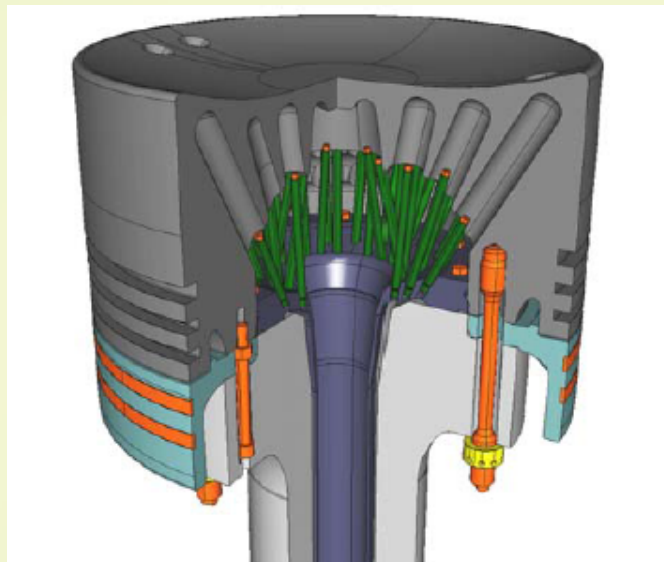
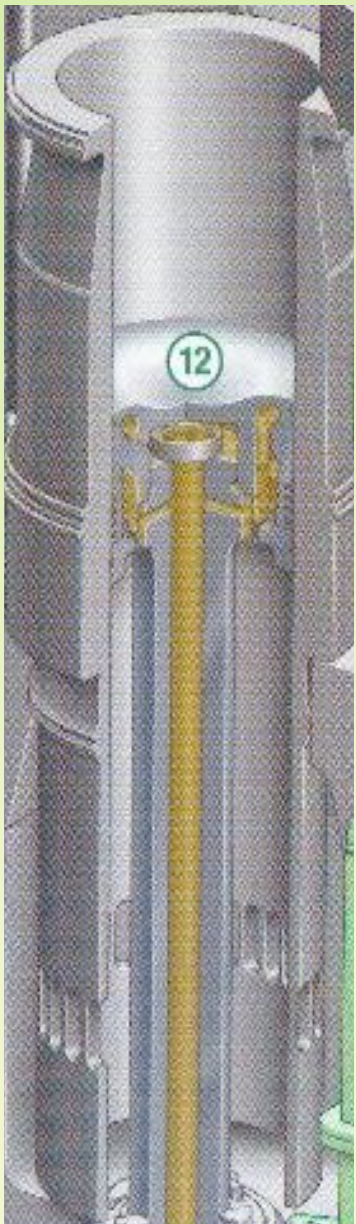




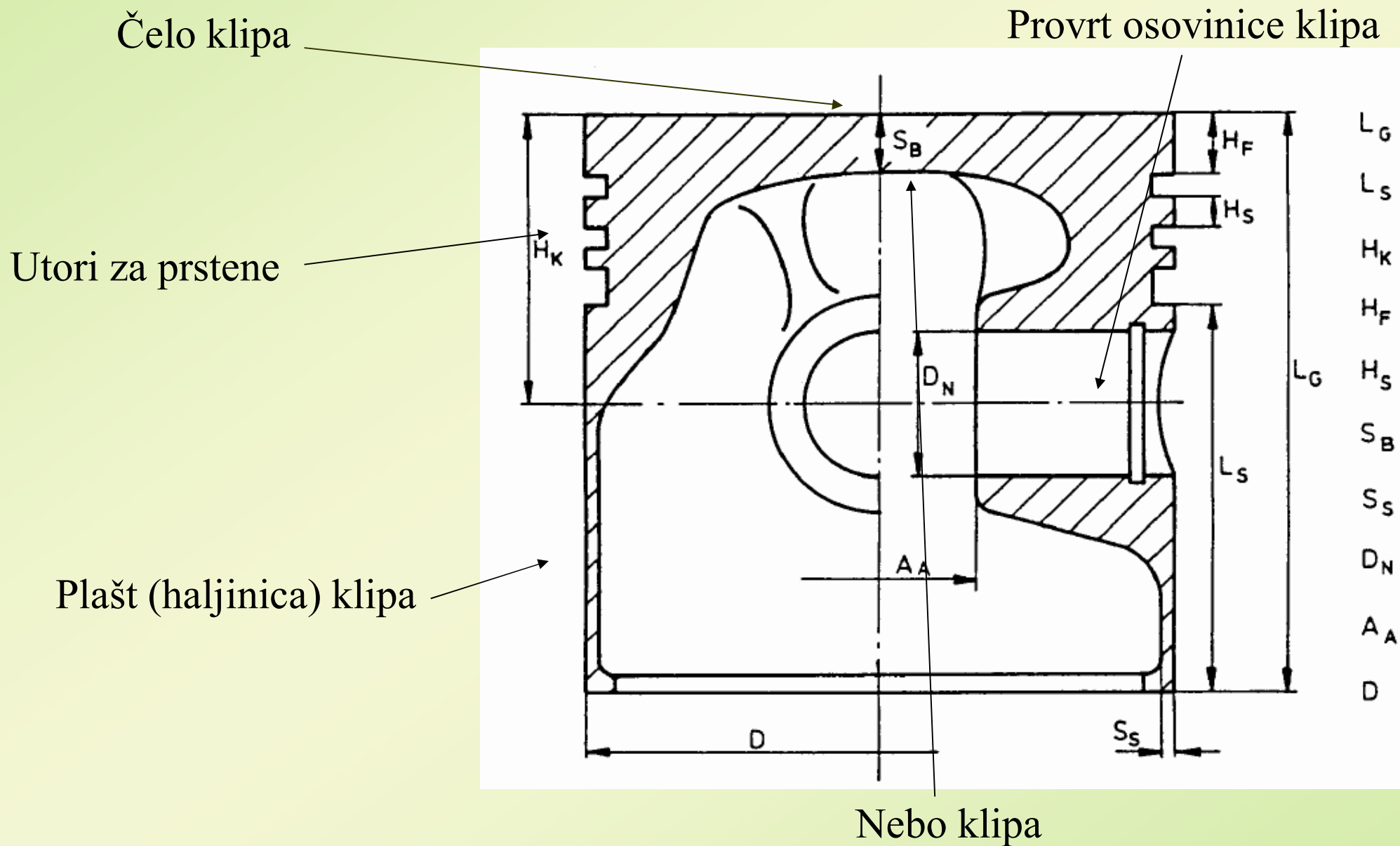
41. 22/1-01123.400

STAP - KLIP

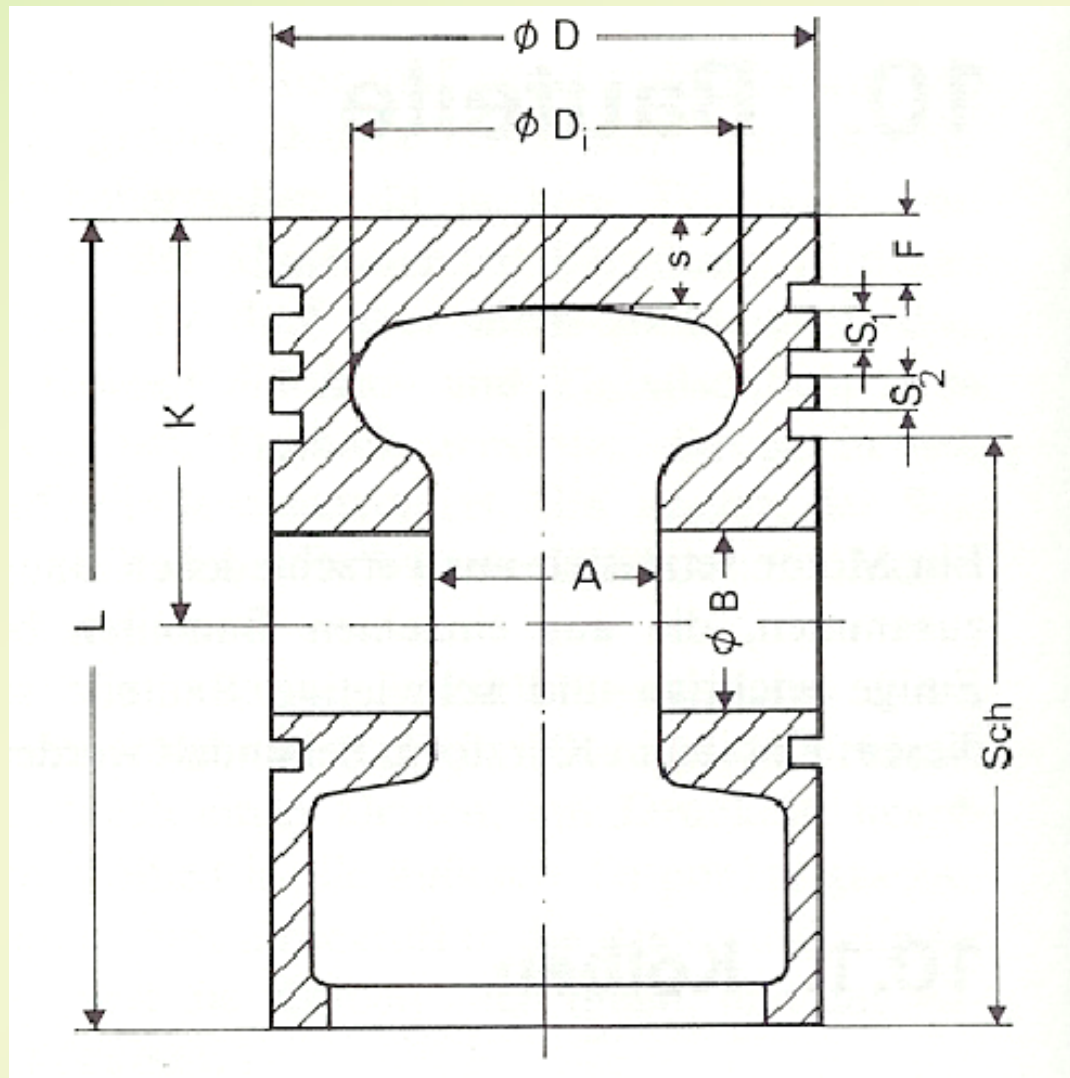
- da sa stapnim prstenovima nepropusno odvaja kompresijski prostor od prostora ispod stapa
- da primi silu plinova i prenese ju na stapni mehanizam (i bočnu silu)
- da odvodi toplinu



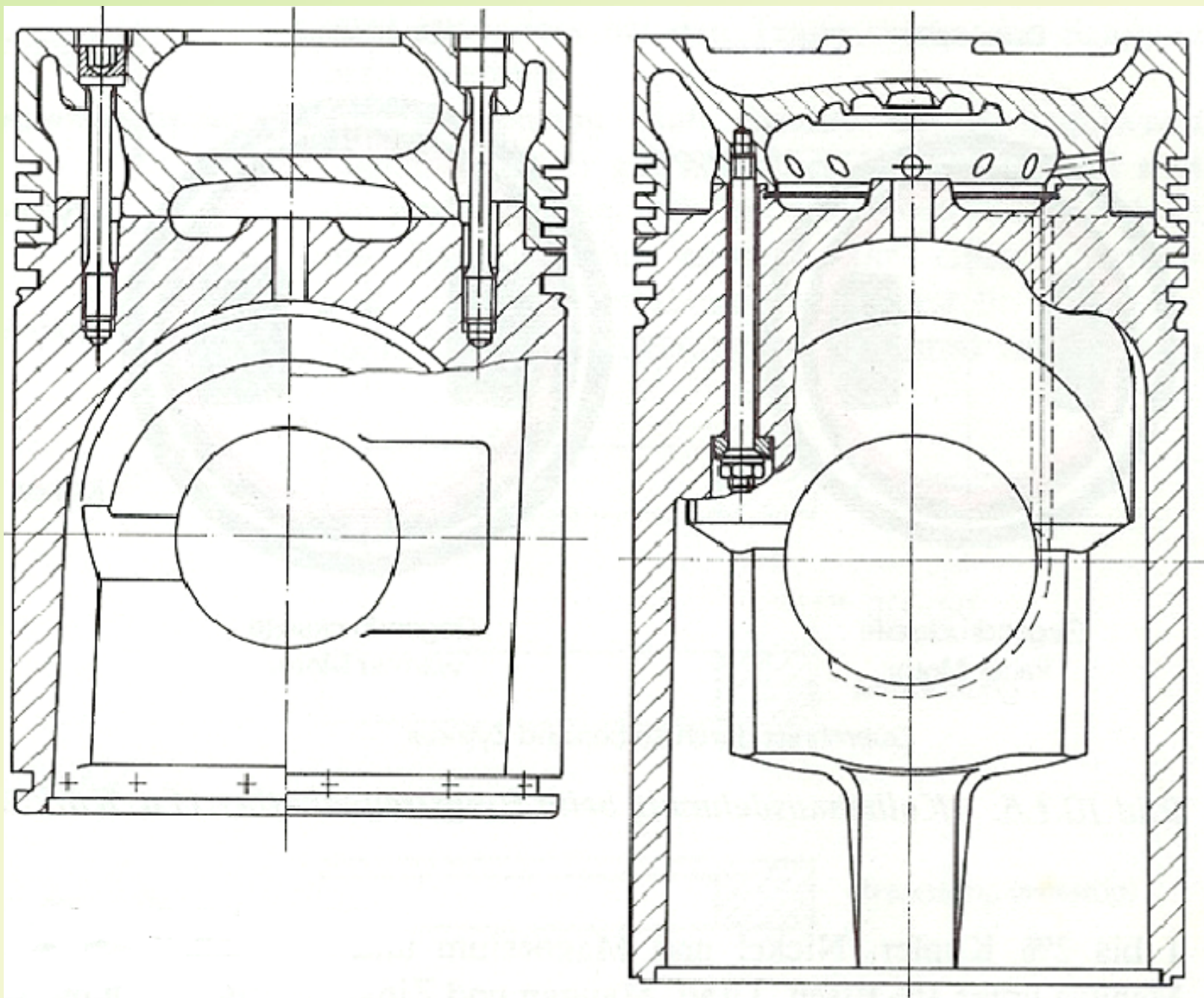
Dijelovi klipa



JEDNODIJELNI KLIP



VIŠEDIJELNI KLIP



Zahtjevi pred klipom:

- nepropusno odvajati u oba smjera
- što lakši
- odvoditi toplinu bez prekomjerne povećanje temperature (1 prsten < 180°C)
- što manje trenje (obrađene površine)

Al legure (silicij)

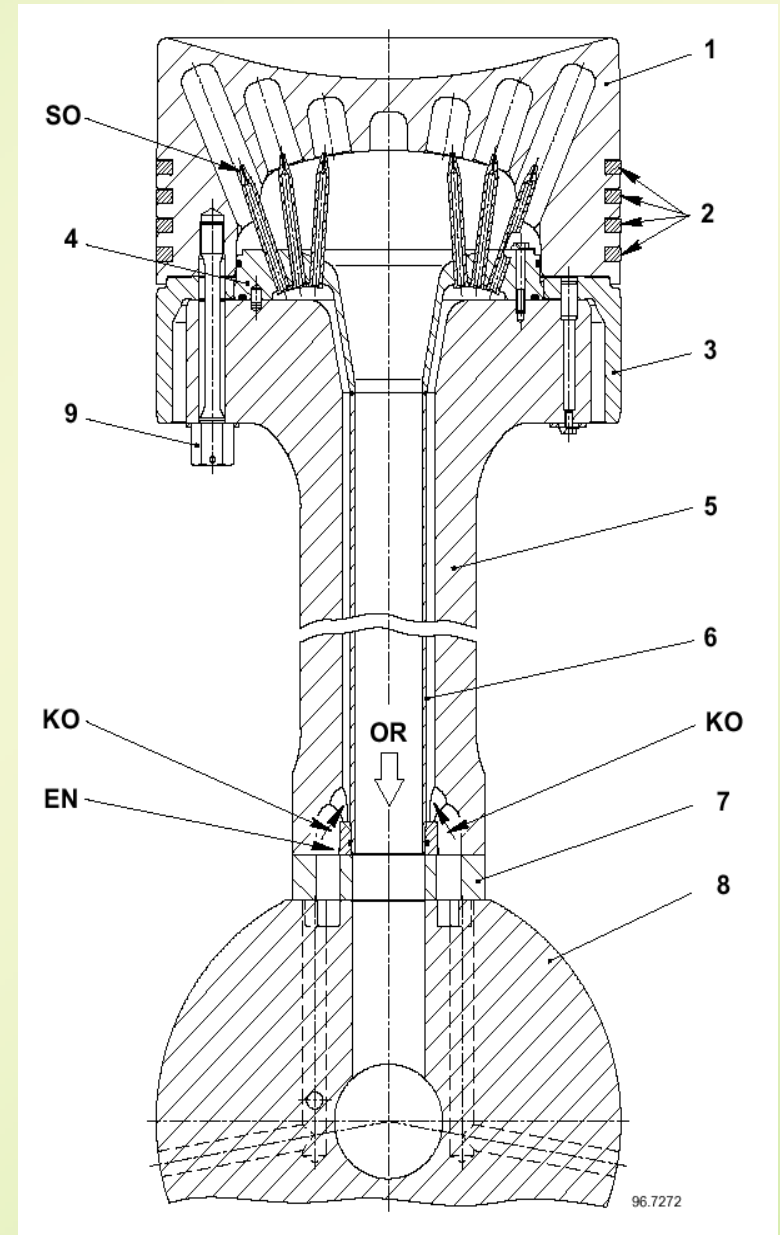
+ lagan, dobro odvođenje topline

- veliki koeficijent rastezanja

Sivi lijev

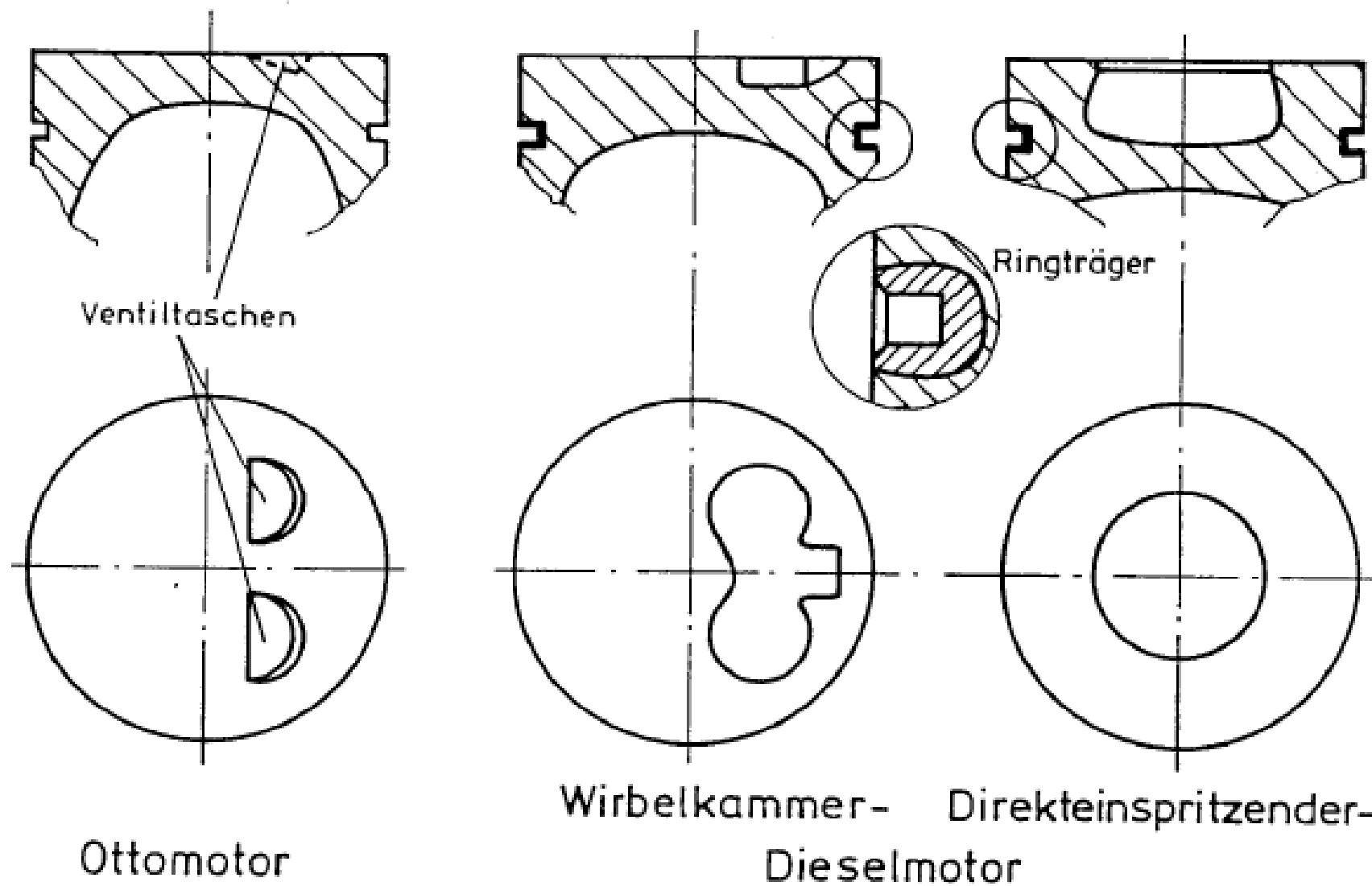
Legirani čelici

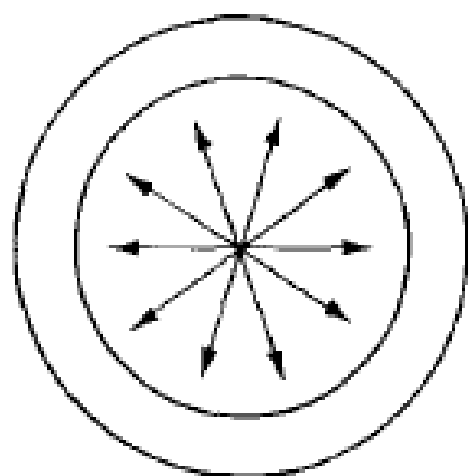
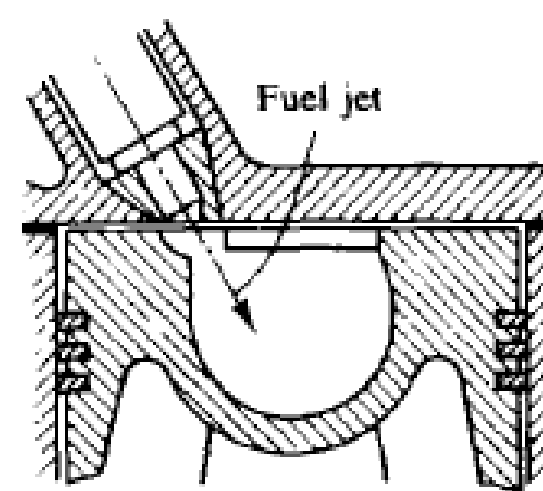
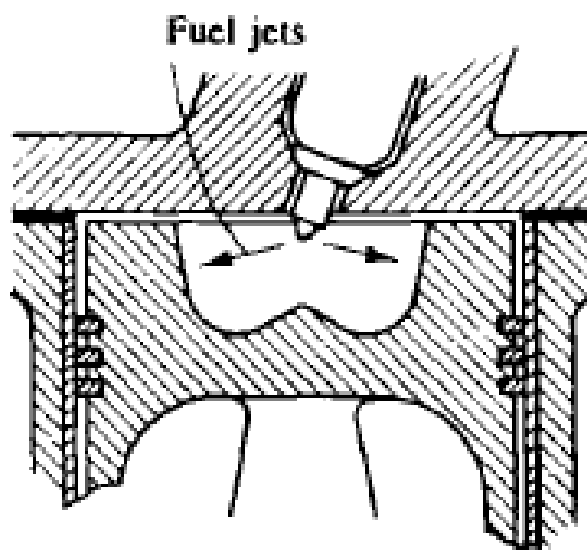
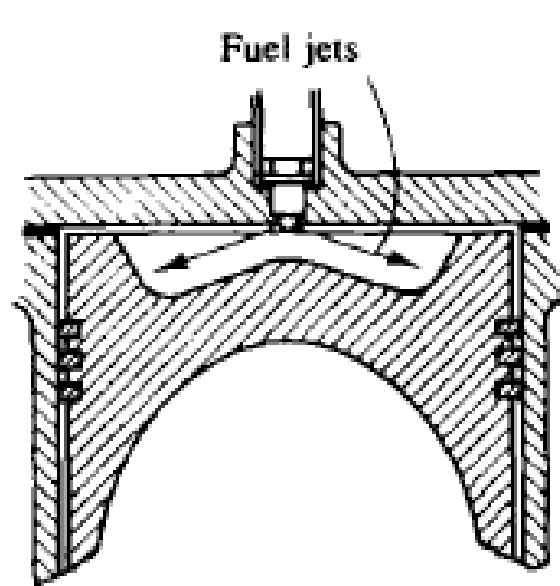
Kovani čelik



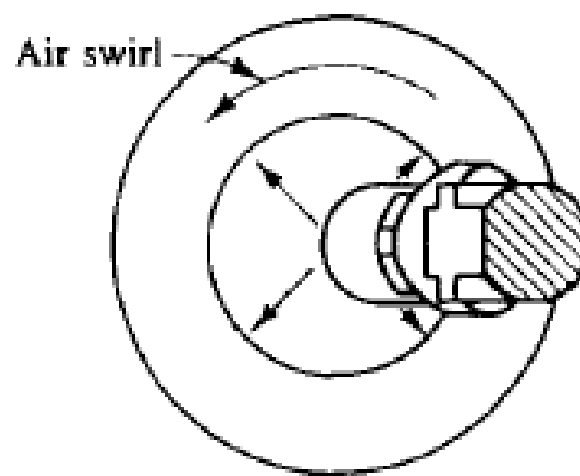
Stap sa stapajicom

OBLICI ČELA KLIPA

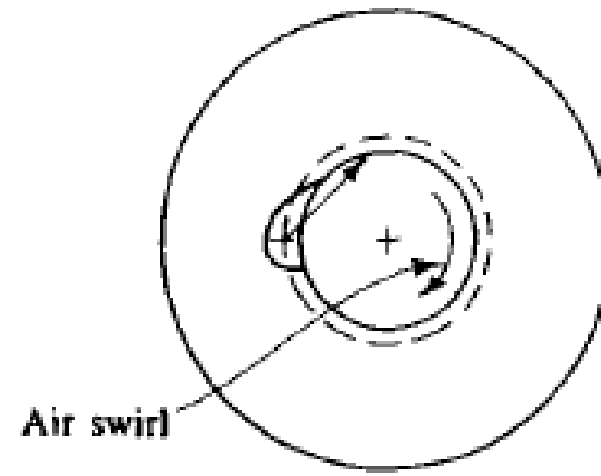




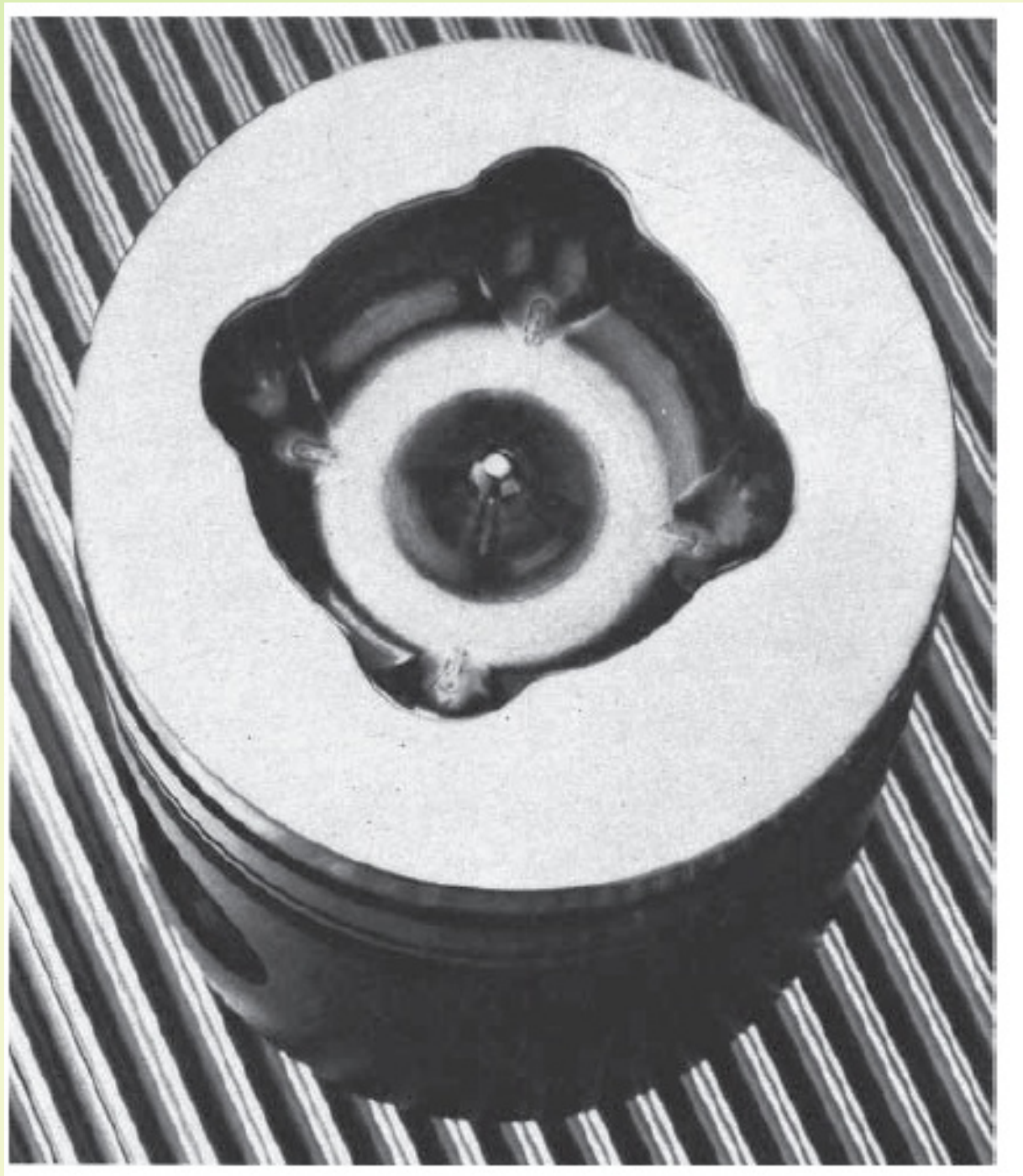
(a)

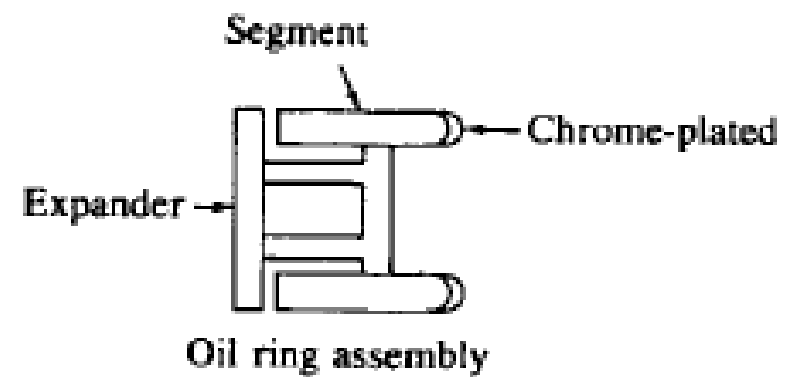
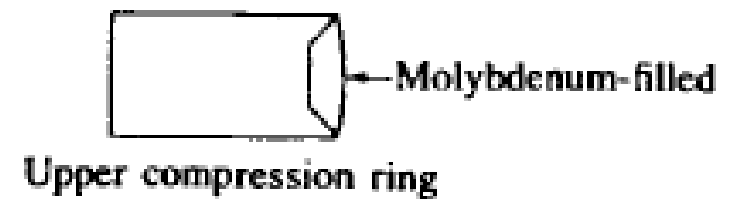
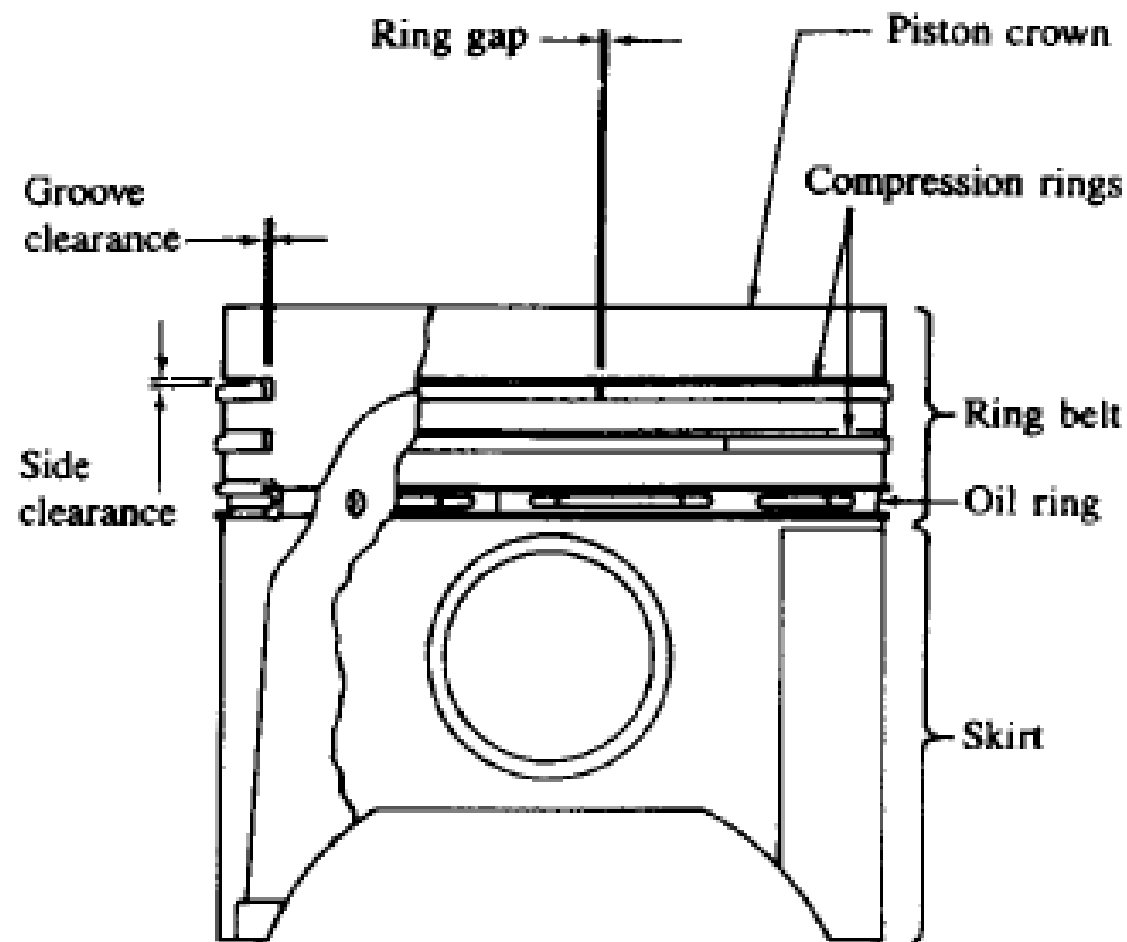


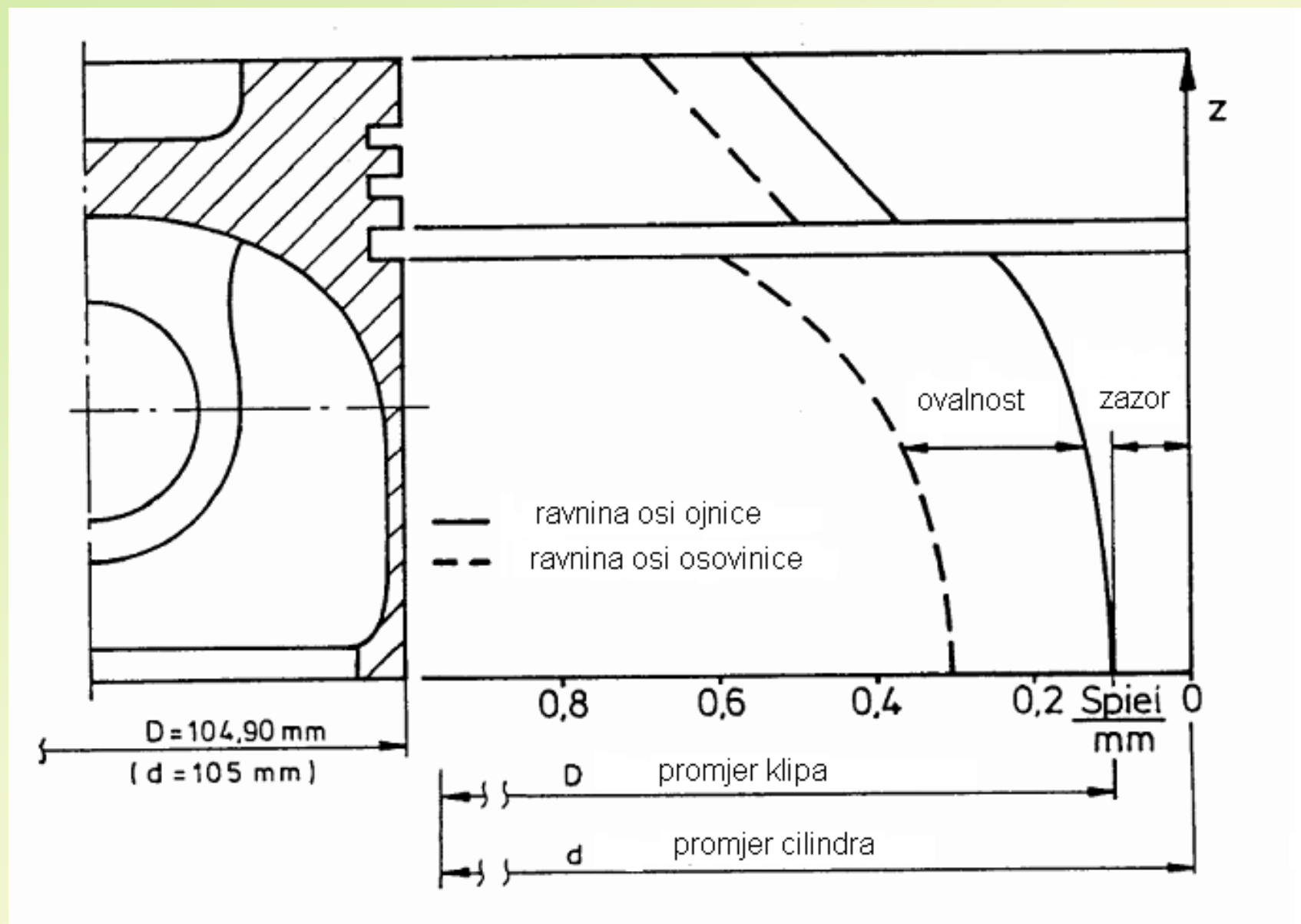
(b)



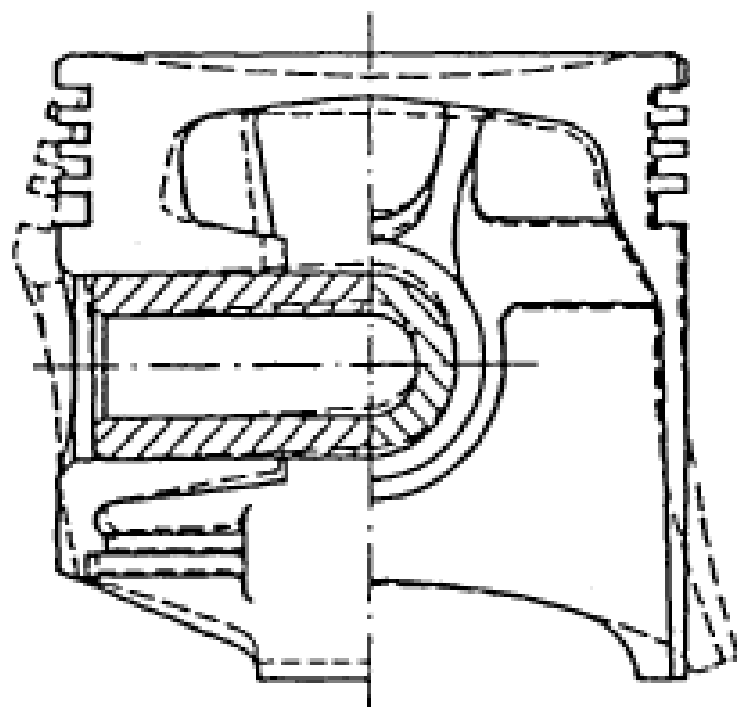
(c)



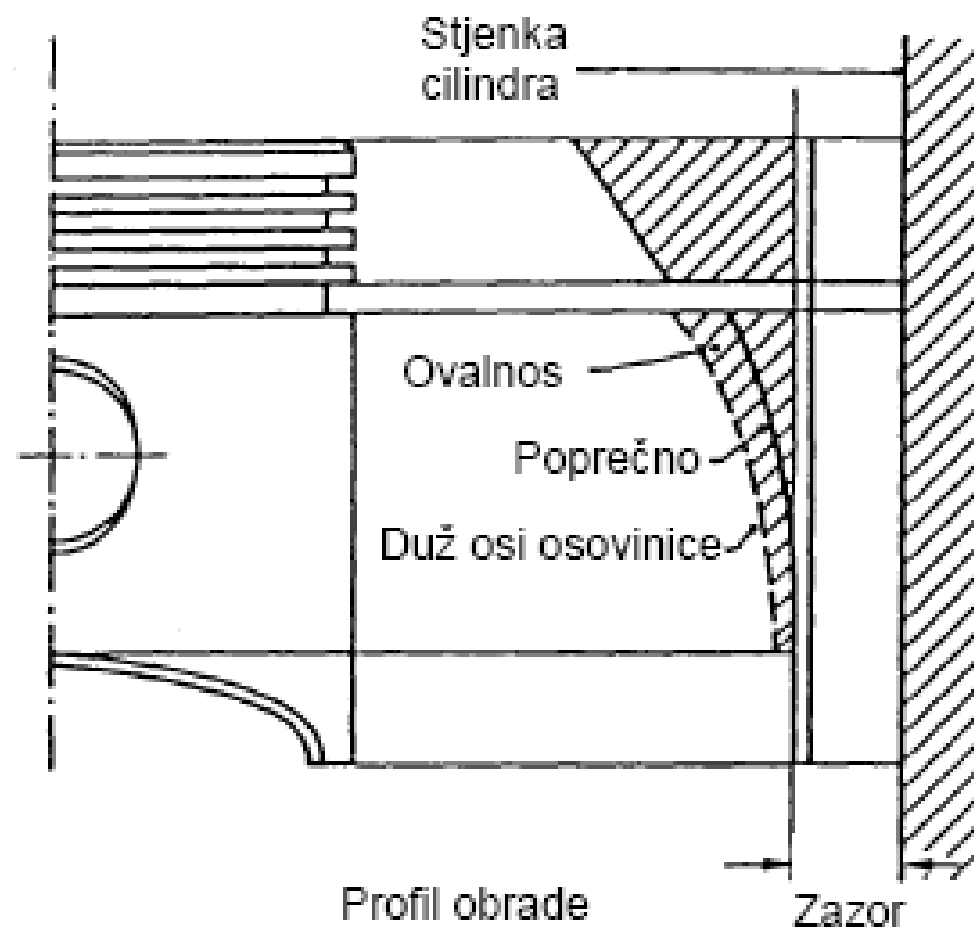




Odstupanje plašta klipa od cilindričnog oblika



Deformacije pod djelovanjem tlaka u smjerovima duž i poprijeko na os osovinice klipa



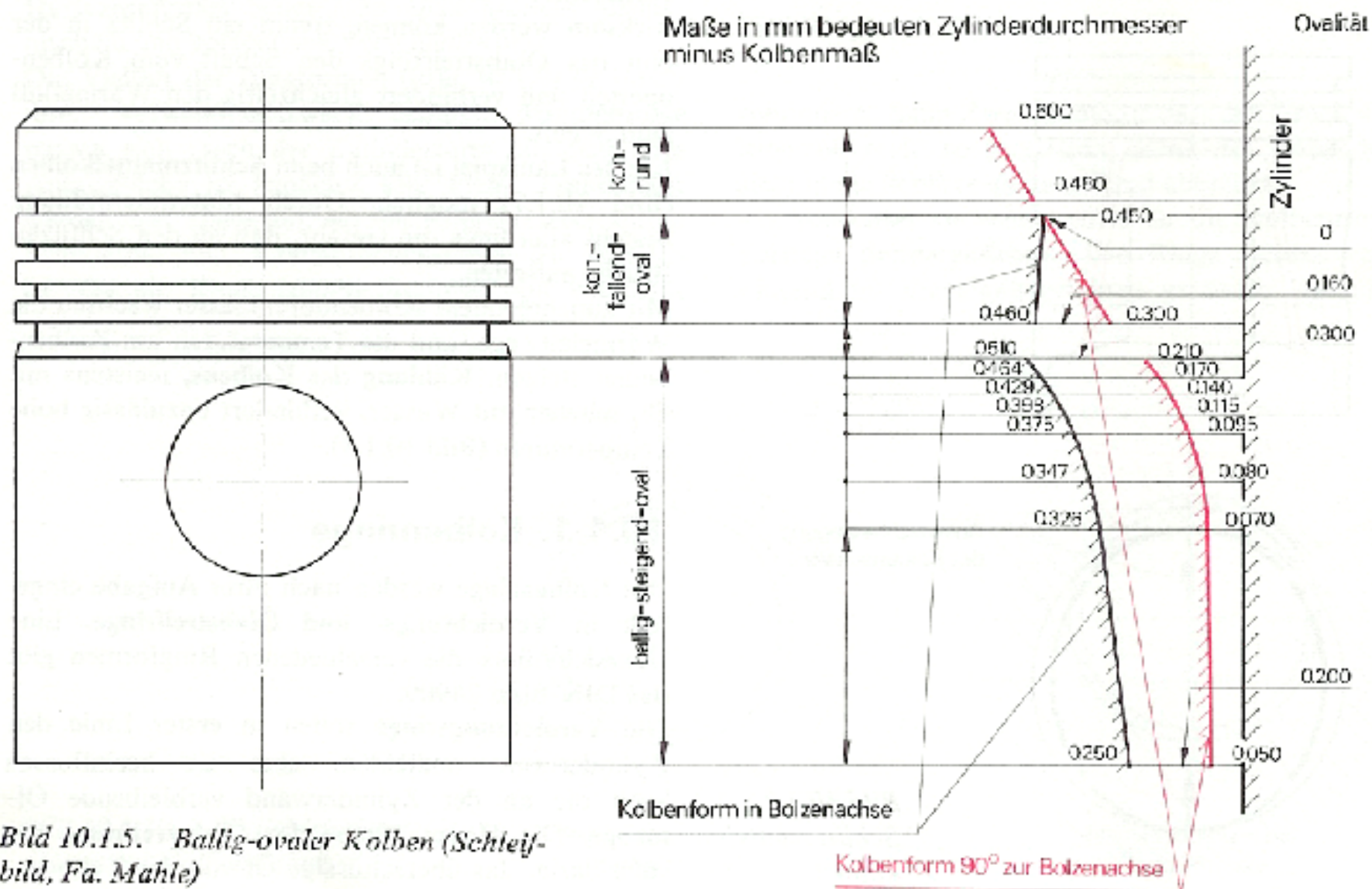
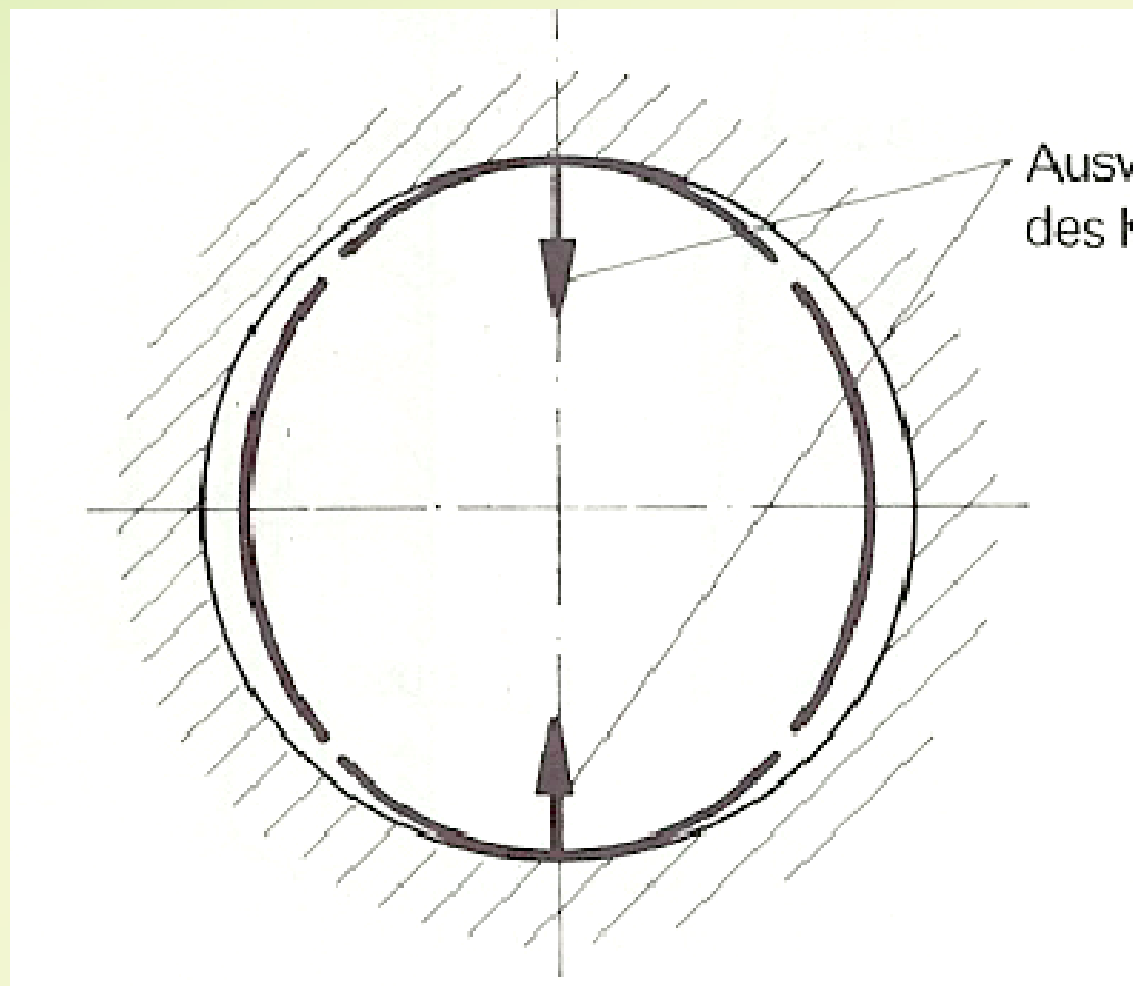
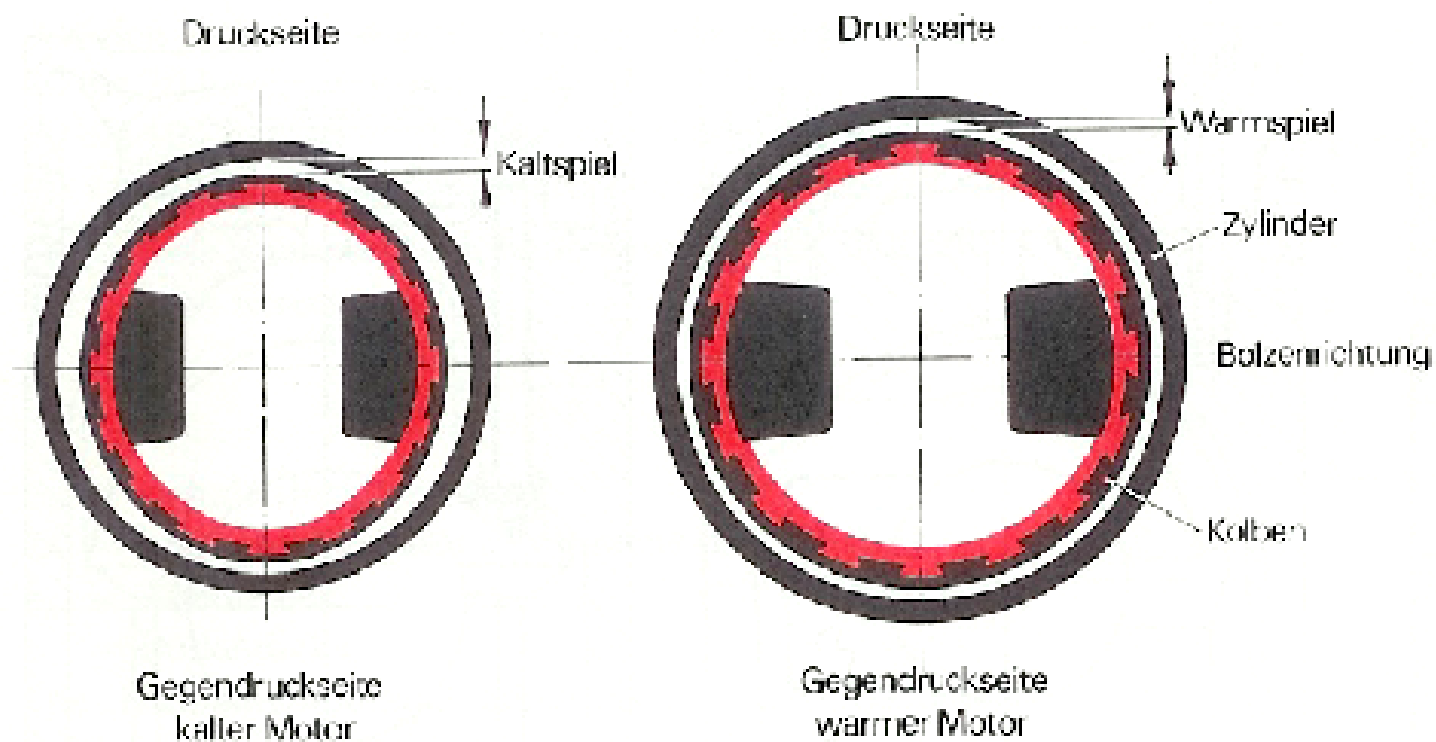
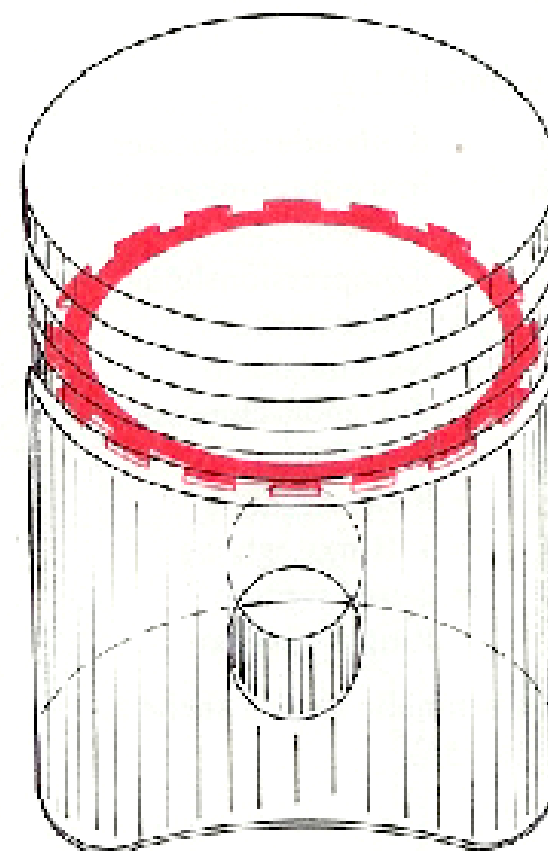


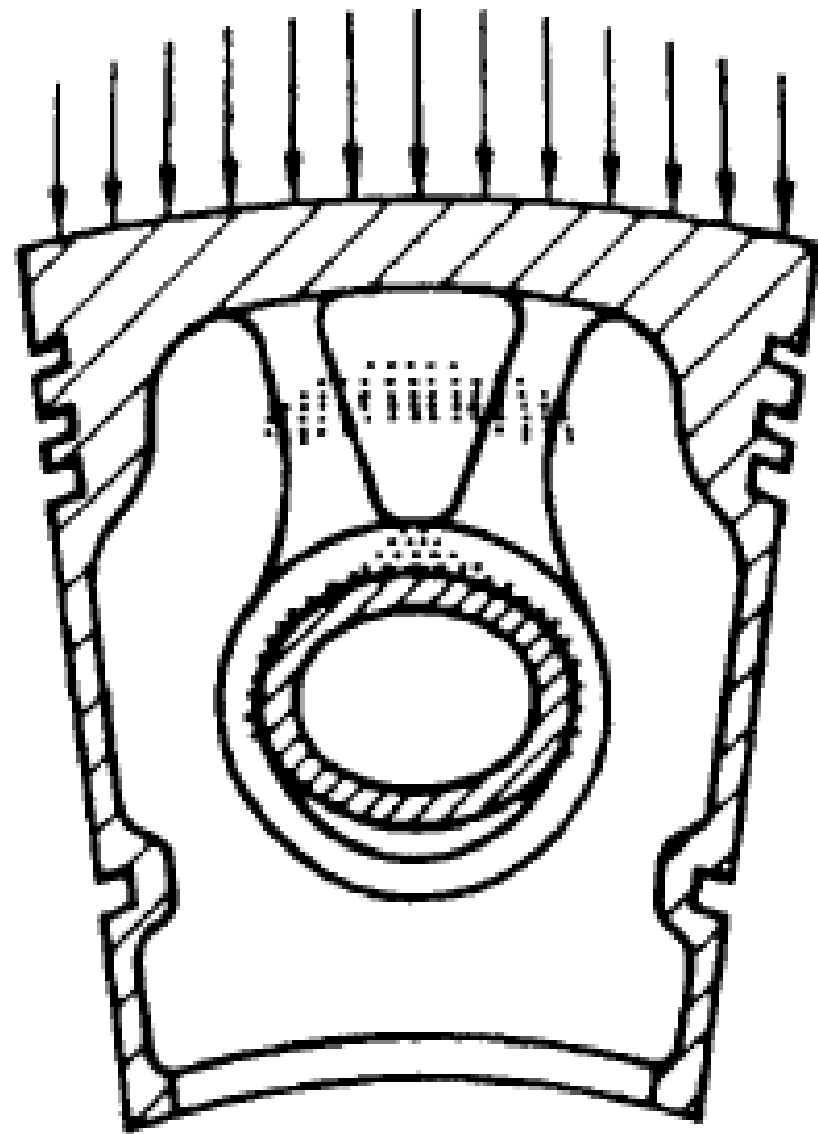
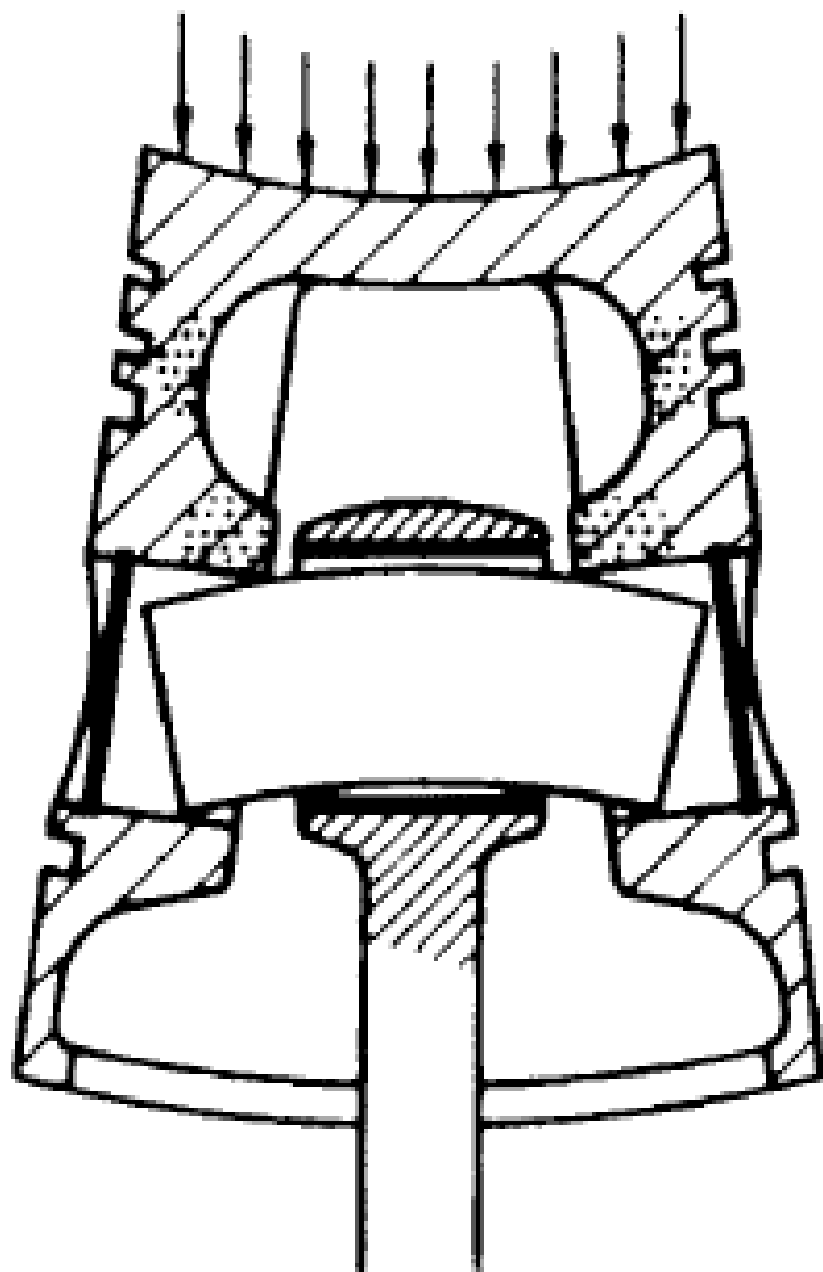
Bild 10.1.5. Ballig-ovaler Kolben (Schleißbild, Fa. Mahle)

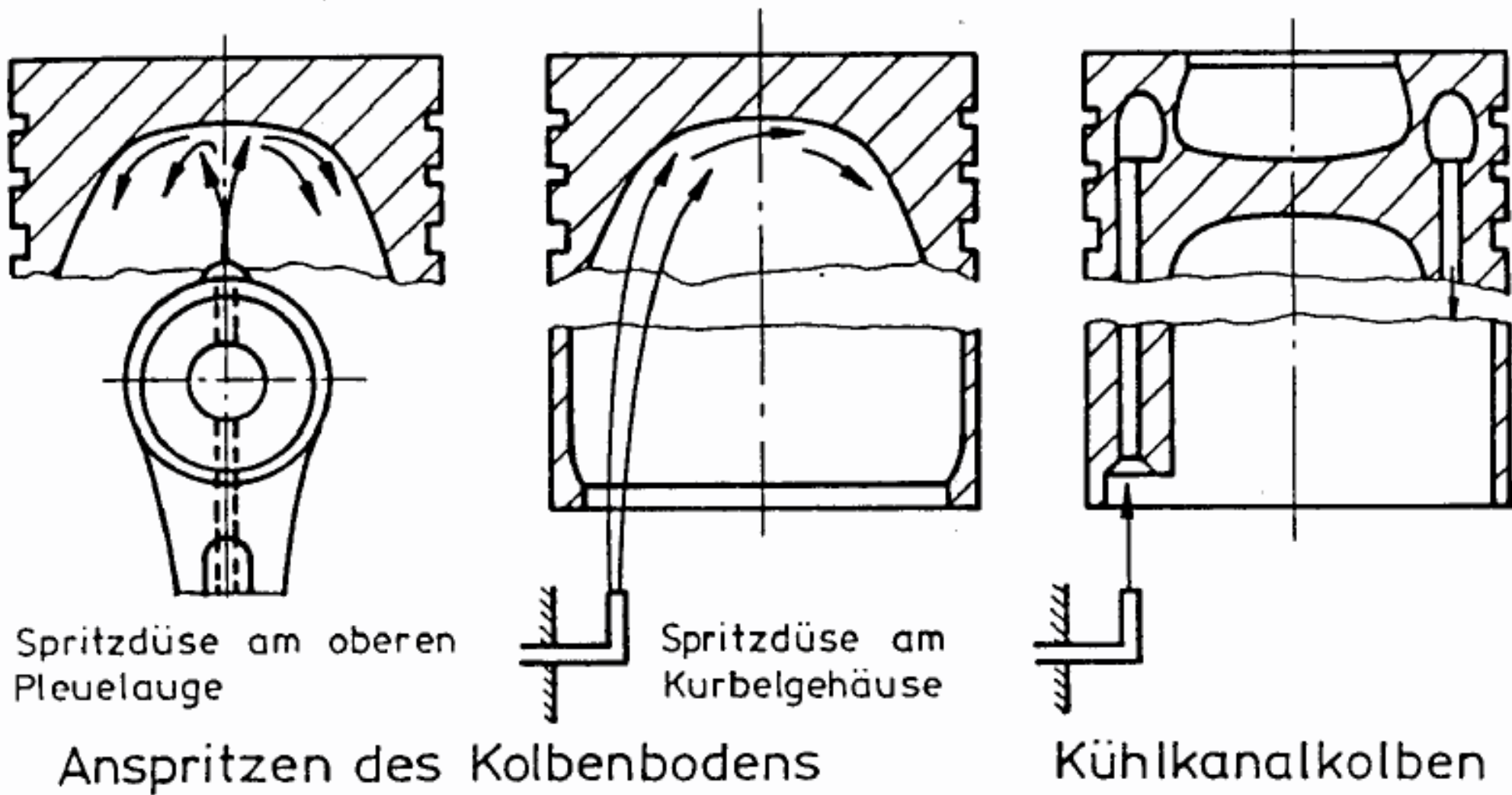




Querschnitt durch Kolben und Zylinder







Izvedbe hlađenja manjih klipova uljem

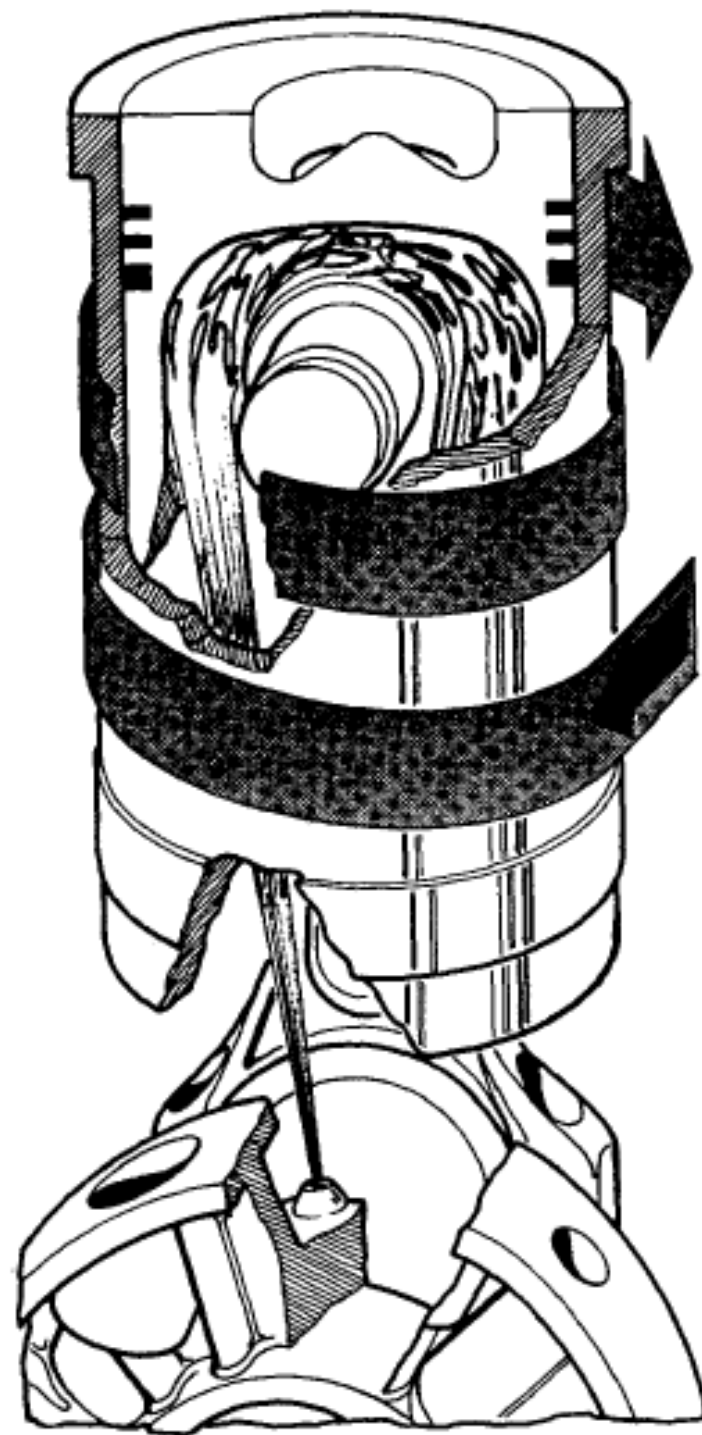
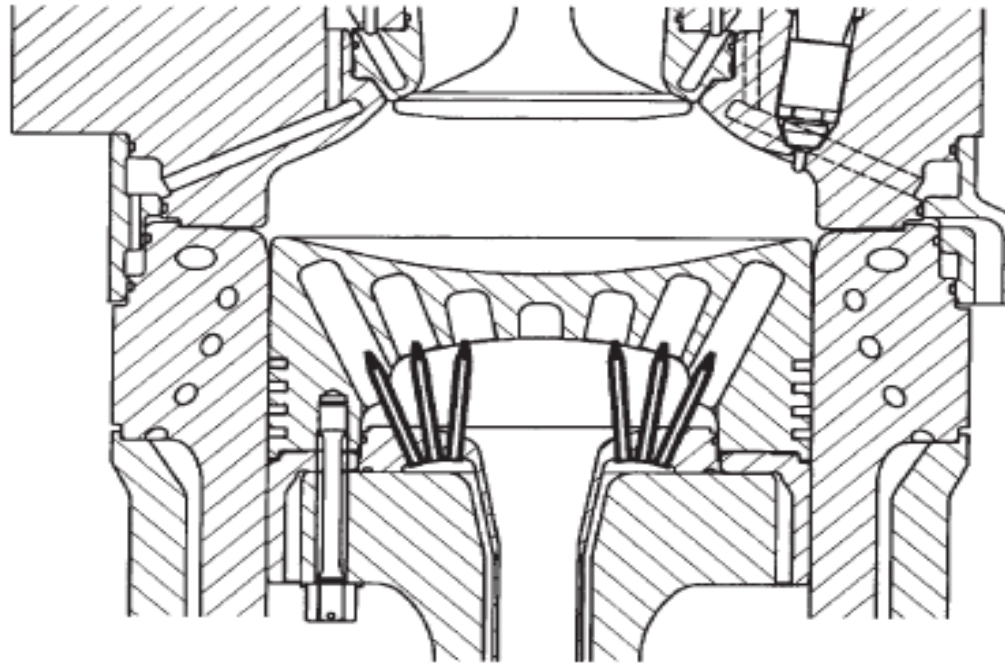
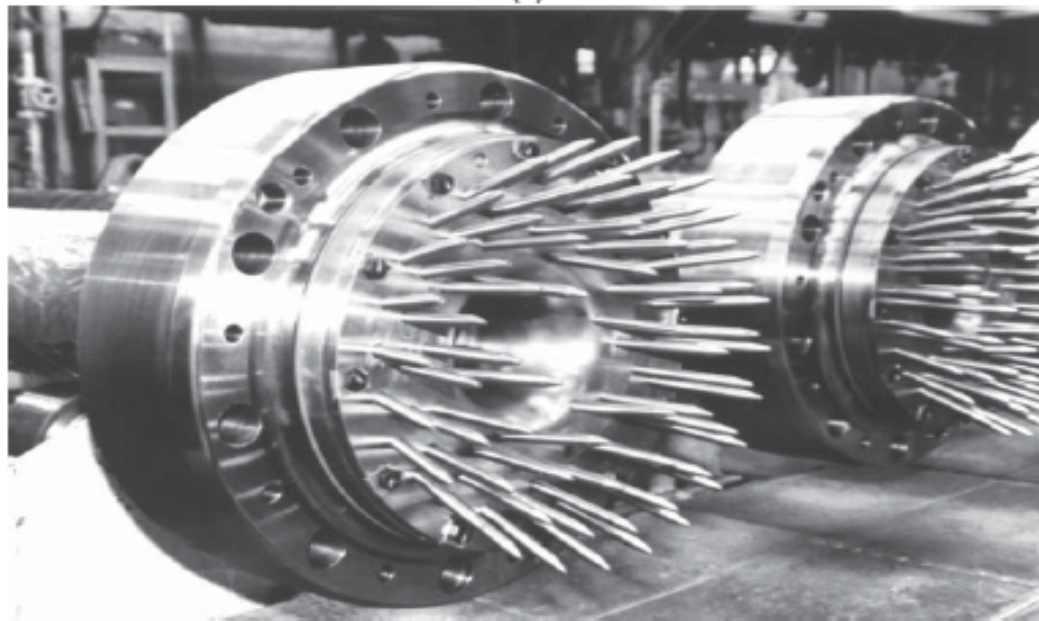
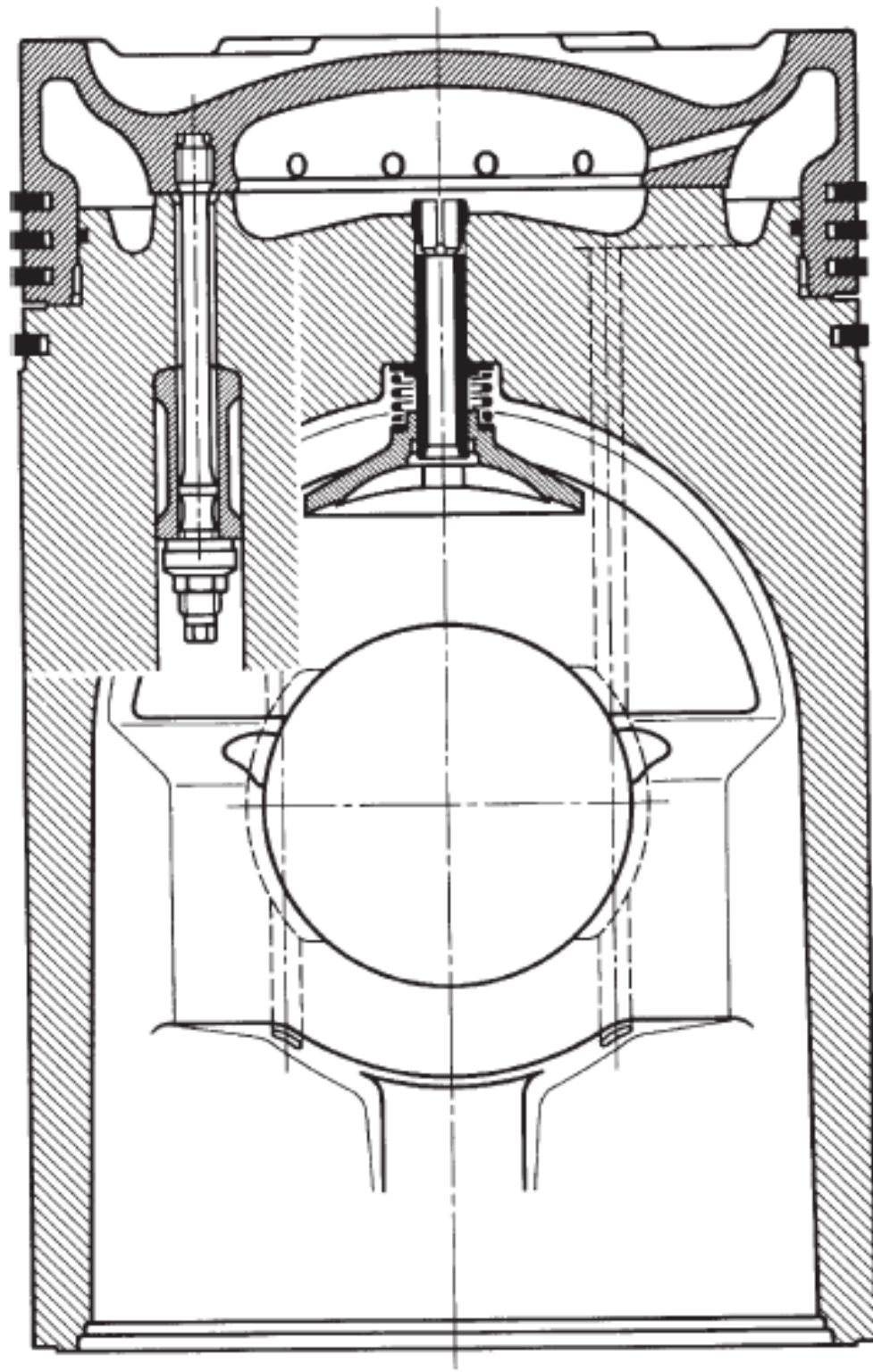


Fig. 12.2 Getto d'olio per il raffreddamento dello stantuffo.

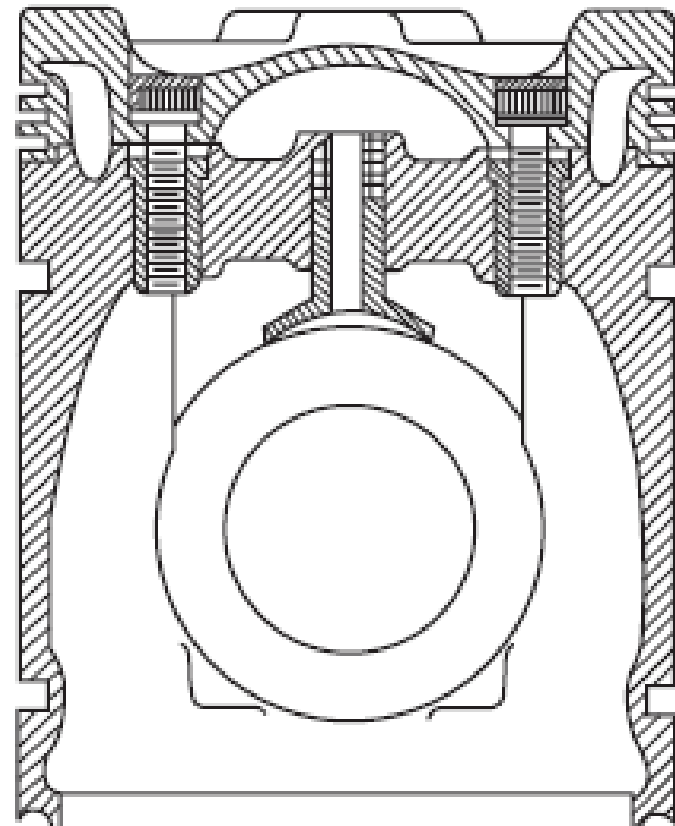
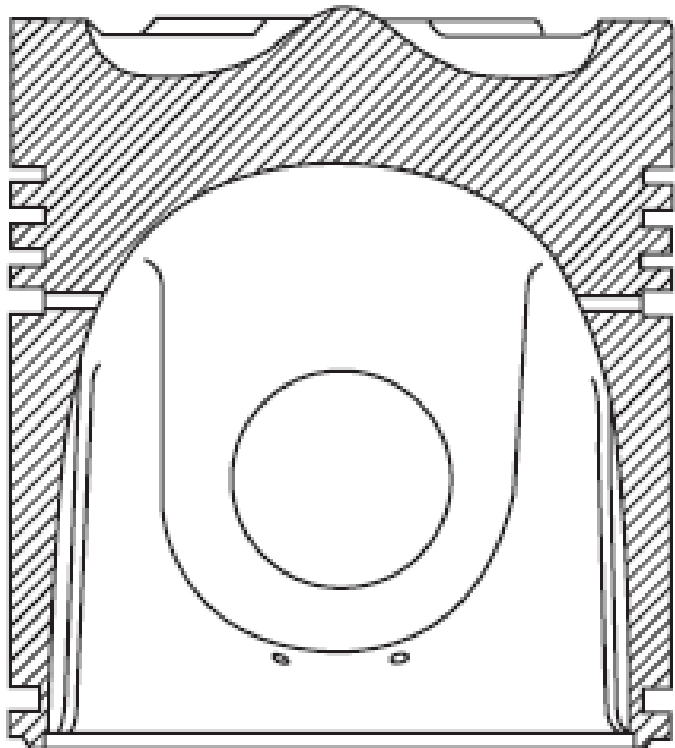


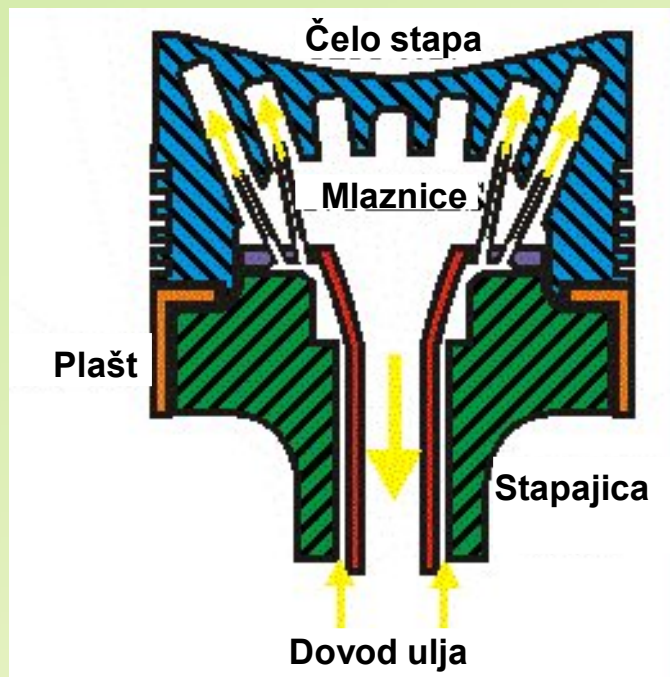
(a)



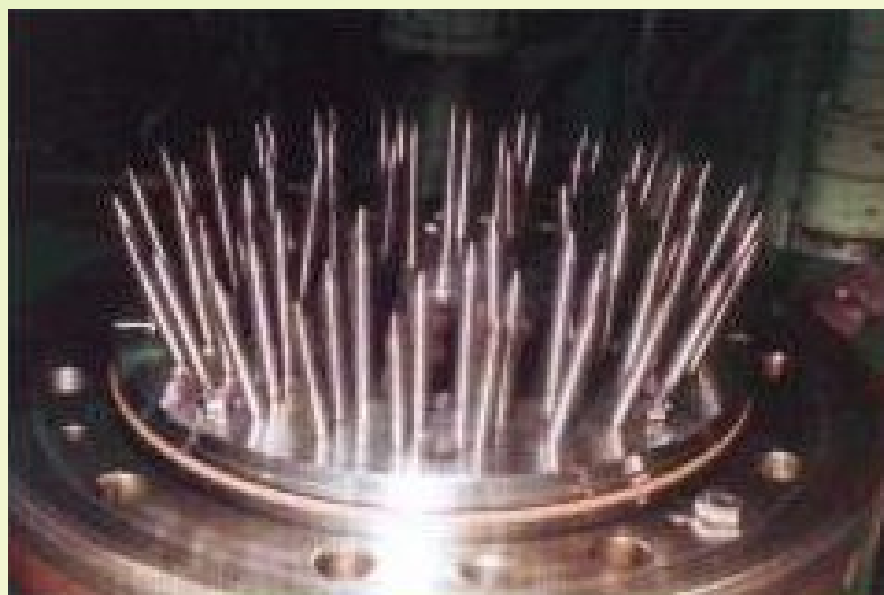
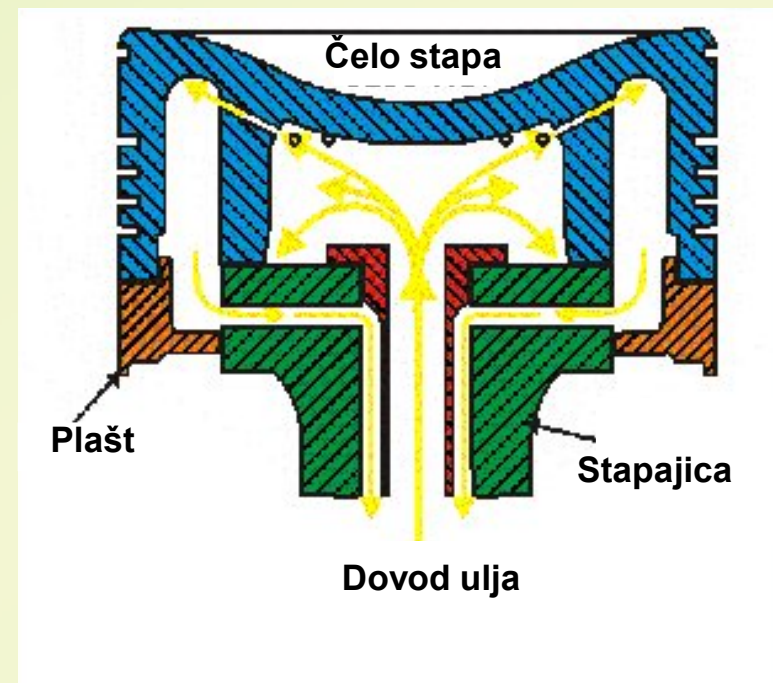








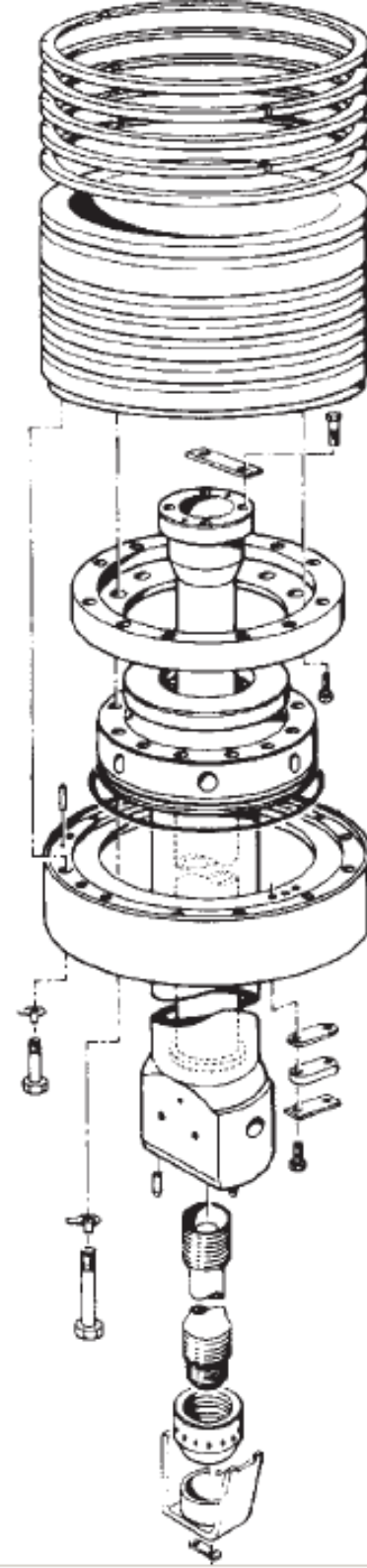
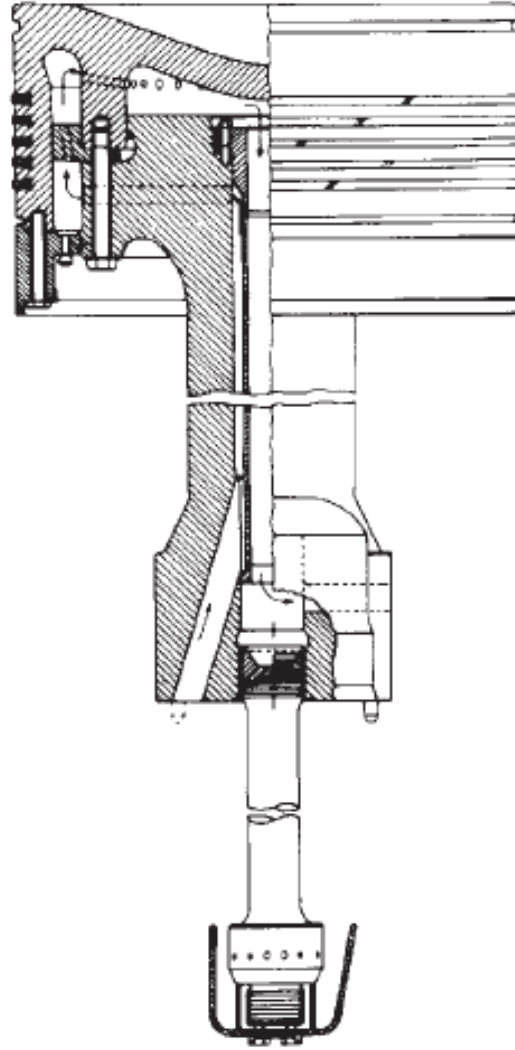
Stap (hlađenje)

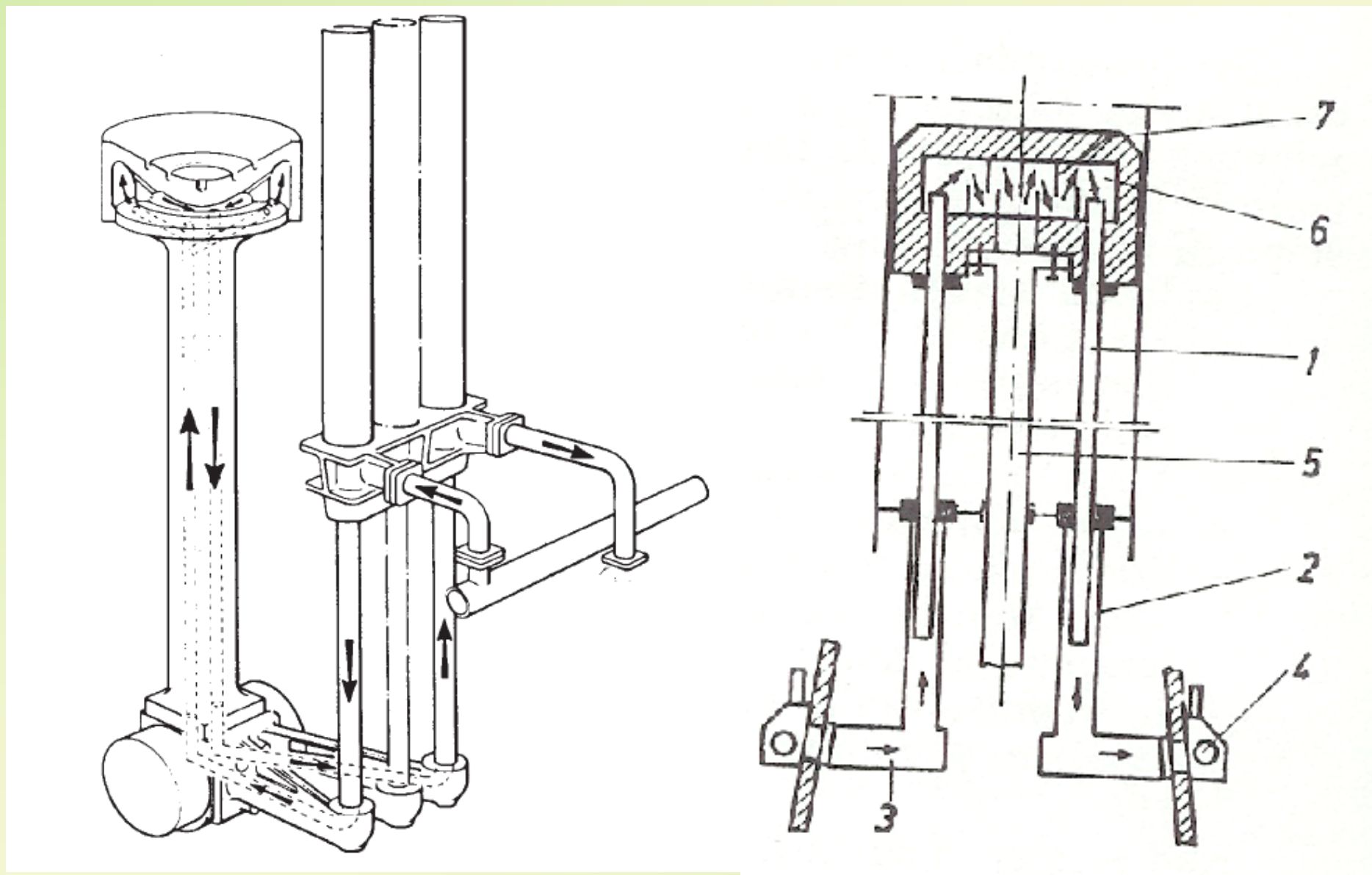


Ploča s mlaznicama ulja (Sulzer RTA)

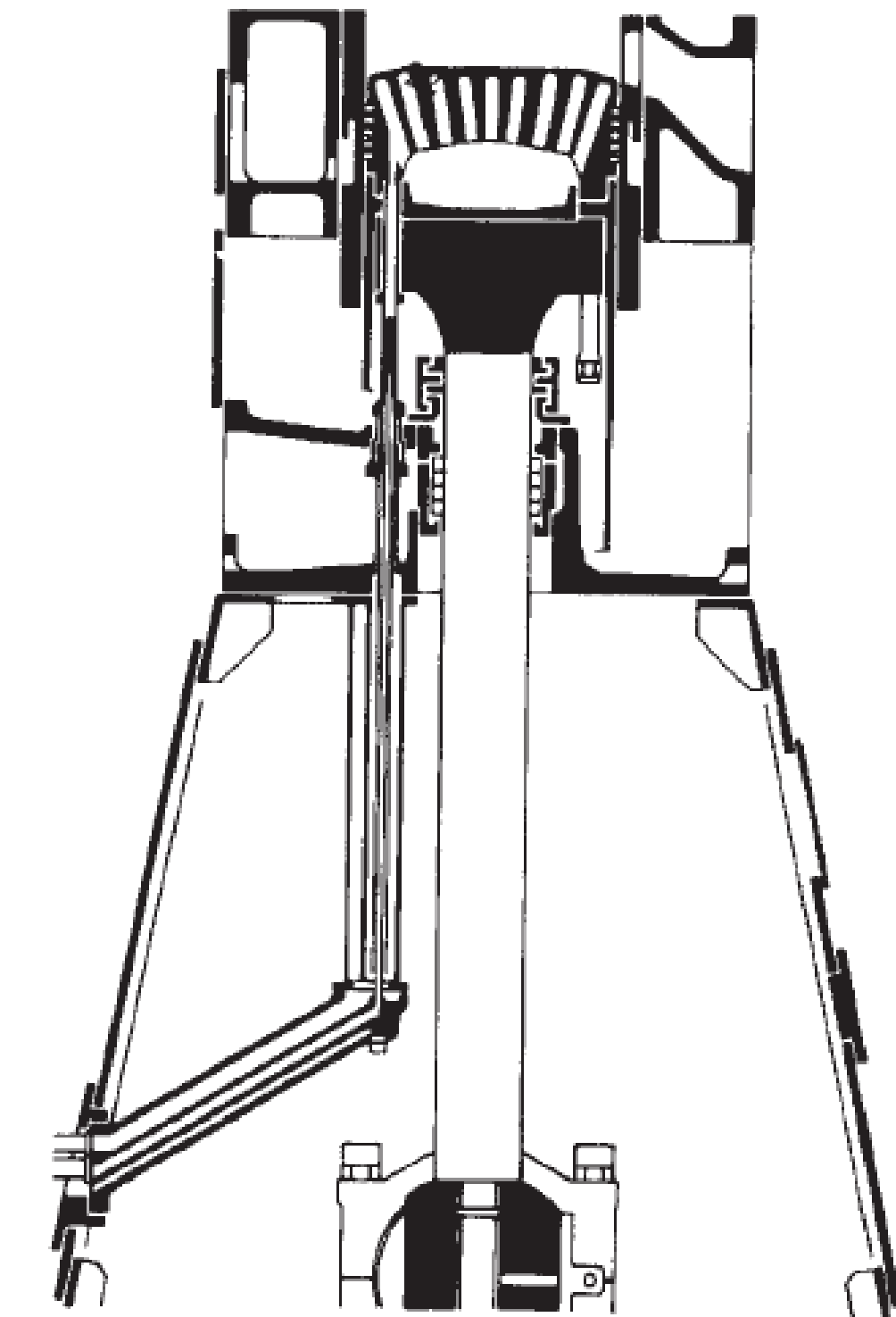
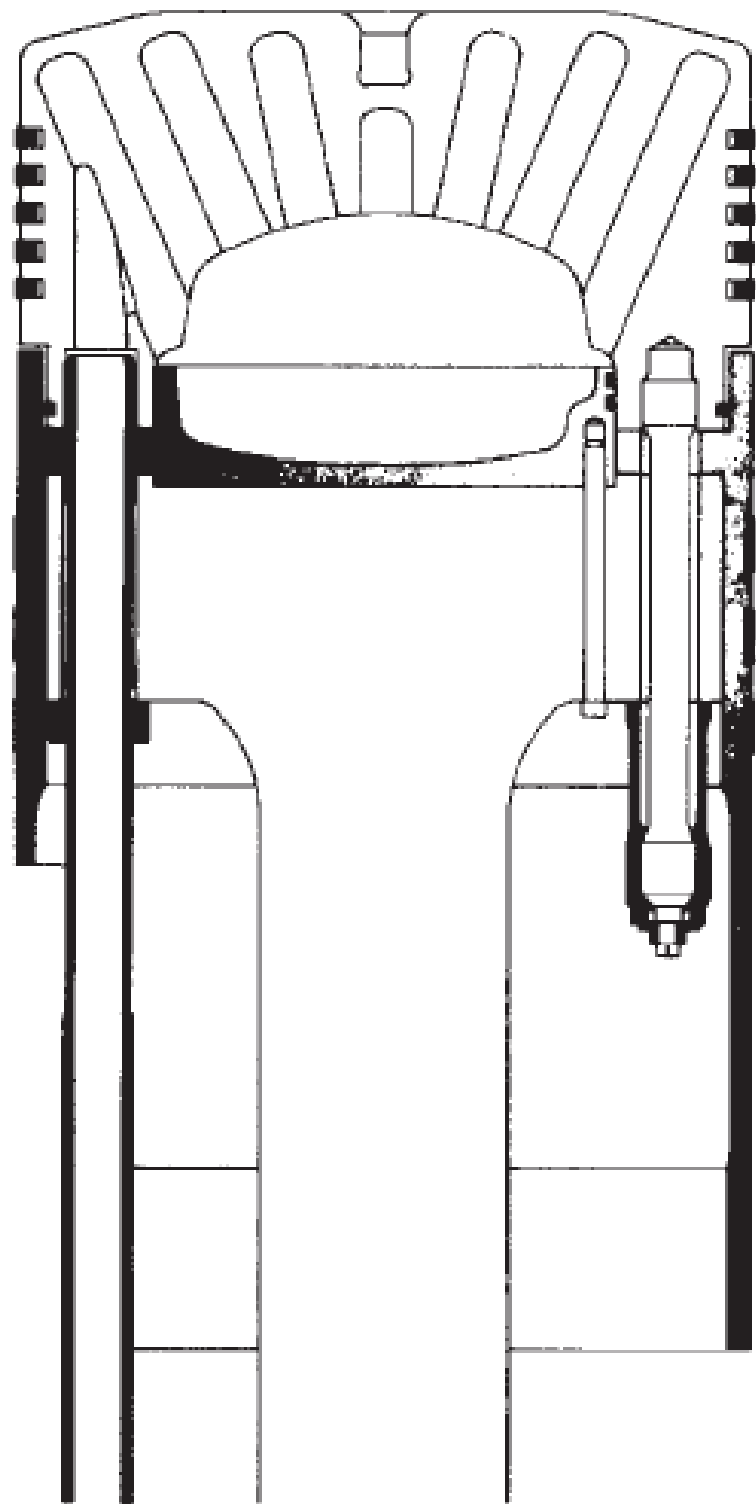


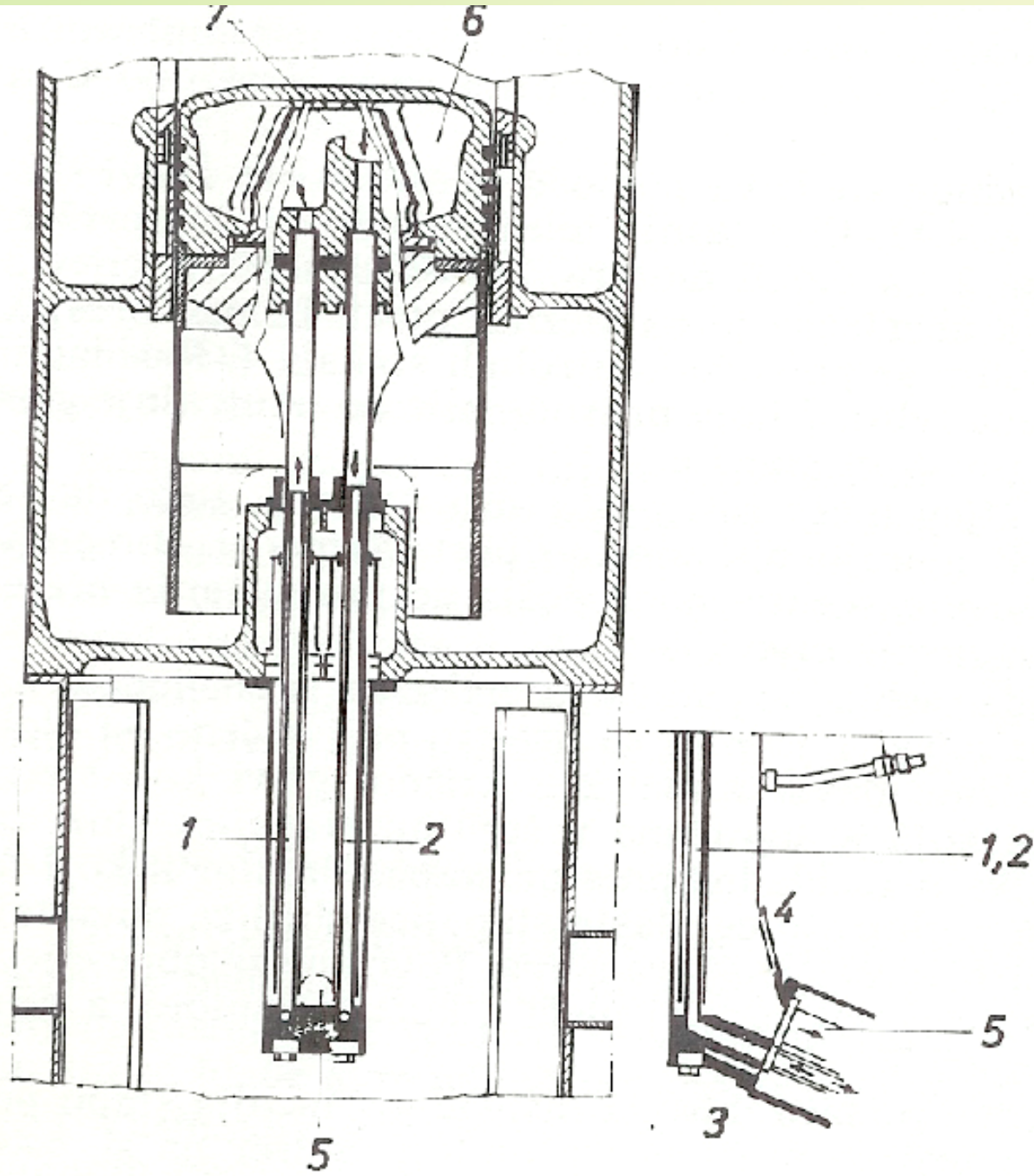
Čelo stapa s donje strane



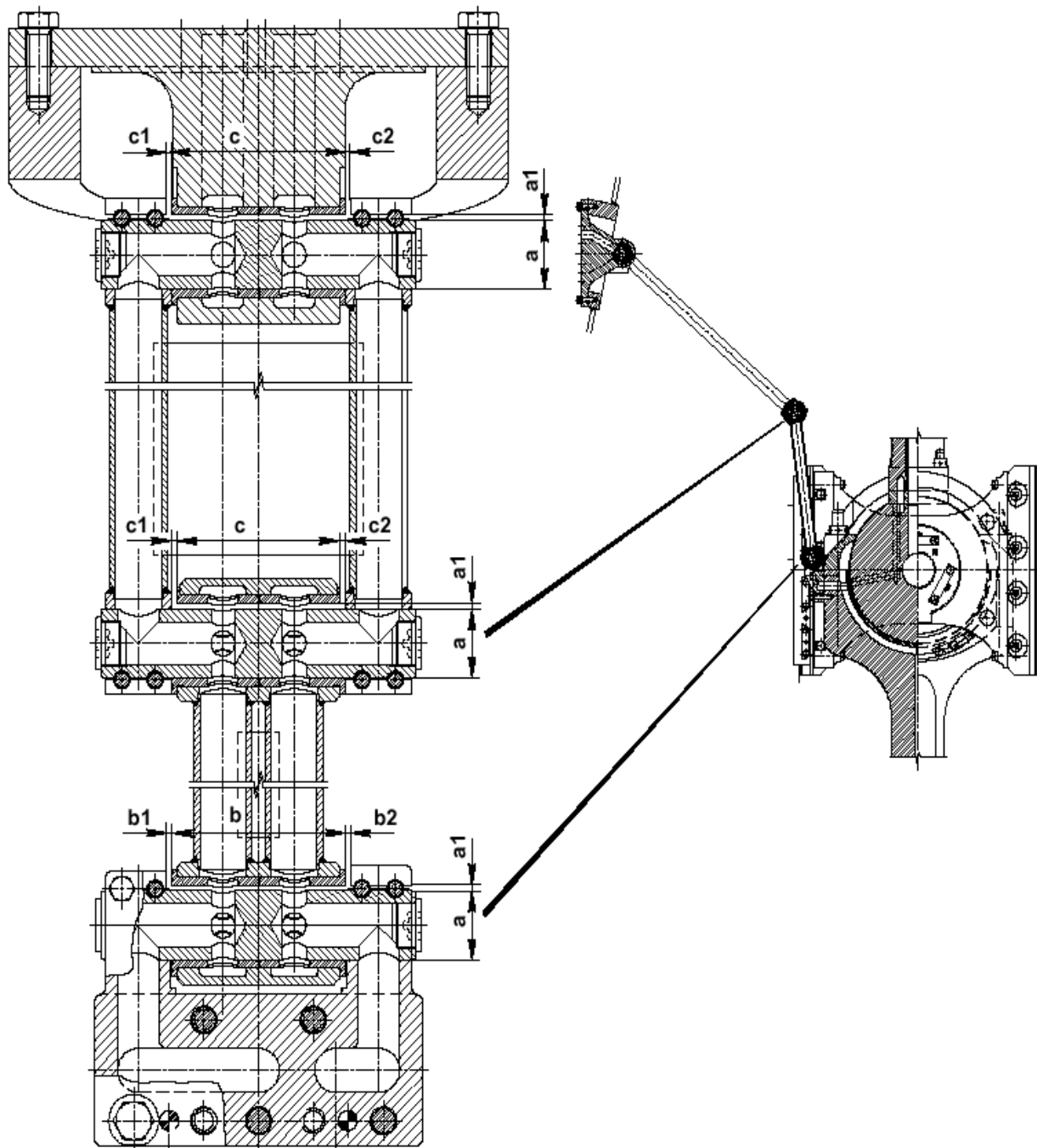


Telekopsko dovodenje rashladnog medija

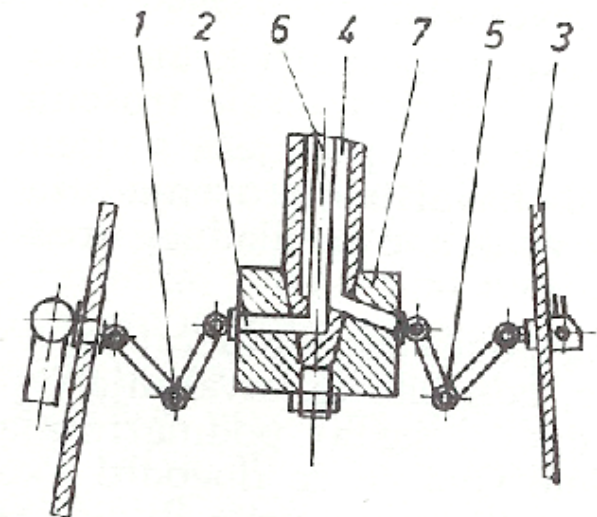


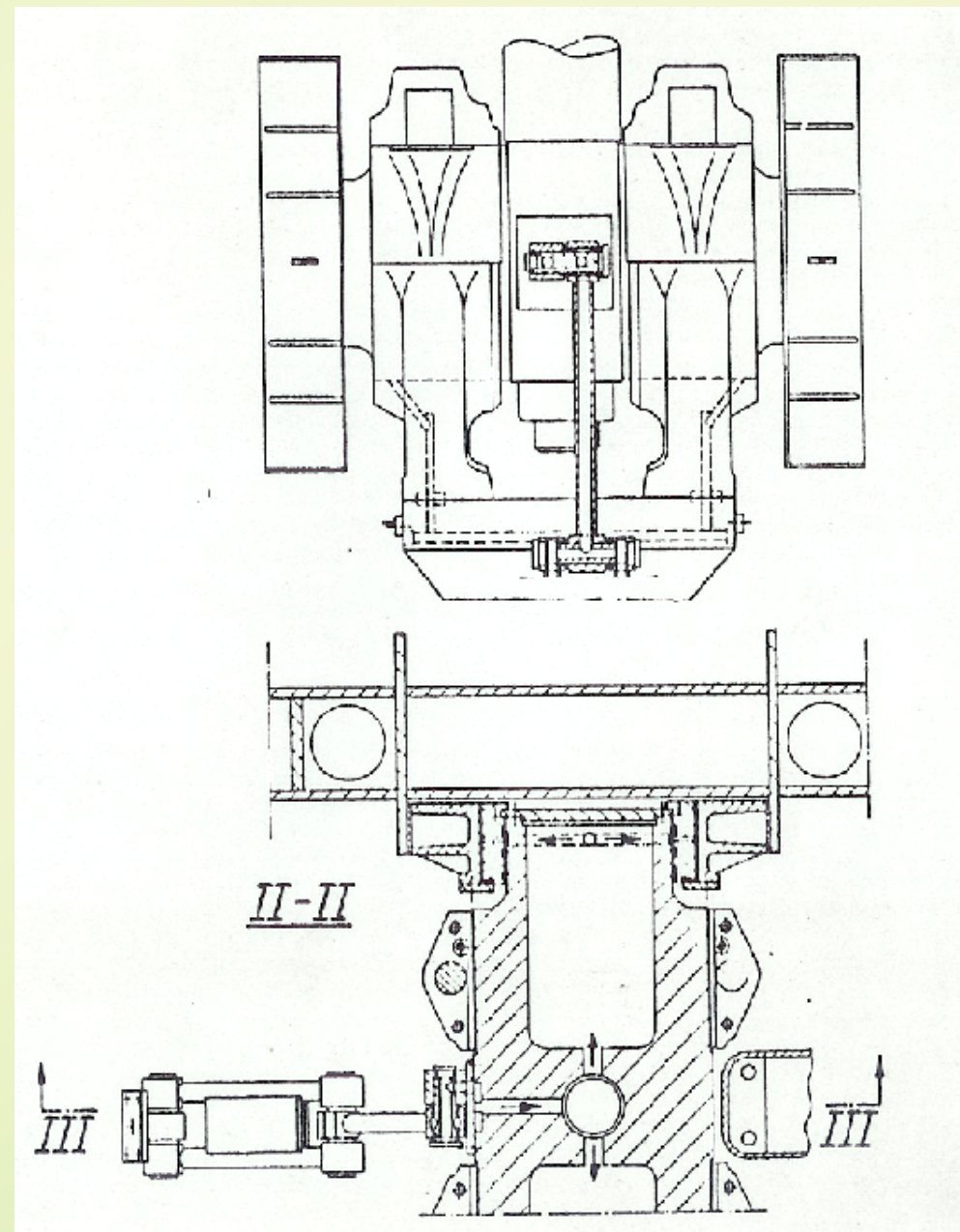
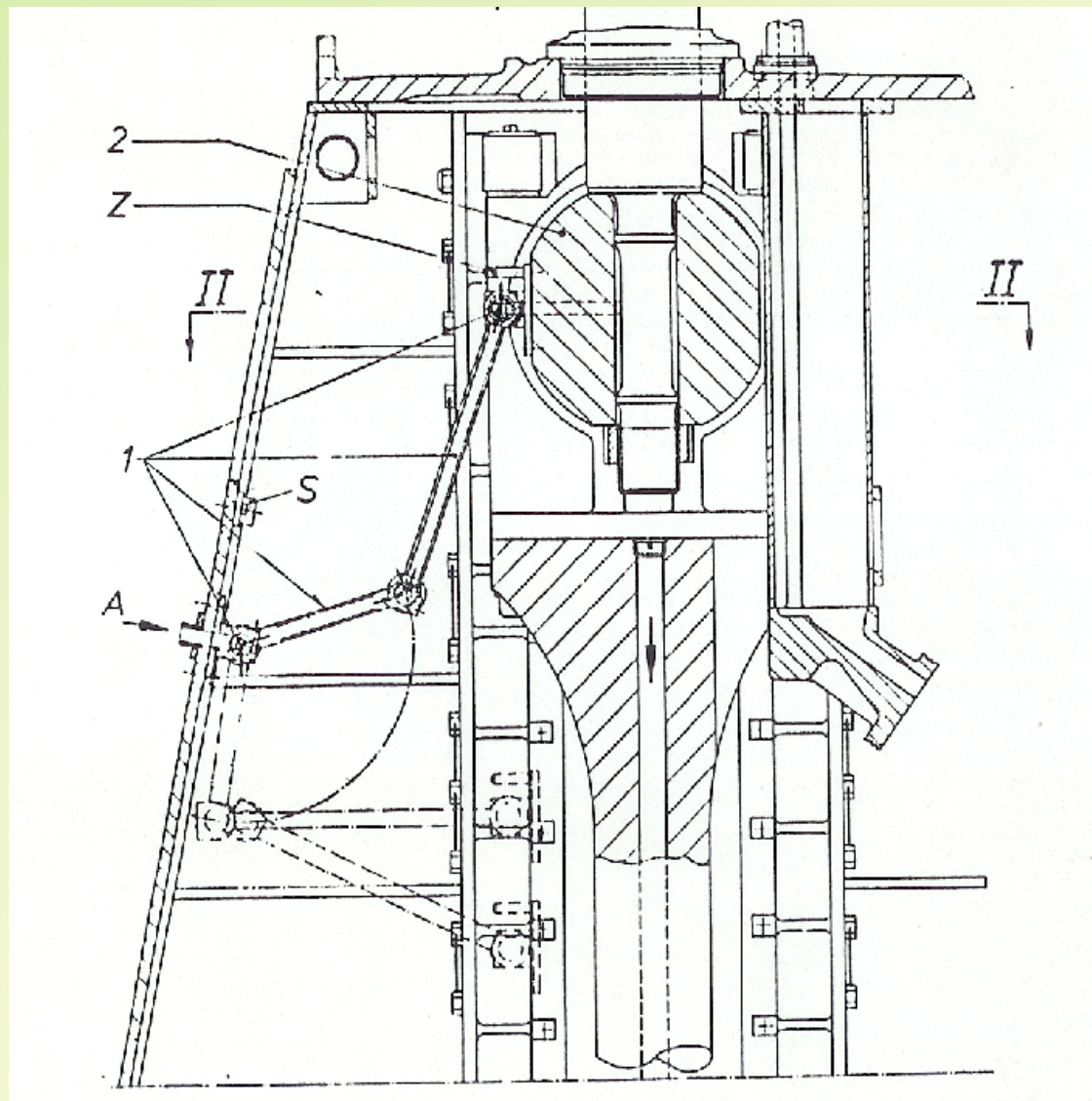


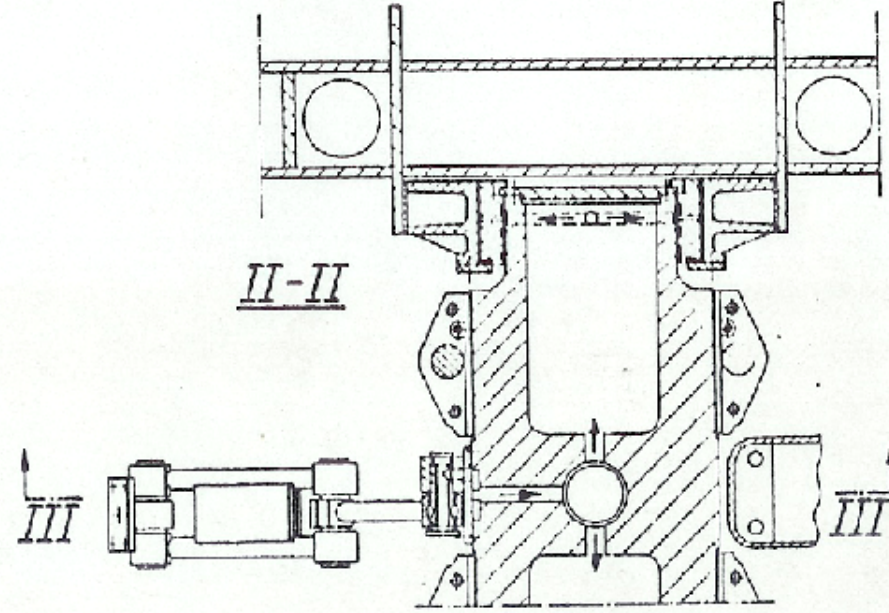
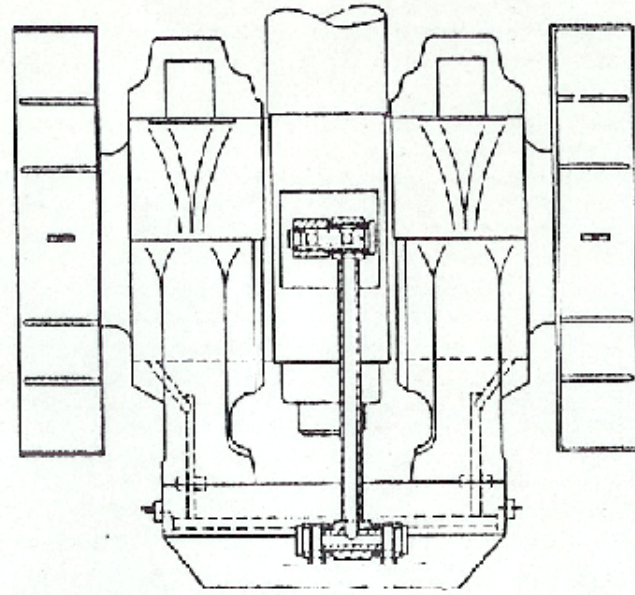
Zglobne cijevi za dovod rashladnog medija

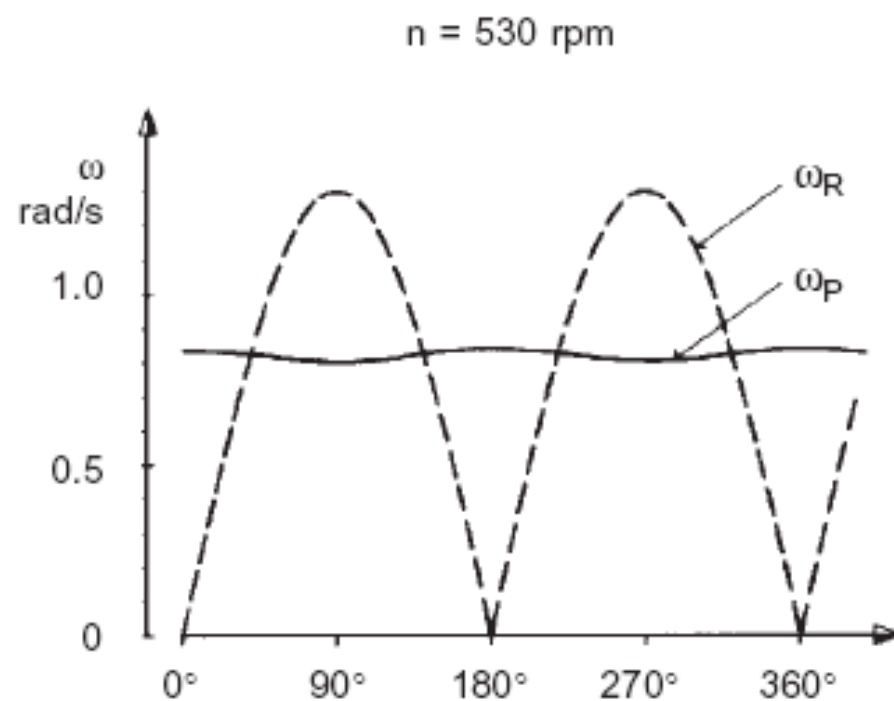
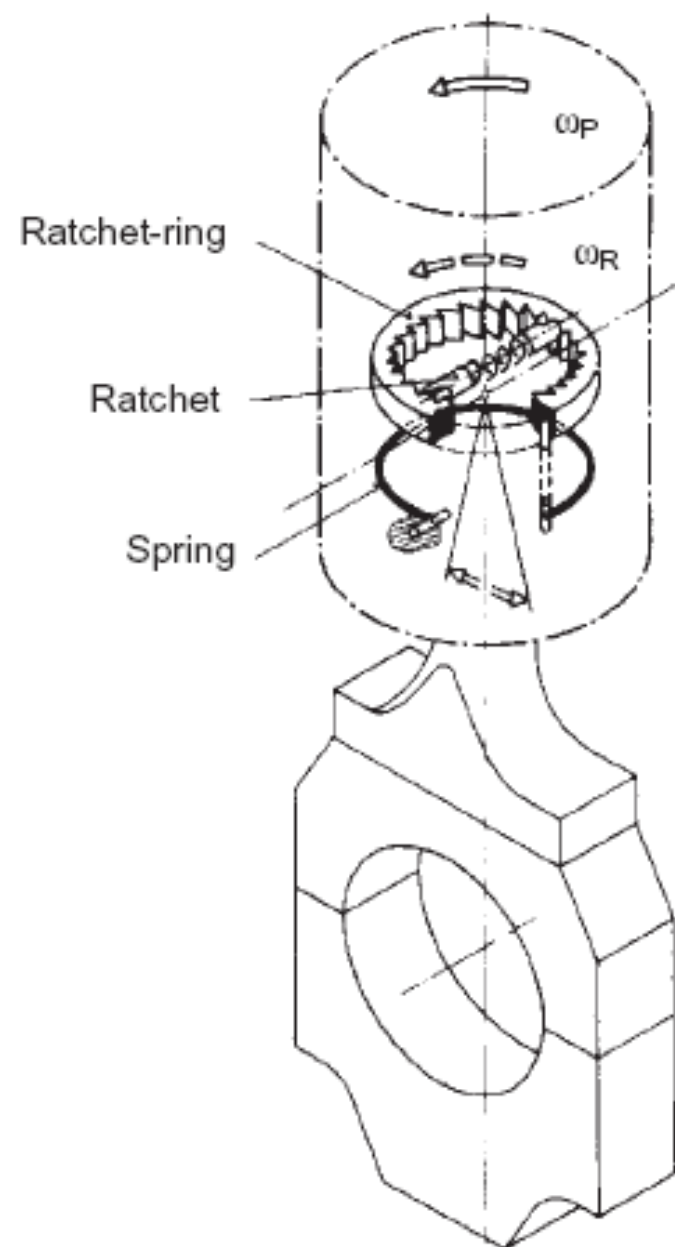


95.7726

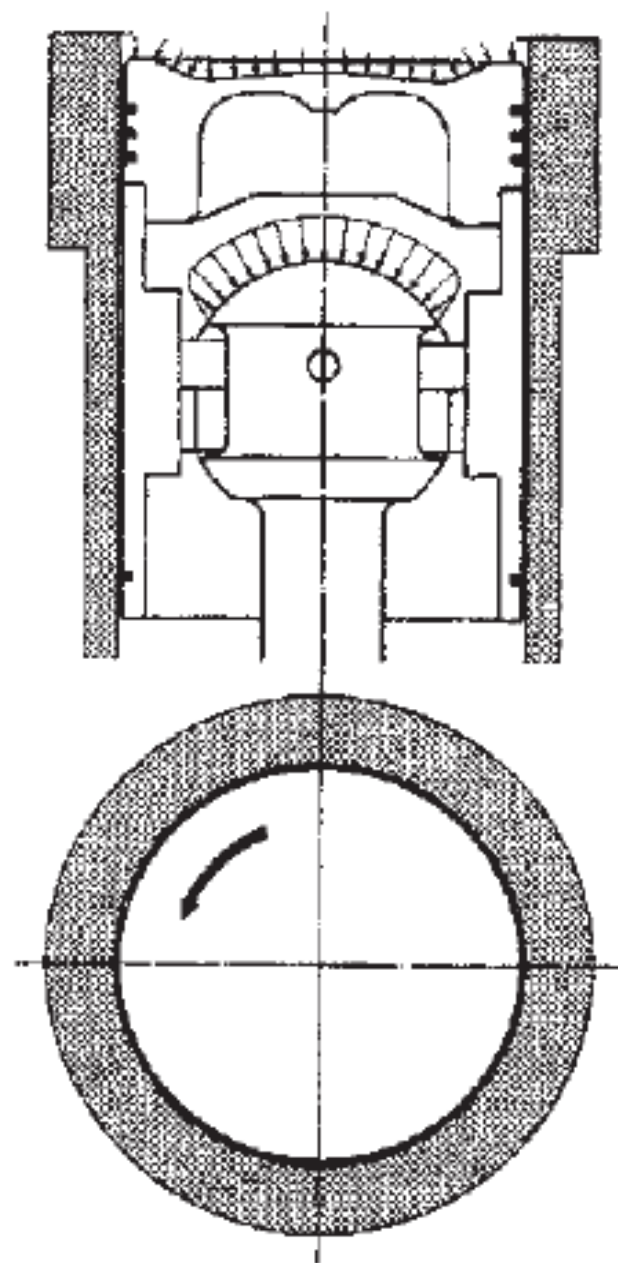
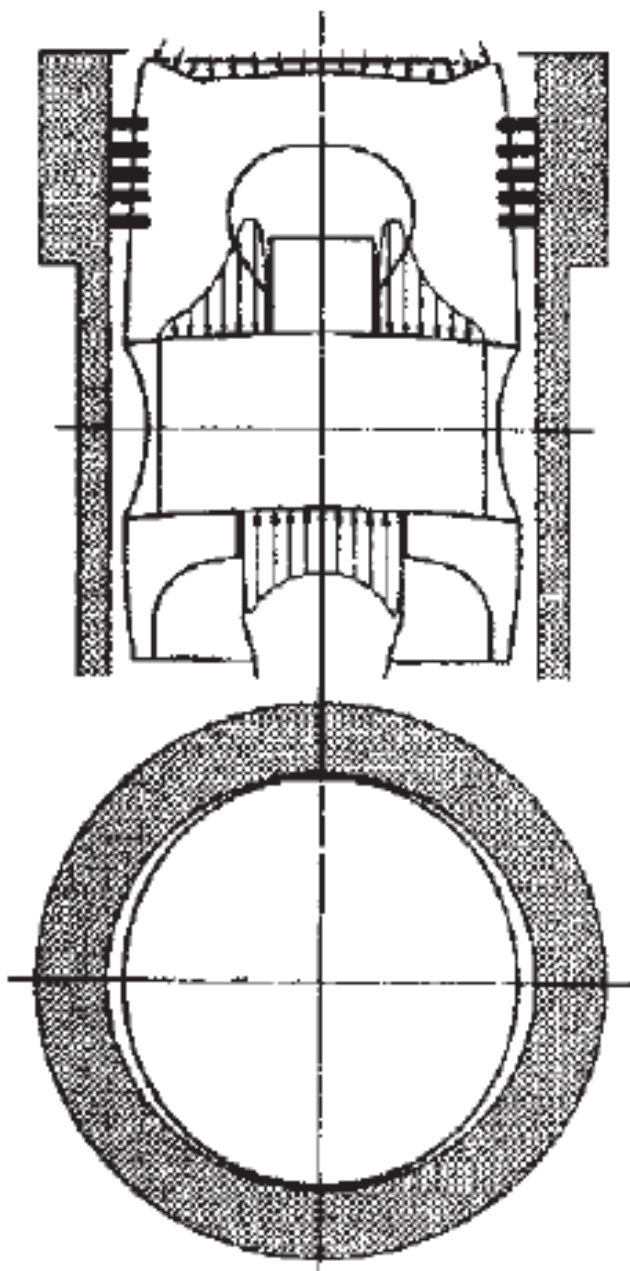








ω_P = Angular velocity of the piston
 ω_R = Angular velocity of the ratchet-ring



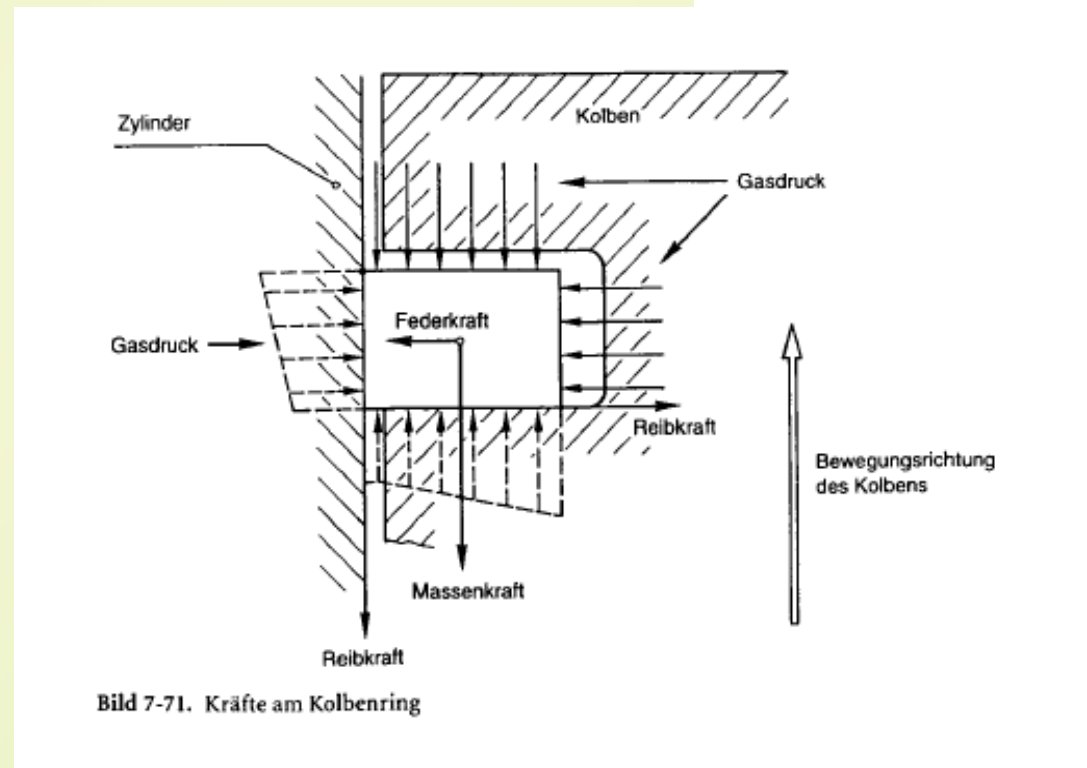
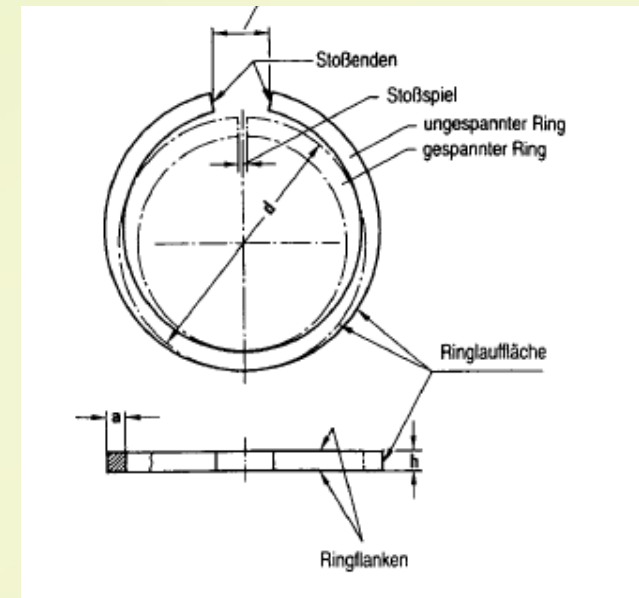
STAPNI-KLIPNI PRSTENI

Funkcija :

- brtvljenje plinova iz kompresionog prostora prema karteru (ulje pomaže),
- odvođenje topline s klipa-stapa
- odstranjivanje ulja u prolazu iz kartera prema kompresionom prostoru

Djele se na:

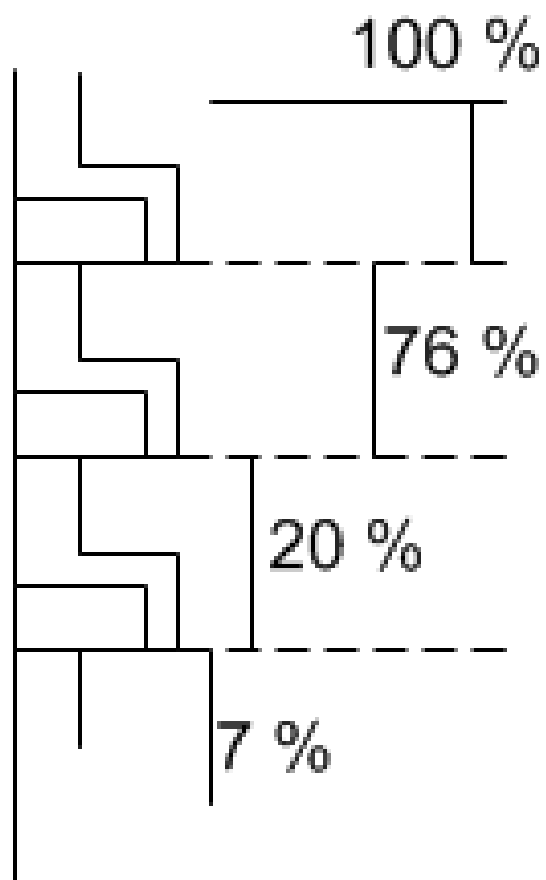
- kompresione
- uljne (strugače)
- sivi lijev



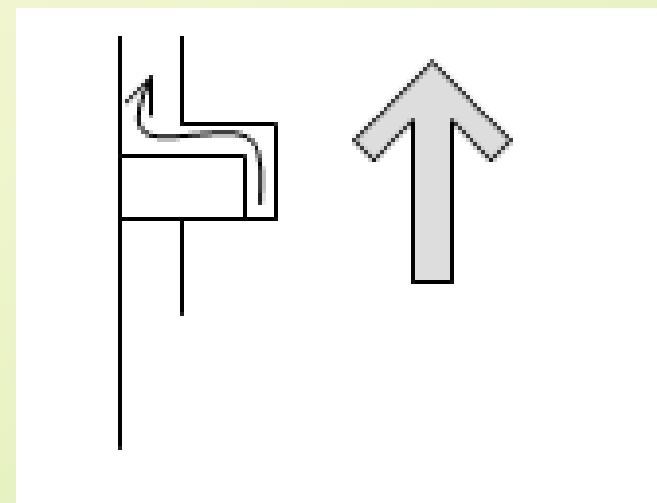
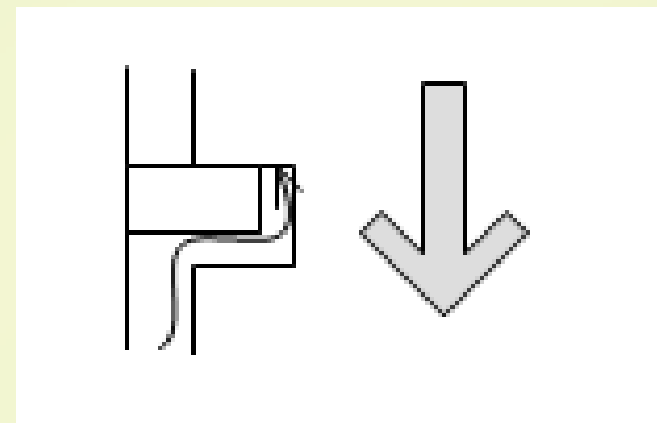
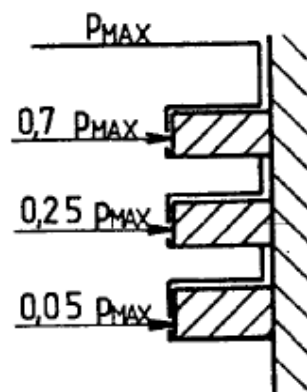
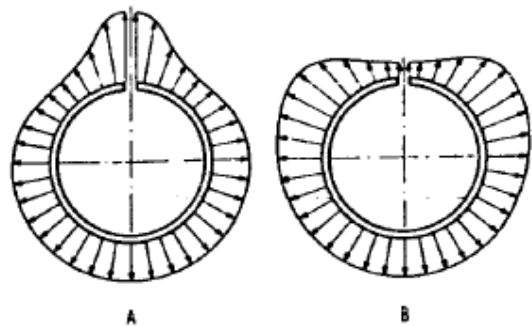
STAPNI-KLIPNI PRSTENI

Brtvljenje prstena

pumpanje ulja

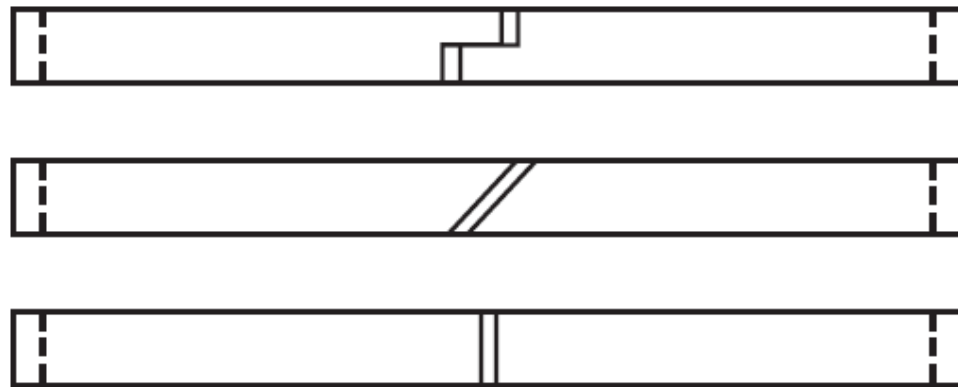


čizak 73.



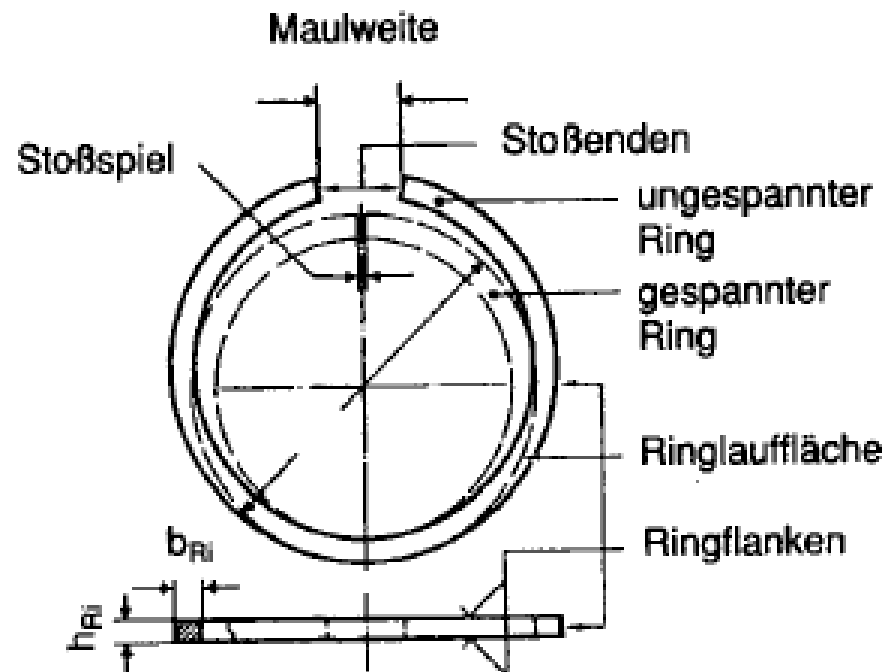
STAPNI-KLIPNI PRSTENI

- Prsteni moraju također :
- - biti dovoljno elastični da omogućavaju montažu i demontažu bez trajnih deformacija
- - moraju biti manje tvrdoće od košuljice
- - spoj krajevi mora biti izveden da propuštaju što manje
- - kod 2T ne smiju rotirati zbog mogućnosti upada u kanal

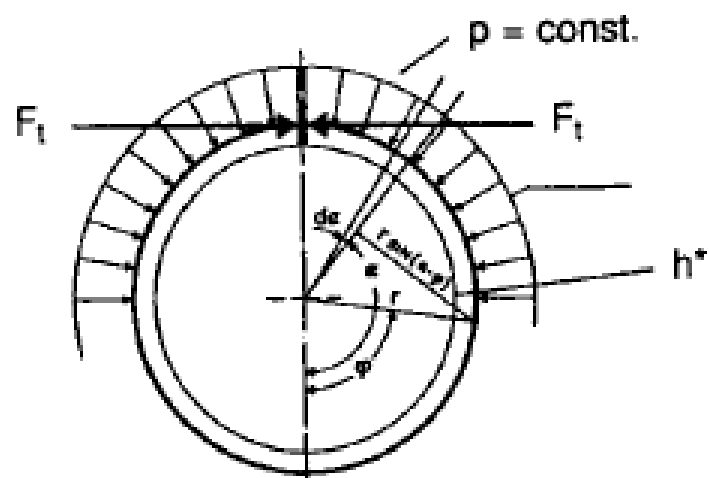


STAPNI-KLIPNI PRSTENI

a)

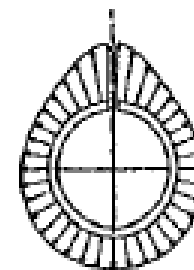


b)

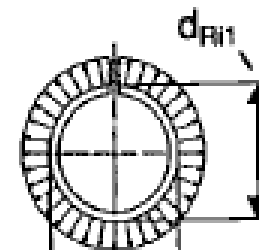


c)

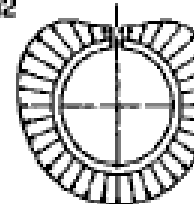
Ovalität $d_{Ri1} - d_{Ri2}$
gemessen im
Spannband



Viertakt-Charakteristik
(positiv oval)
 $d_{Ri1} > d_{Ri2}$

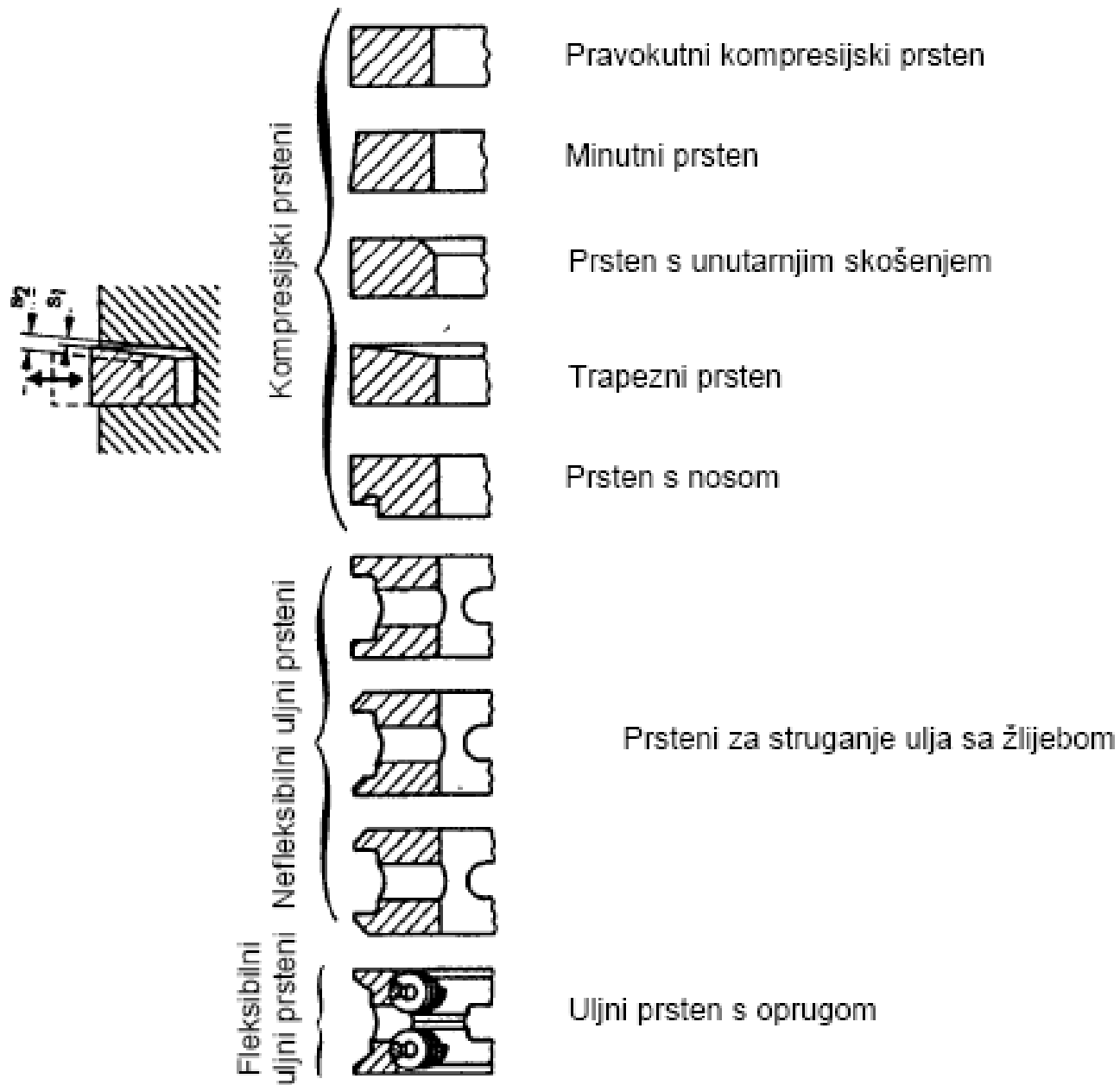


gleichmäßige
Druckverteilung
 $d_{Ri1} = d_{Ri2}$

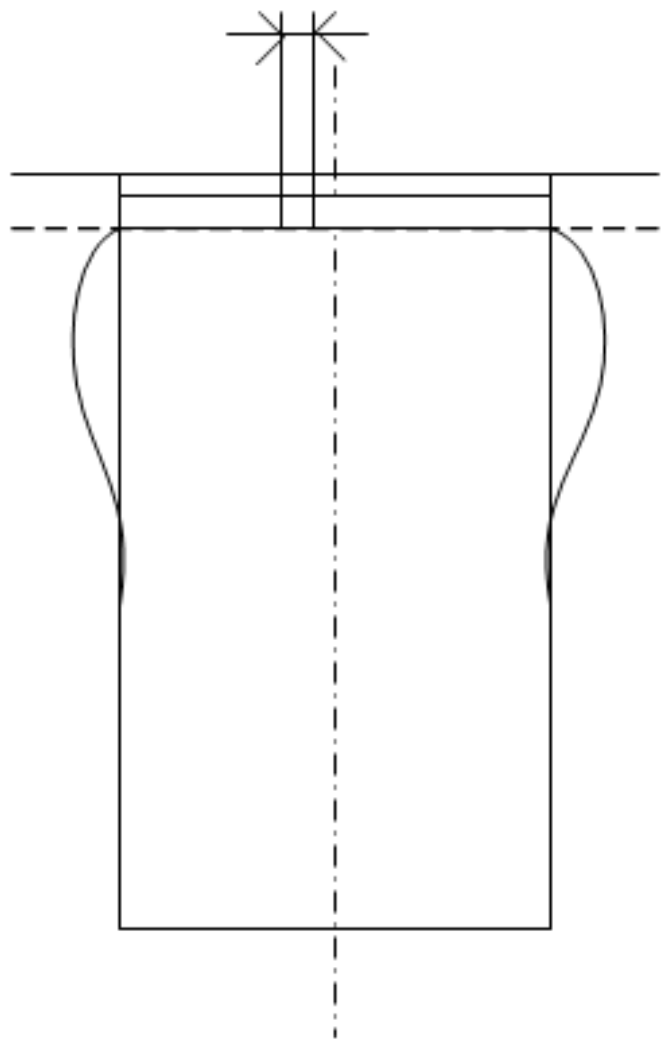


Zweitakt-Charakteristik
(negativ oval)
 $d_{Ri1} < d_{Ri2}$

Izvedbe klipnih prstena

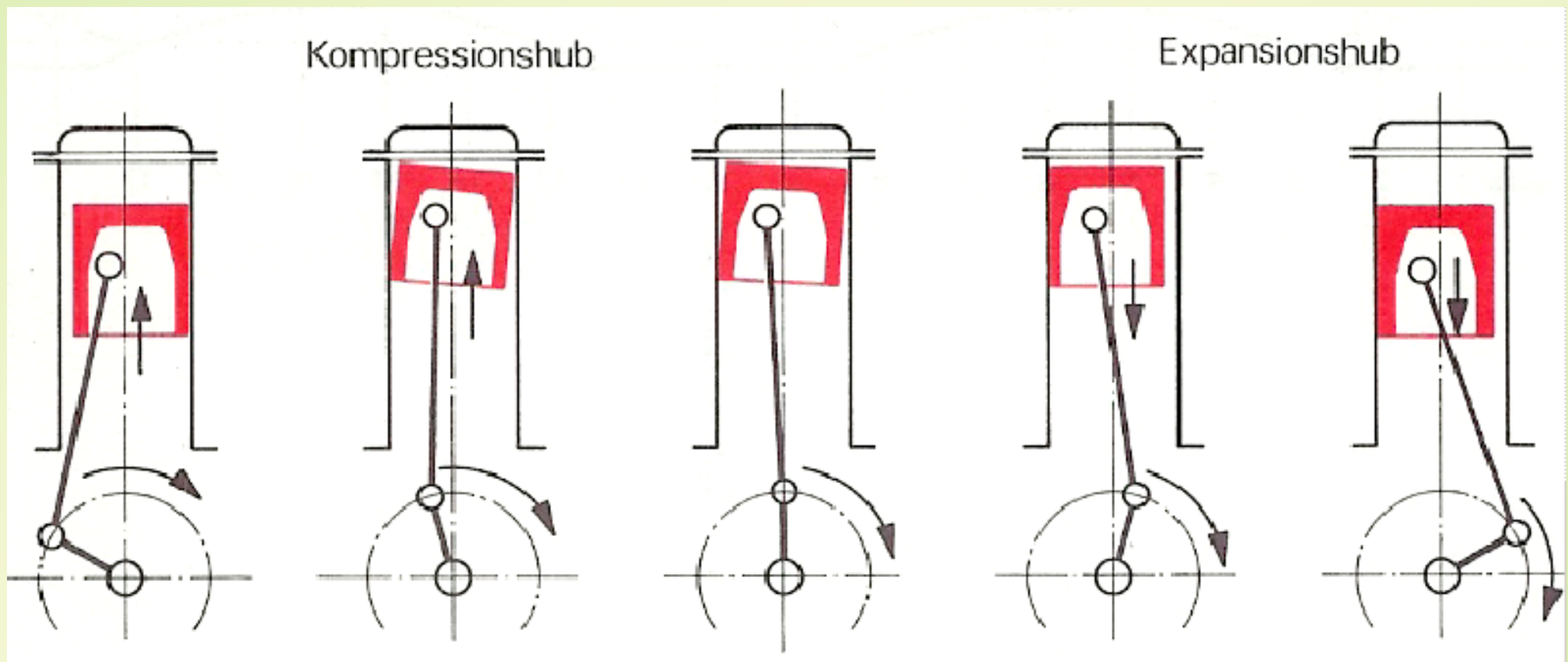


MJERENJE ISTROŠENJA PRSTENA



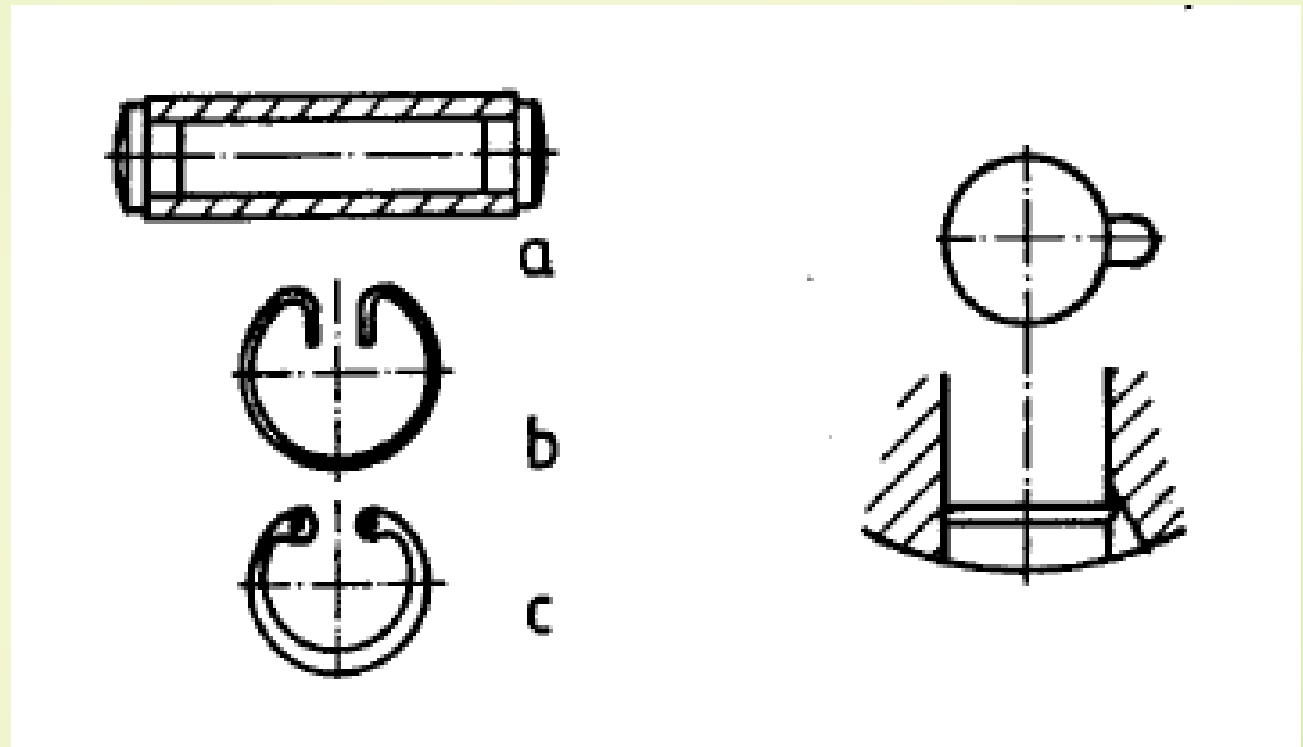
OSOVINICA KLIPA

- Povezuje klip s klipnjačom i prenosi silu na klipnjaču.
- Položaj osovinnice:



OSOVINICA KLIPA

- Osiguranje osovinnice:
- - vijkom
- - preklopni dosjed
- - kružni osigurač



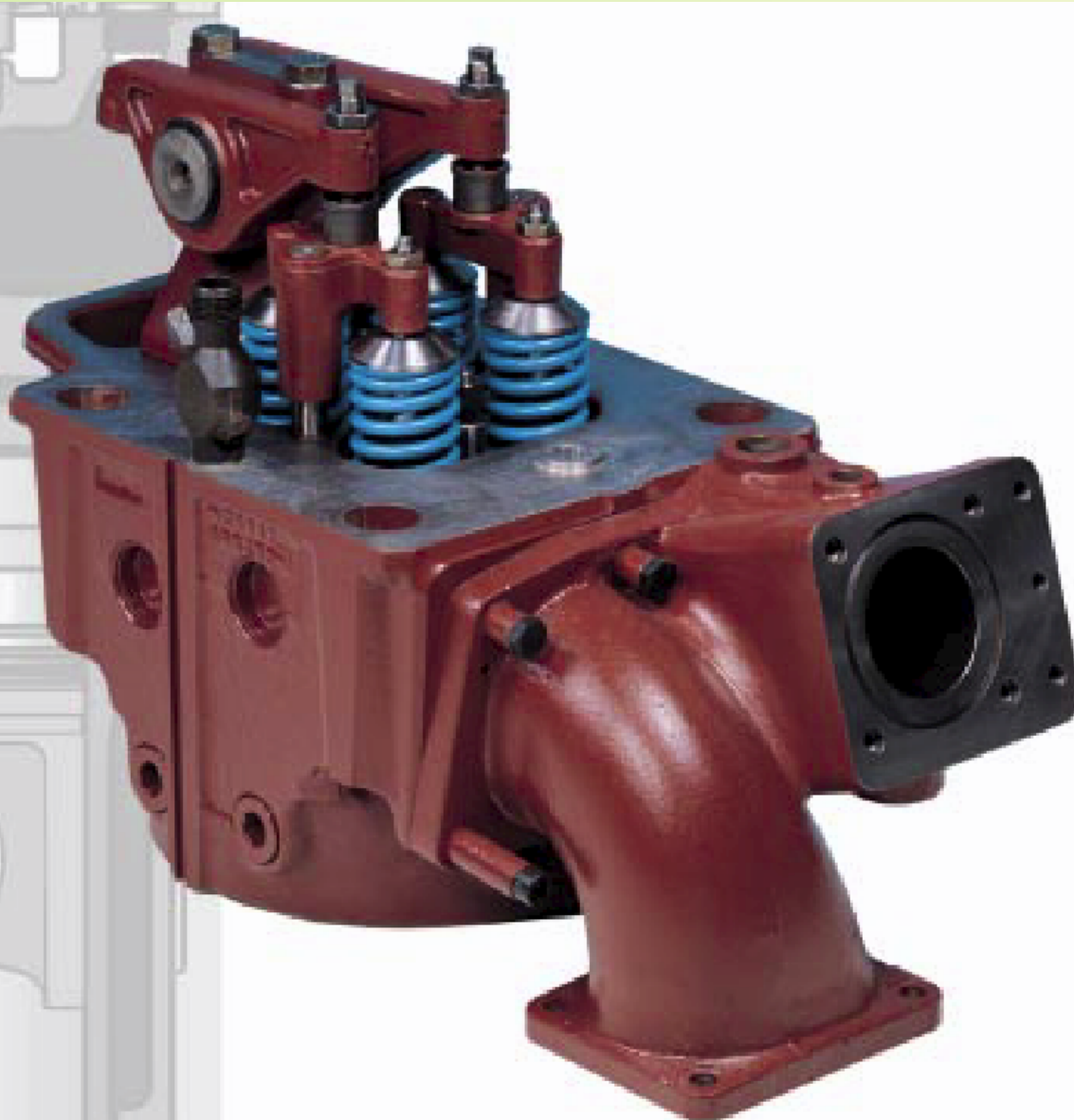
Kraj -> glava motora

Brodski motori

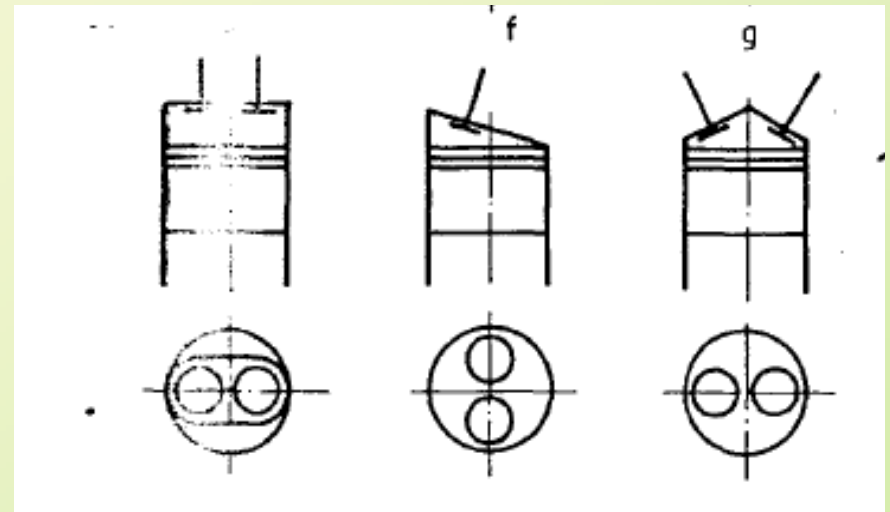
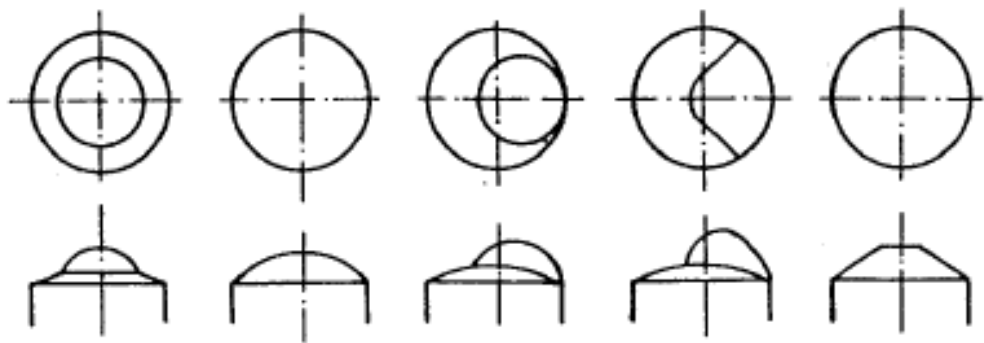
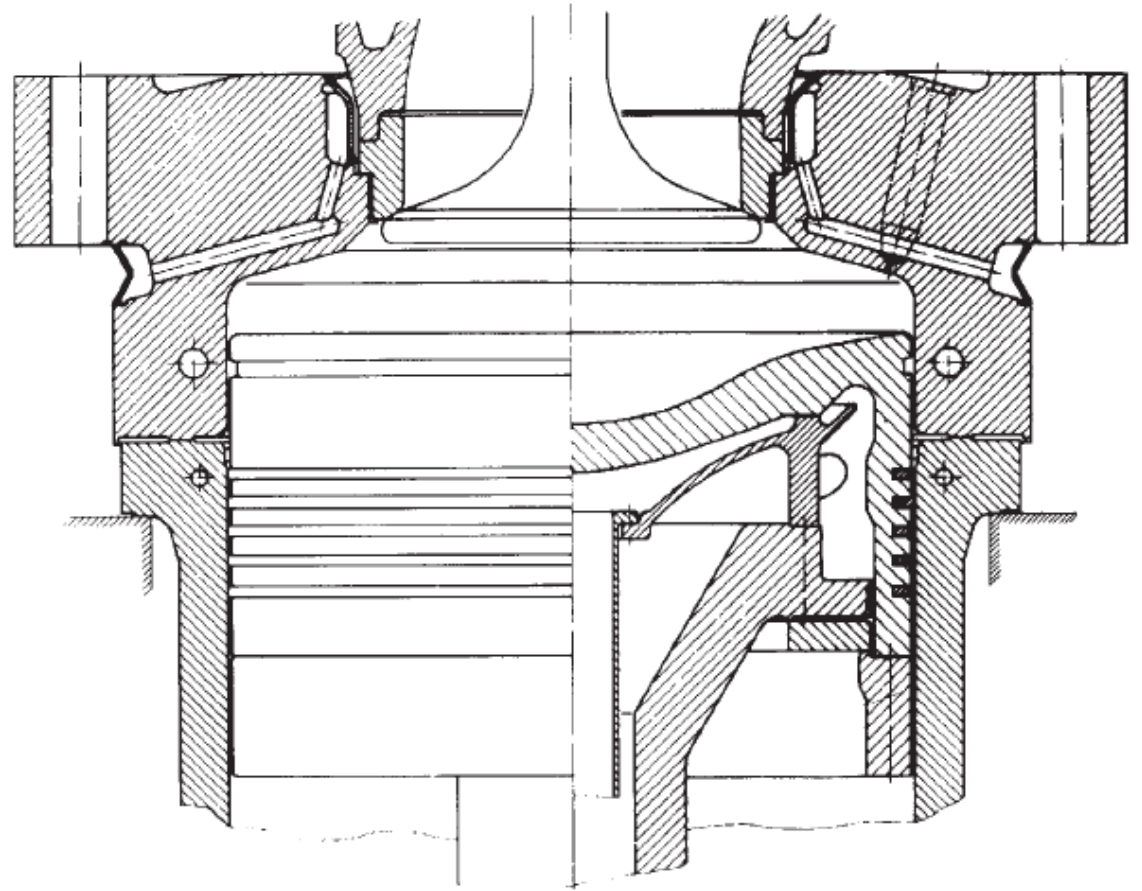
VIII

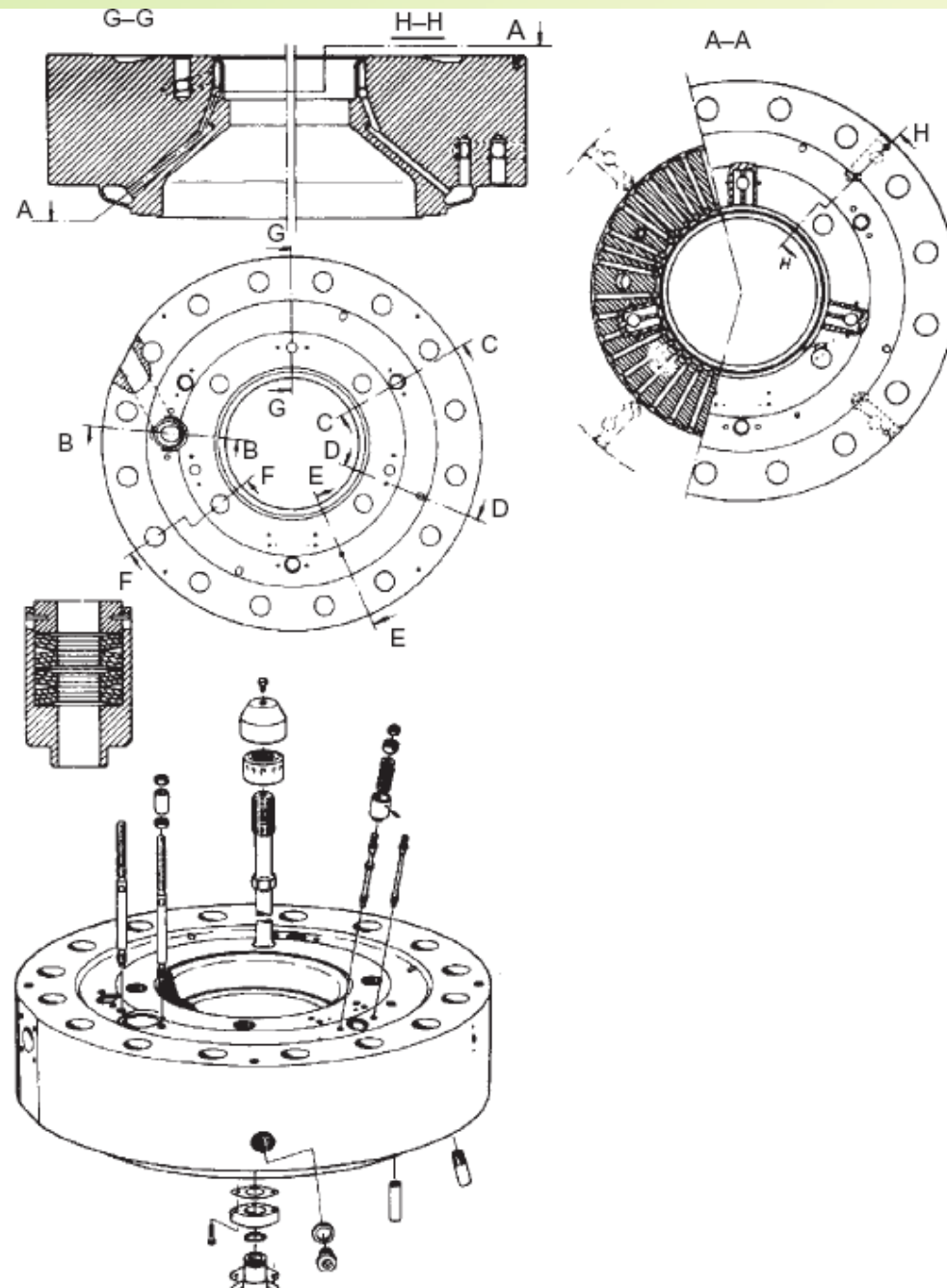
Prof.dr.sc. Ivica Šegulja

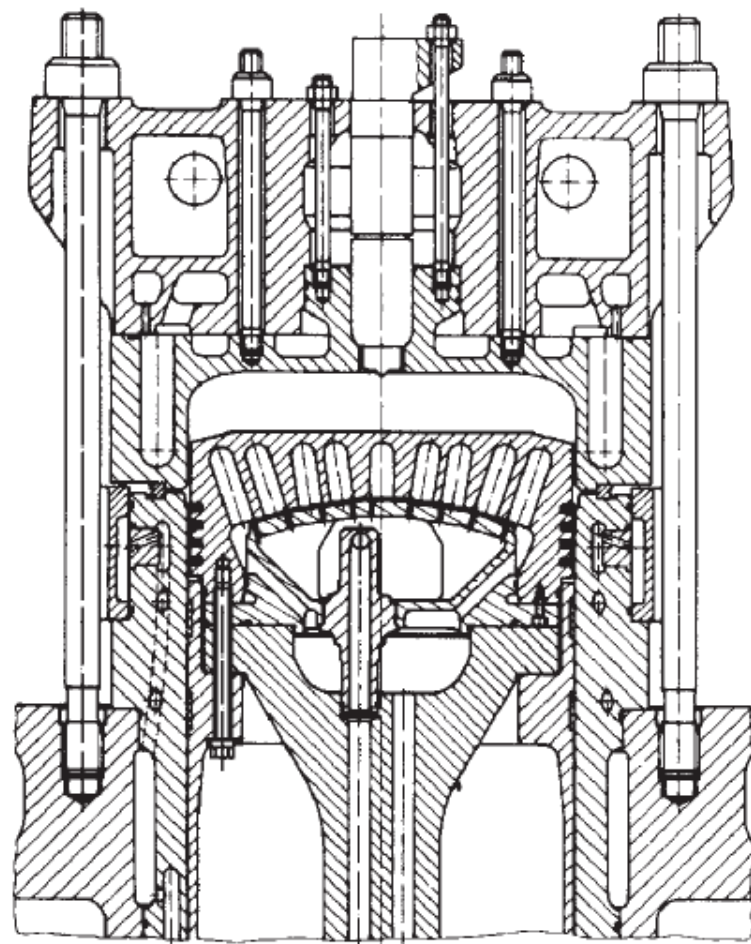
GLAVA MOTORA - POKLOPAC CILINDRA

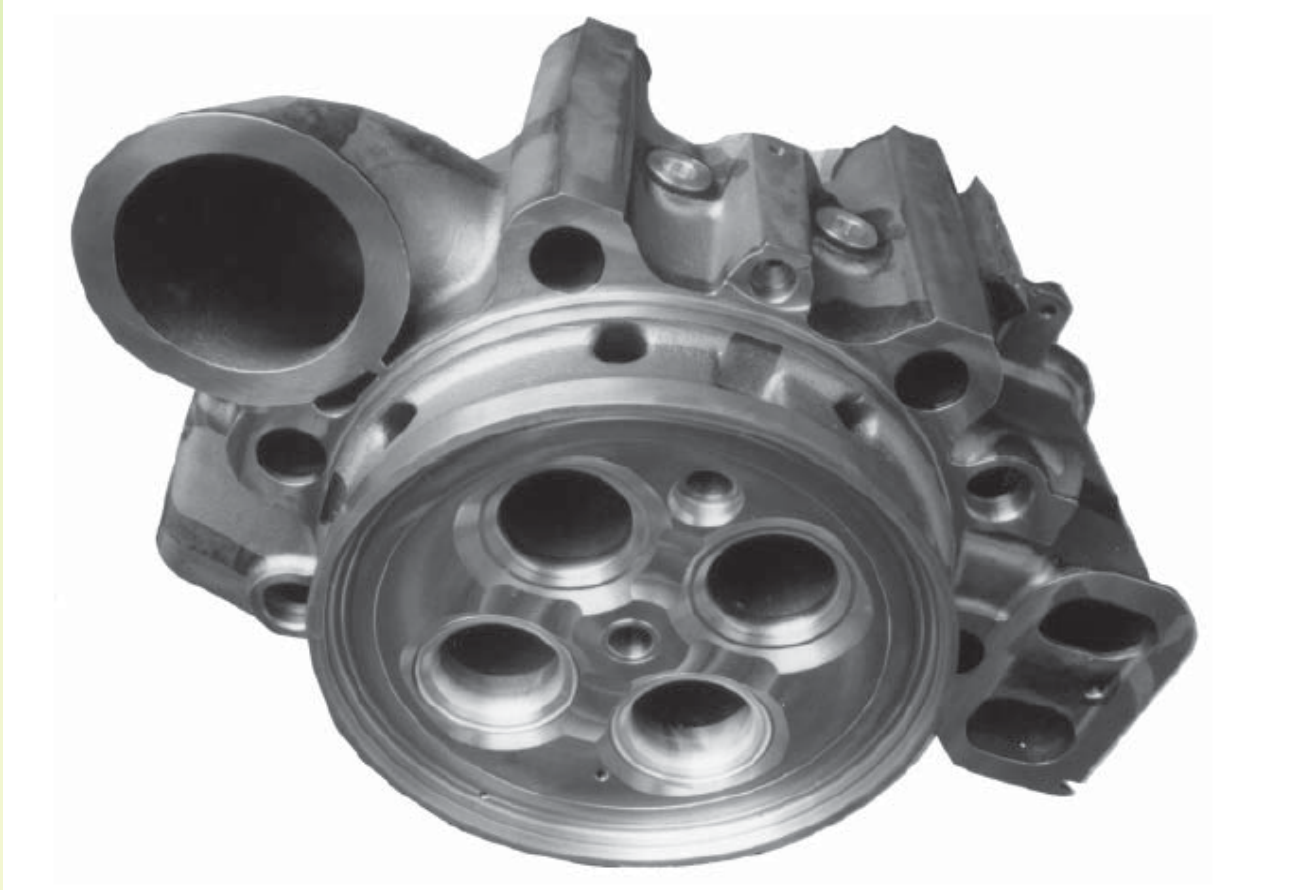


- Nepropusno zatvara kompresioni prostor.
- Mehanički i toplinski opterećen.
- Pojedinačna i grupna izvedba.
- + lakši motor
- + manji motor
- - kvar na jednom cil. zaustavlja cijeli motor
- Unutarnji oblik je najvažniji (prostor za izgaranje).
- Materijali :
 - - lijevano željezo
 - - čelični lijev
 - - kovani čelik
 - - AL legure









- armatura glave:
- uputni ventil
- sigurnosni ventil
- indikatorski pipac
- rasprskič
- ispušni kavez

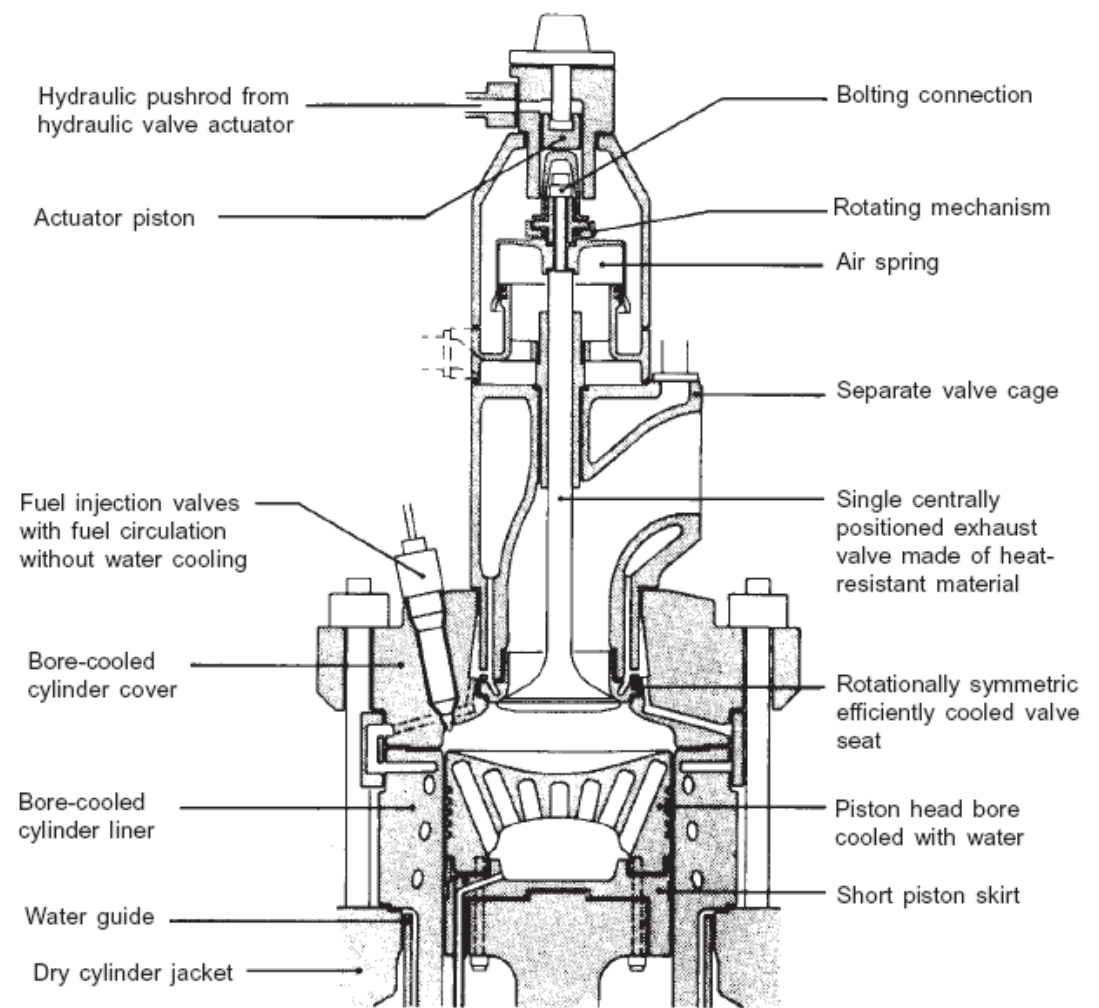
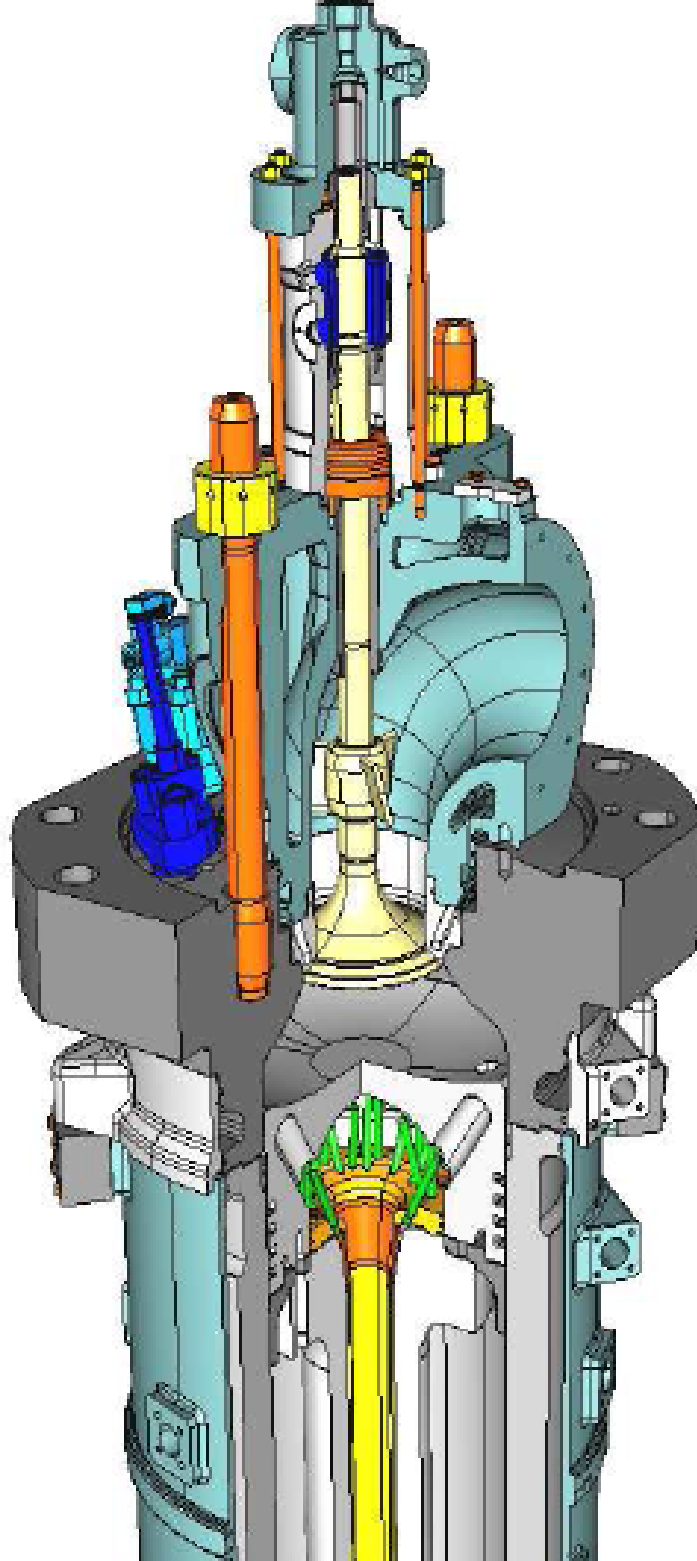
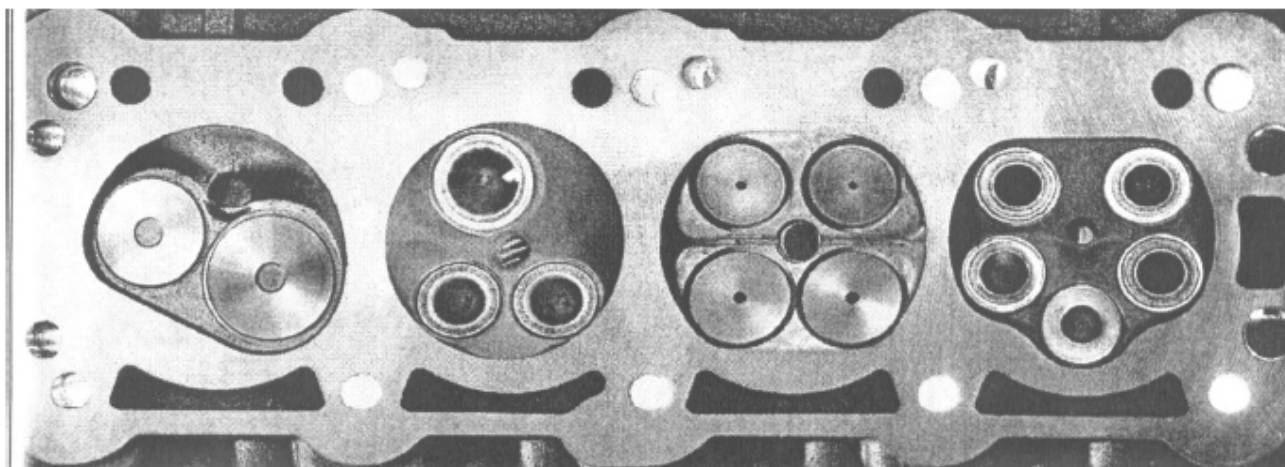


Figure 12.2 RTA engine combustion chamber components



Dva ventila

Usisni ventil je značajno veći, svjećica je izvan središta

Tri ventila

Oba usisna ventila su manjeg promjera, svjećica je u središtu

Četiri ventila

Vrlo kompaktni prostor izgaranja, veći presjeci ventila, svjećica je u središtu

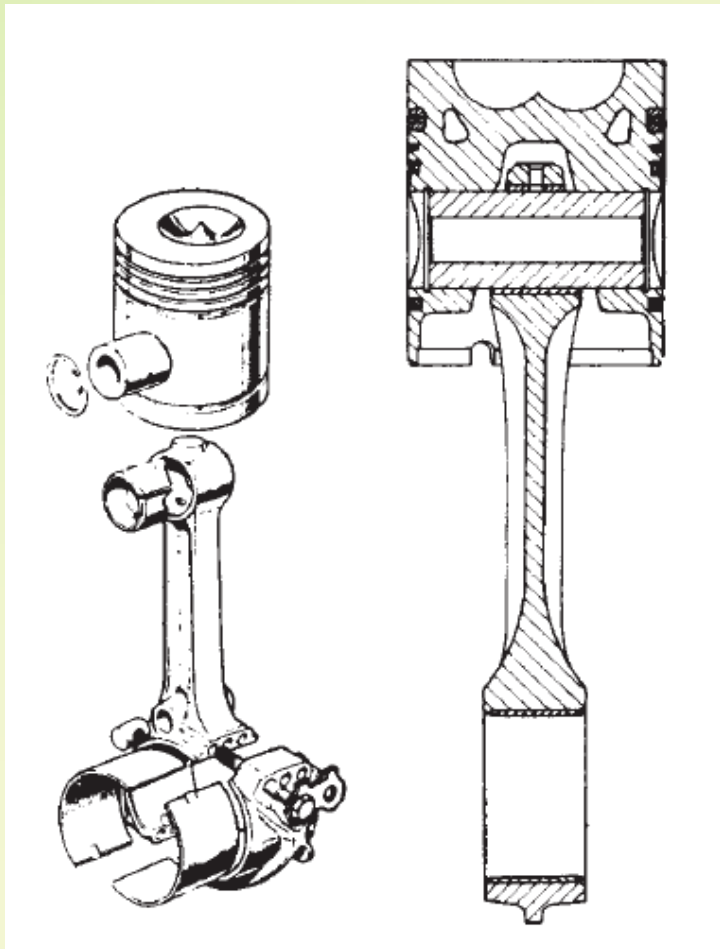
Pet ventila

Povećani broj ventila jedva da može iskoristiti raspoloživu površinu cilindarske glave

Slika 3.71 Izvedbe s različitim brojem ventila po jednom cilindru (eksperiment)

OJNICA - KLIPNJAČA

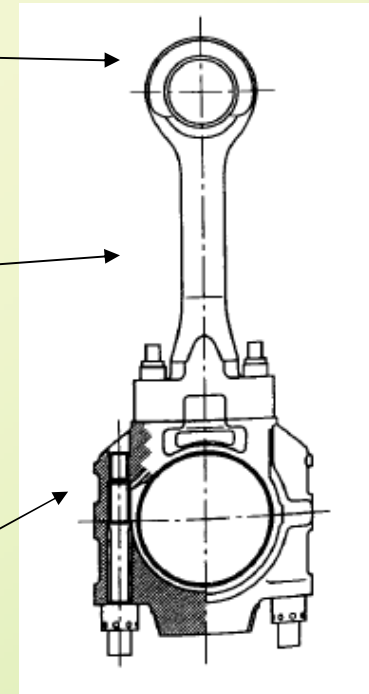
Prenosi silu s osovinice klipa ili od osnjaka križne glave na rukavac koljenaste osovine.



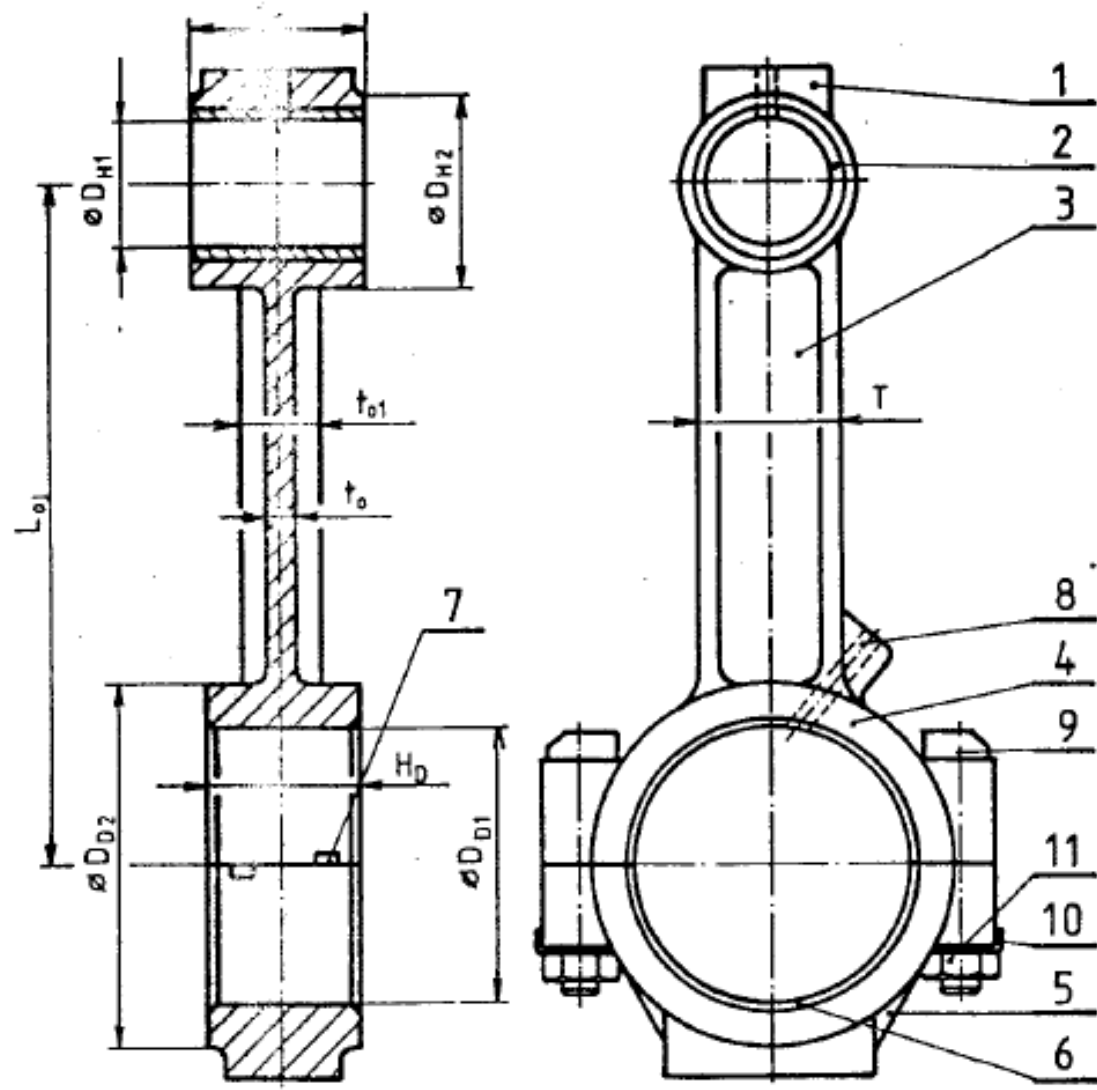
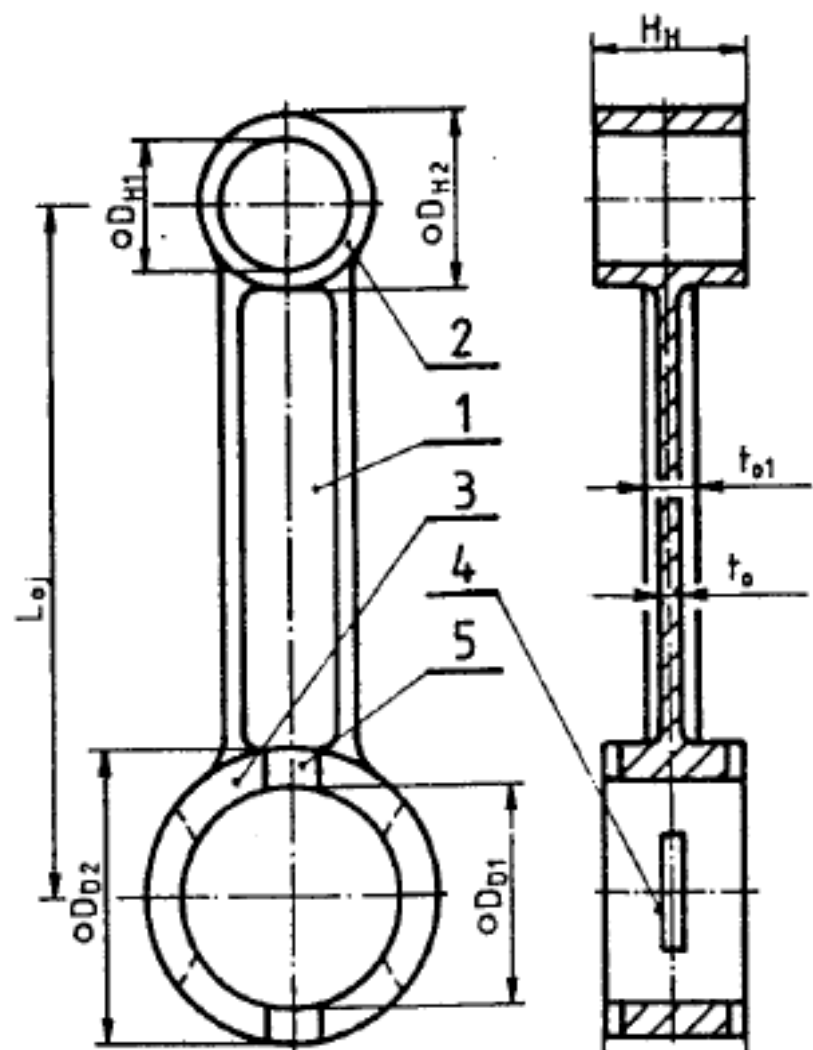
Gornja glava ojnice

Tijelo ojnice

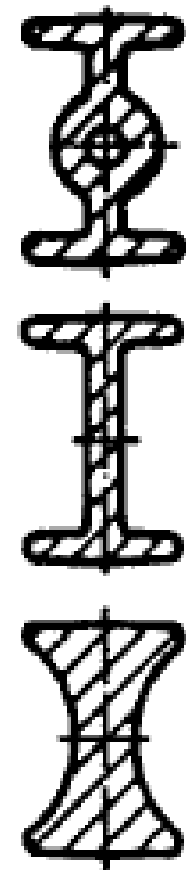
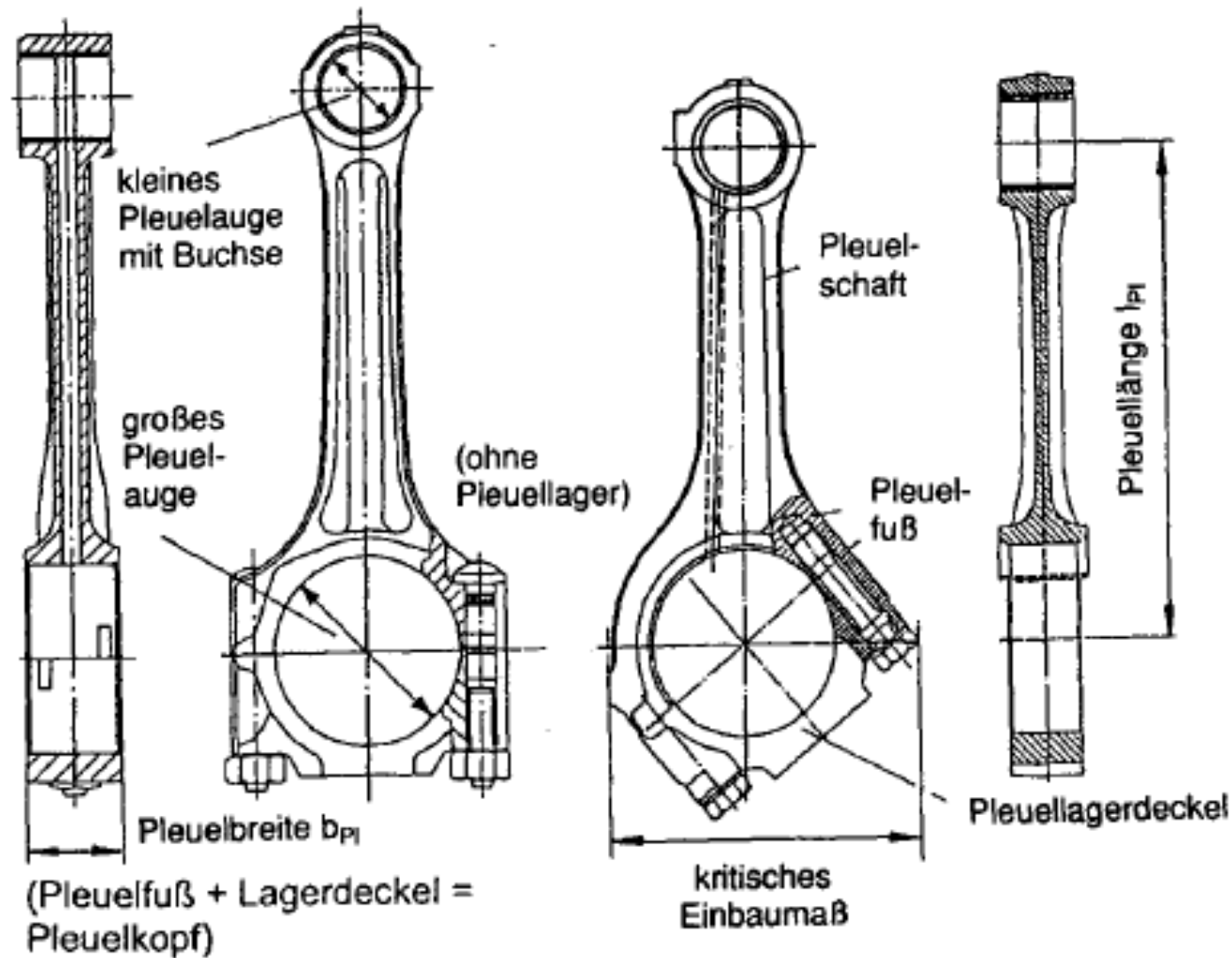
Donja glava ojnice

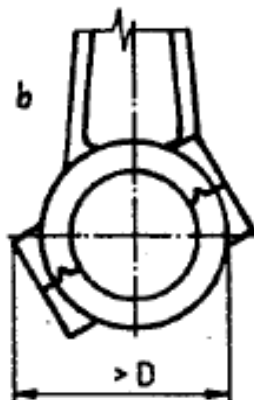
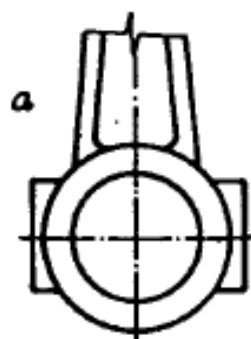
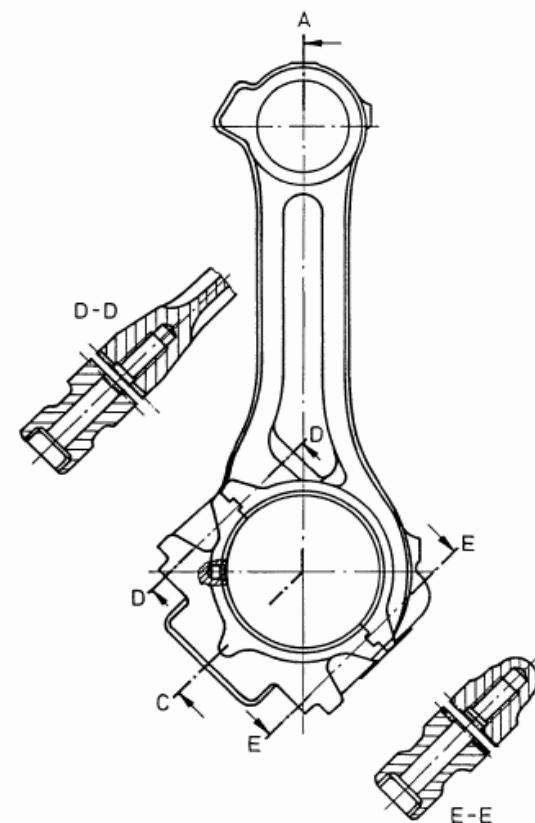
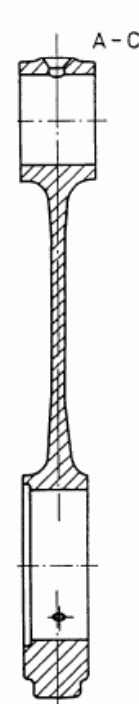
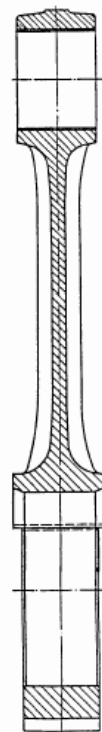
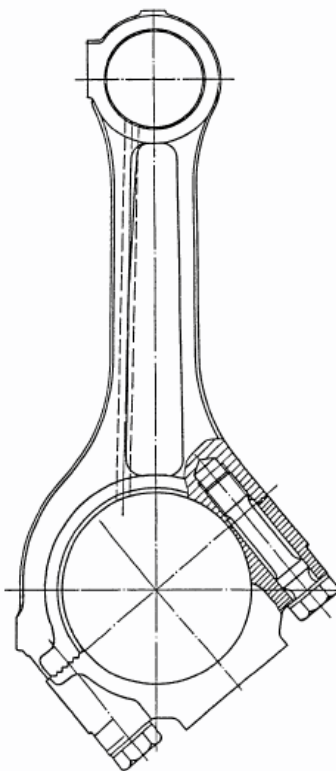
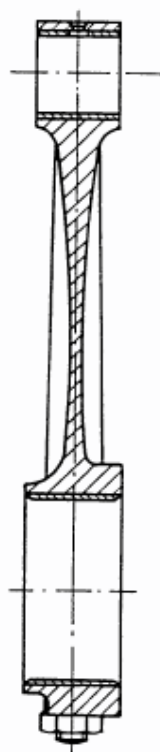
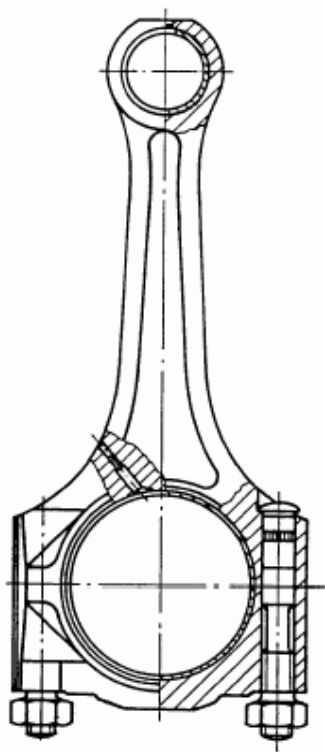


Kovani čelik
Al legure



OJNICE MALIH MOTORA

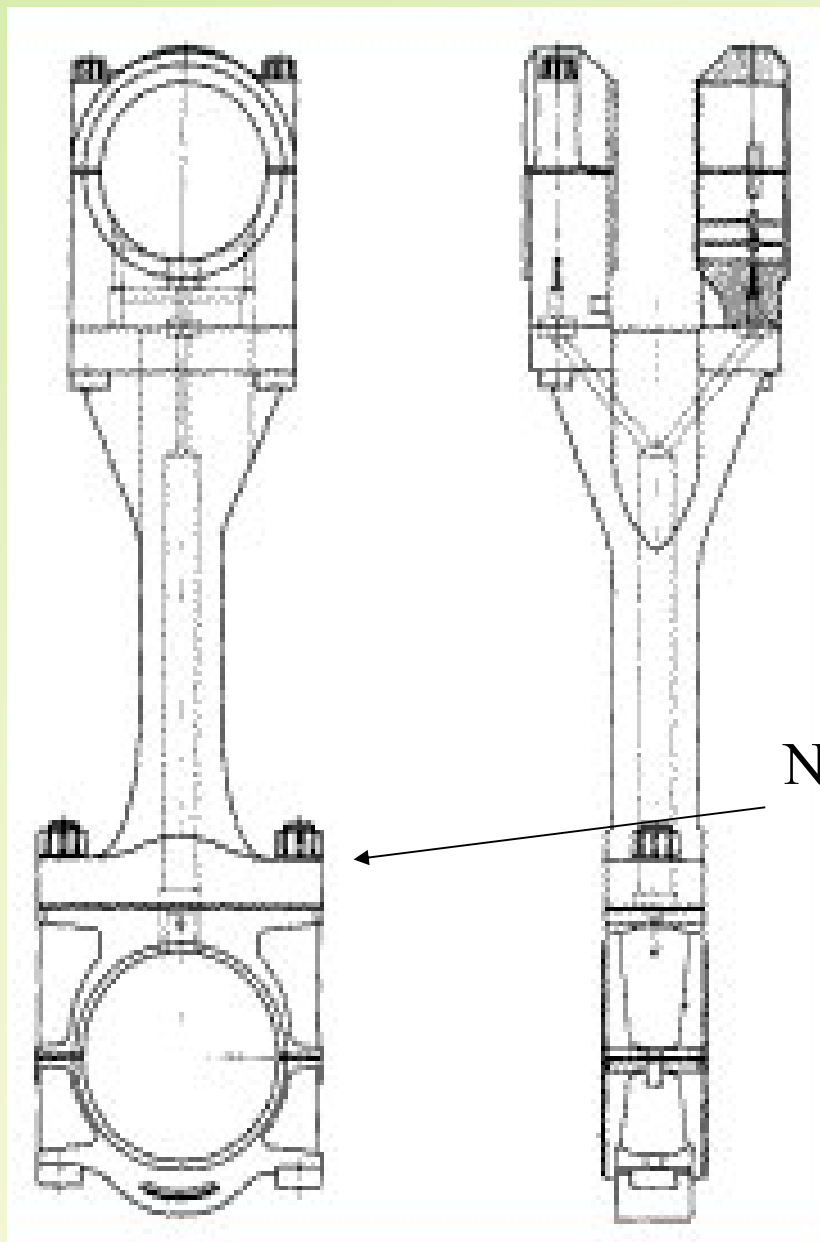




Izvedbe ojnica

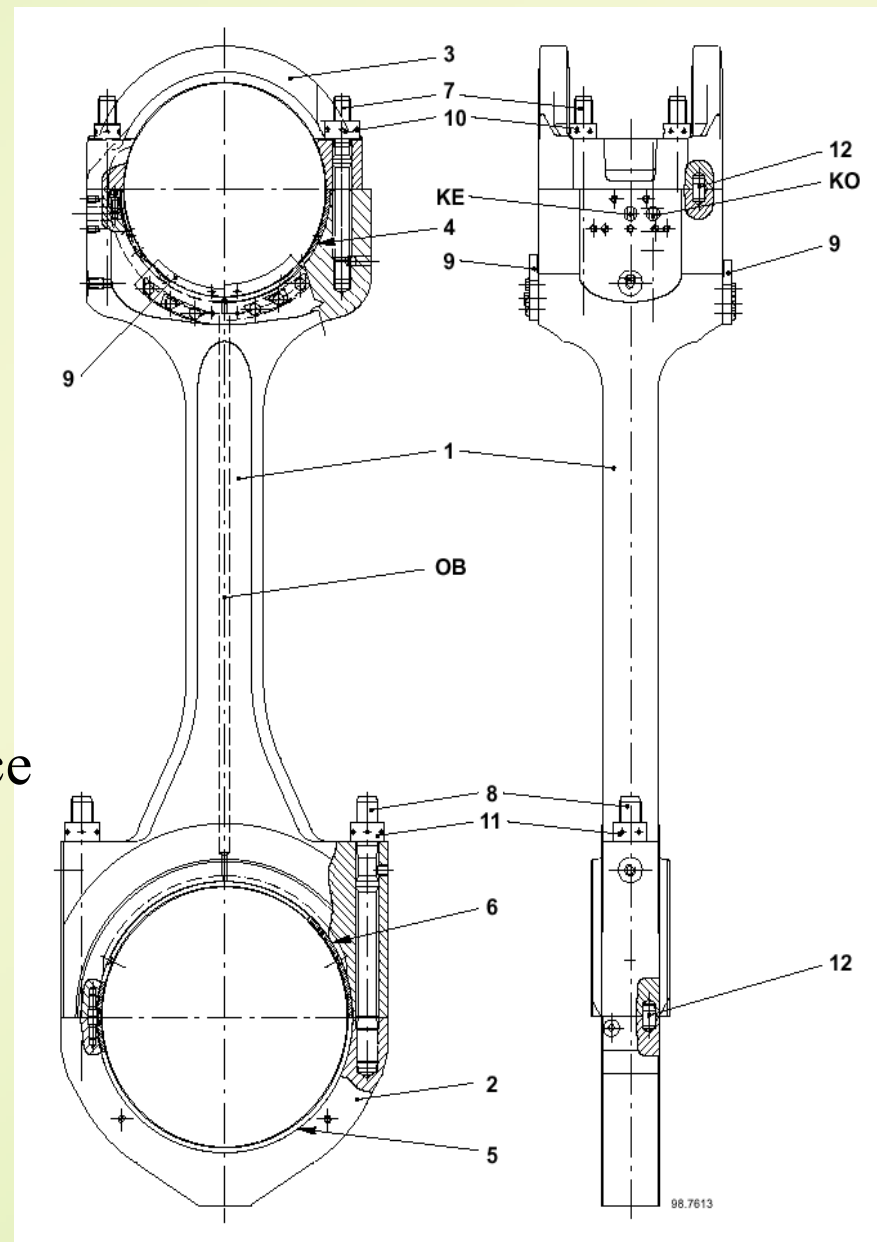


OJNICE VELIKIH MOTORA

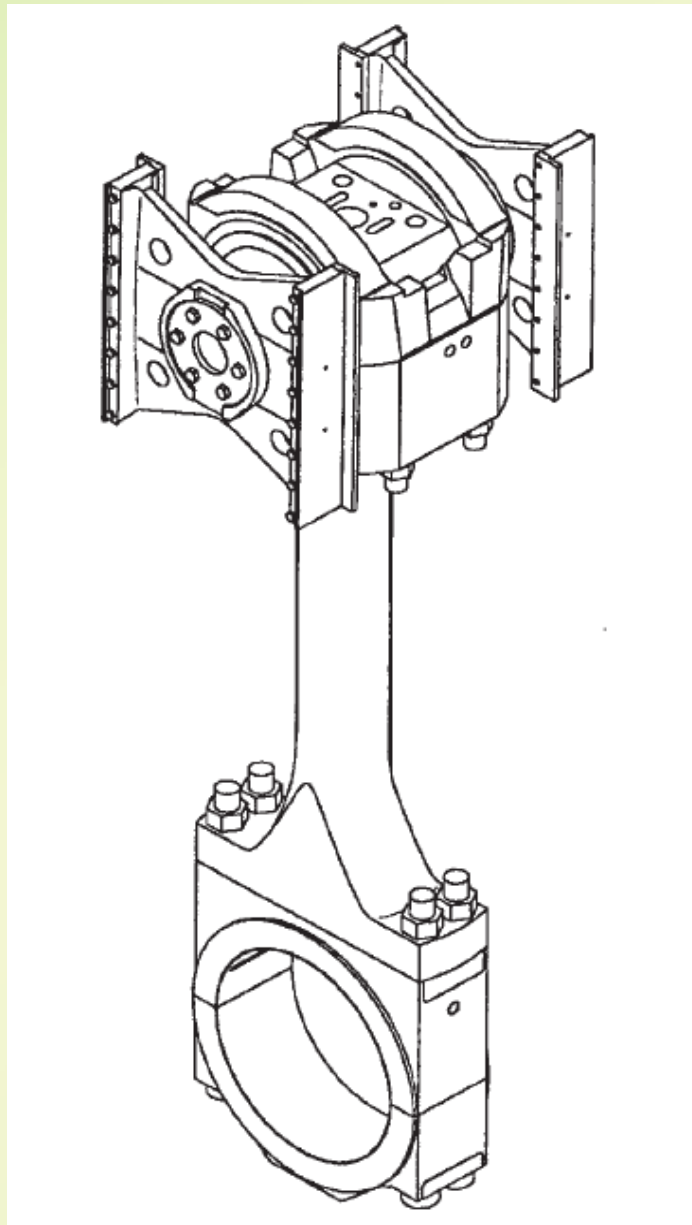


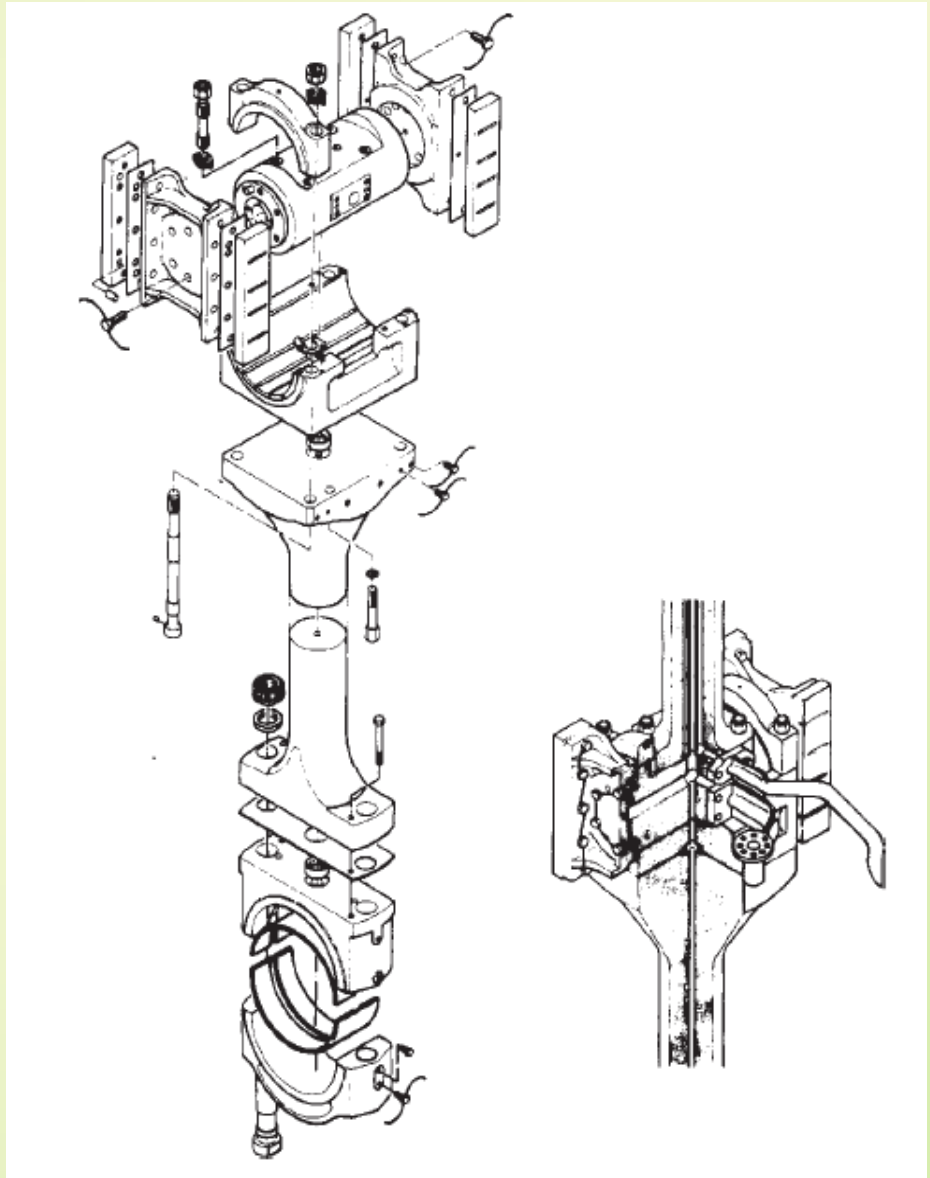
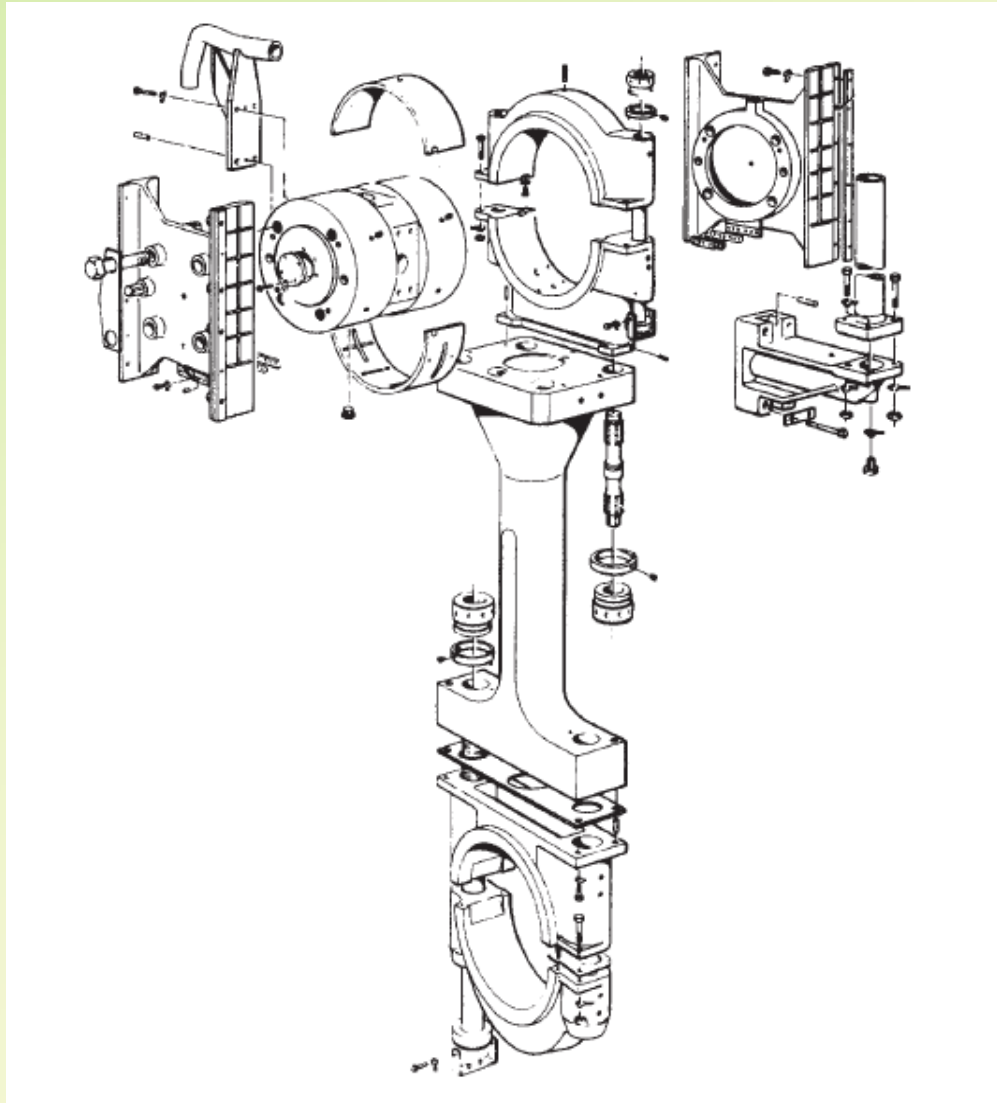
Noga ojnice

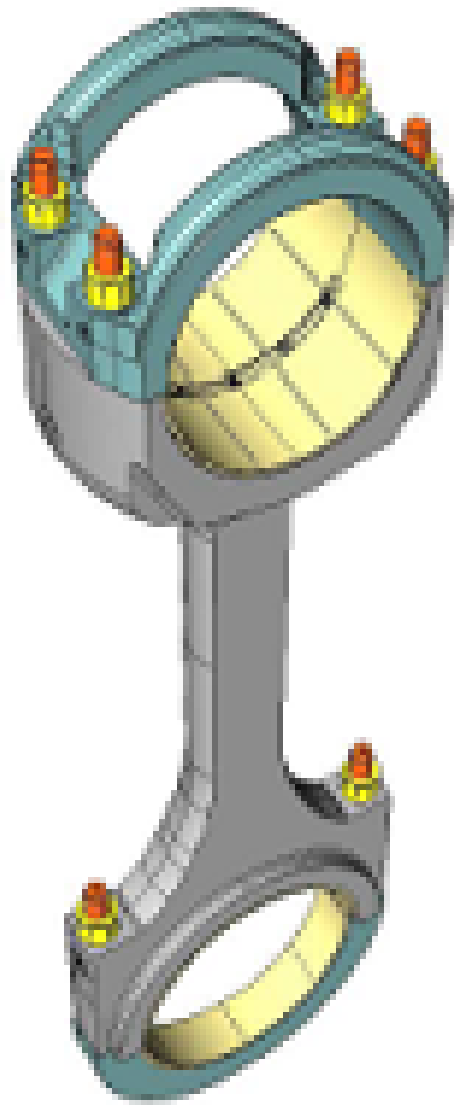
Viličasta izvedba



Izvedba s cijelom površinom ležaja

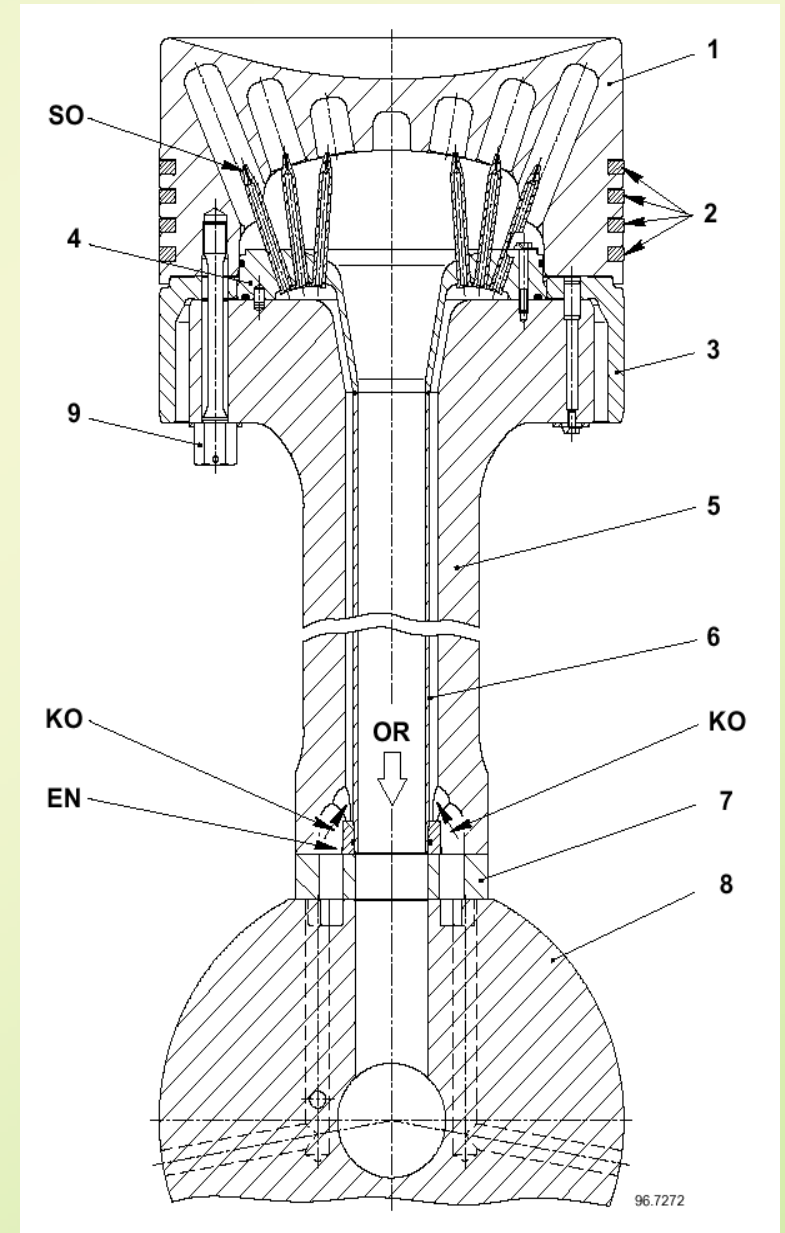






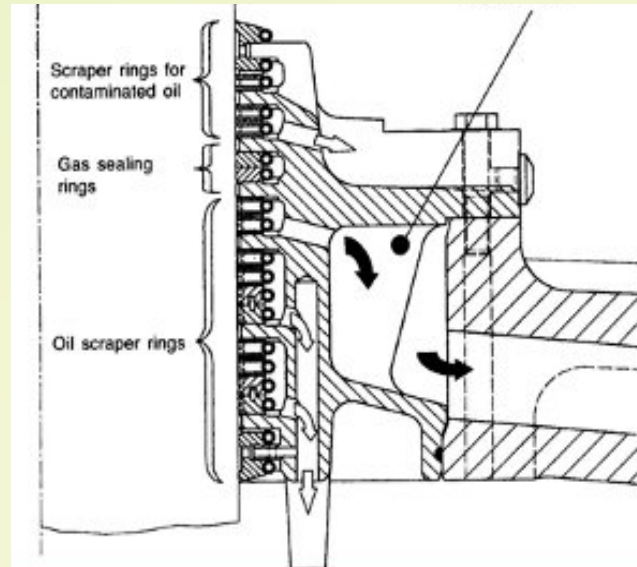
STAPAJICA

- Samo kod motora s križnom glavom.
- Spaja stap i križnu glavu.



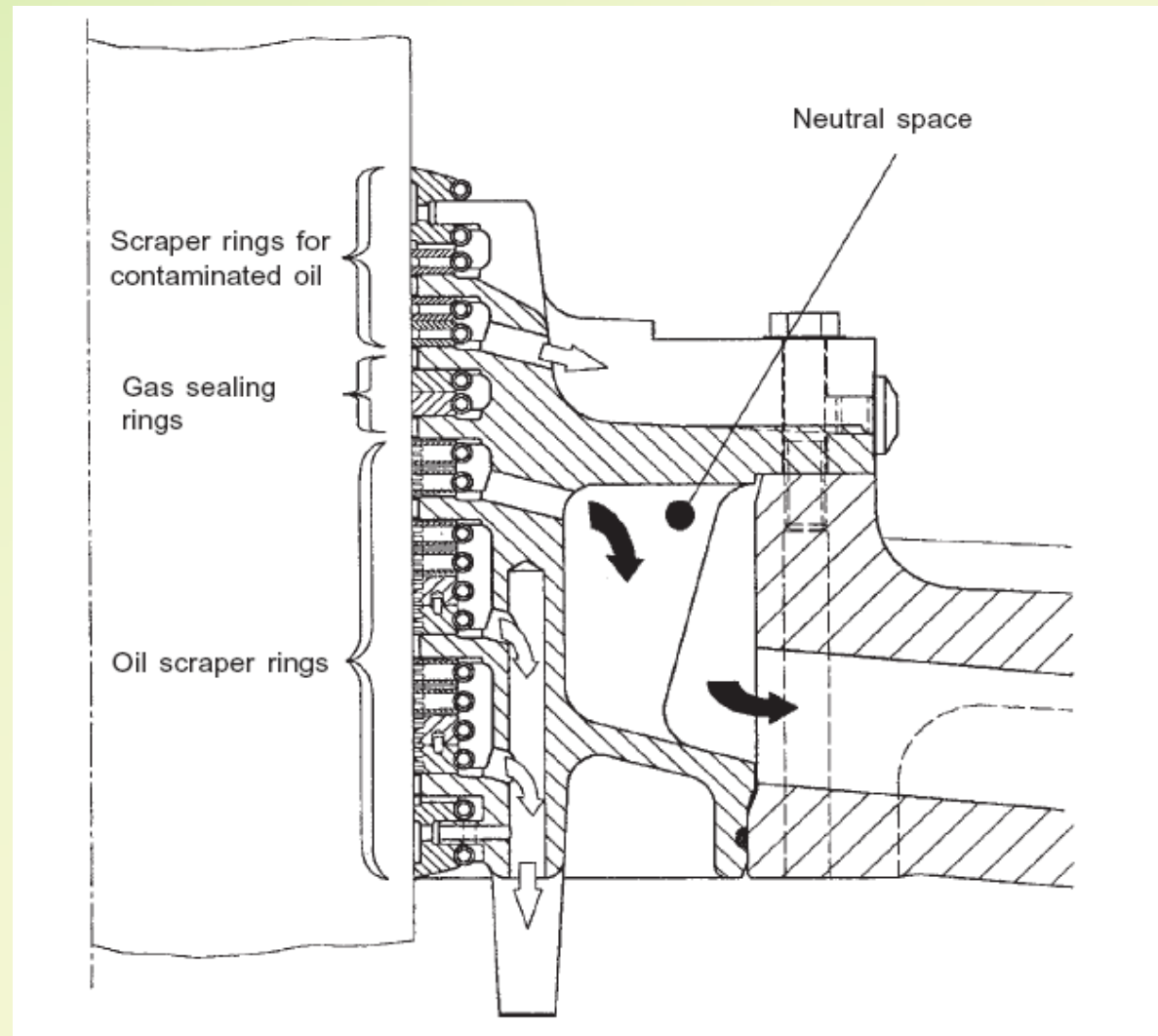
BRTVENICA - ŠUPERNICA

BRTVENICA STAPAJICE



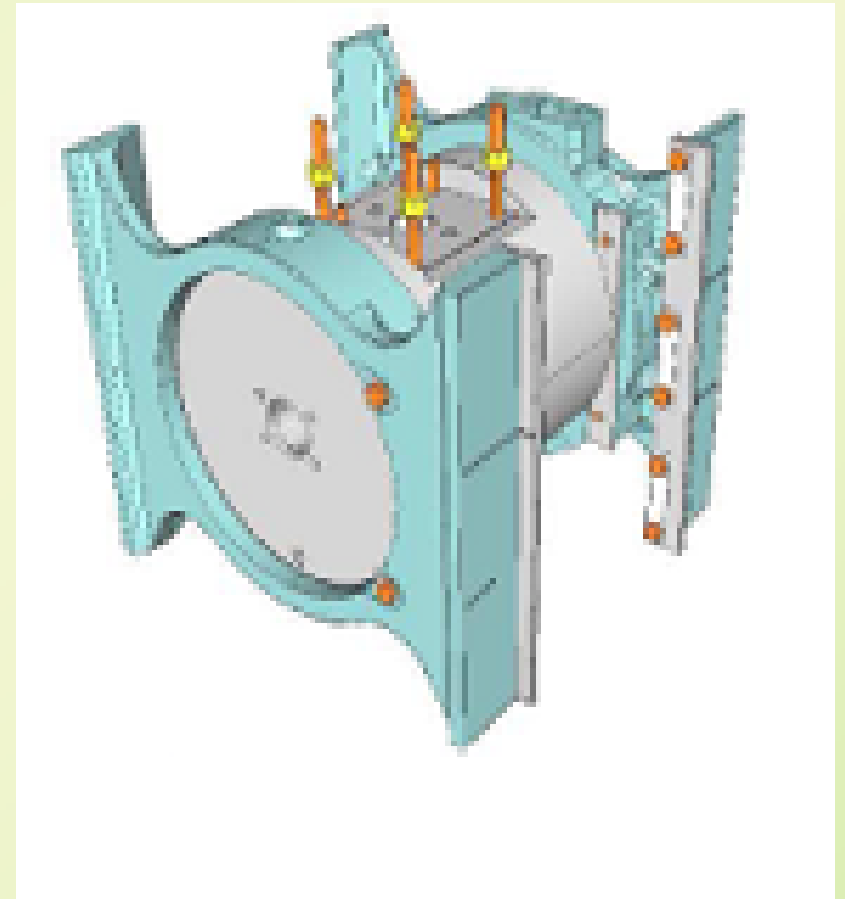
Brtvenica odvaja prostor ispod stapa od ostalog prostora kućišta motora:

- sprečava prolaz ispirnog zraka u kućište
- sprečava prolaz prljavog cilindarskog ulja u kućište motora
- sprečava prolaz ulja za podmazivanje iz kućišta motora u prostor ispod stapa

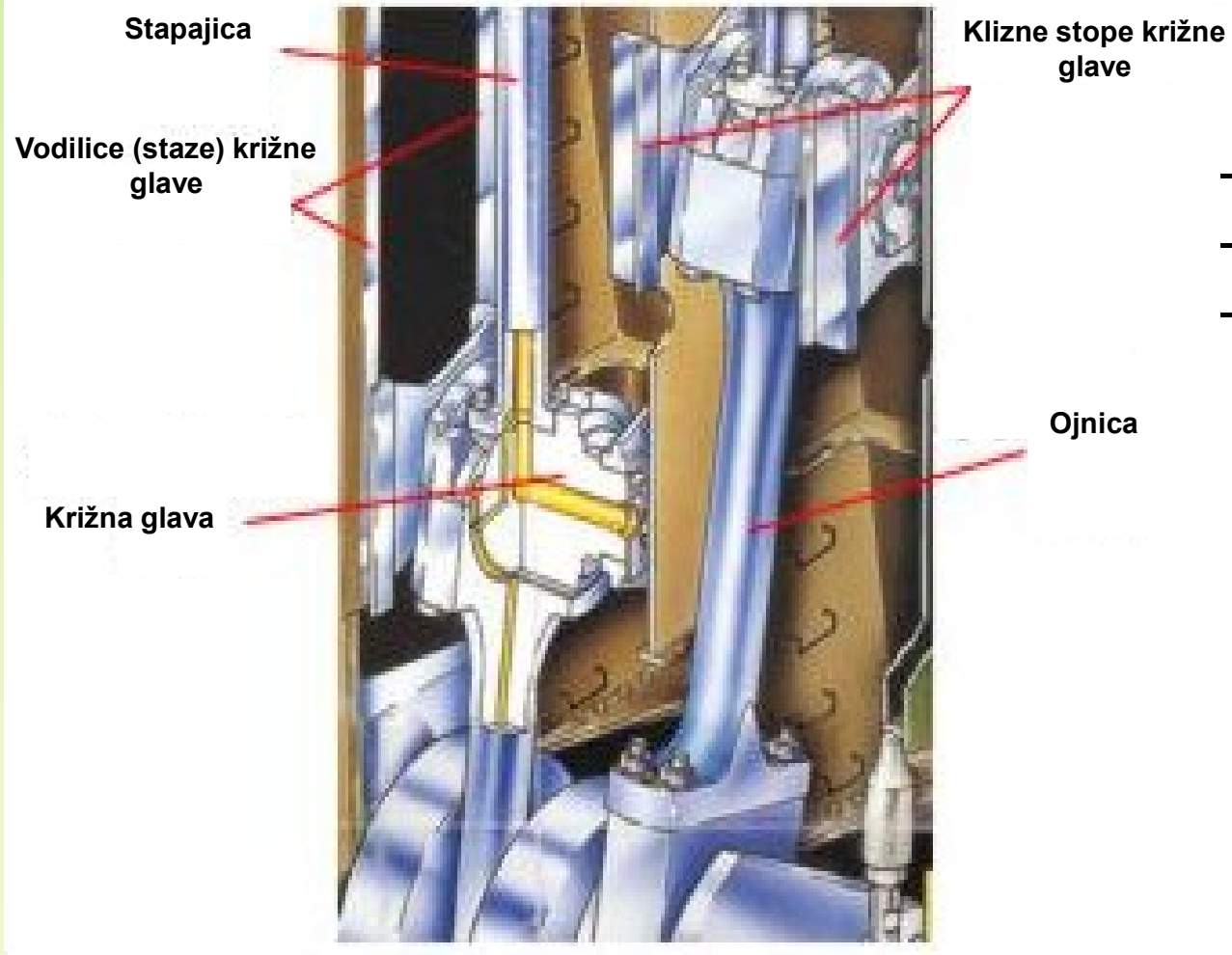


KRIŽNA GLAVA

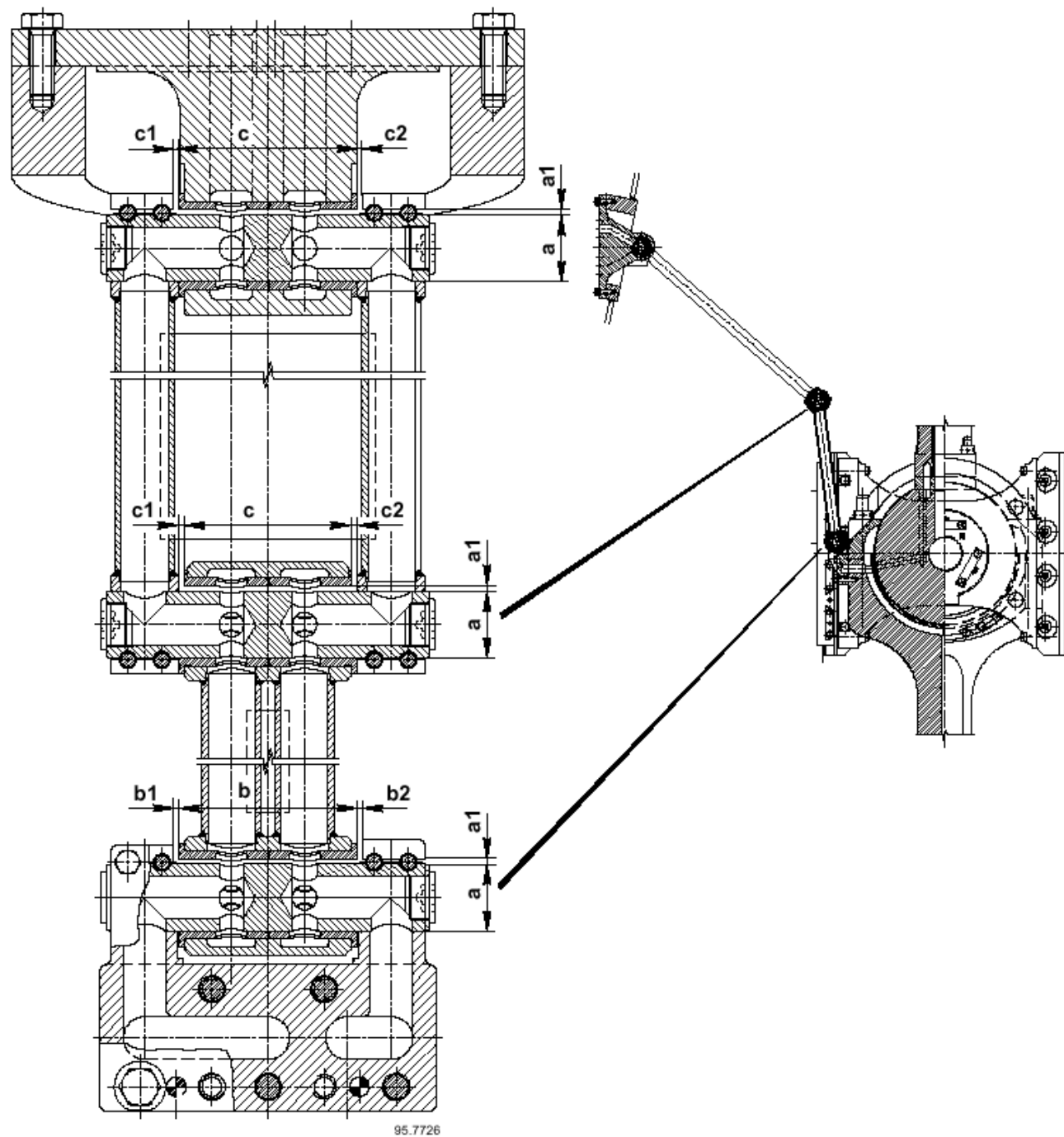
- Predstavlja zglobni spoj između stapajice i ojnice. Preuzima silu stapajice i prenosi ju ojnici. Bočne sile prenosi preko kliznih papuča na klizne staze. Klizne staze se nalaze na stalcima kućišta motora.
- Ležaj KG se danas izvodi kao STATIČKI LEŽAJ (12 bara).
- Materijali :
 - - osnjak - kovani čelik
 - - papuče i staze - sivi lijev
- Posebni sustav podmazivanja (hladenja).



KRIŽNA GLAVA



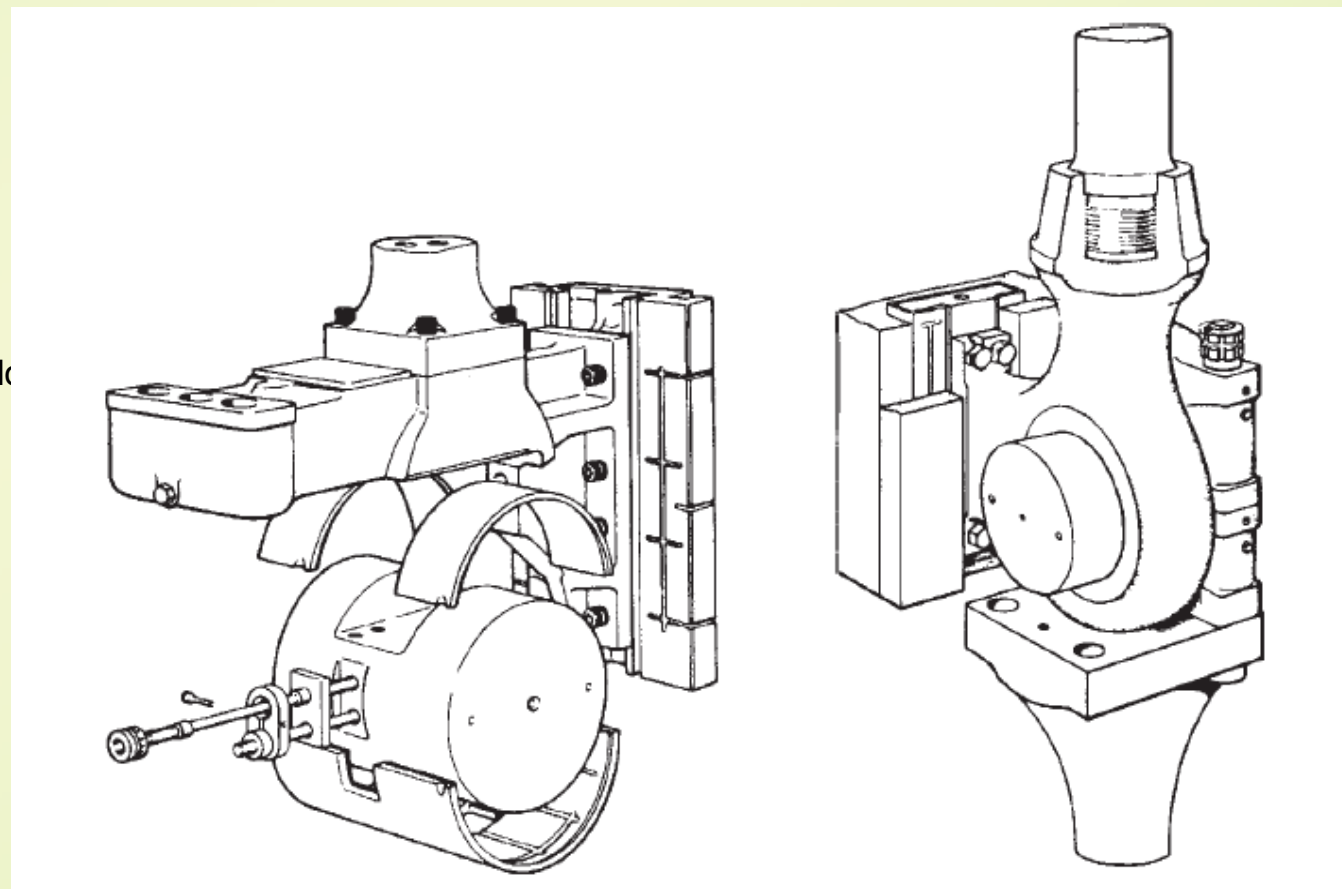
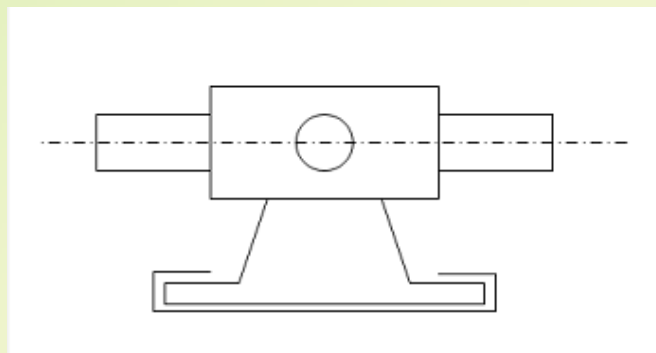
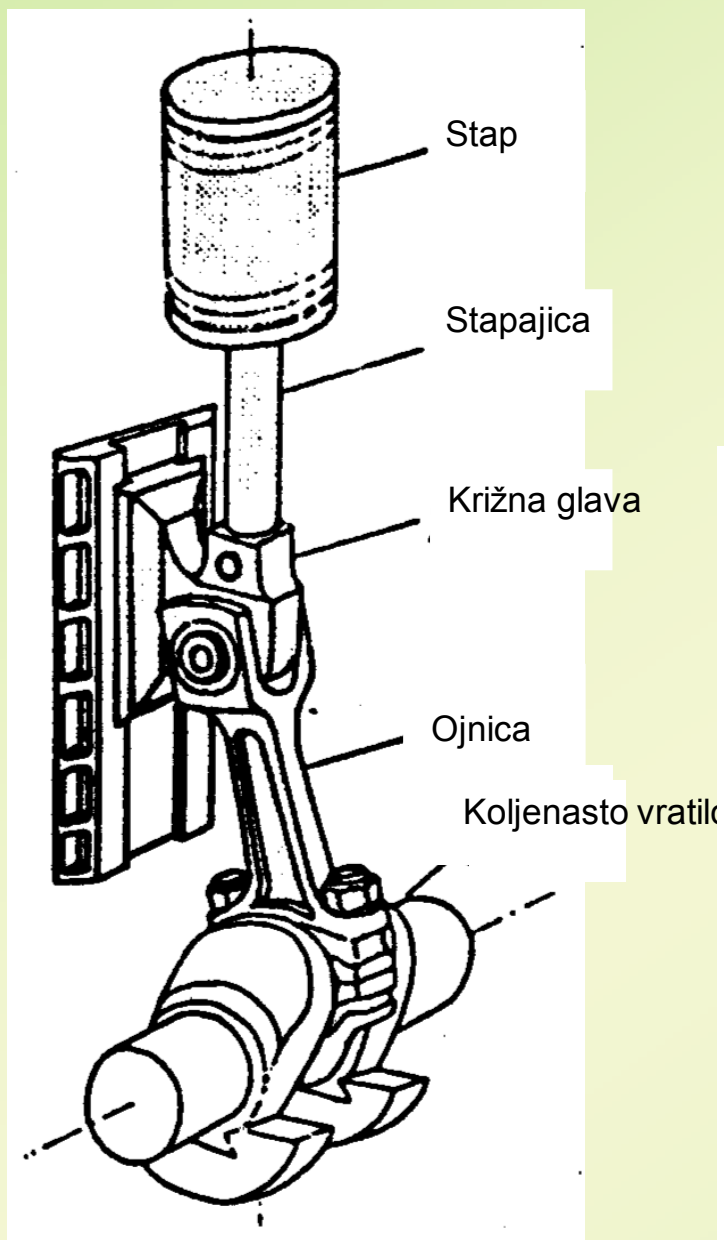
- “kocka” križne glave
- osnjaci gornjeg ležaja ojnice
- osnjaci kliznih stopa



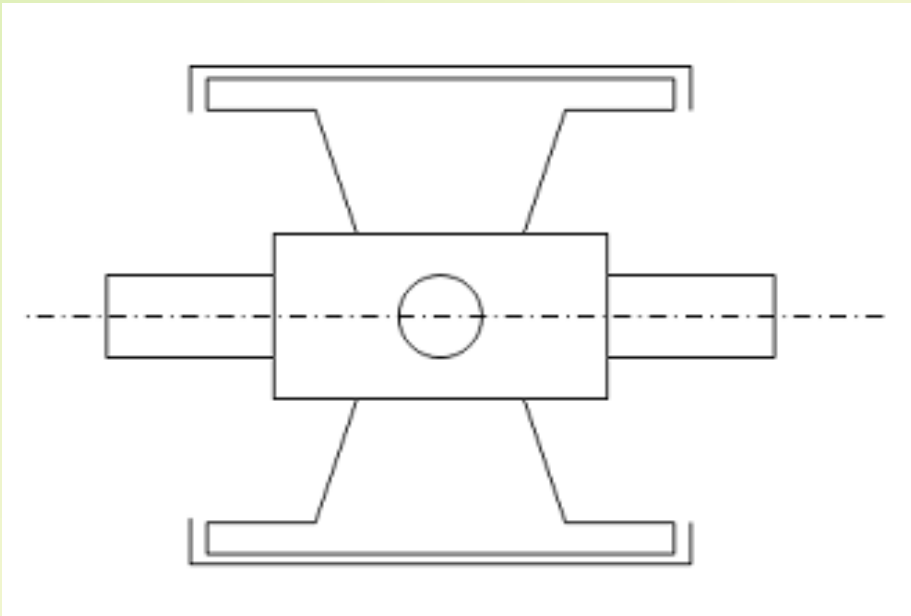
95.7726

Zglobne cijevi za dovod
ulja na križnu glavu

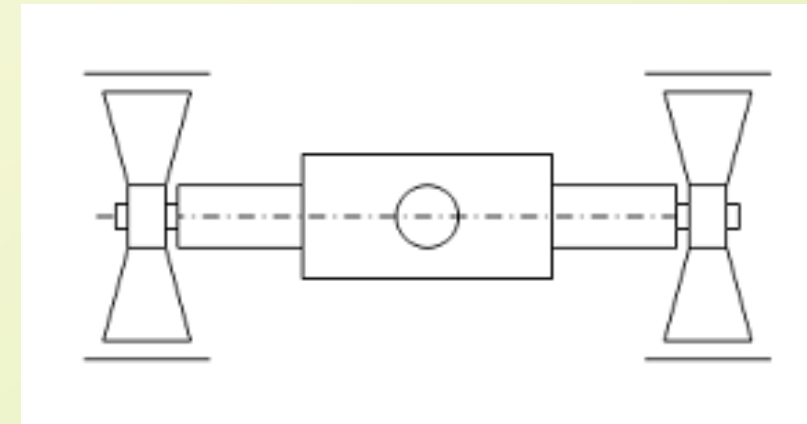
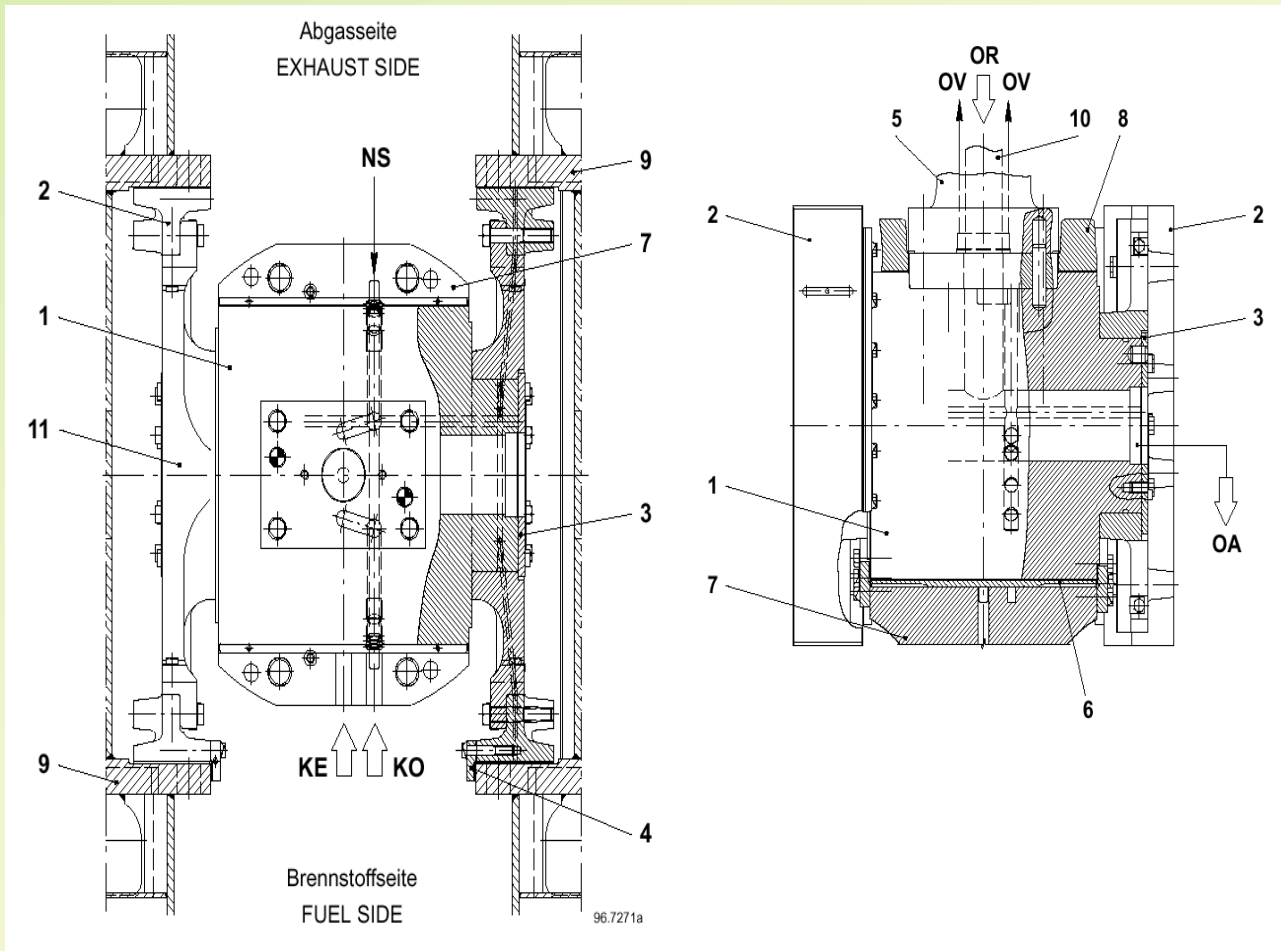
Jednostrano vođenje KG



Dvostrano vođenje KG

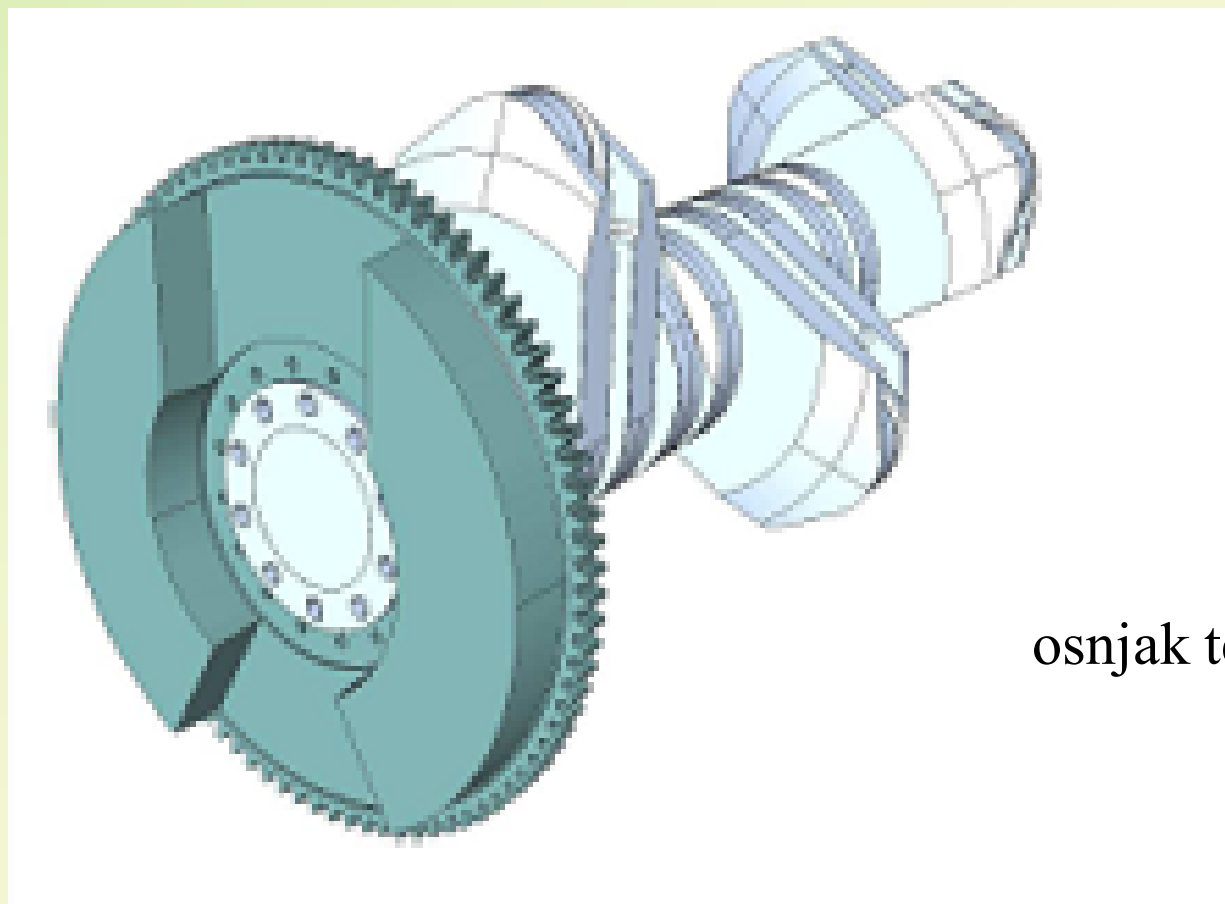


Četverostrano vođenje KG

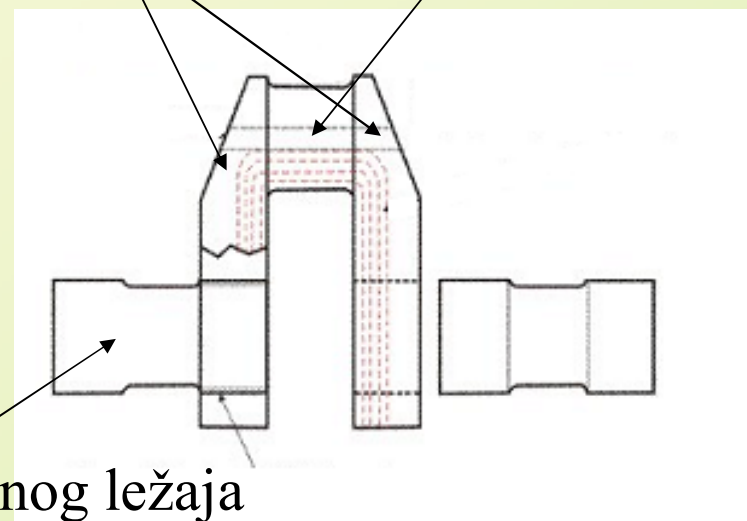


KOLJENASTA OSOVINA

Pretvara translatorno kretanje klipa (stapa) u okretno gibanje i prenosi rezultirajući moment na prirubnicu.

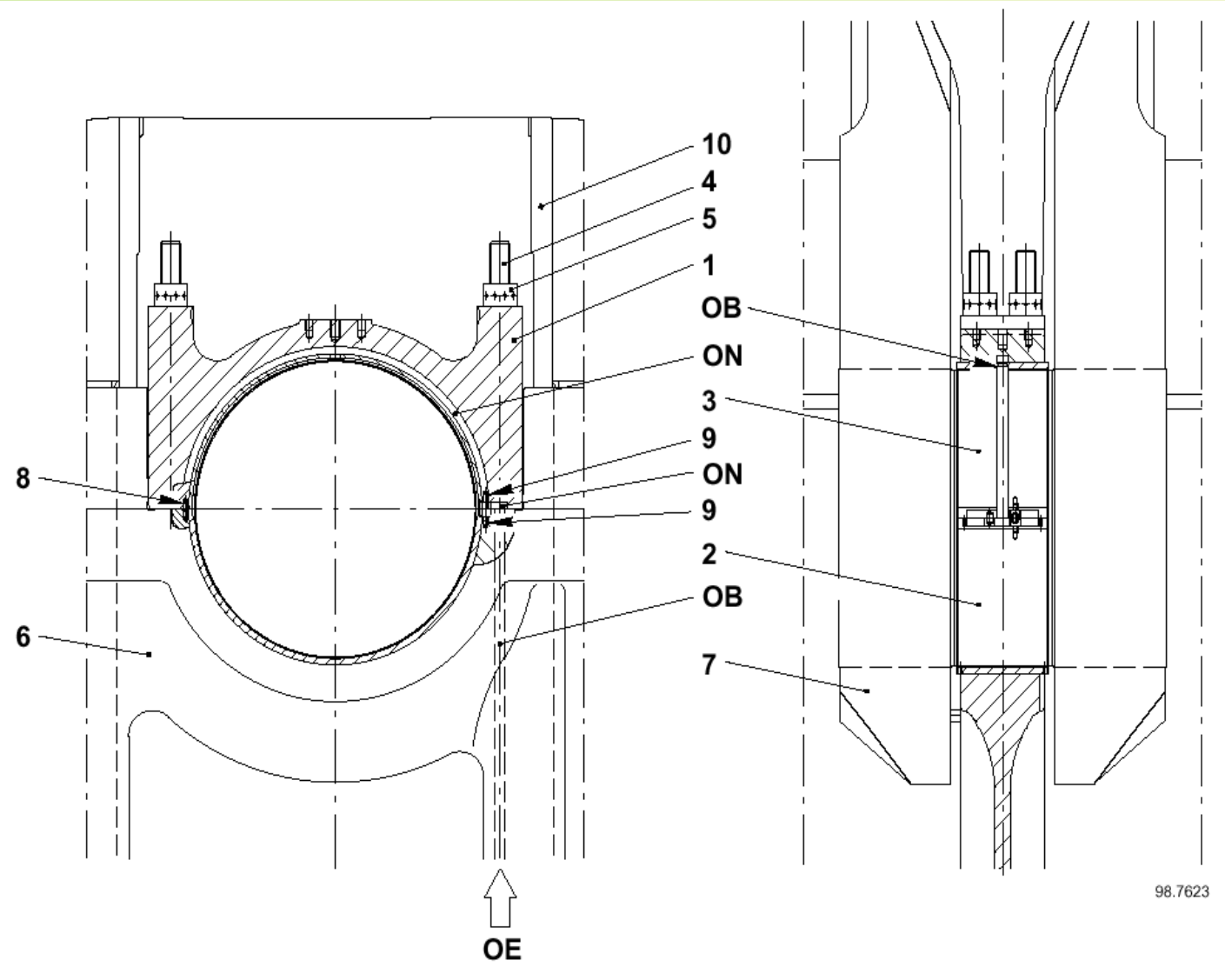


osnjak letećeg ležaja
ramena, koljena

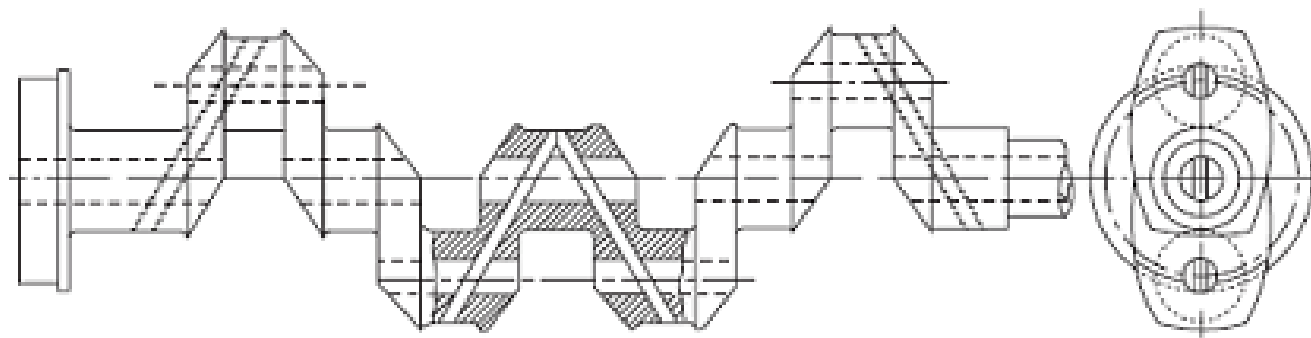
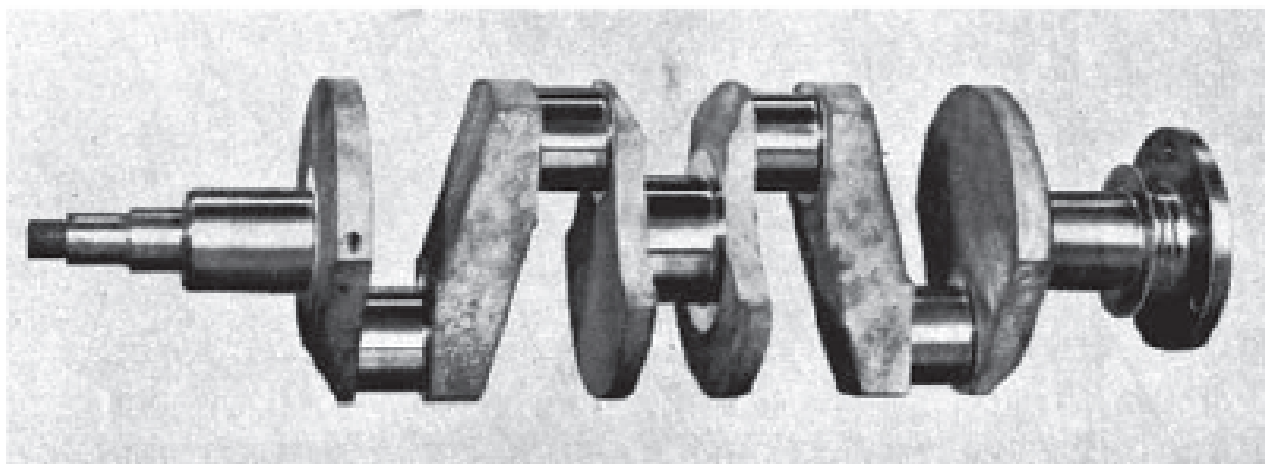


osnjak temeljnog ležaja

Stezni preklopni spoj glavnog
rukavca i kovanog ramena koljena



Koljeničasta osovina leži u temeljnim ležajima



Par temeljnih ležaja po cilindru ili par tem.ležaja na par cilindara

Kutni pomak - najčešće simetričan, a ovisi o broju cilindara i taktnosti.

Red paljenja - kutno ujednačen, ali nikada dva susjedna cilindra

A.) četverotaktni redni motor

Broj cilindara	Razmještaj rukavca vratila	Kutni razmak paljenja	Redosljed paljenja cilindara
2		2π (360°)	1-2
2		$\pi, 3\pi$ (180°; 540°)	1-2
3		$4\pi/3$ (240°)	1-2-3 ili 1-3-2
4		π (180°)	1-3-4-2 ili 1-2-4-3
6		$2\pi/3$ (120°)	1-5-3-6-2-4 ili 1-4-2-6-3-5

C.) dvotaktni redni motor

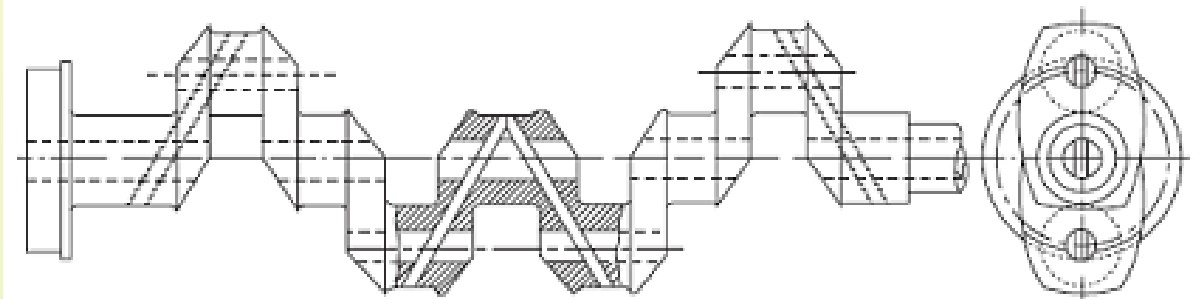
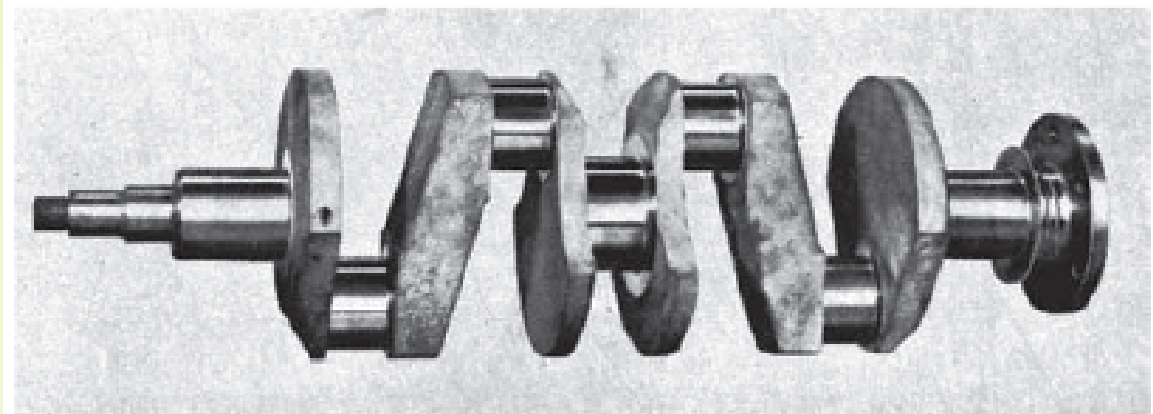
Broj cilindara	Razmještaj rukavca vratila	Kutni razmak paljenja	Redosljed paljenja cilindara
2		π (180°)	1-2
3		$2\pi/3$ (120°)	1-3-2 ili 1-2-3
4		$\pi/2$ (90°)	1-3-4-2 ili 1-2-4-3
6		$\pi/3$ (60°)	1-5-3-4-2-6 ili 1-6-2-4-3-5

Izvedba :

- monolitne (lijevanjem, kovanjem)
- rastavljive

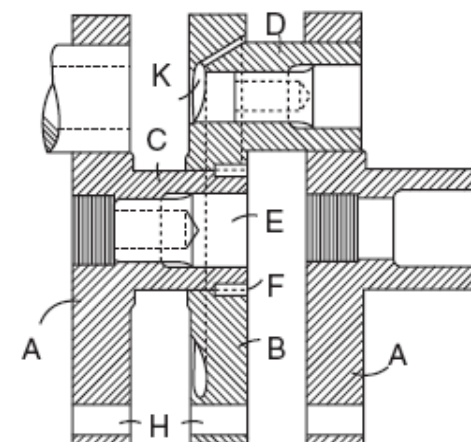
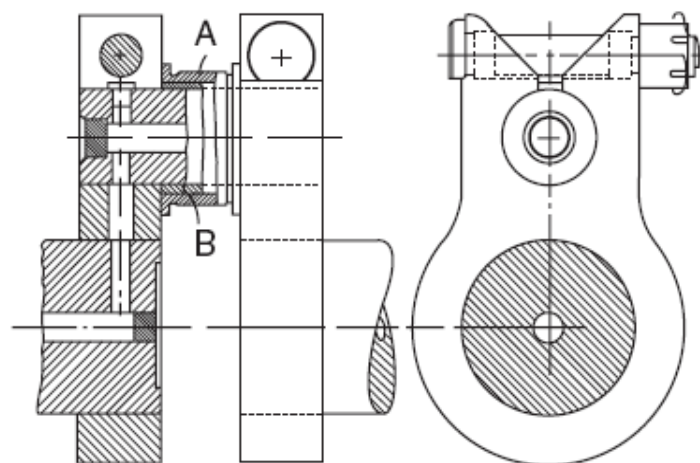
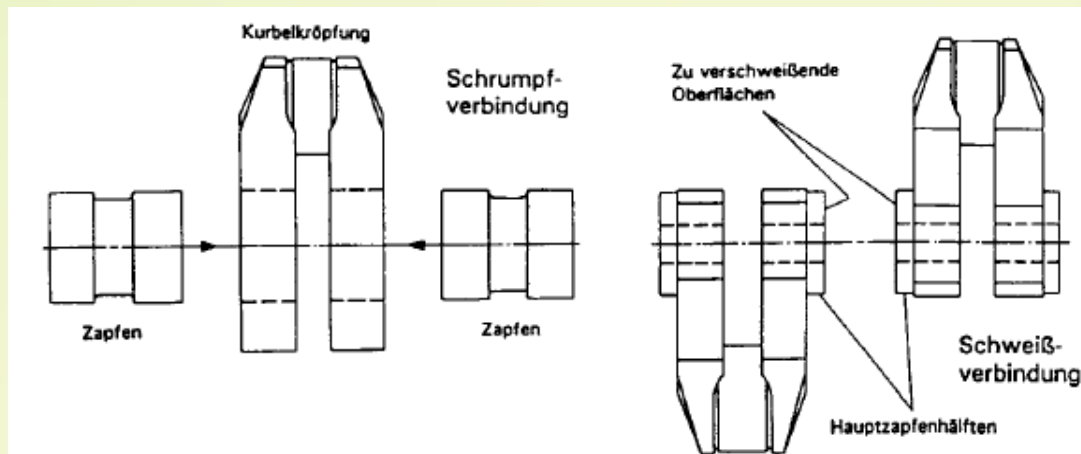
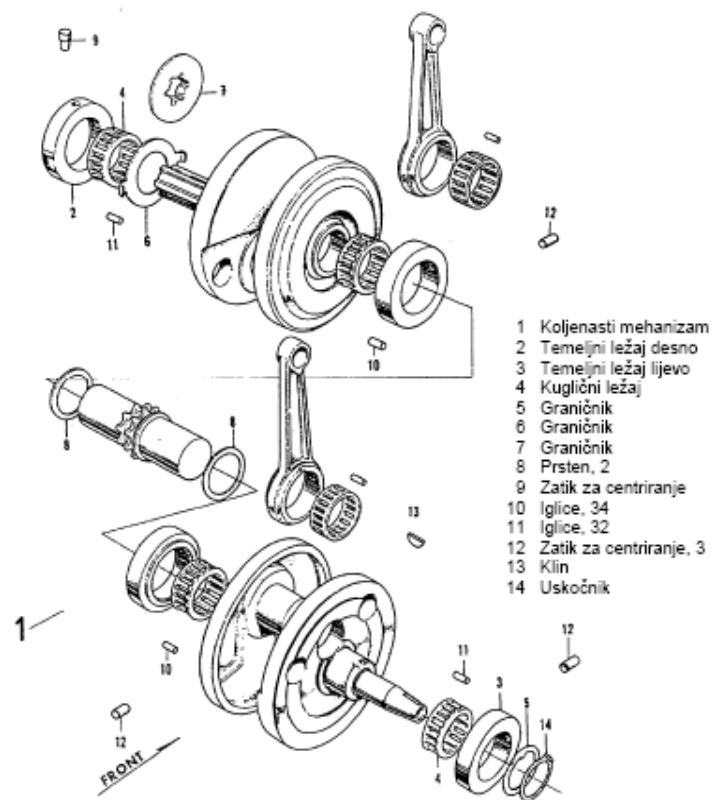
Materijali:

- čelični lijev,
- ugljični čelici,
- sivi lijev
- legirani čelici
- titan



Monolitna izvedba

Rastavljiva izvedba



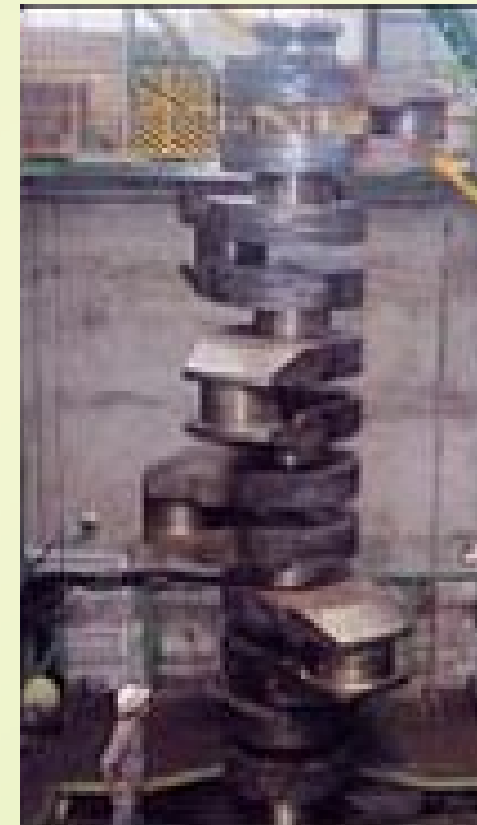
Koljenasta osovina



Obrađeni otkivci koljena



Zagrijavanje koljena plinskim plamenom prije spajanja koljena i glavnog rukavca



Sastavljanje koljenastoga vratila u jami



Sastavljeno koljenasto vratilo u završnoj obradi Po čovjeku uz stroj može se ocijeniti dimenzije koljenastoga vratila

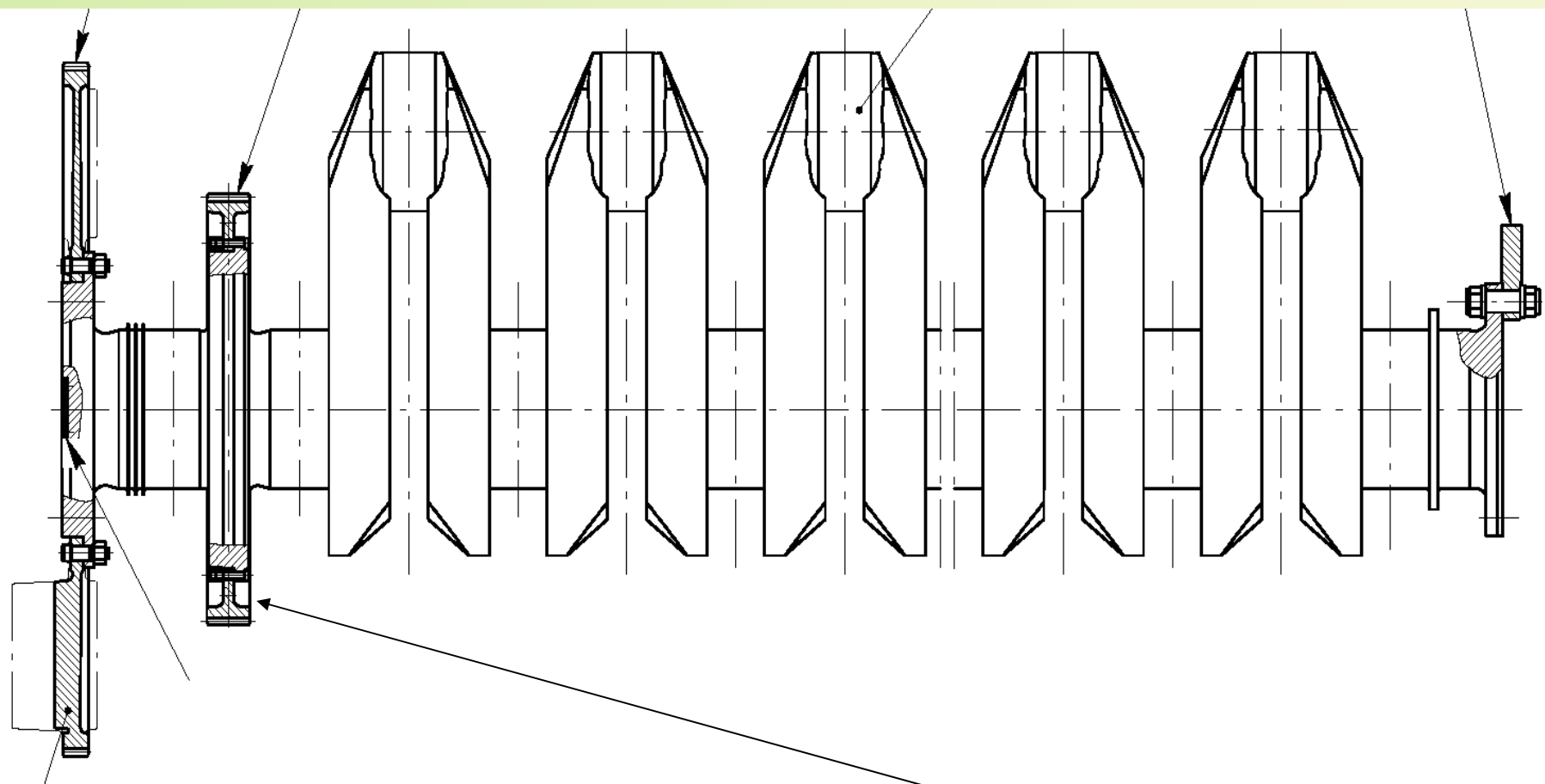
Koljenasta osovina



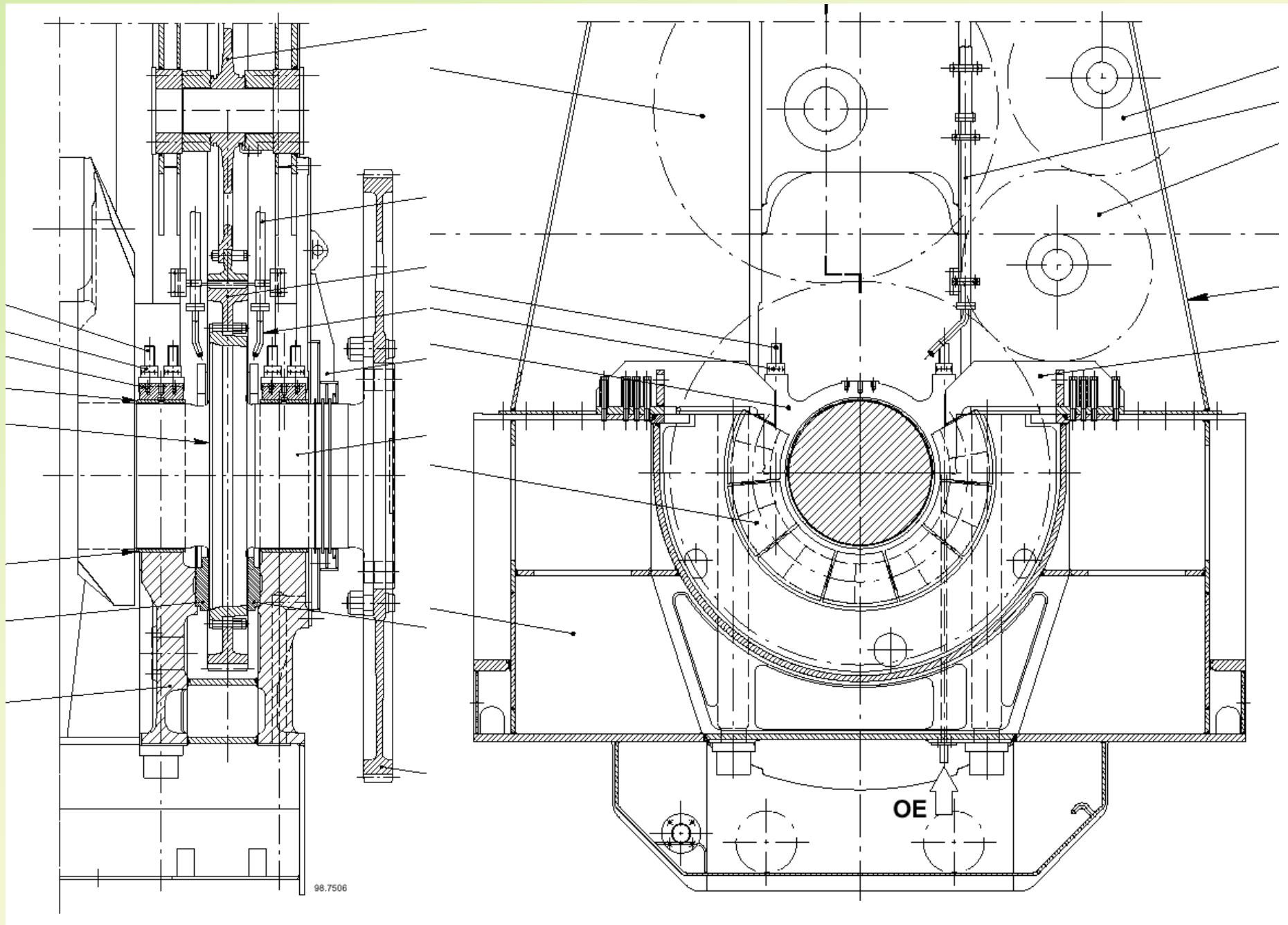
Spuštanje koljenaste osovine u ležajeve u temeljnoj ploči motora



Koljenasta osovina u temeljnoj ploči motora



Na kraju na kojem se odvodi moment se nalazi ODRIVNI LEŽAJ.



Zbog olakšanja osnjaci se buše, ali i za dovođenje ulja u temeljne i leteće ležaje

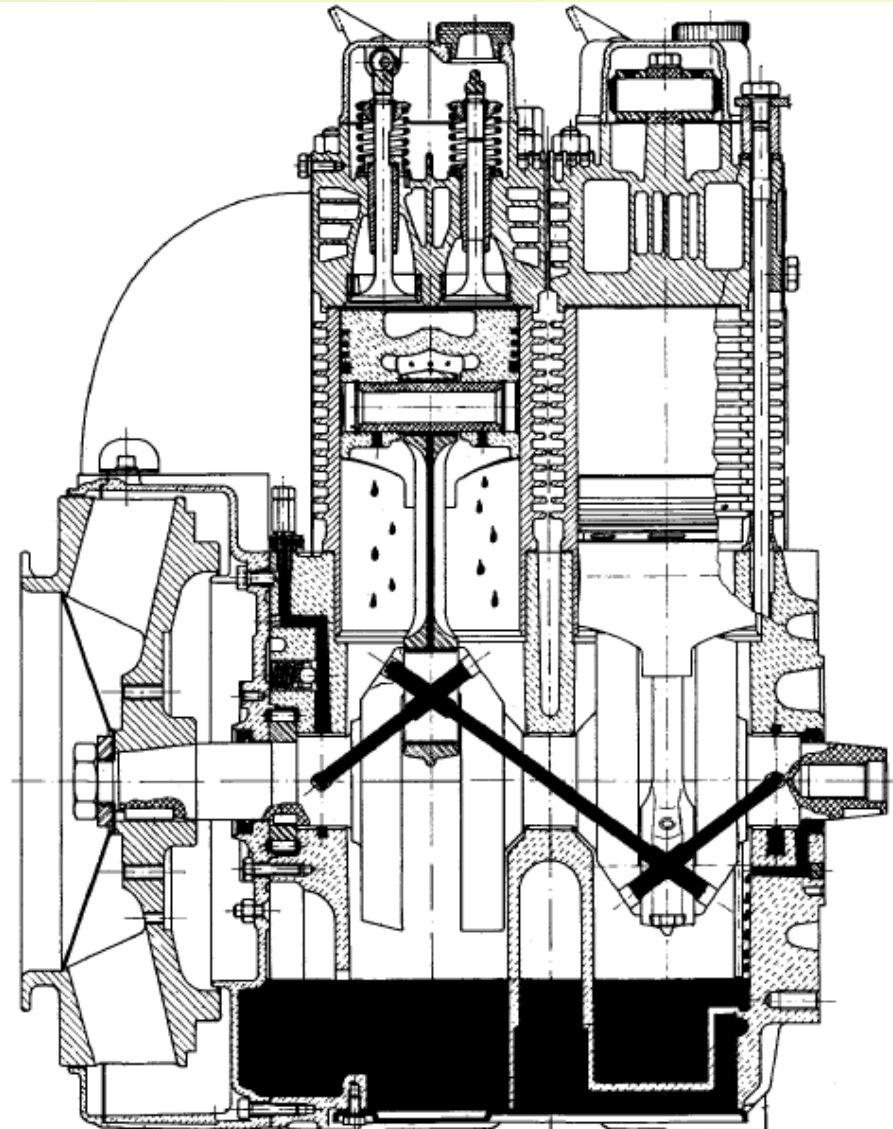
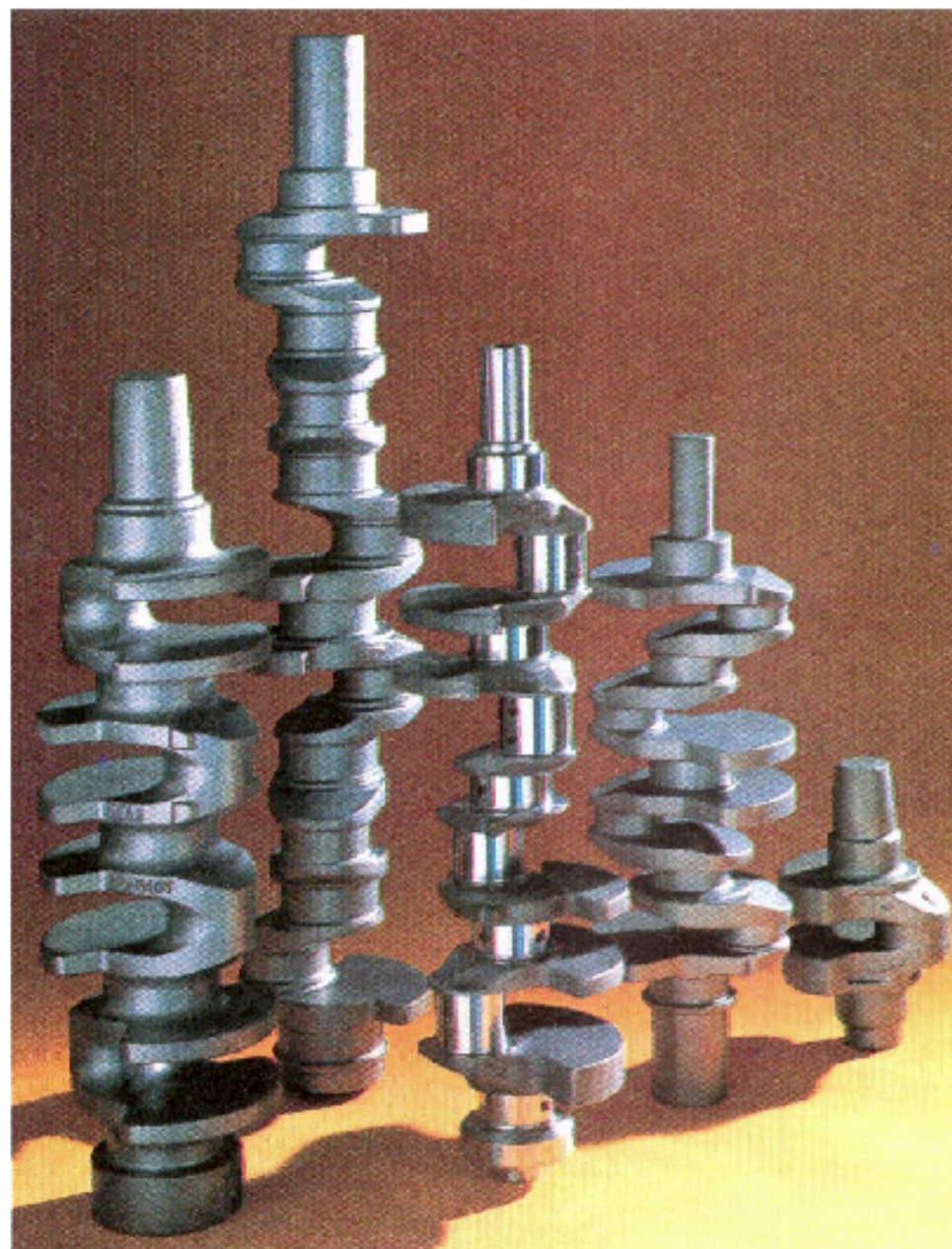
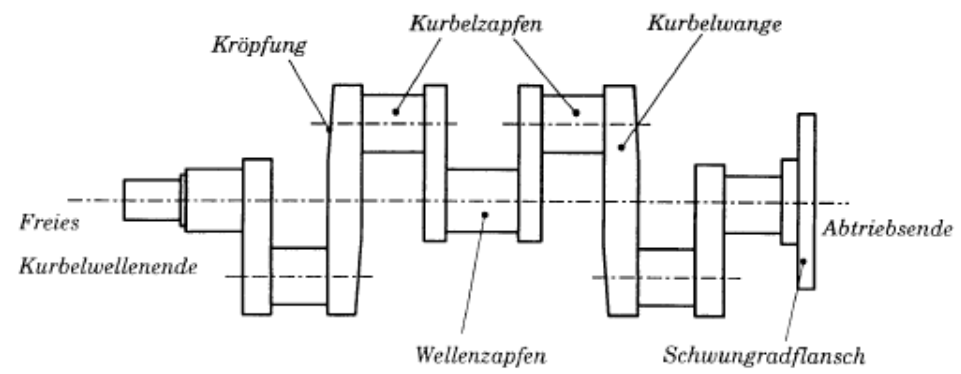
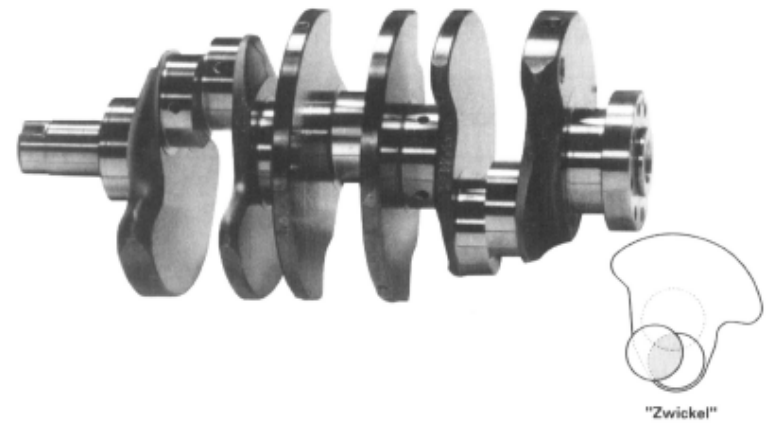
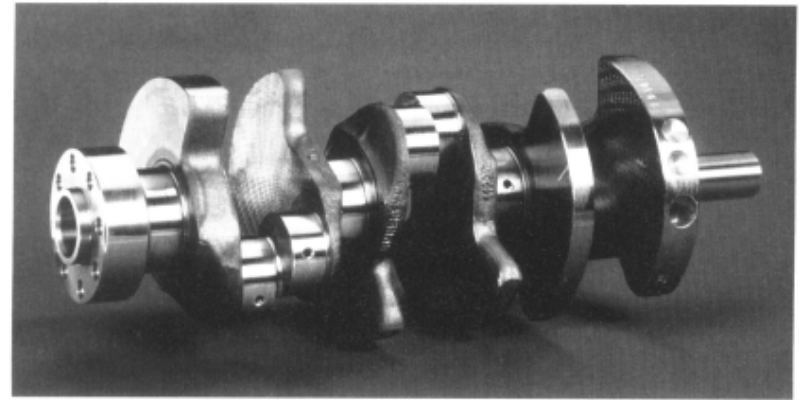


Fig. 12.3 Lubrificazione del piede di biella.



Slika 21.36 Koljenasta vratila

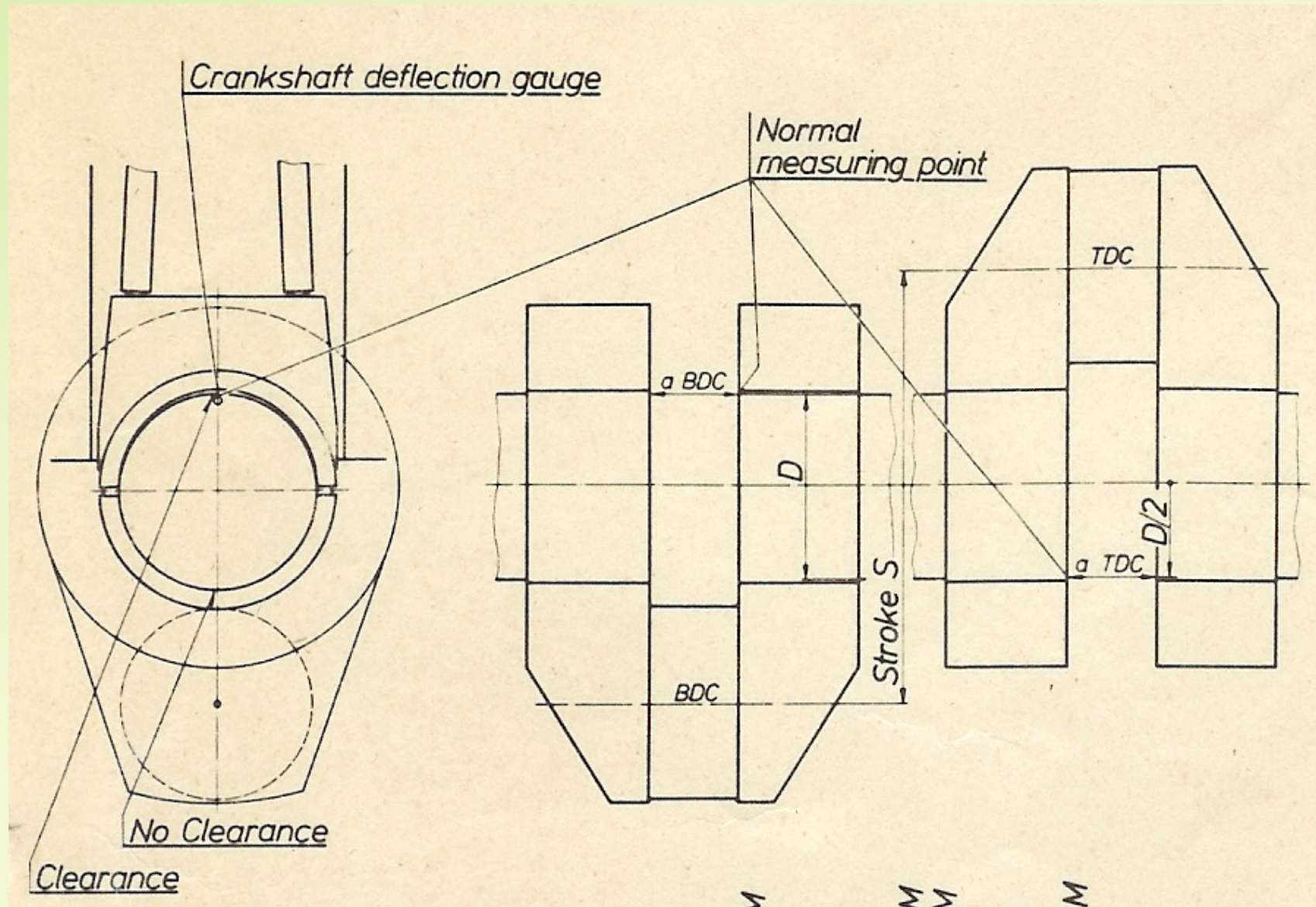




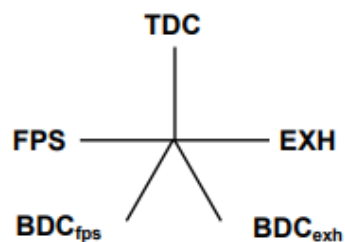
MJERENJE DEFLEKSIJE KOLJ. OSOVINE

- provjera kolinearnosti temeljnih ležaja
- uvijek u istim uvjetima : temperatura, gaz broda
- vrši se :
 - najmanje jednom godišnje
 - kod nasukavanja
 - nakon mijenjanja temeljnog ležaja
 - nakon 100 sati od zamjene tem. ležaja

MJERENJE DEFLEKSIJE KOLJ. OSOVINE



crank pin position
view from engine aft end
(default in WCH documentation)



dial gauge position
view from engine aft end

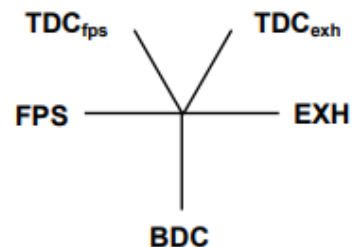
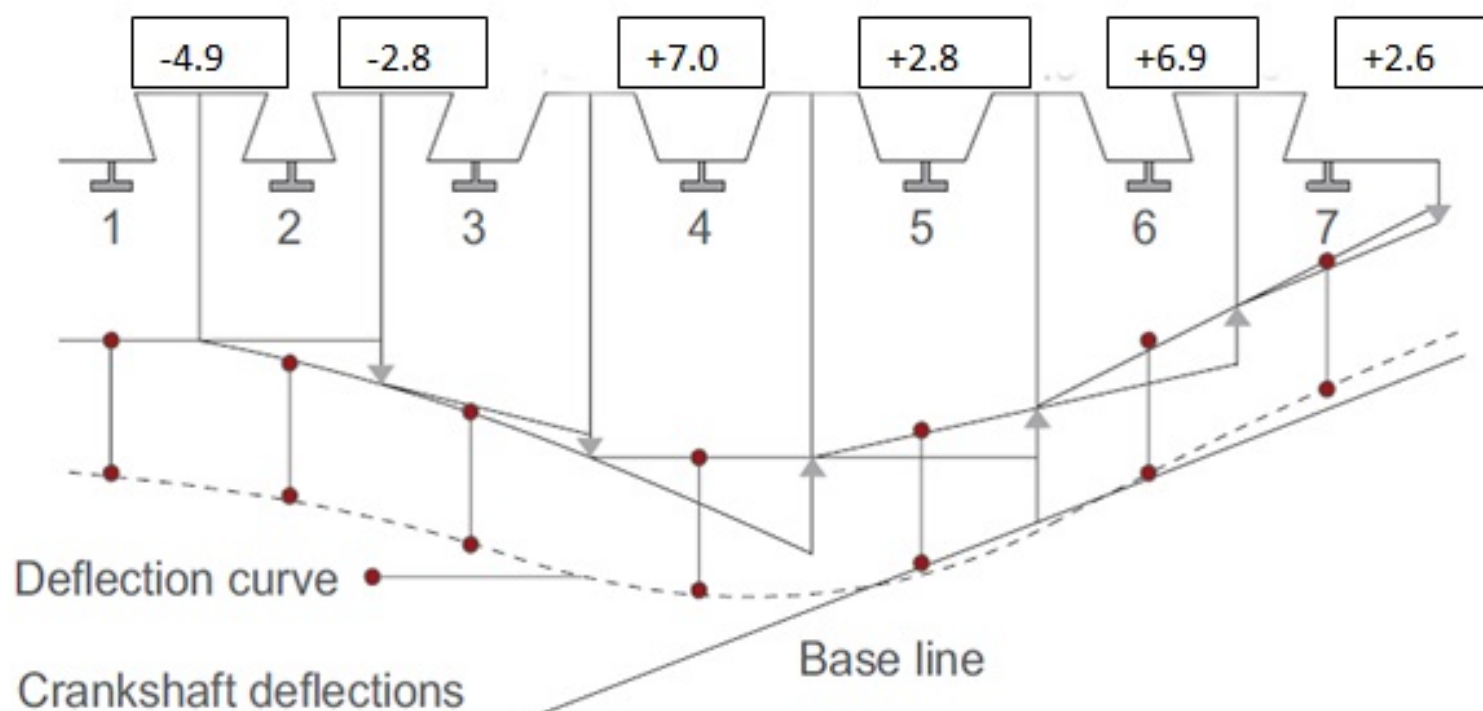
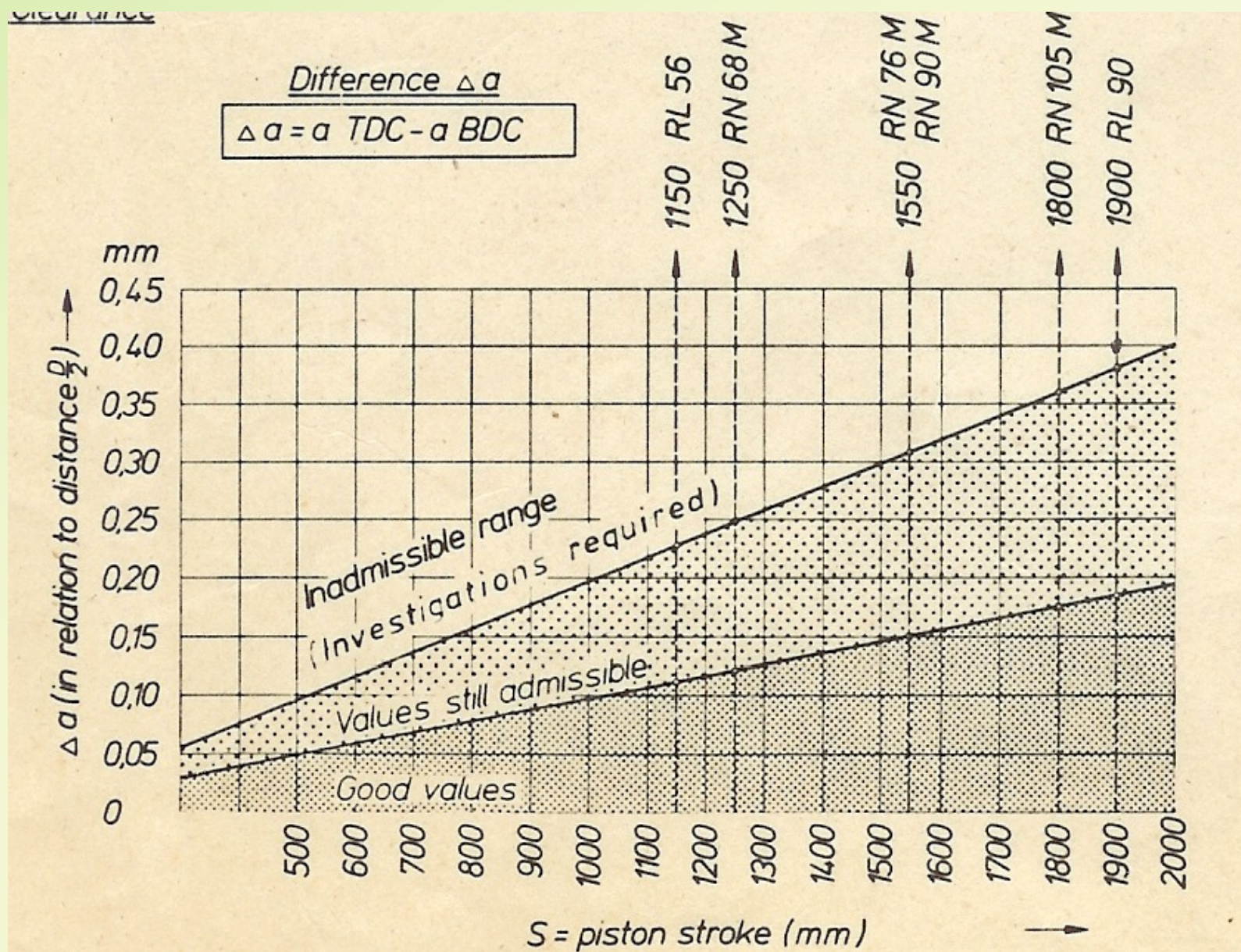


Table 3	Calculation of vertical and horizontal crankweb deflections	
	crank pin position readings (default in WCH documentation)	dial gauge position readings
vertical deflection:	$TDC - \frac{BDC_{exh} + BDC_{fps}}{2}$	$BDC - \frac{TDC_{exh} + TDC_{fps}}{2}$
horizontal deflection:	$FPS - EXH$	$EXH - FPS$



MJERENJE DEFLEKSIJE KOLJ. OSOVINE



MJERENJE DEFLEKSIJE KOLJ. OSOVINE

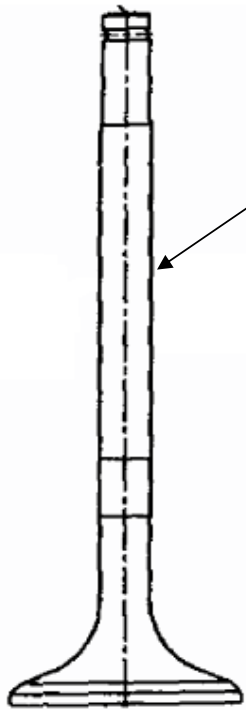
Mogući razlozi prevelikog odstupanja:

- uništen ležaj
- temelj poremećen zbog deformacije trupa
- otpušteni temeljni vijci
- oštećen ležaj osovine propelera

SUSTAV RAZVODA

VENTILI

Stablo, vreteno ventila



Pečurka, pladanj ventila

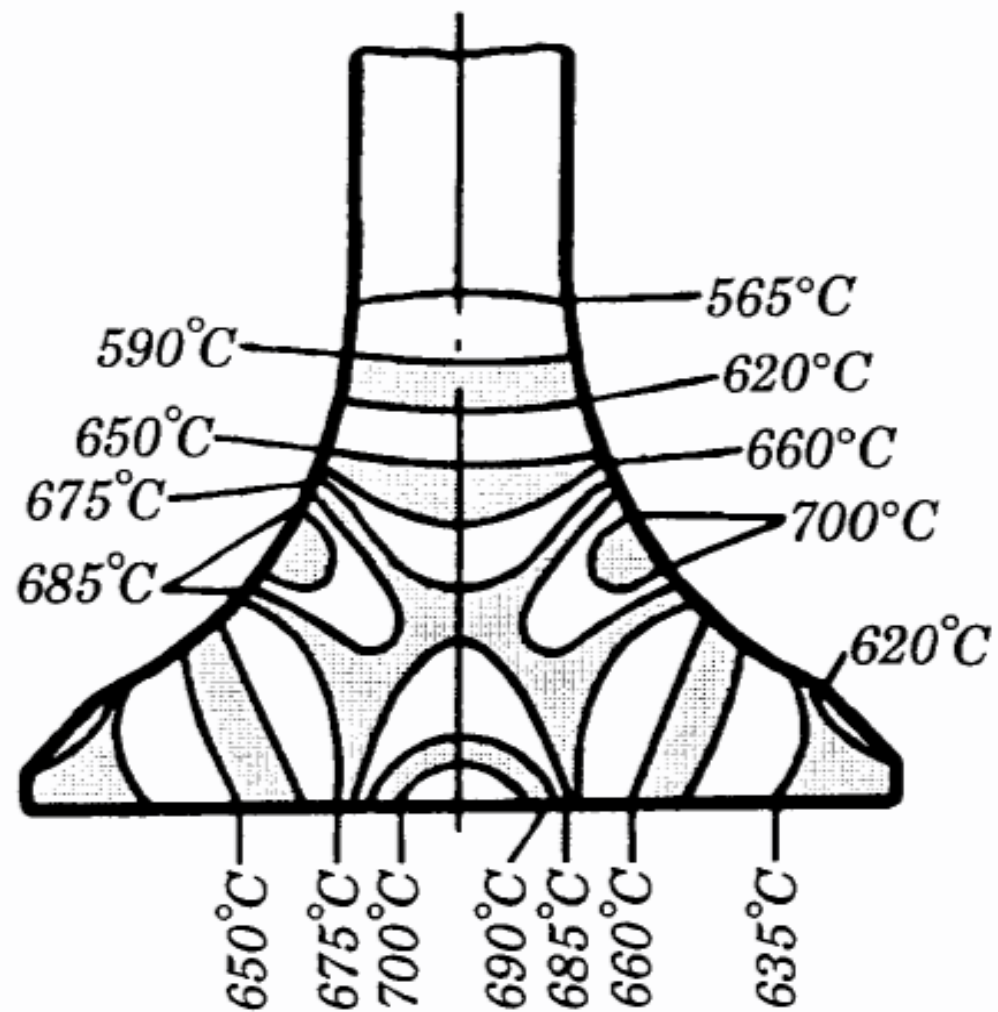
Zahtjevi pred ventilom :

1. Što manji otpor ustrujavanja- istrujavanja= veća obodna površina
2. Podnošenje visokih temperatura
300-500°C usisni
700-800°C ispušni

Najbitnije utječe na trajnost ventila !!!

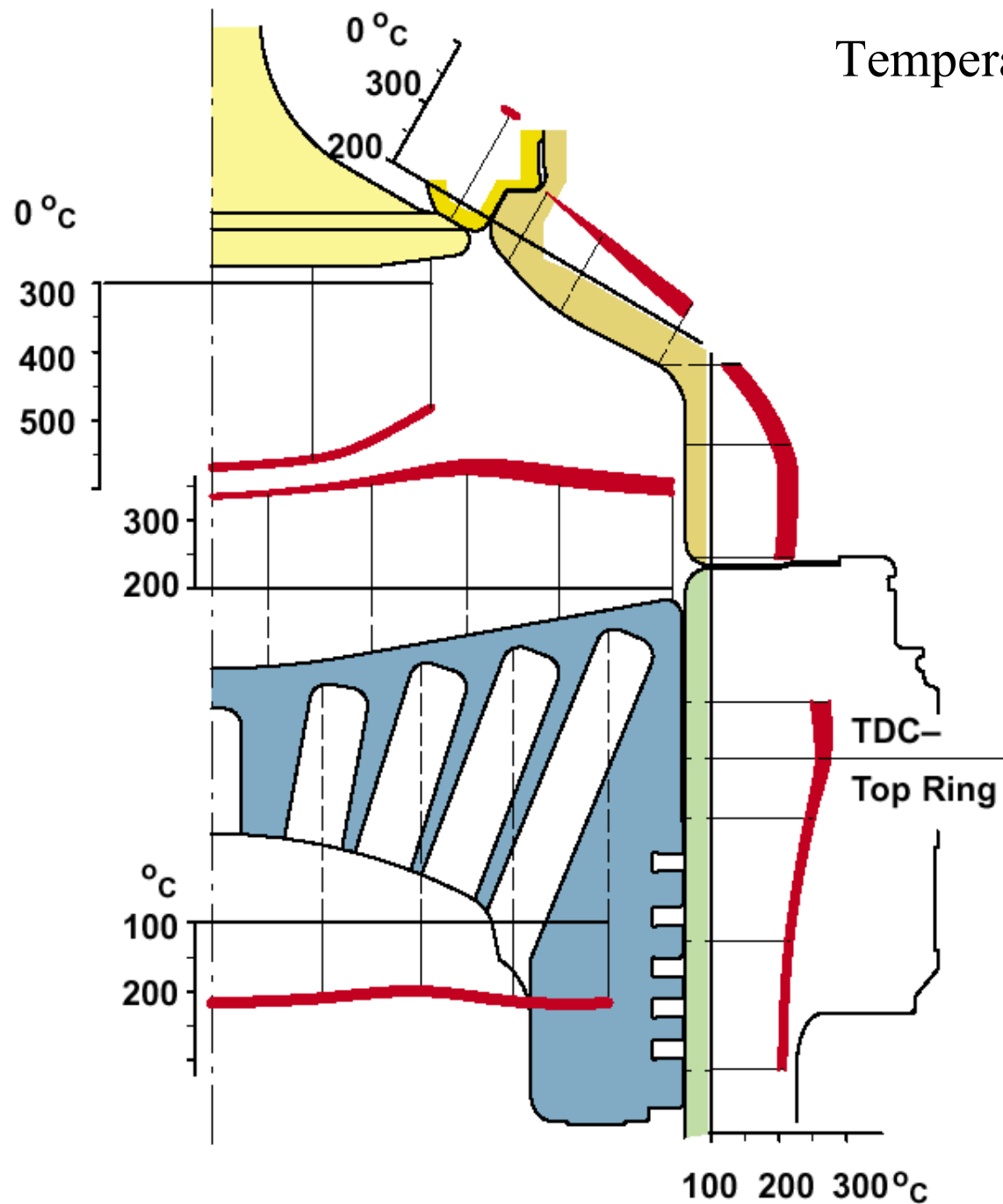
Ventil se hladi preko sjedišta ventila !!!

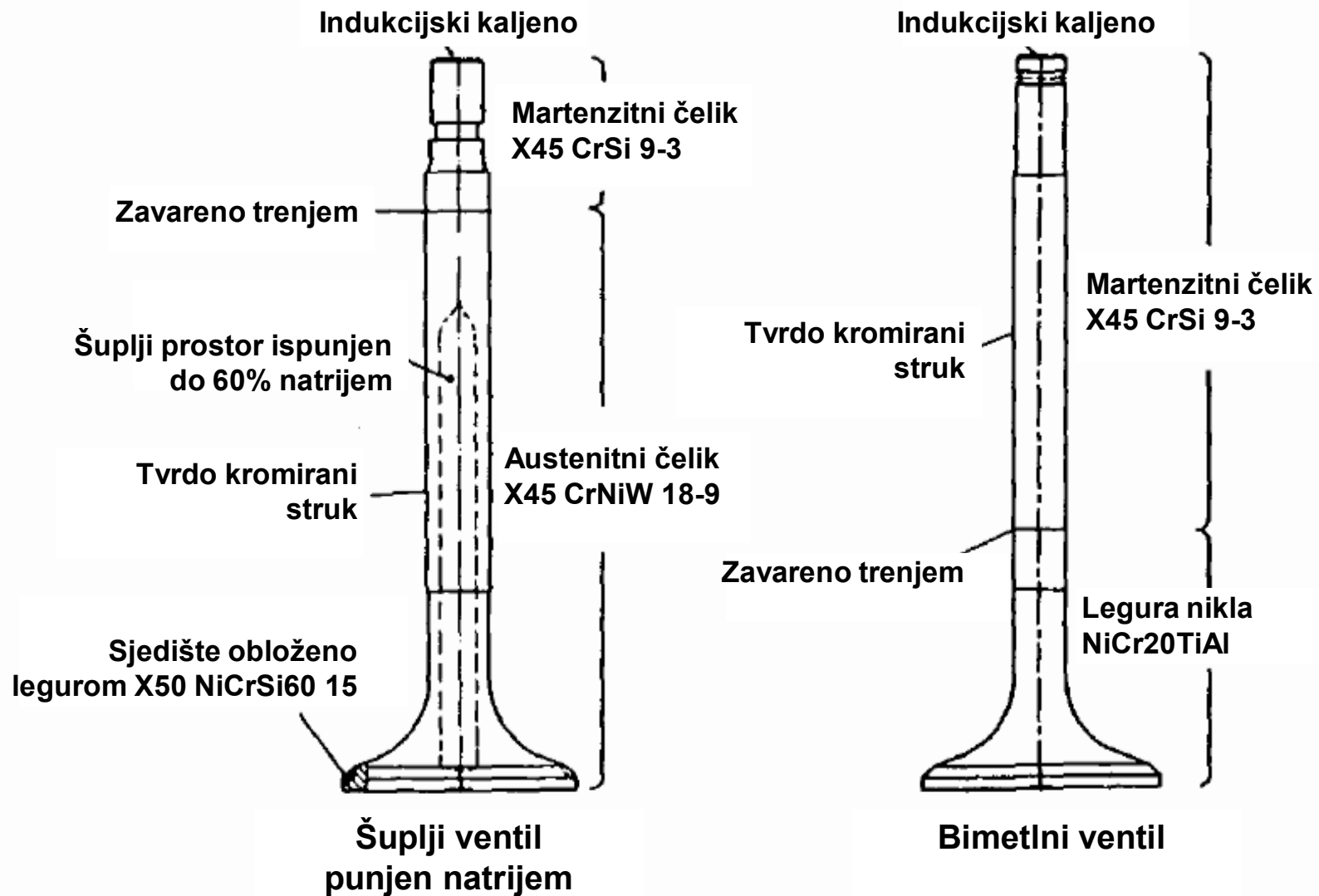
Materijali : otporni na visoke temperature
i koroziju (čelik legiran s kromom i niklom)
NIMONIC I STELIT



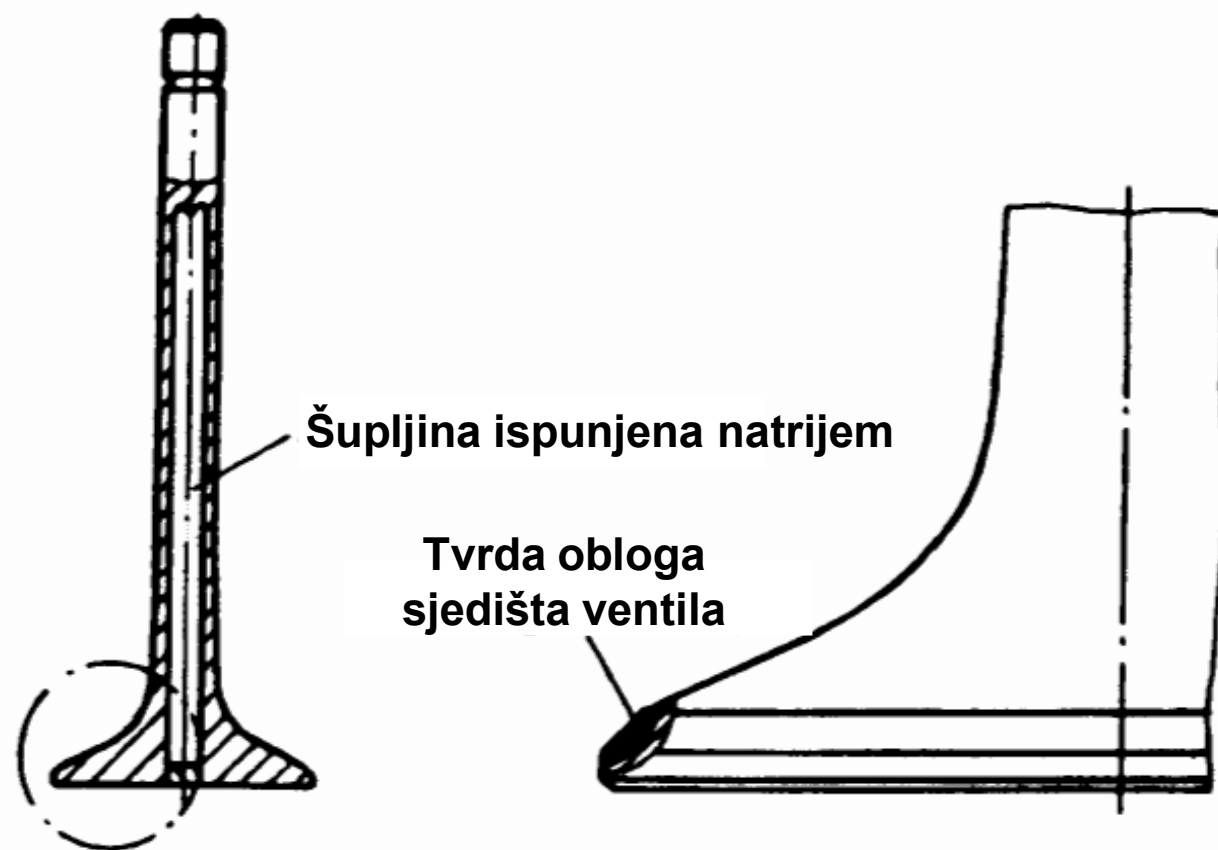
Razdioba temperature na primjeru ispušnog ventila

Temperature ispušnog ventila i stjenki prostora izgaranja

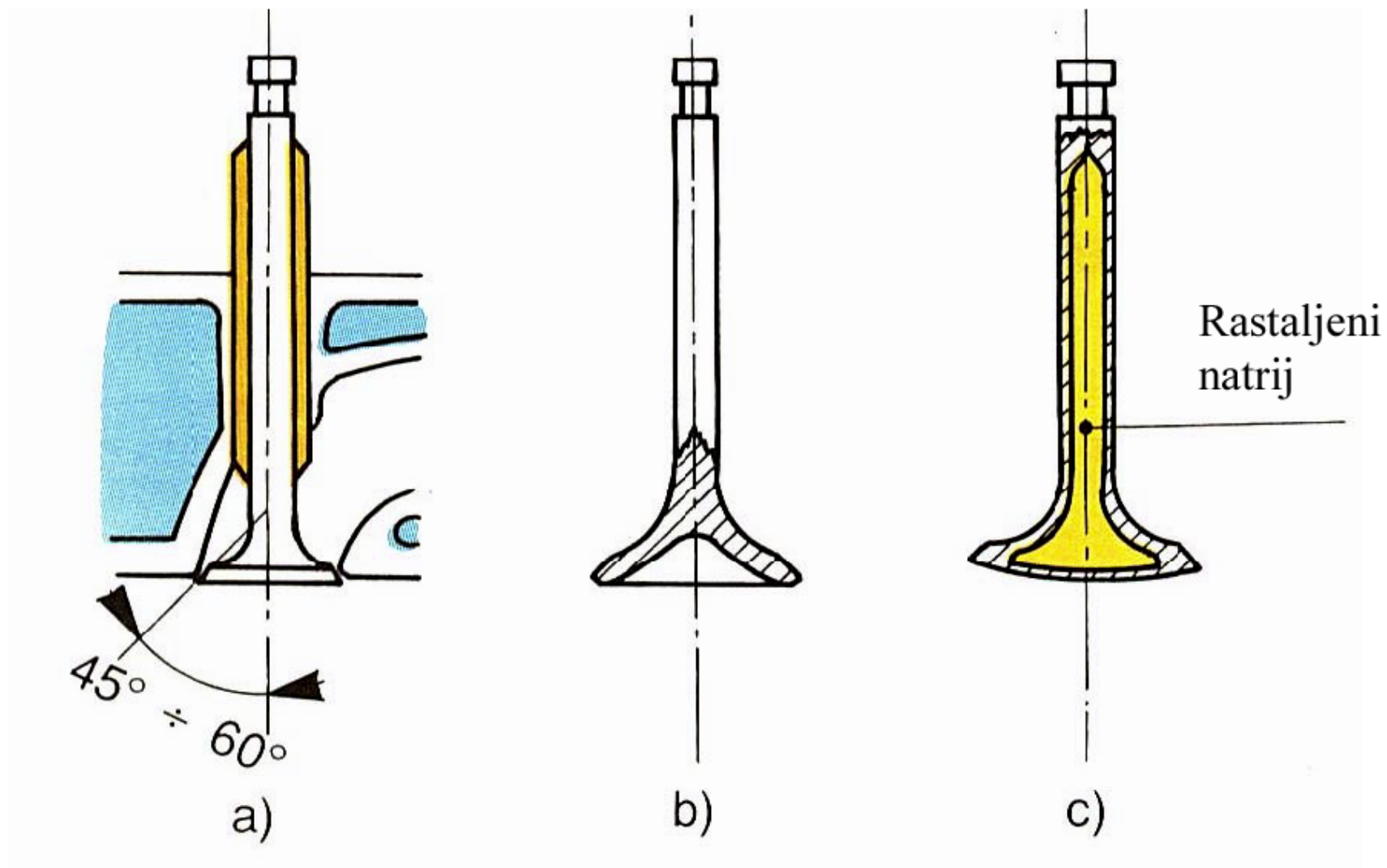




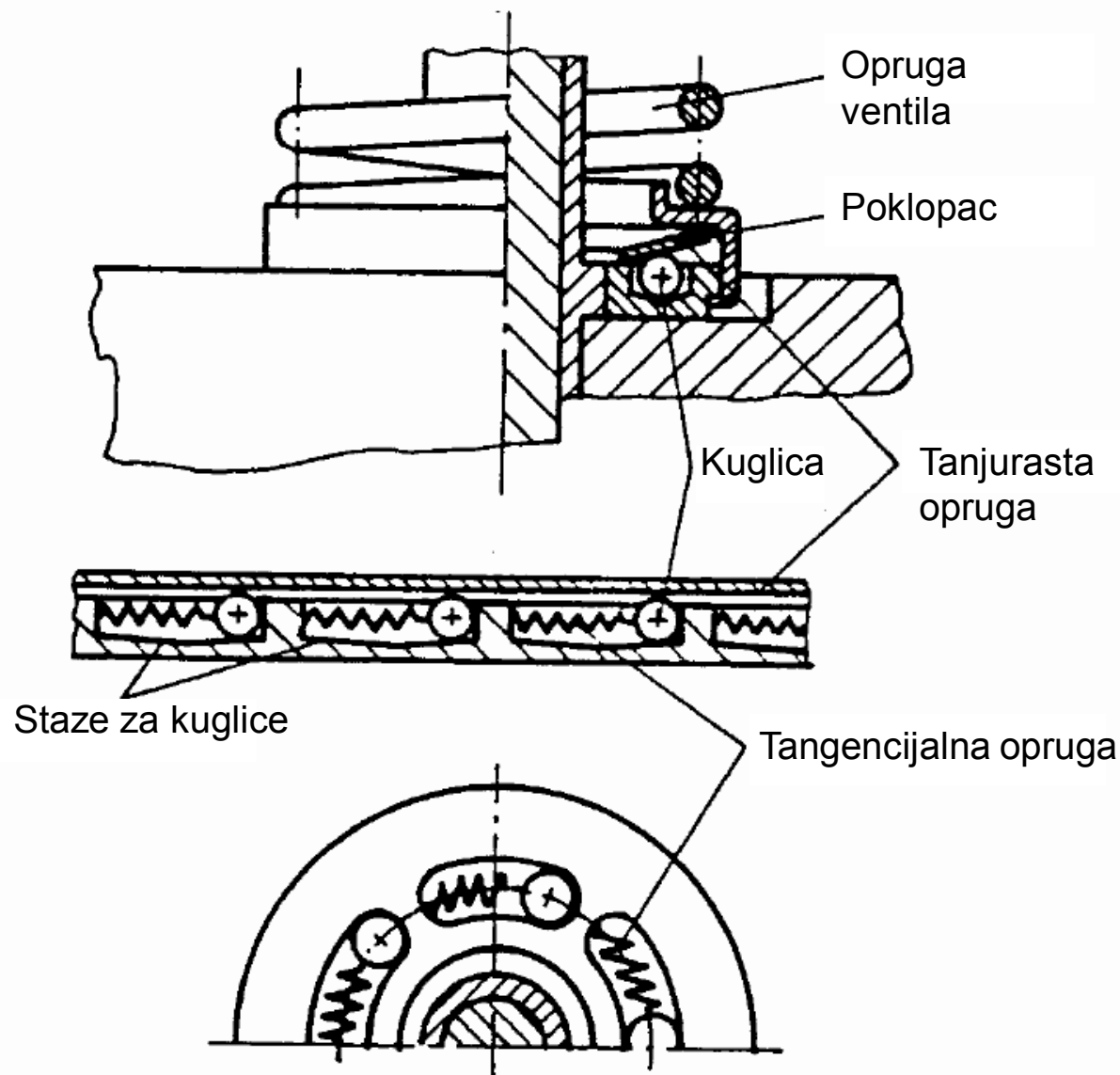
Ispušni ventili



Ispušni ventil hlađen natrijem



Slika 21.7 Izvedbe ventila



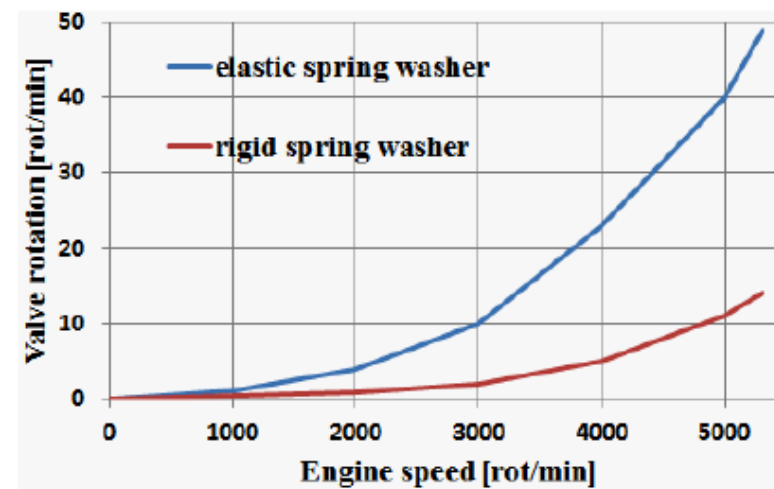
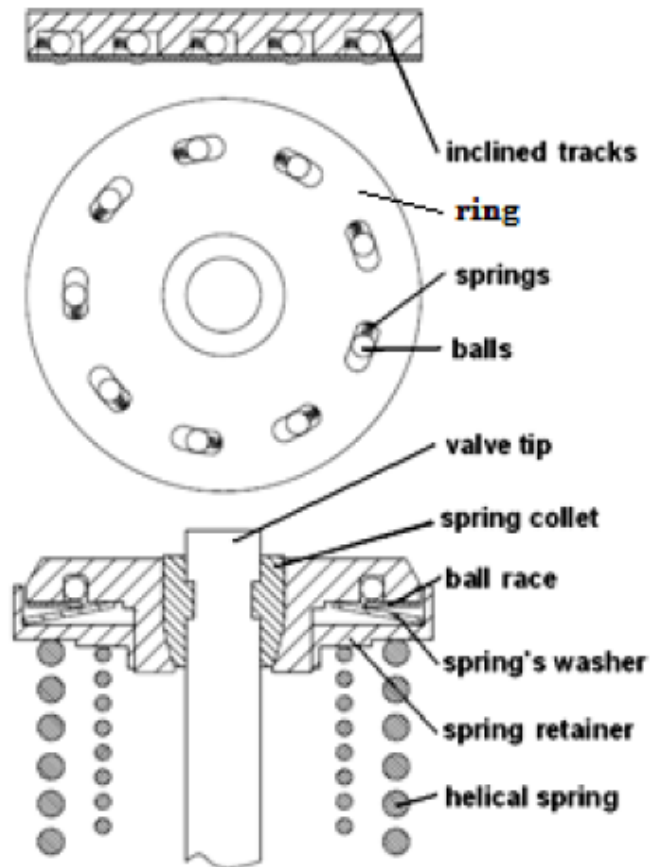
Način rada:

Prilikom otvaranja ventila sila u opruzi se poveća zbog njenoga skraćenja. Ta se sila prenosi na klizni poklopac i tanjurastu oprugu. Tanjurasta opruga osloni se na kuglice. Kako je staza ispod kuglica nagnuta, kuglice se otkotrljaju prema najnižem mjestu. Pritom se i cijeli ventil zakrene u otvorenom stanju i ostaje tako zakrenut sve do svoga zatvaranja.

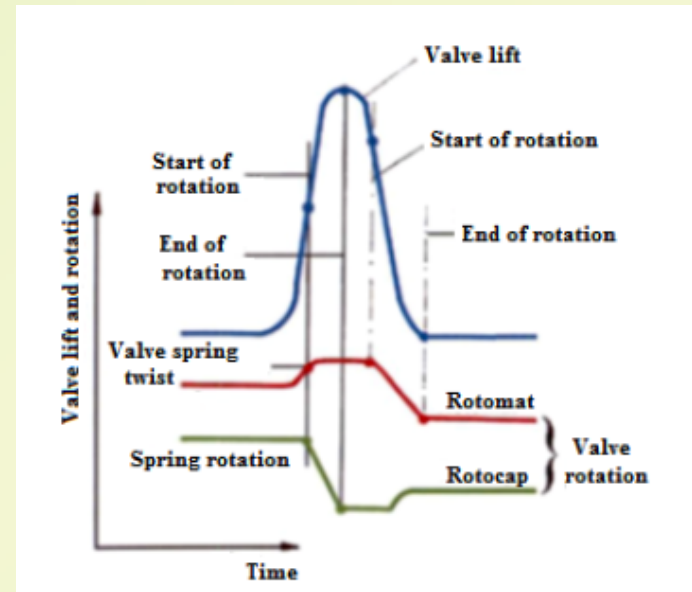
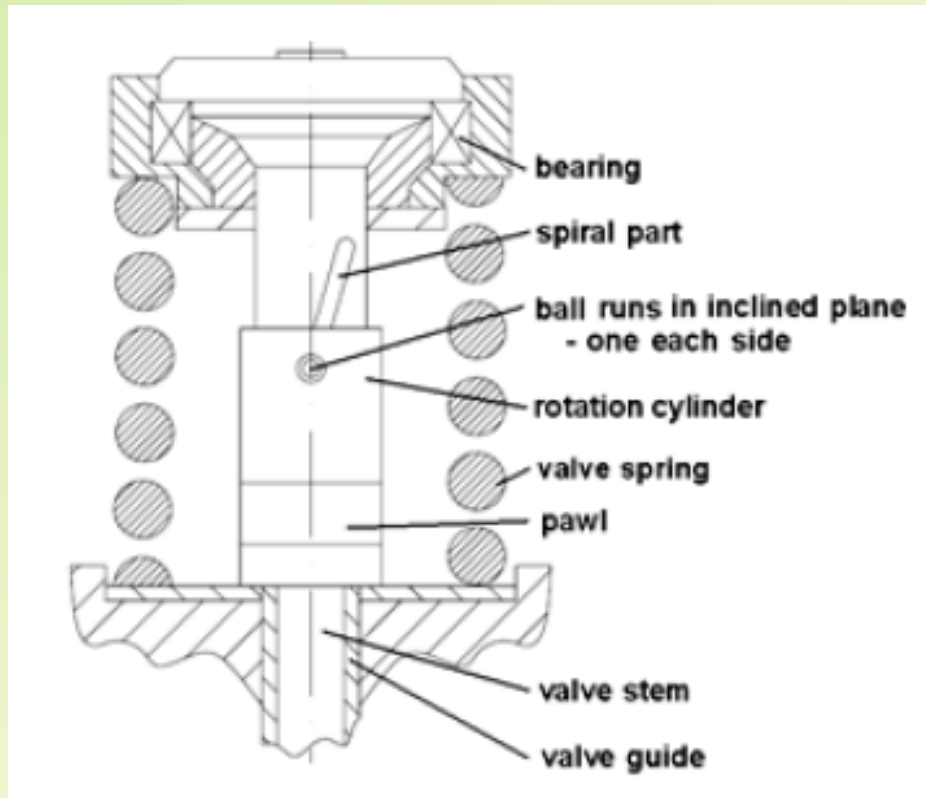
Nakon ponovnog sjedanja ventila na svoje sjedište, on se više neće moći zakrenuti natrag u početni položaj. Pri sjedanju ventila na sjedište, sila u opruzi ventila se smanjuje, a s njom i sila pritiska na tanjurastu oprugu. Ona se vraća u početni položaj i oslobađa kuglice. Male spiralne opruge vraćaju kuglice u početni položaj za sljedeći podizaj ventila i sljedeće zakretanje.

Za jedan okretaj ventila oko svoje osi potrebno je 15 do 25 podizaja ventila

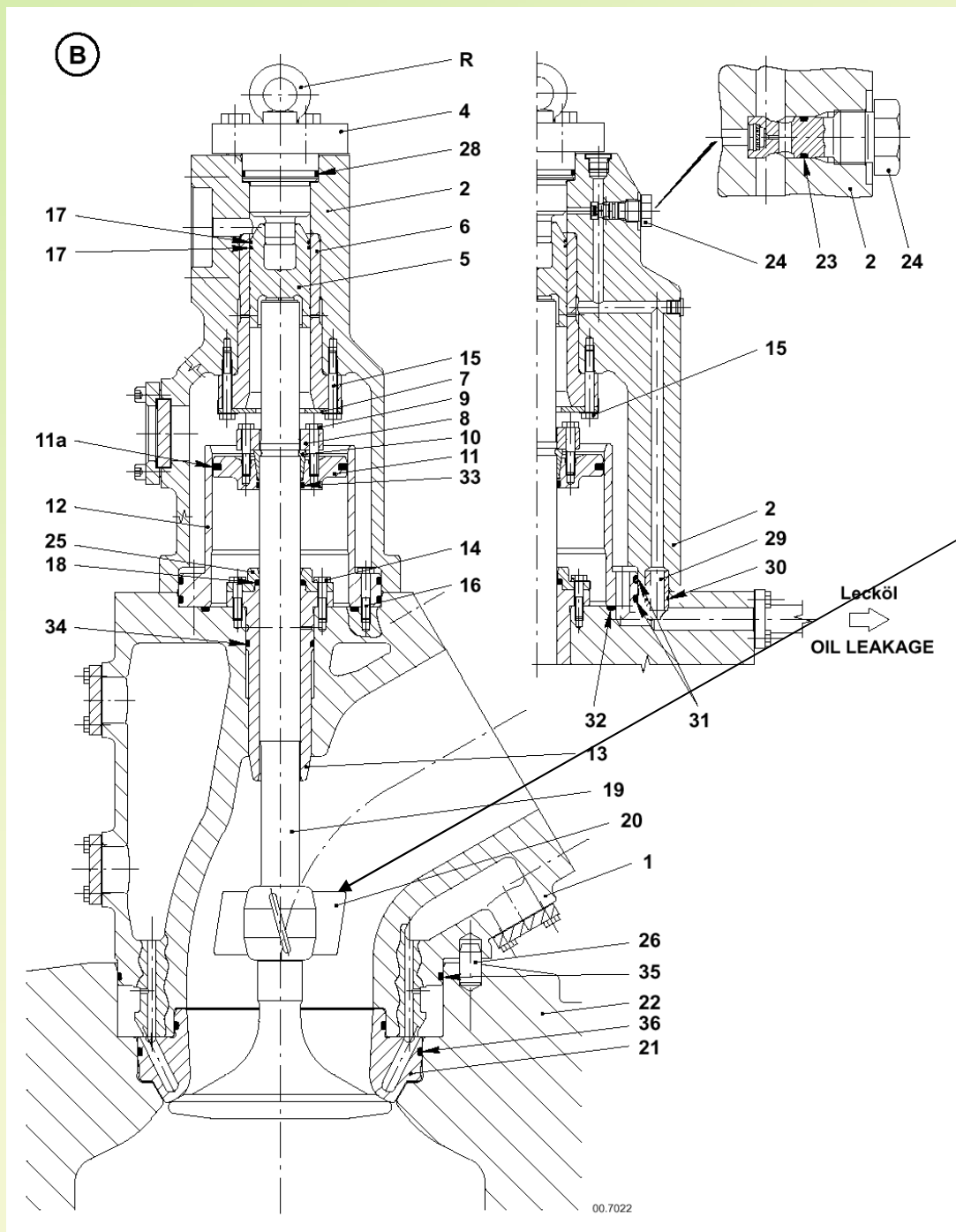
Rotacap uređaj za rotaciju ventila pri podizanju



ROTOMAT iii TURNOMAT

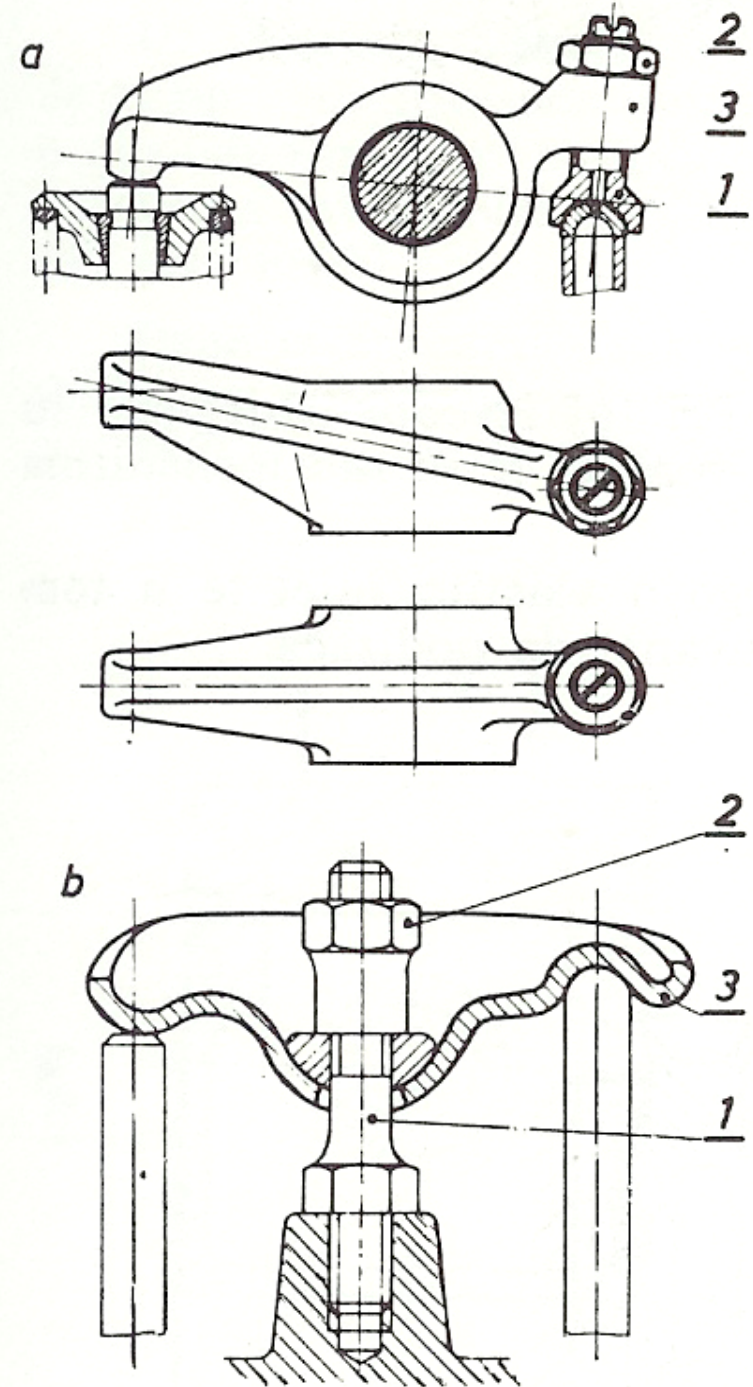


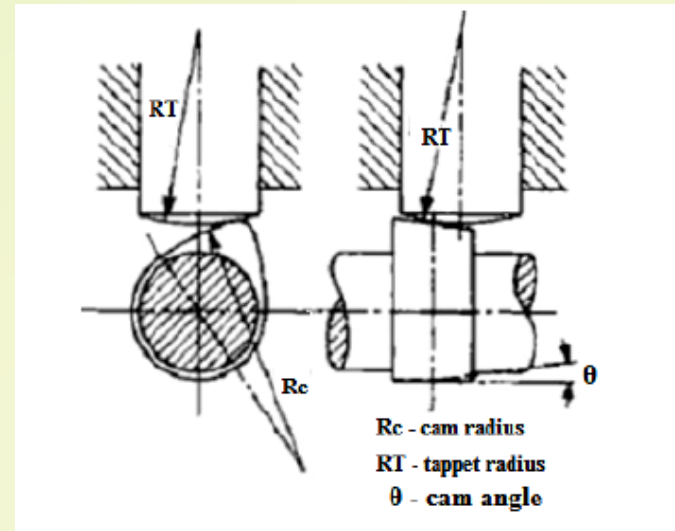
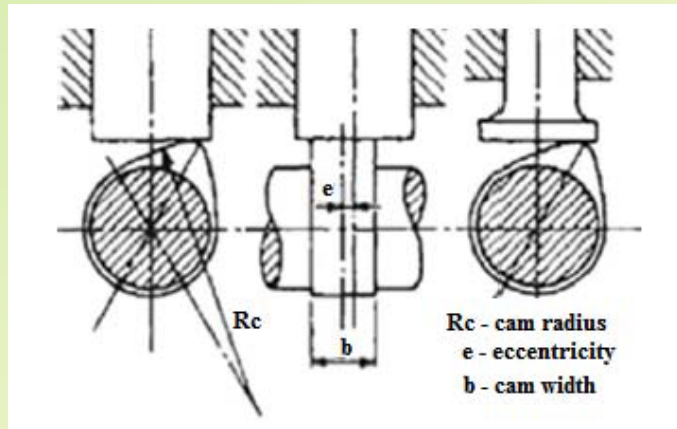
ROTOCOIL



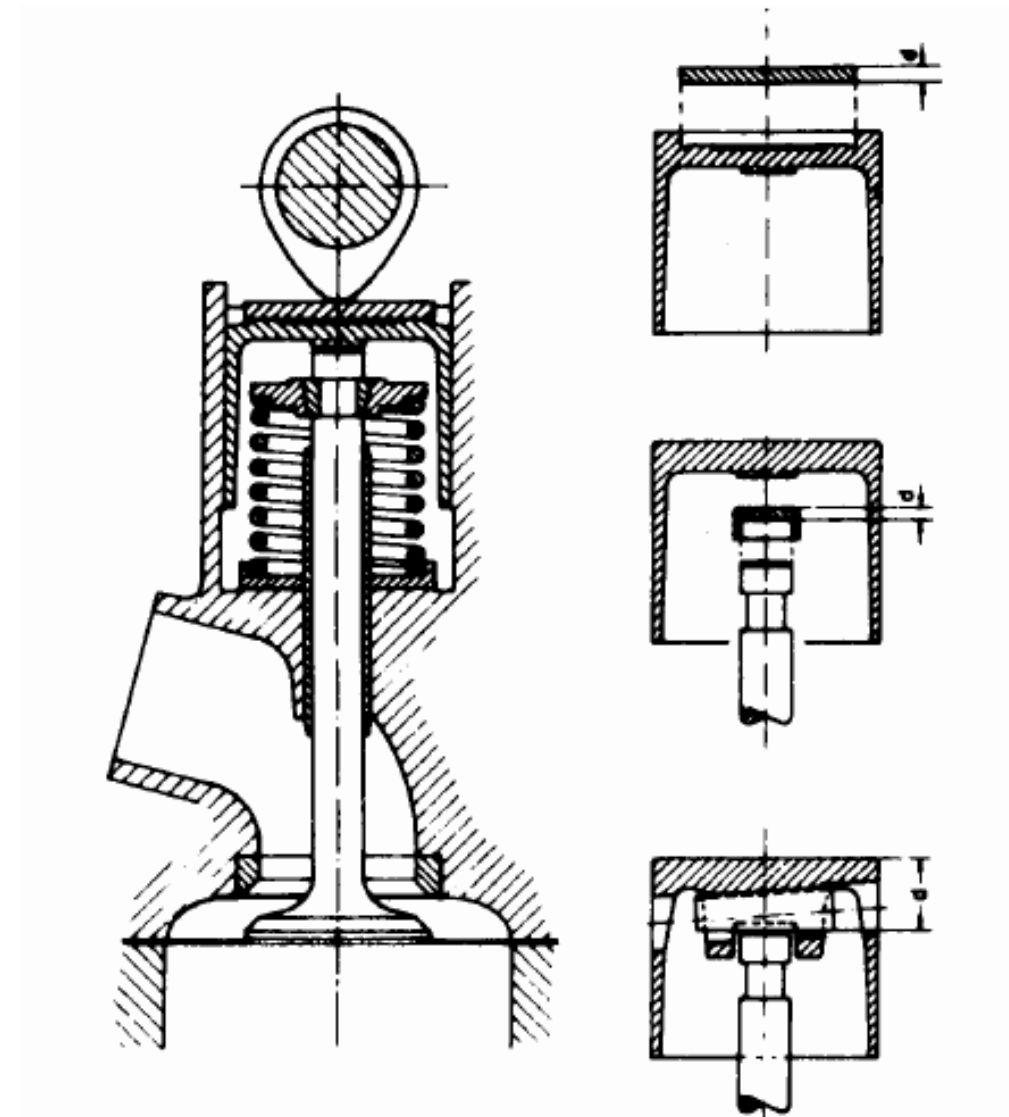
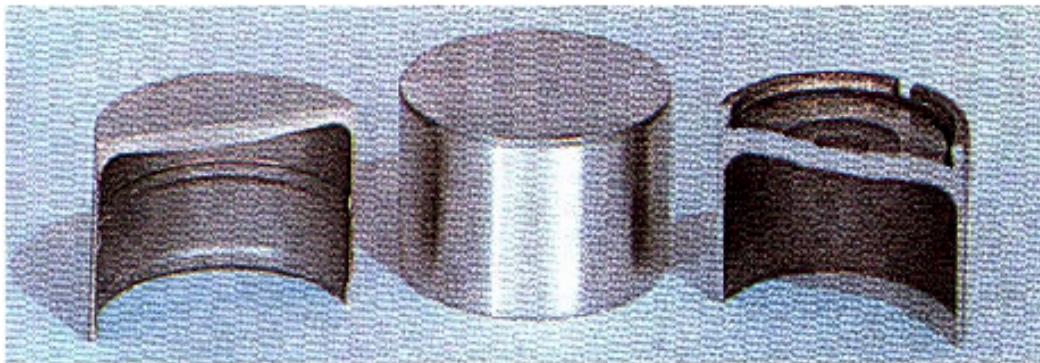
Krilca za zakretanje ventila

ZAZOR VENTILA





ZAZOR VENTILA



Slika 21.8 Izravni pogon ventila bregastim vratilom preko čašice podizača

Hidraulička kompenzacija zazora ventila

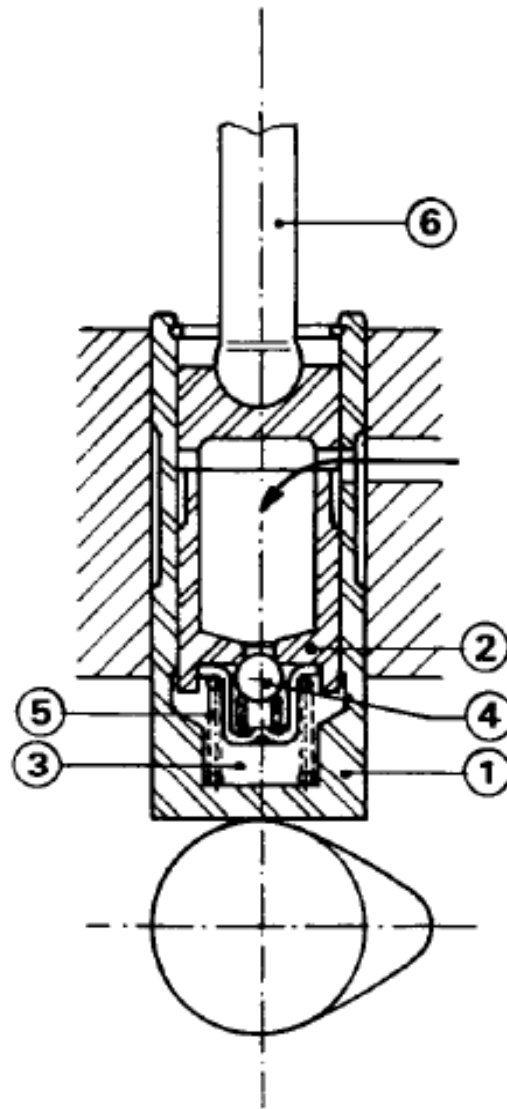
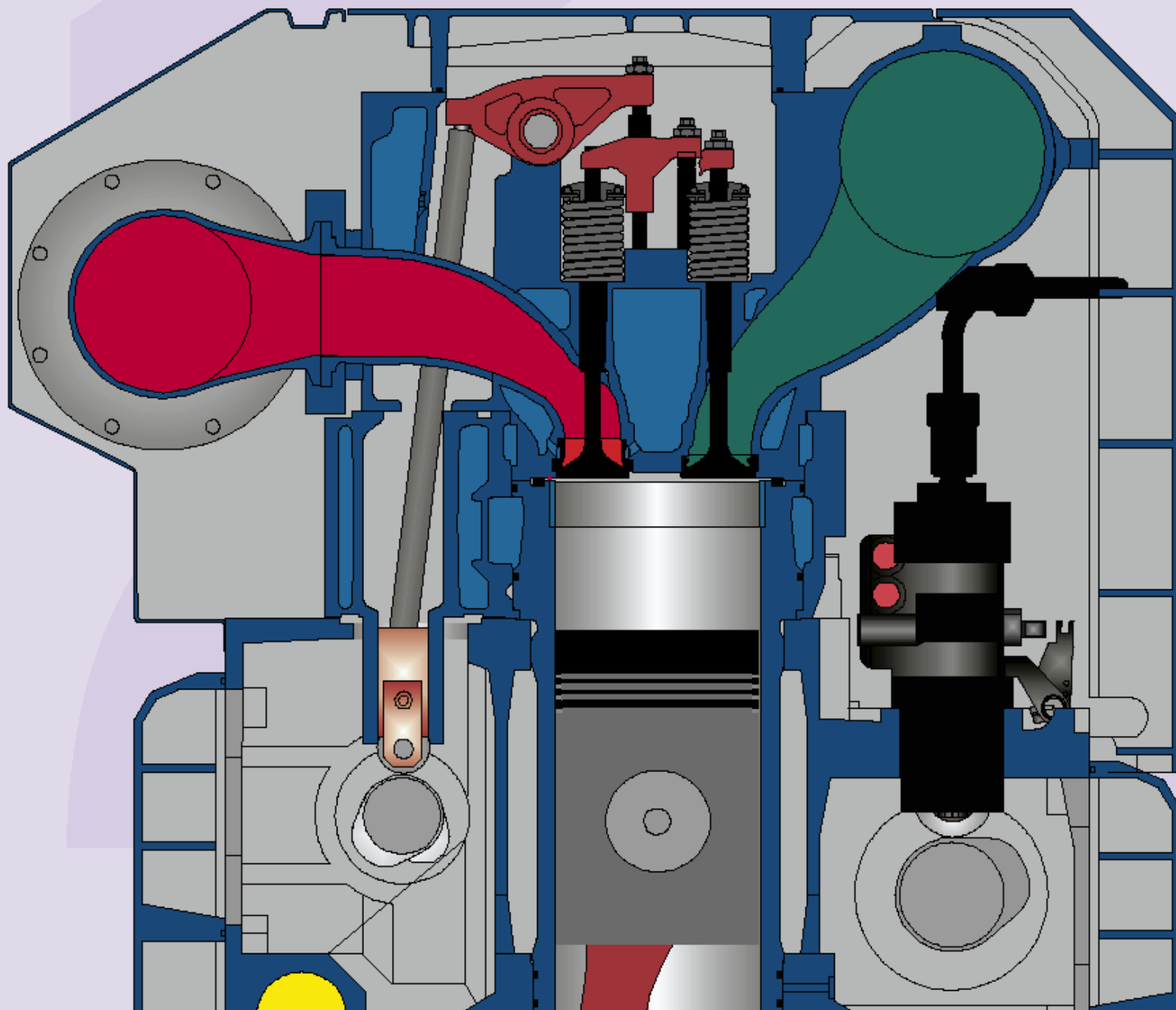
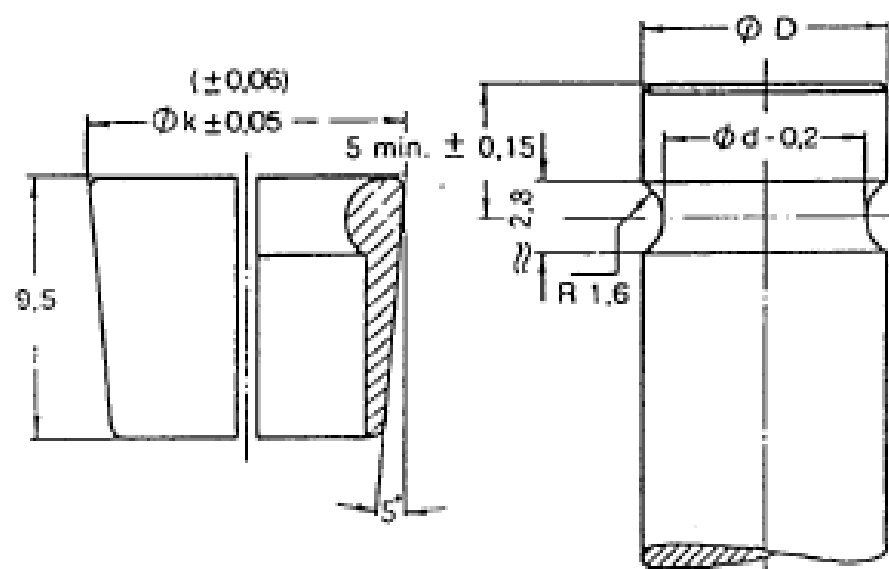


Fig. 11.58 Punteria idraulica.

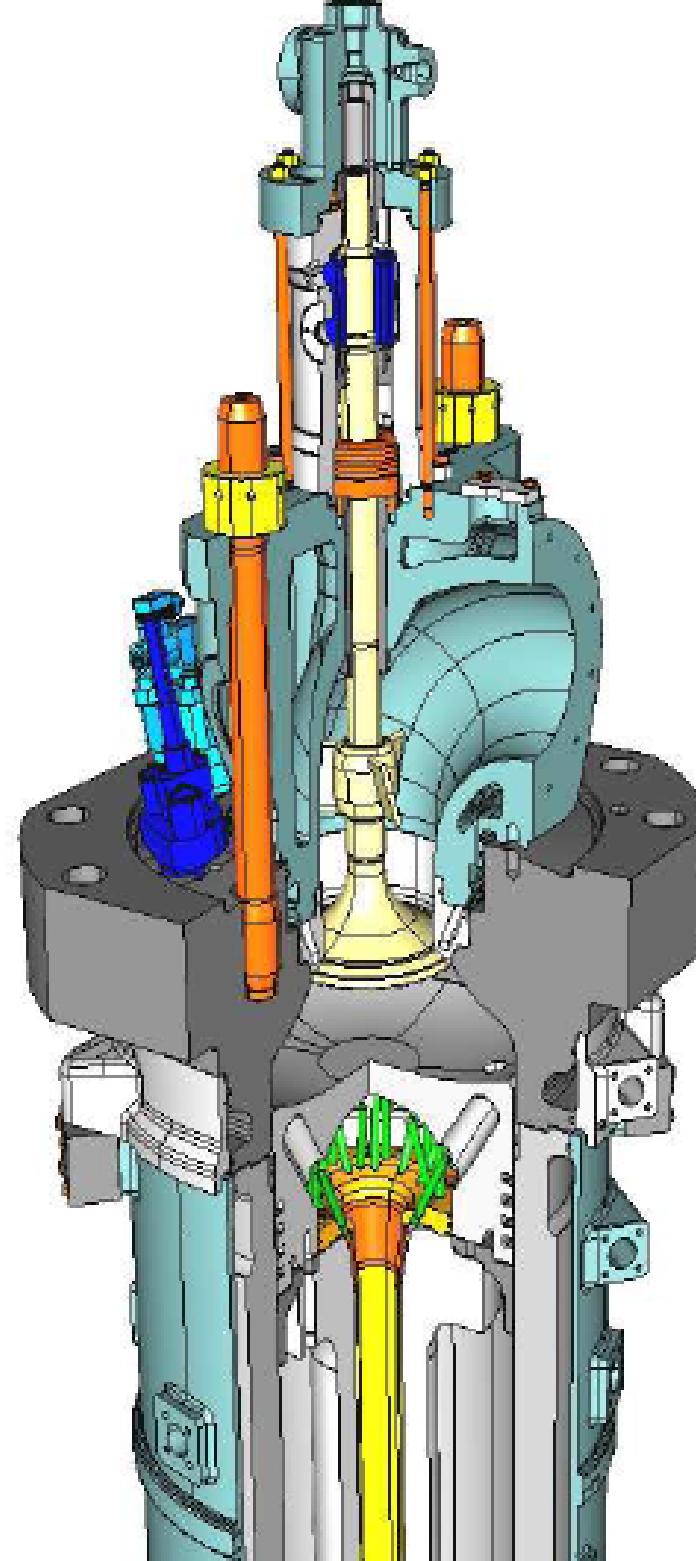
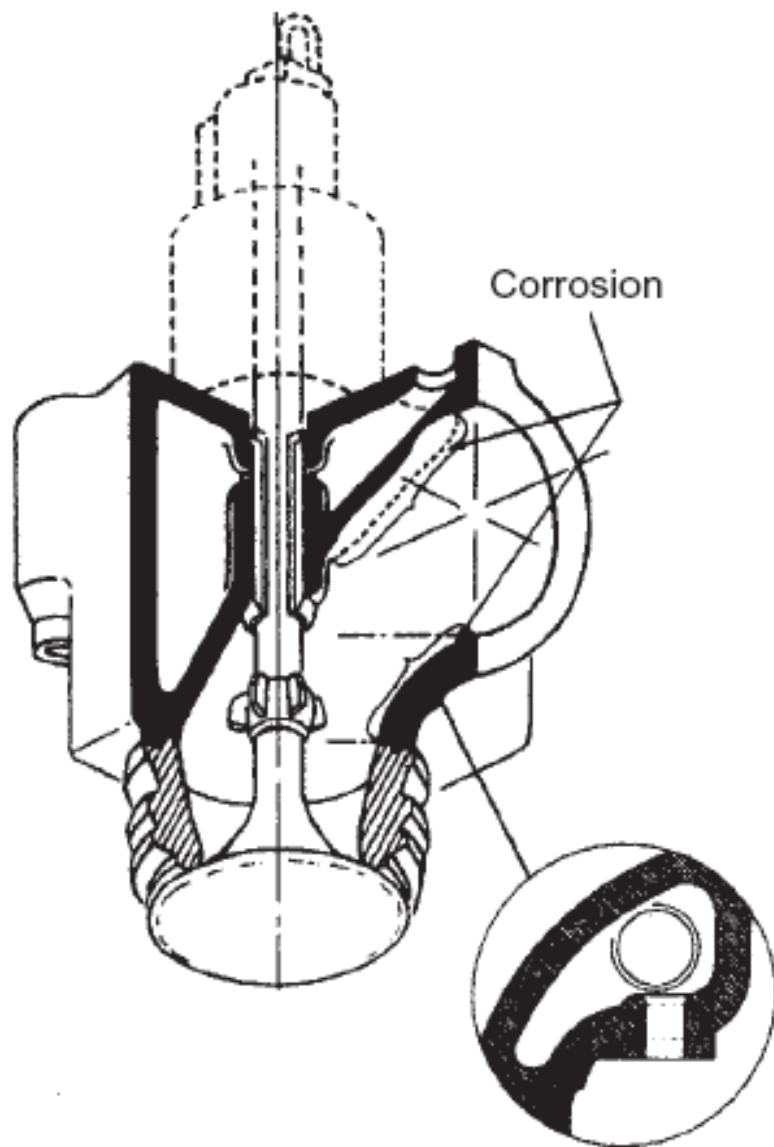
1) corpo della punteria; 2) elemento flottante; 3) camera ad alta pressione; 4) valvola di non ritorno; 5) molla; 6) asta di comando.

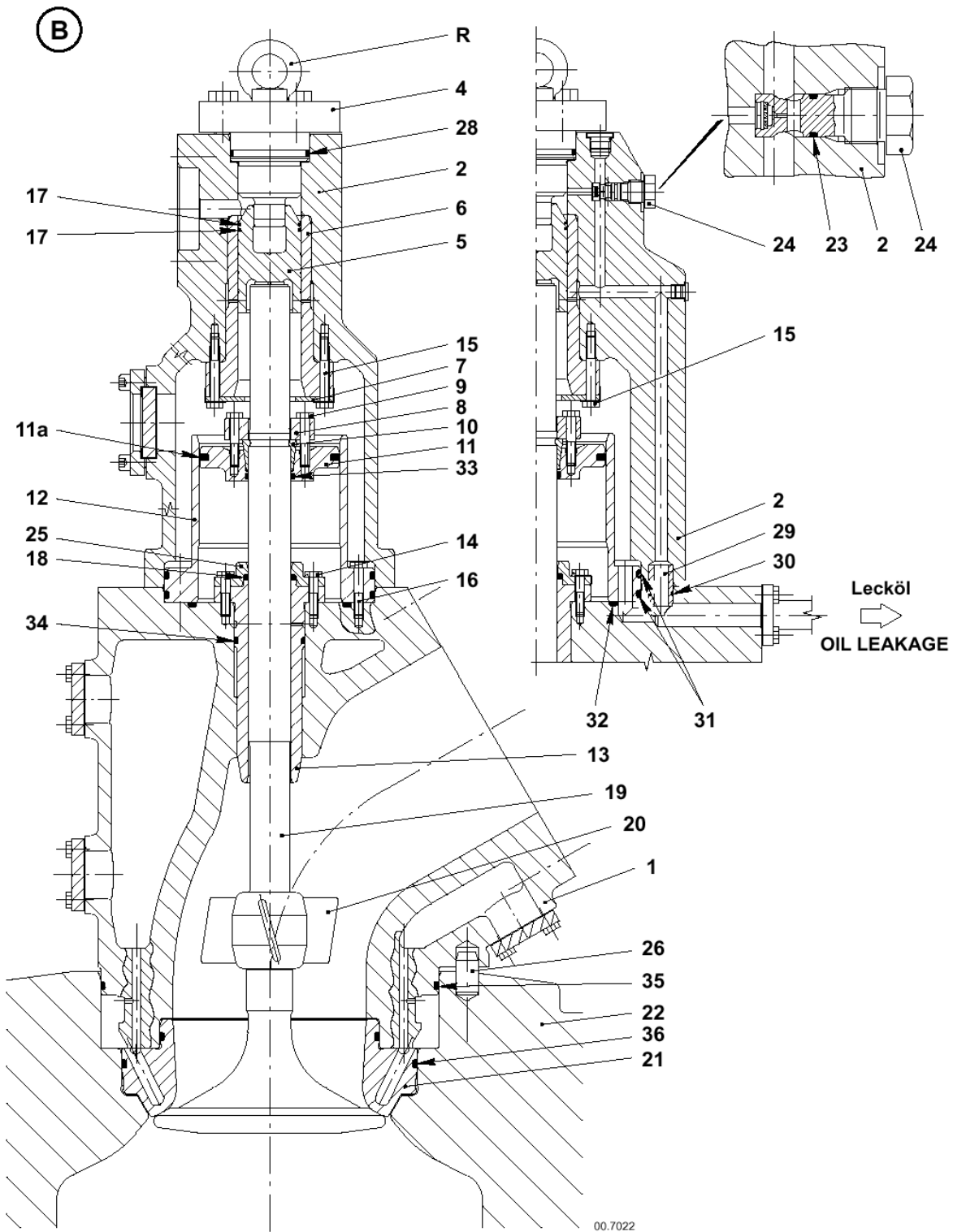




Slika 3.66 Klinovi za spajanje tanjurića opruge na ventil

KAVEZ S ISPUŠNIM VENTILOM





Ispušni ventil s kavezom
(kučištem)

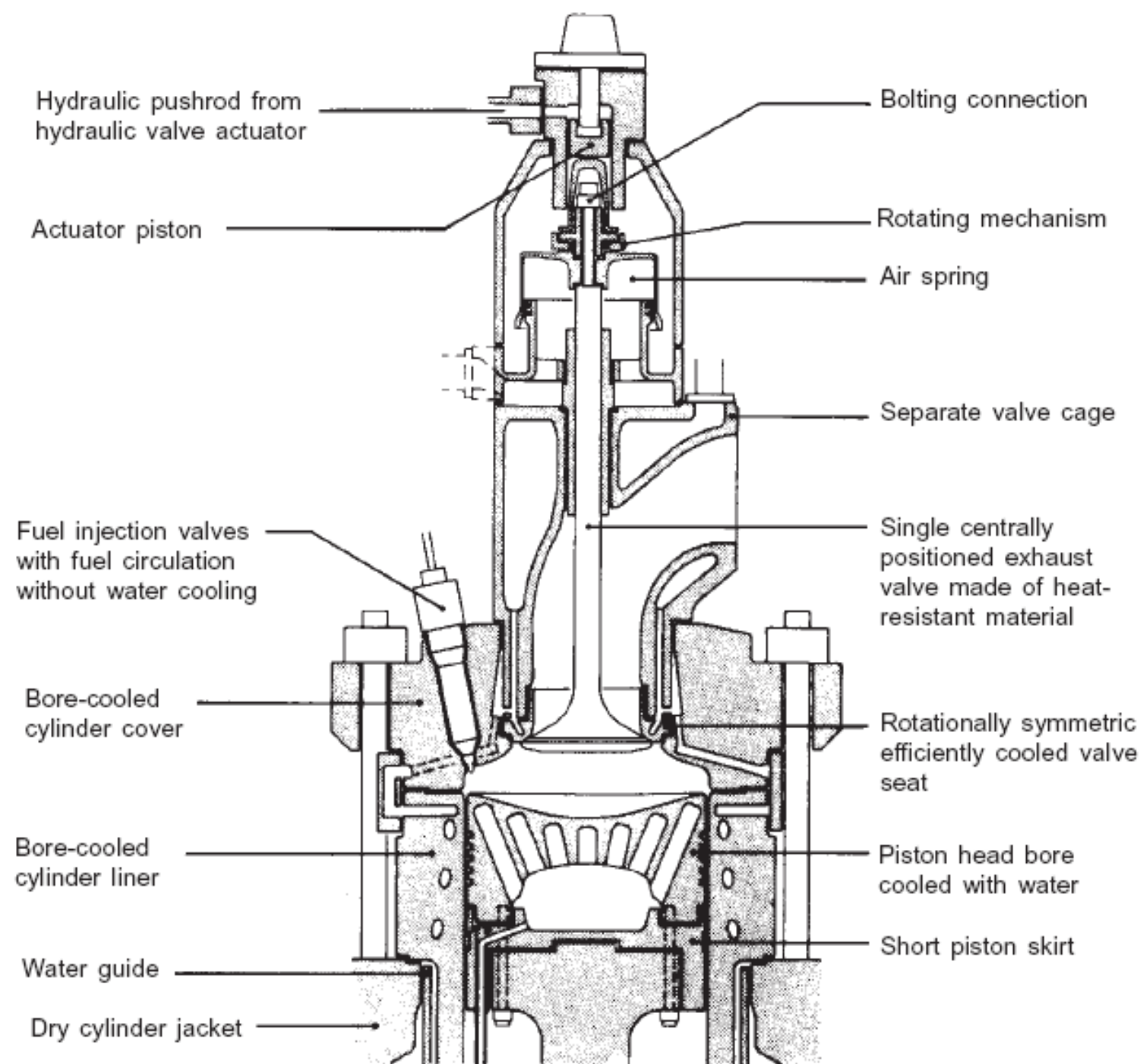
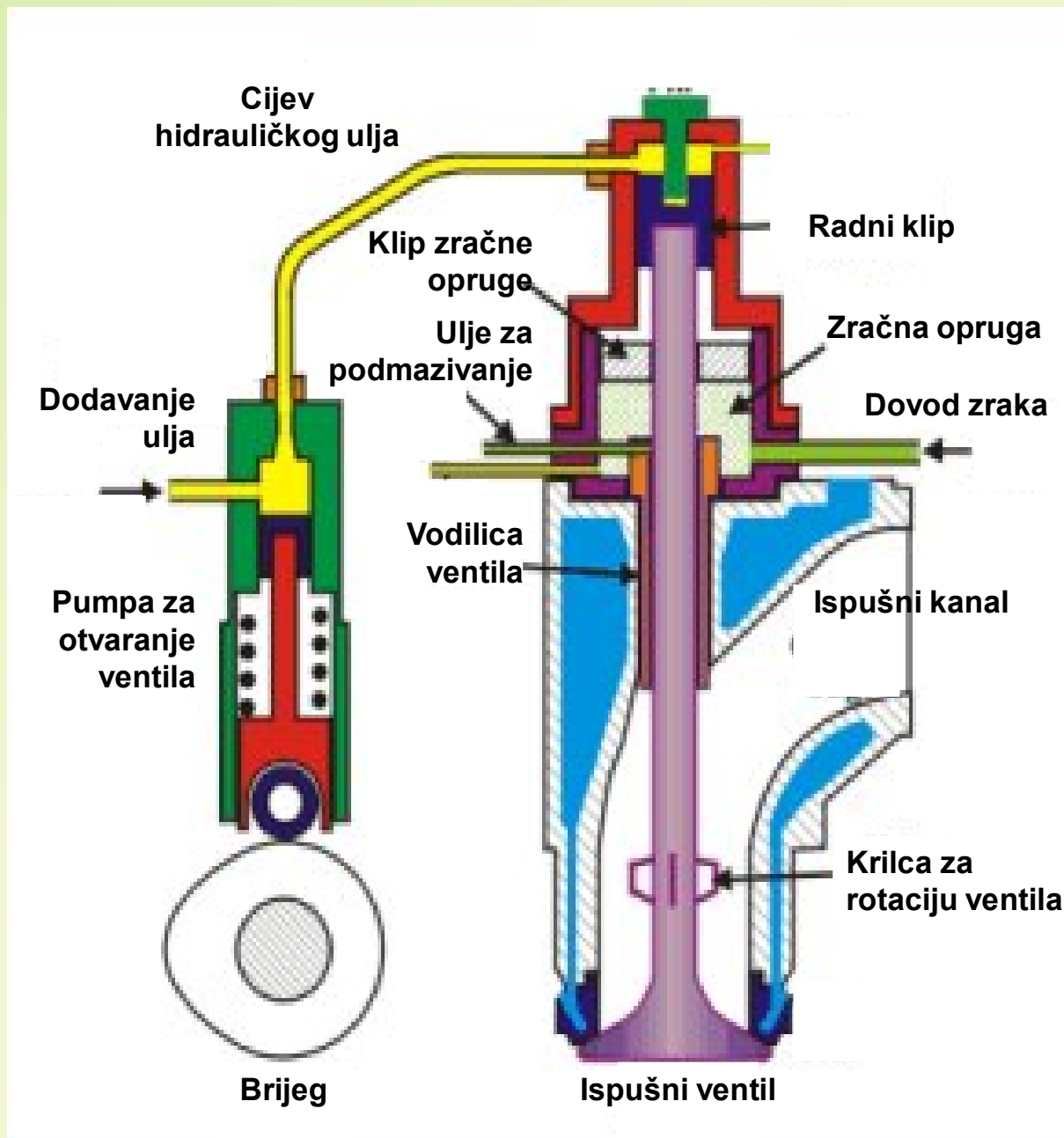
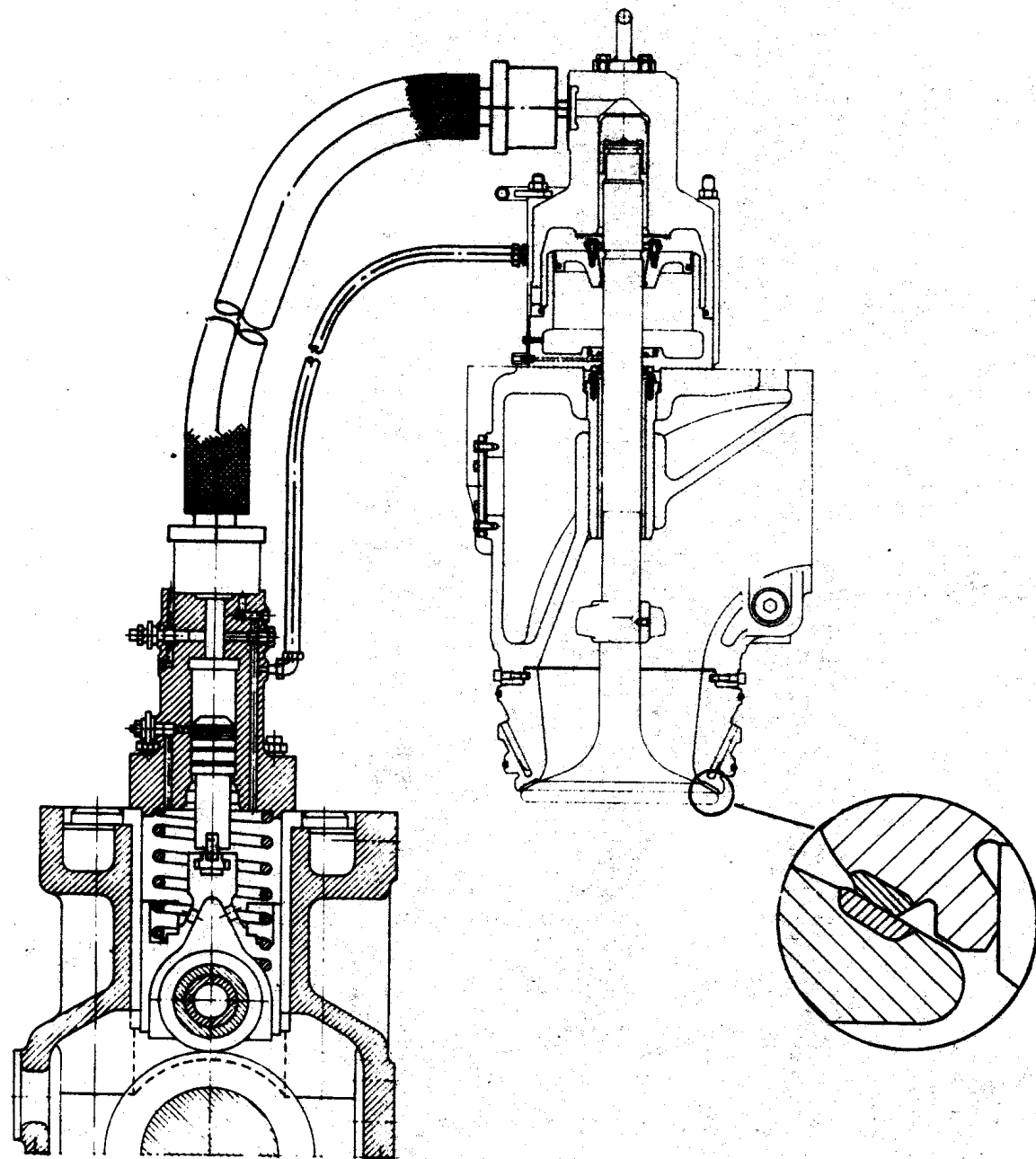
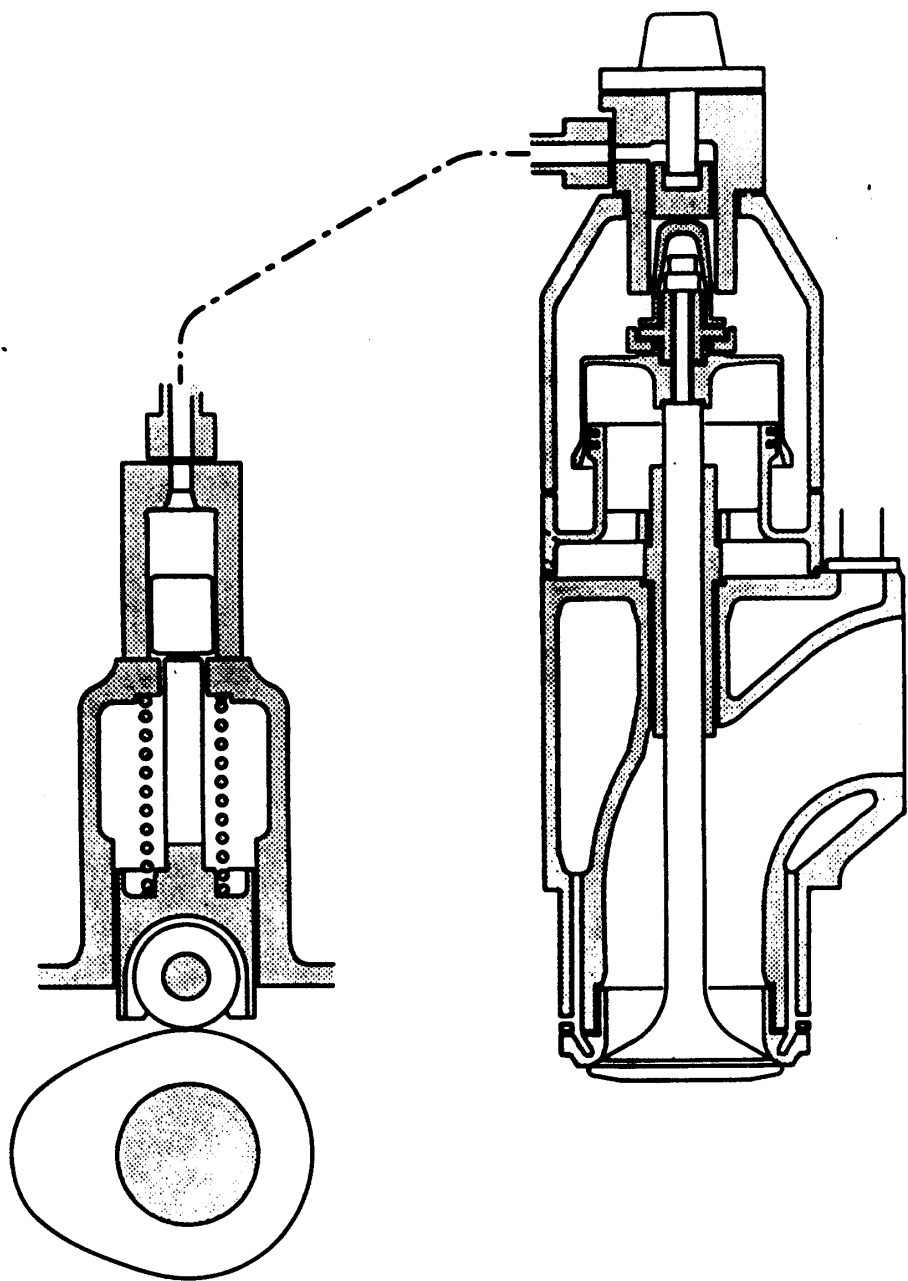
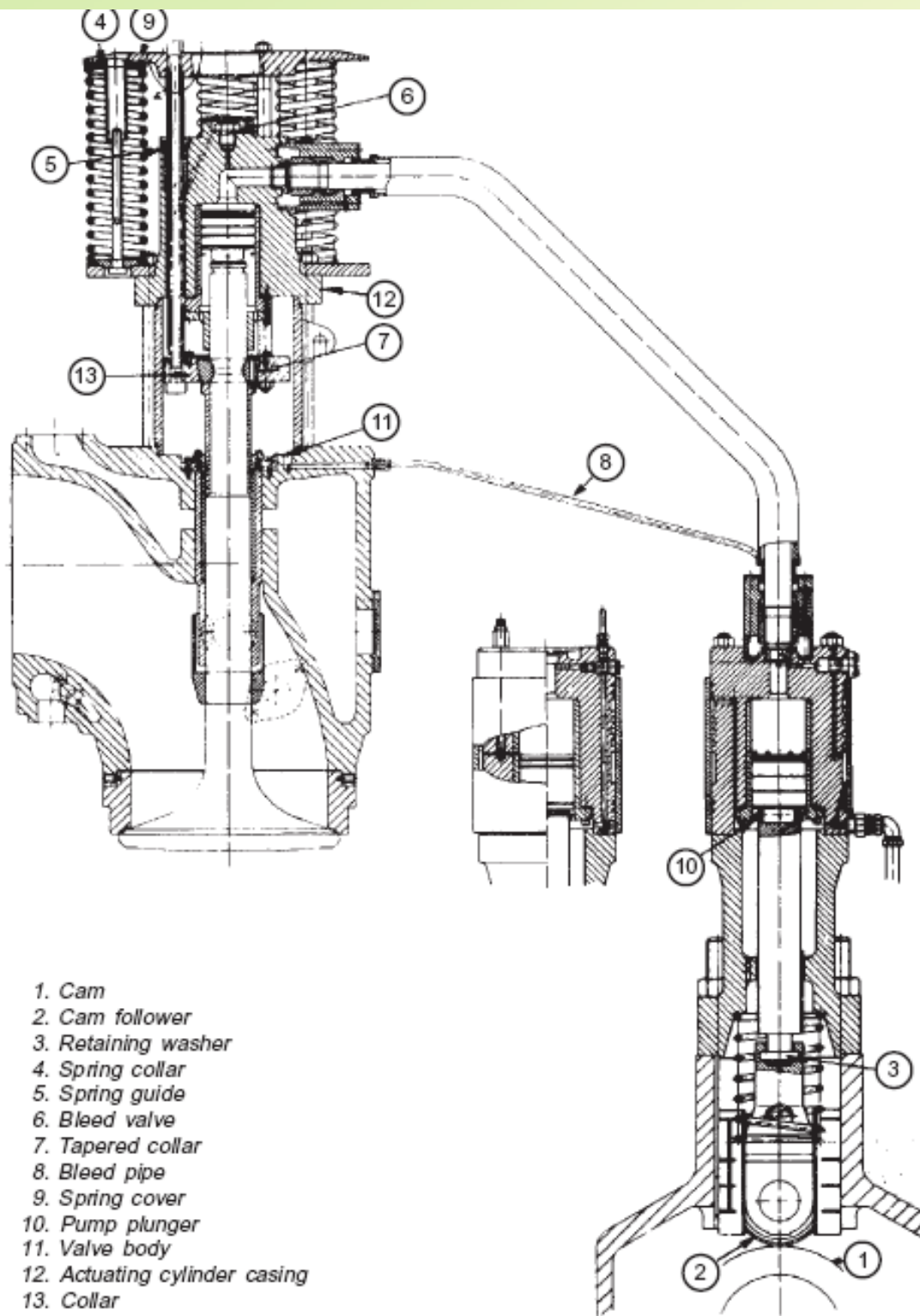


Figure 12.2 RTA engine combustion chamber components





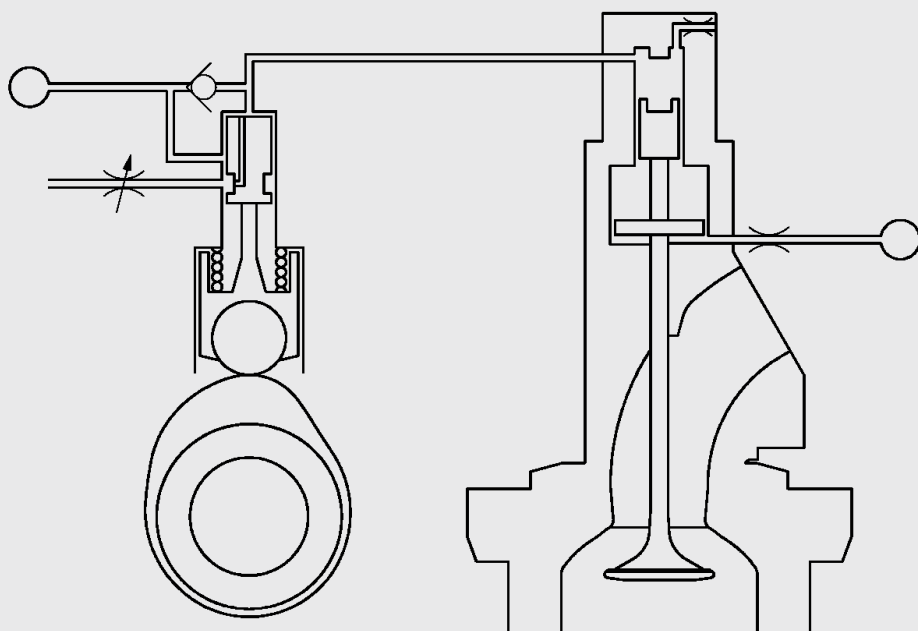
Hidraulički pogon ispušnih ventila brodskih 2T dizelskih motora



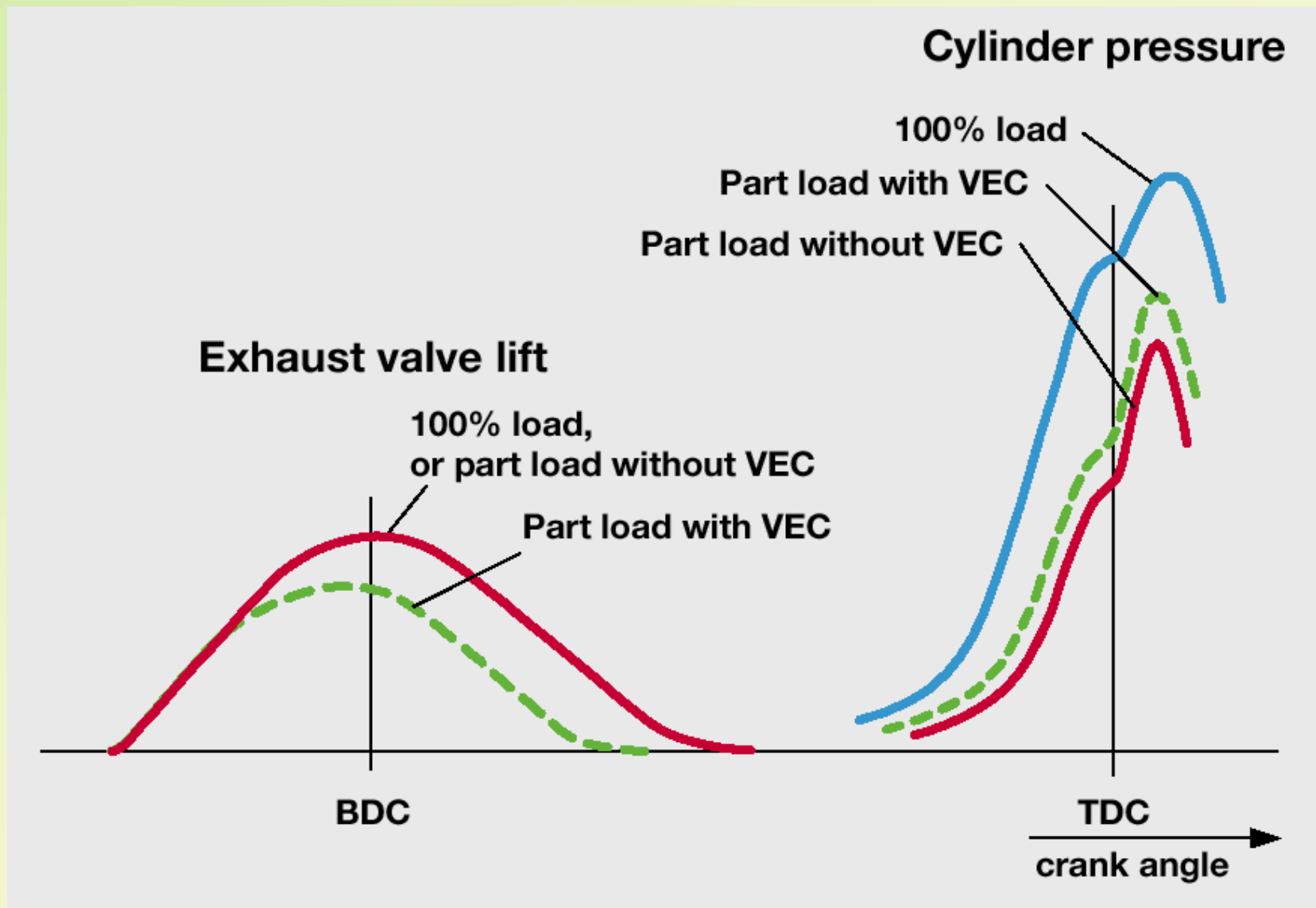
oil supply

control

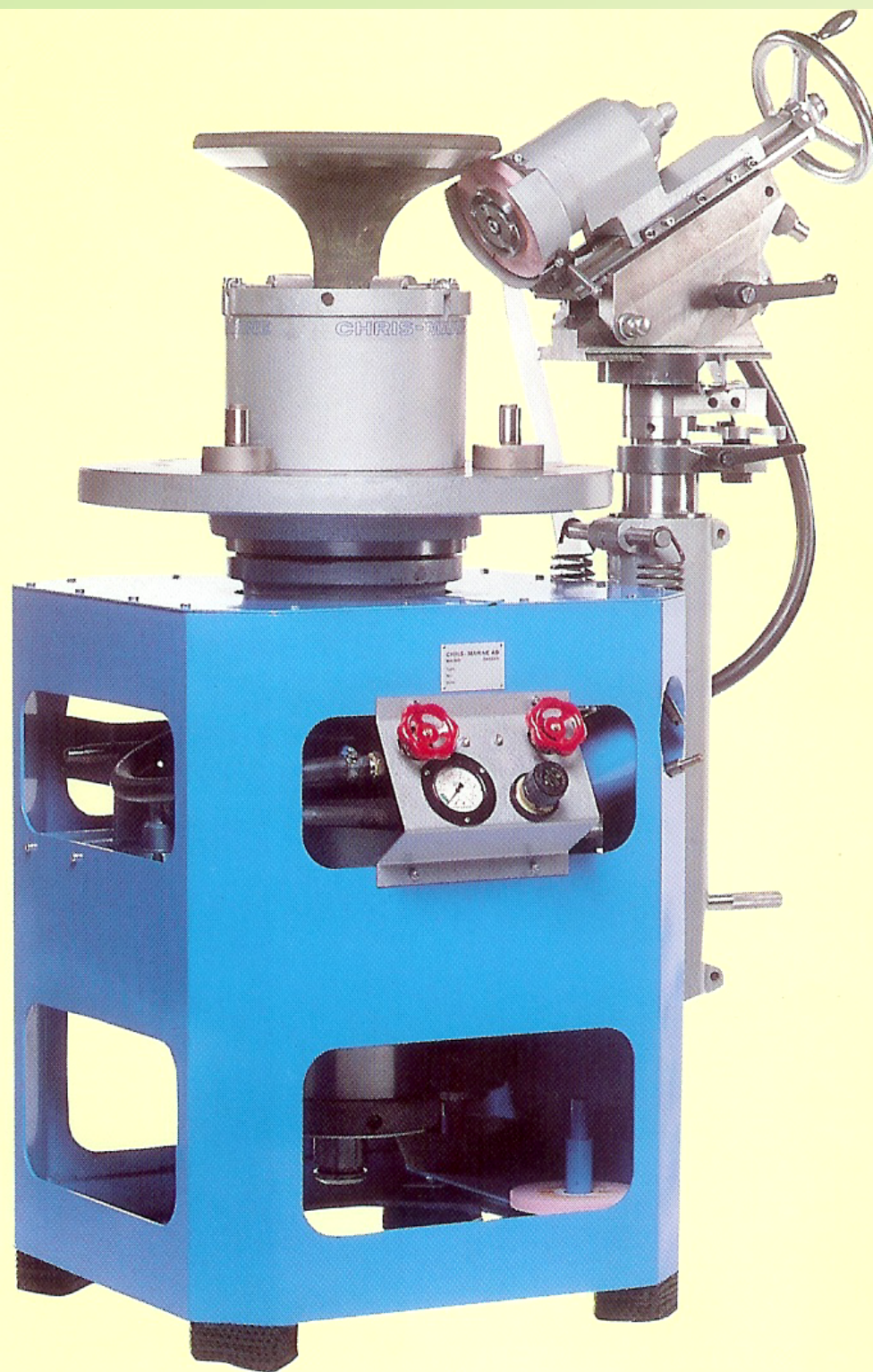
compressed air



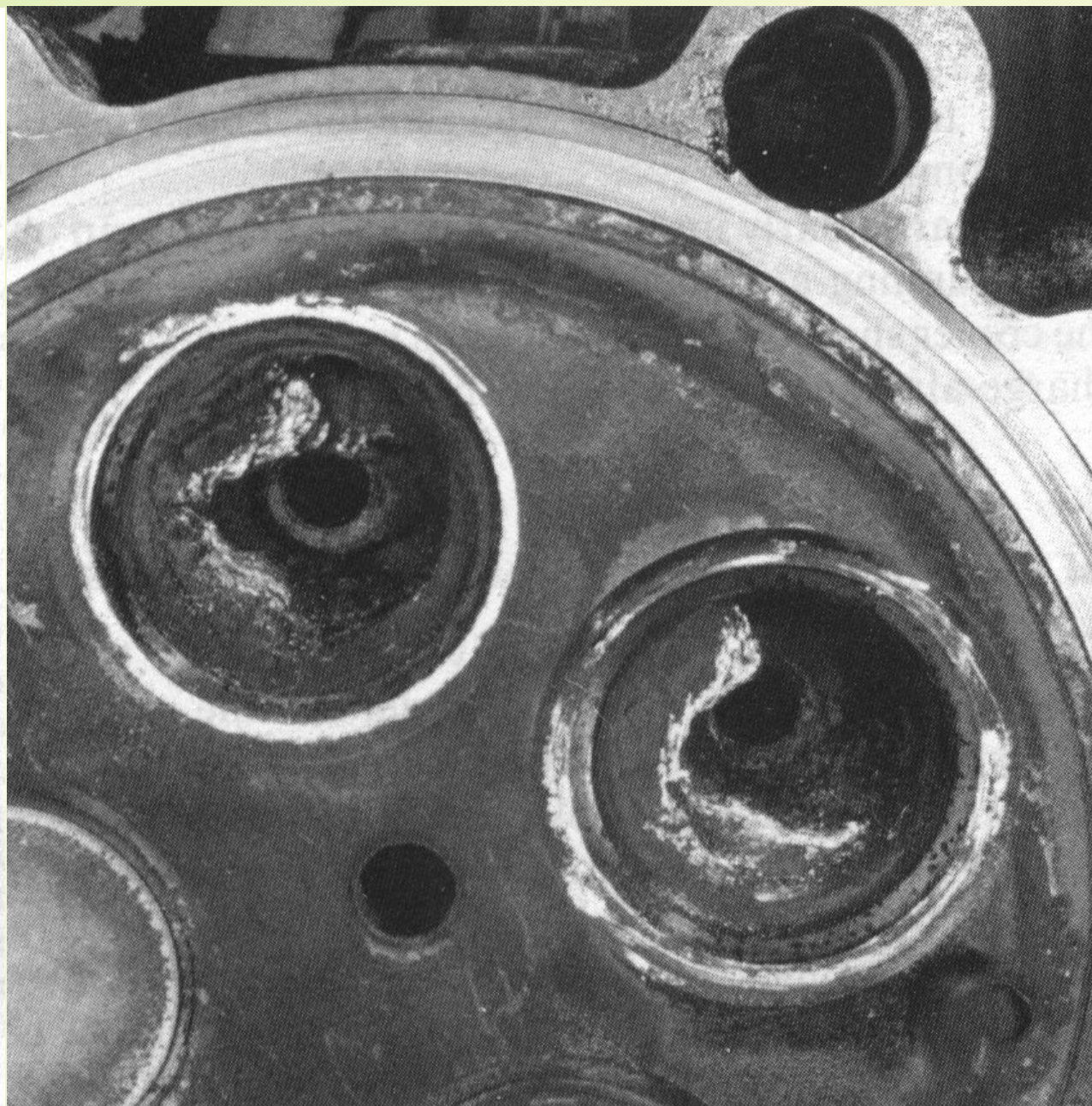
Hidraulično upravljanje za
varijabilno zatvaranje
ispušnog ventila
(VEC, Wartsilla)



Hidrauličko upravljanje za varijabilno zatvaranje ispušnog ventila
(VEC, Wartsilla)



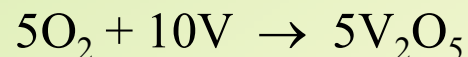
BRUŠENJE VENTILA I SJEDIŠTA



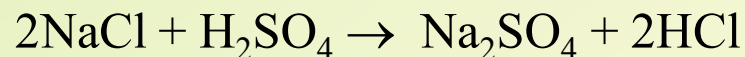
Stvaranje naslaga na usisnim ventilima i u usisnim kanalima

VISOKOTEMPERATURNNA KOROZIJA

Visokotemperaturna korozija pripisuje se djelovanju smjese vanadijevog pentoksida V_2O_5 i natrijeva sulfata Na_2SO_4 . Vanadijev pentoksid nastaje oksidacijom vanadija pri izgaranju u motoru:

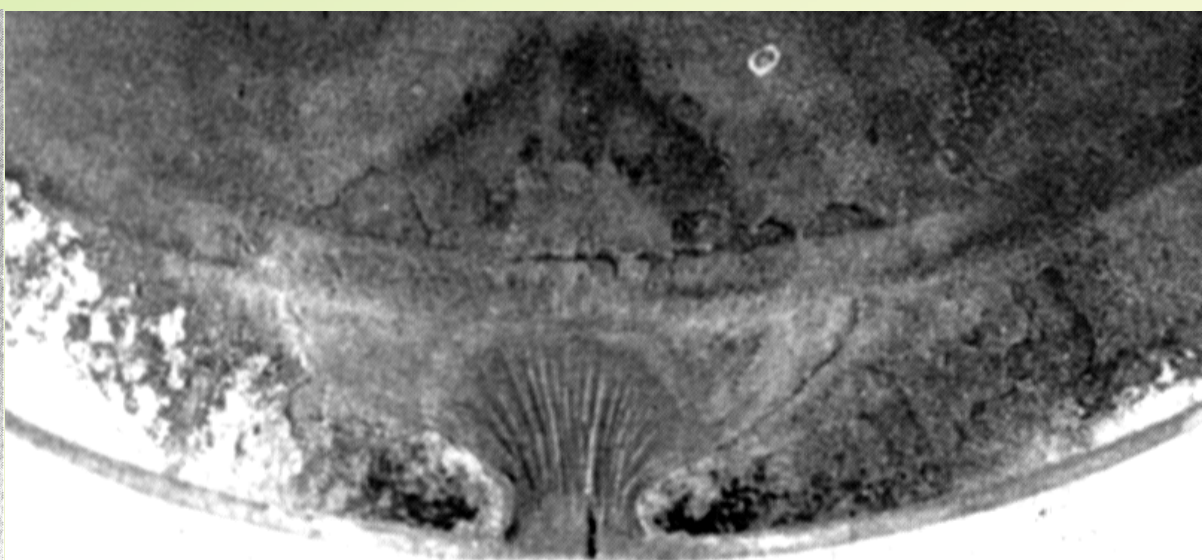
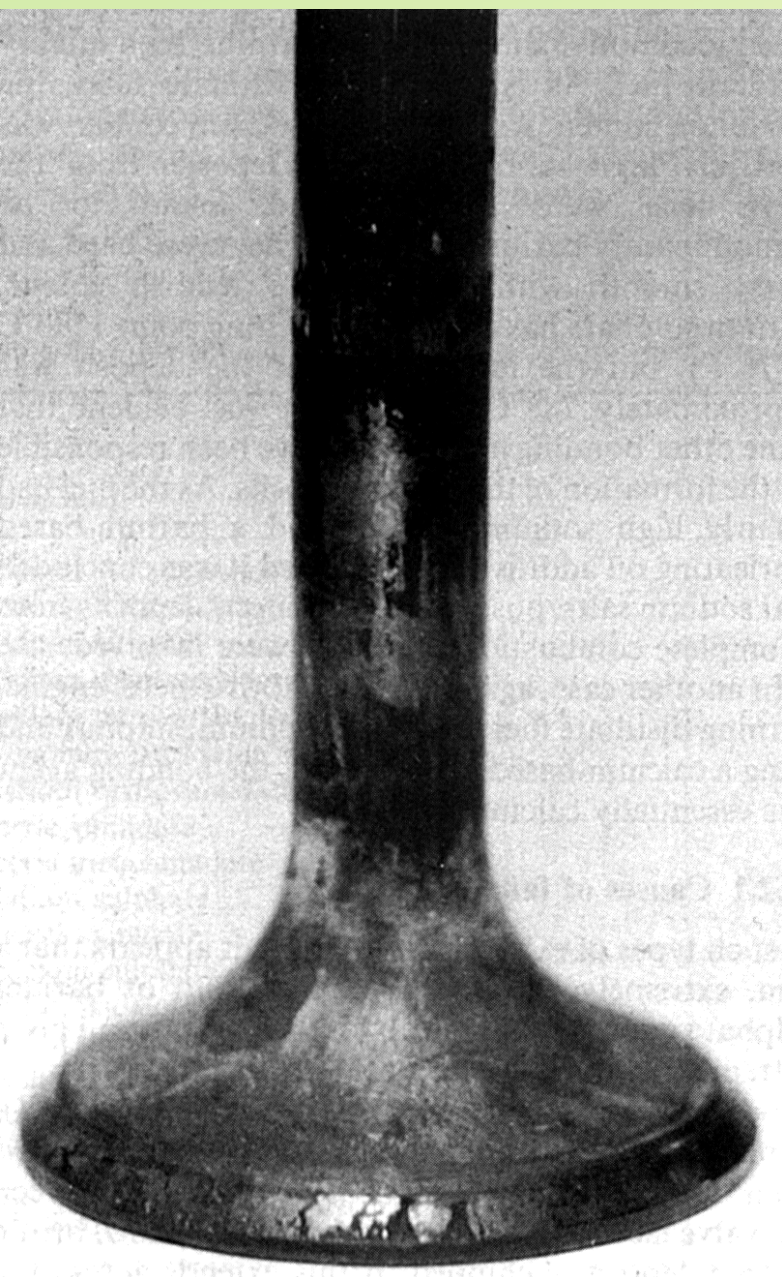


Natrijev sulfat nastaje reakcijom soli iz morske vode sa sumpornom kiselinom:

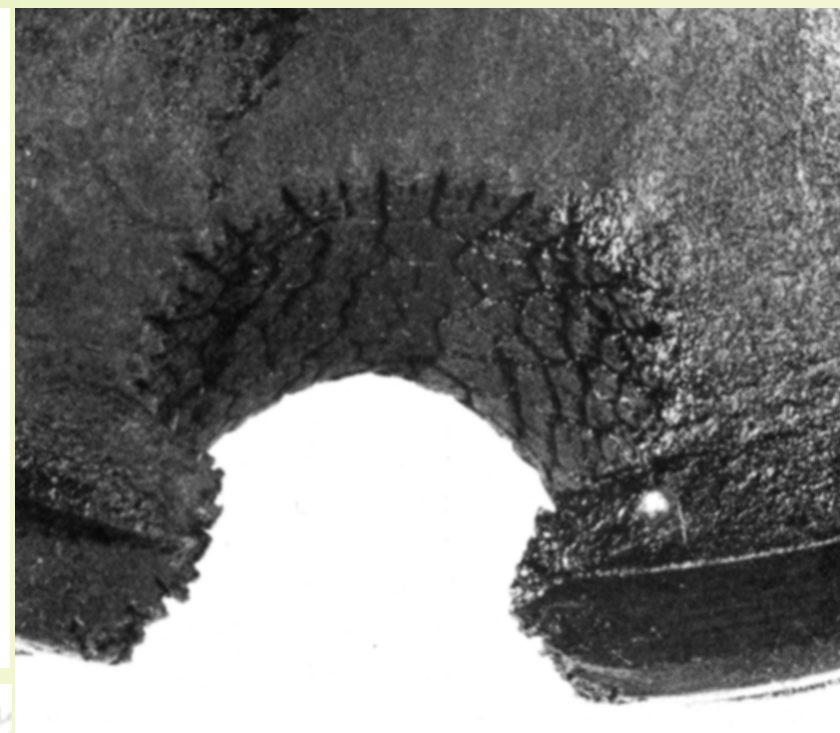
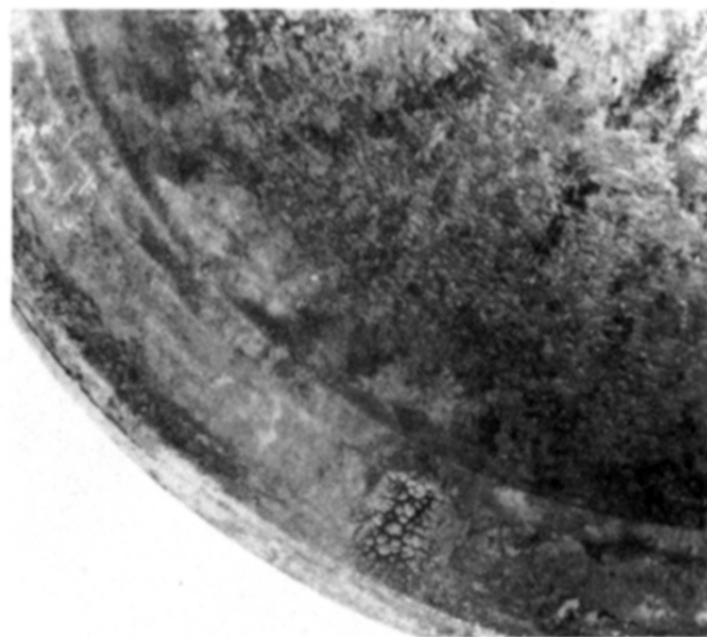
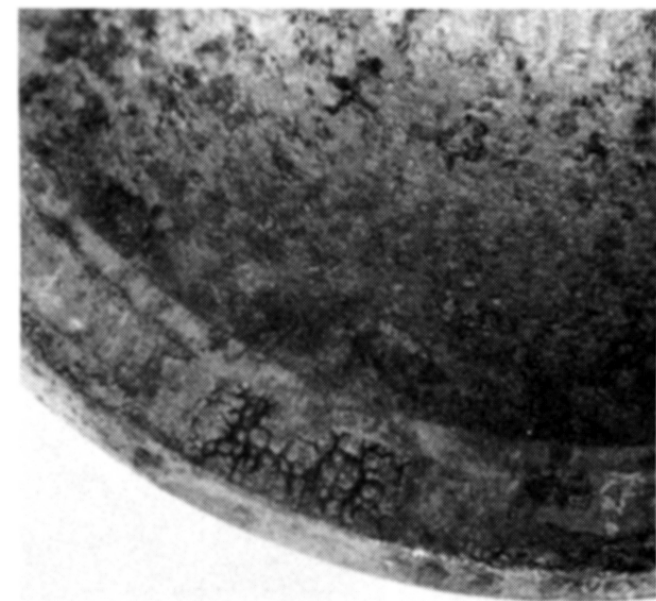


Pri visokim temperaturama oba spoja su u stanju tekućine. Na vrelim površinama dolazi do nakupljanja kapljica koje izuzetno jako korozijski djeluju na površini feritnih materijala, koja djeluje po granicama među kristalnim zrnima i napada materijal po dubini. Najčešće napadnuta mjesta su sjedišta ispušnih ventila, a rijeđe i čelo klipa.

Djelovanju te korozije suprotstavljamo se dovoljno niskom temperaturom dijelova, odnosno hlađenjem dijelova kako njihova temperatura nebi prešla 400 °C.



Oštećenja sjedišta ventila zbog djelovanja visokotemperaturne korozije



Oštećenja sjedišta ventila pod
djelovanjem
visokotemperaturne korozije

BRIJEGOVI

Zahtjevi pred brijegom:

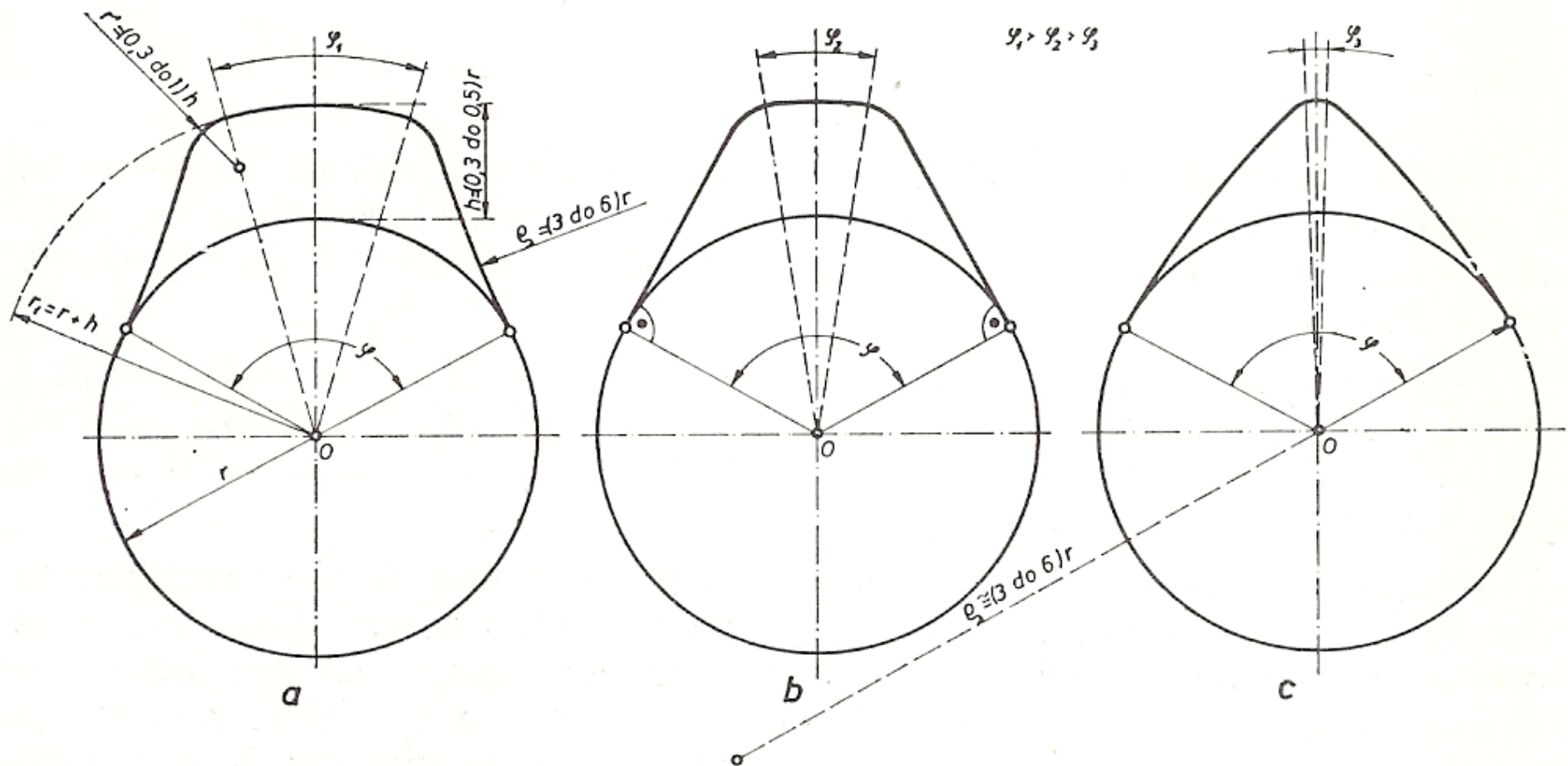
1. Vrijeme otvaranja ventila što duže
2. Ubrzanje i usporenje ventila moraju biti umjerena
3. Ne smiju zahtijevati prekvalitetne materijale (čelici za cementiranje i kaljenje)

Osovina na kojoj se nalaze BREGASTA ili RAZVODNA OSOVINA.

Po konstrukcije se dijele na :

- a. Konkavni brijeg : - najduže otvaranje
 - najveća ubrzanja
 - nije za brzookretne motore
- b. Tangencijalan brijeg: - najjednostavniji za izradu
 - umjerena ubrzanja
- c. Harmoničan brijeg : - jednolična i umjerena ubrzanja i usporenja
 - najkraće vrijeme otvaranja
 - za brzookretne motore

BRIJEGOVI



RAZVODNA OSOVINA

Na sebi sadrži:

- brijegove ventila
- brijegove VT pumpi
- uređaj za prekret
- pilot ventil - razvodnik zraka
- regulator broja okretaja i sigurnosni regulator

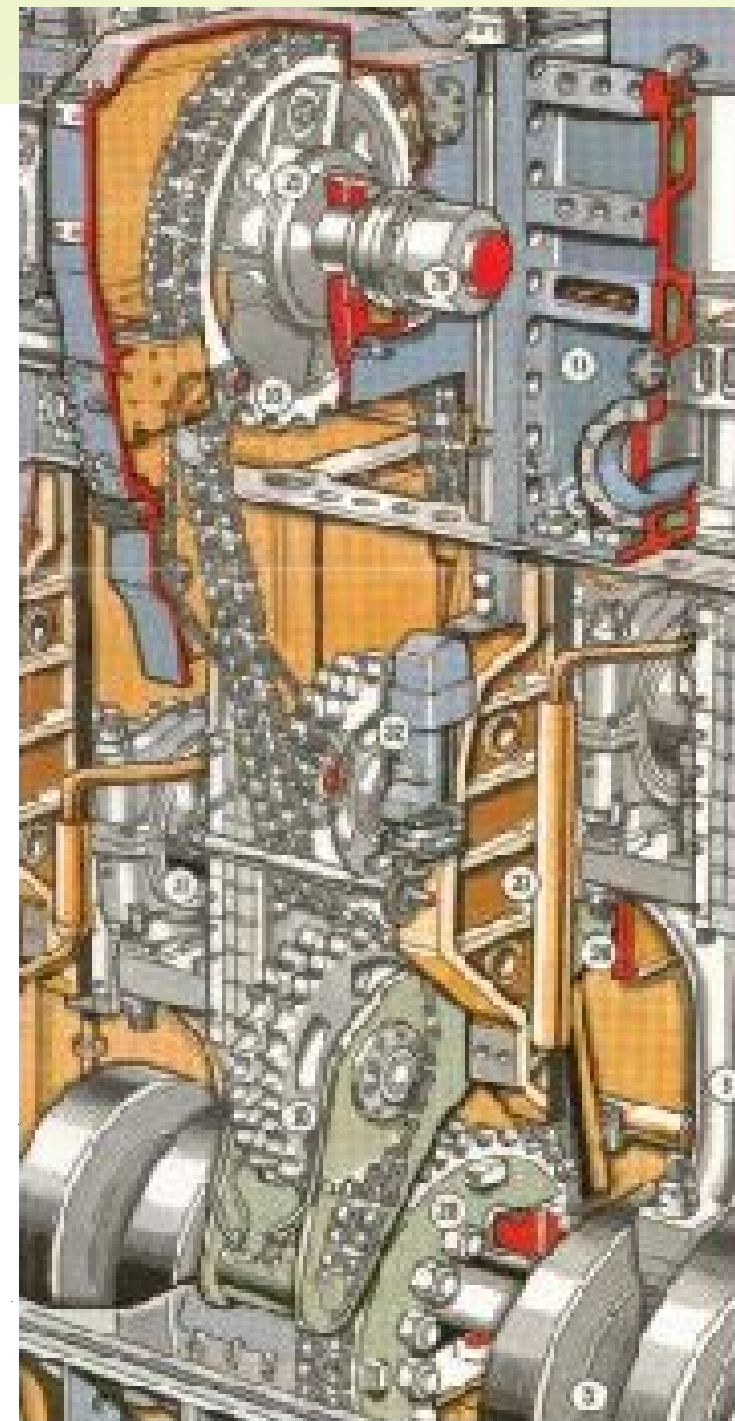
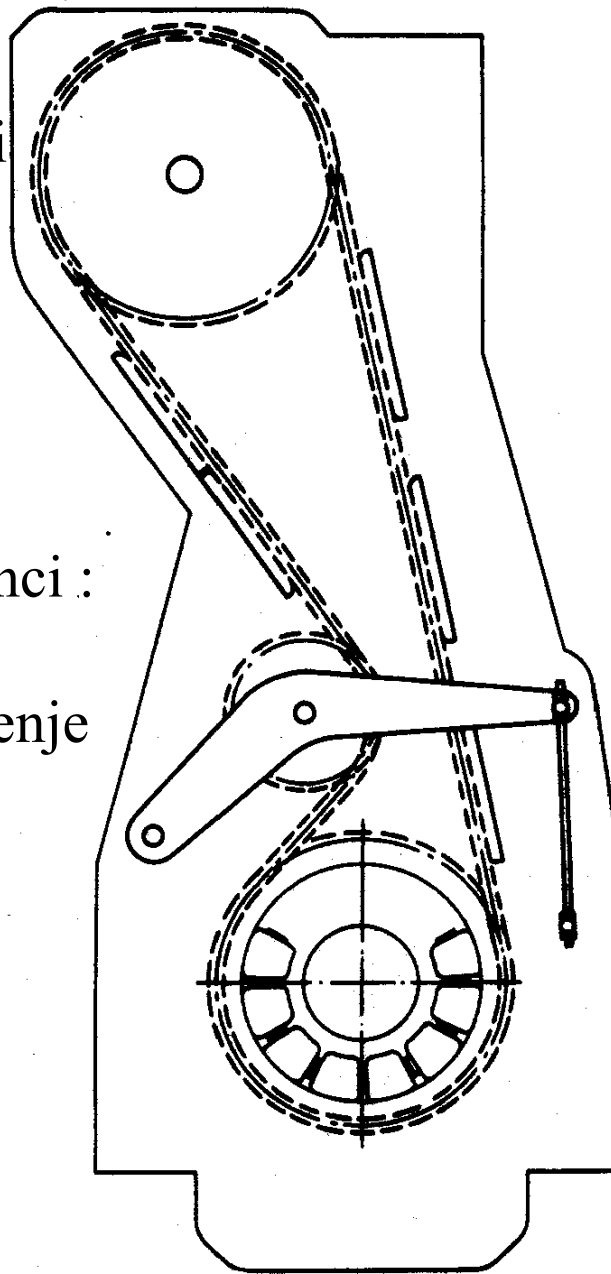
POGON RAZVODNE OSOVINE

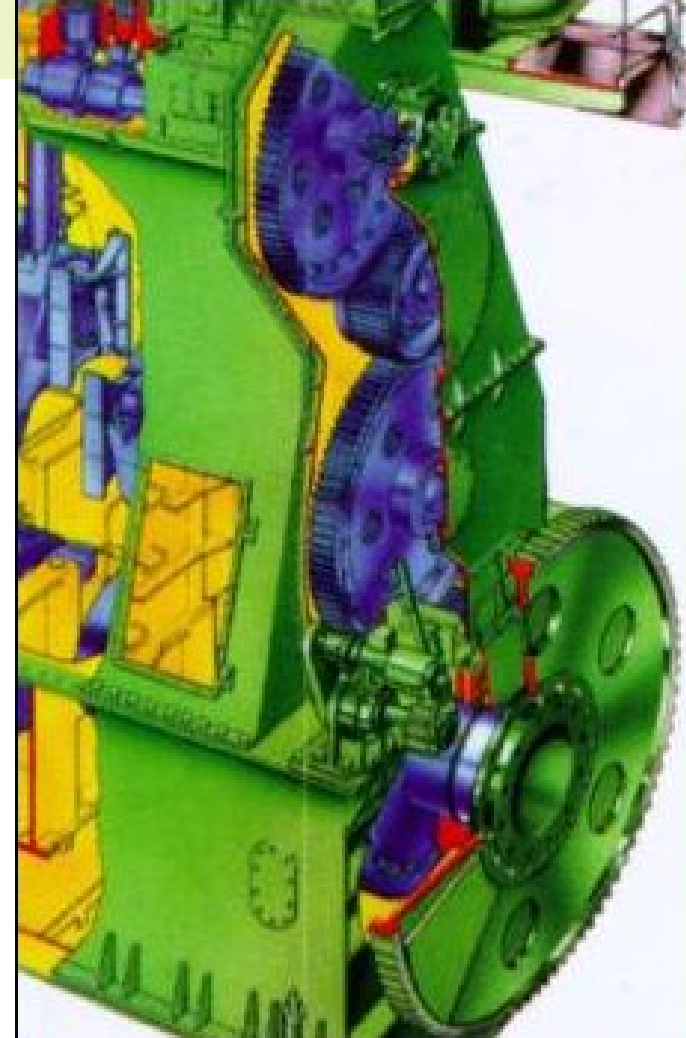
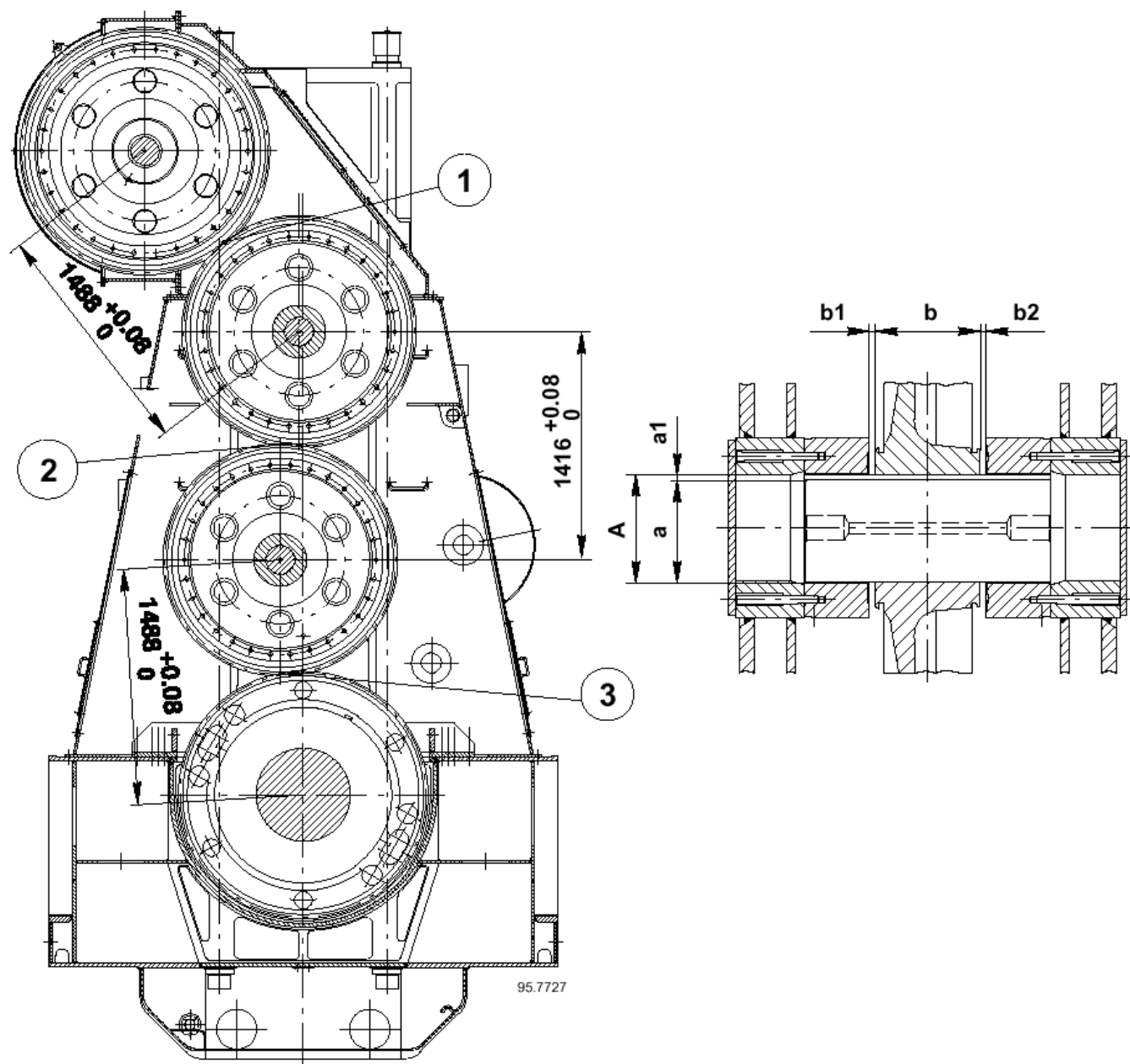
Odnos brzina vrtnje kolj.osovine i
razvodne osovine

- kod 2T 1 : 1
- kod 4T 2 : 1

Valjčasti ili zglobni (MORSE) lanci :

- bučni
- zbog povećanja zahvata, veće trenje
- mogućnost “natezanja”
- fazni pomak



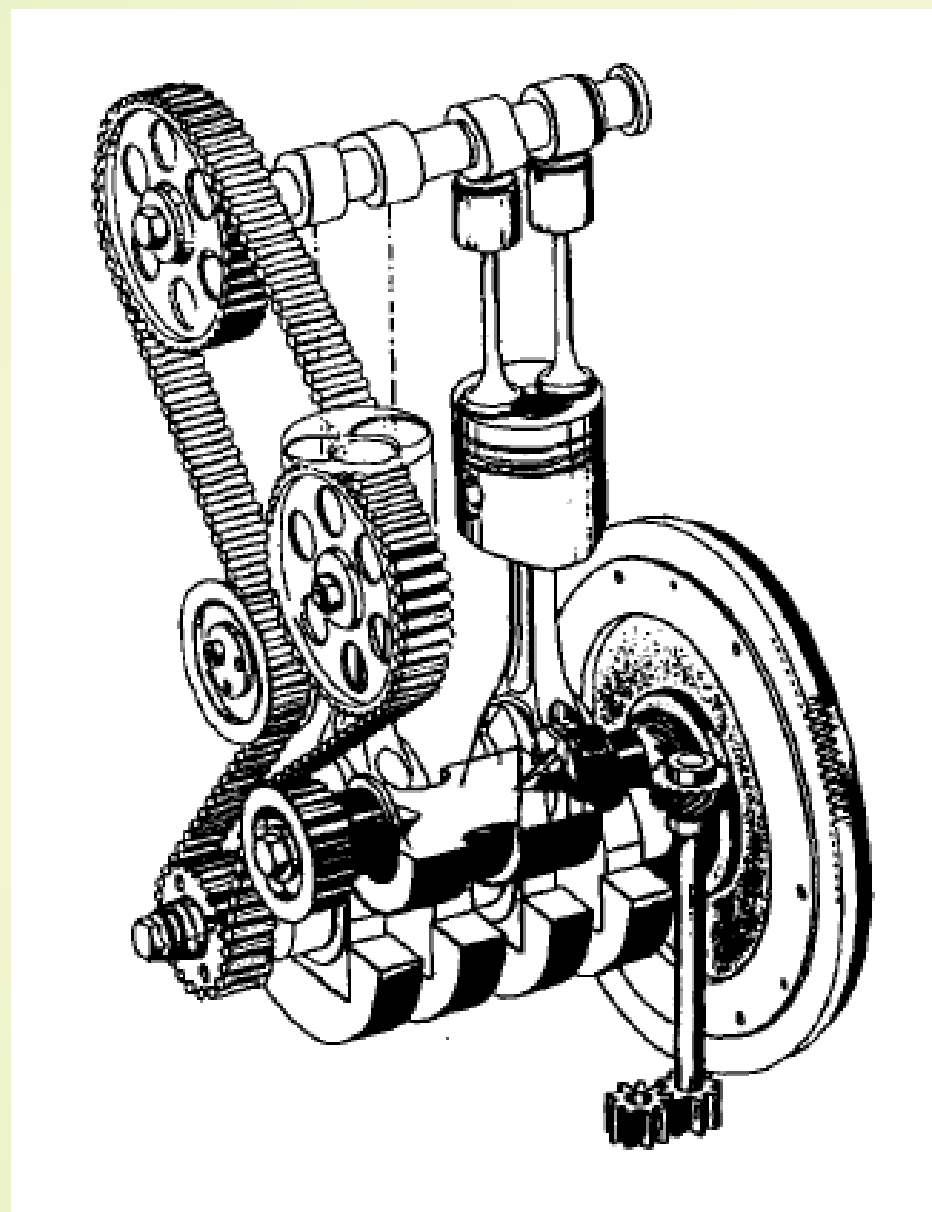
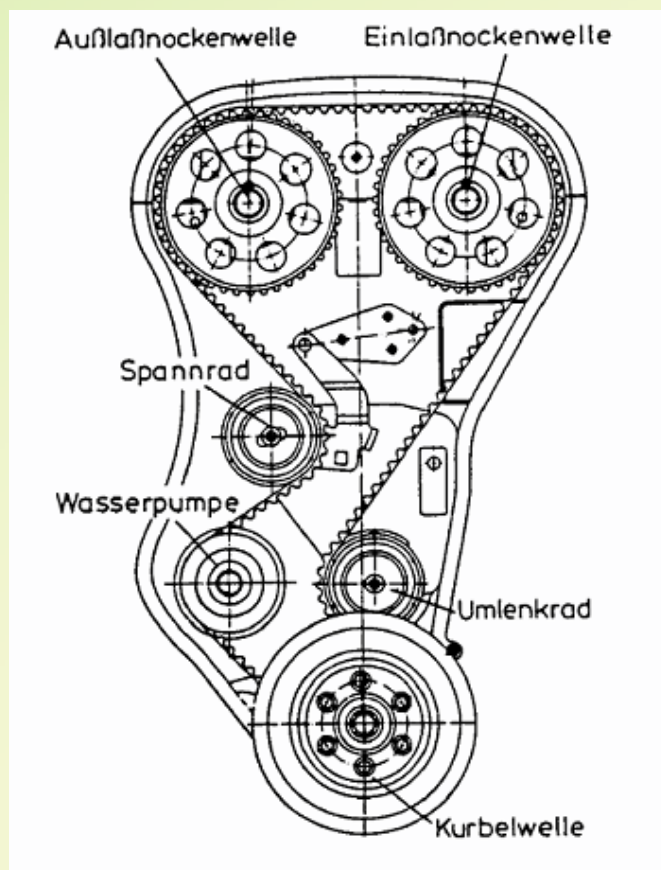


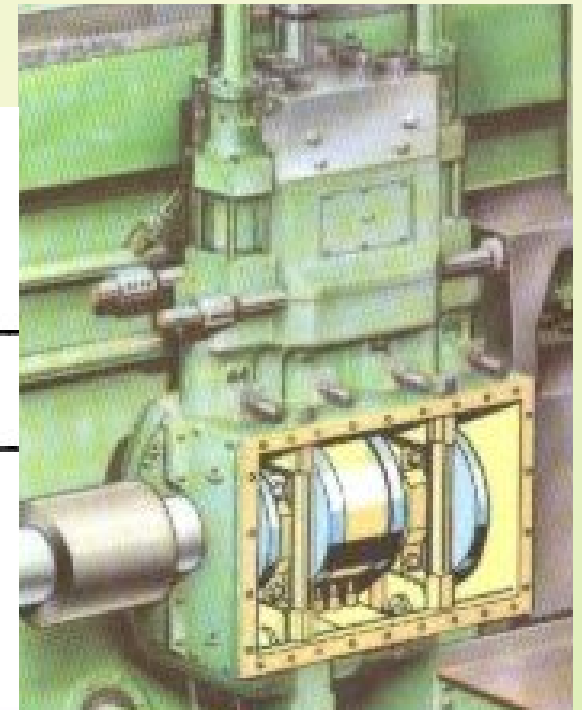
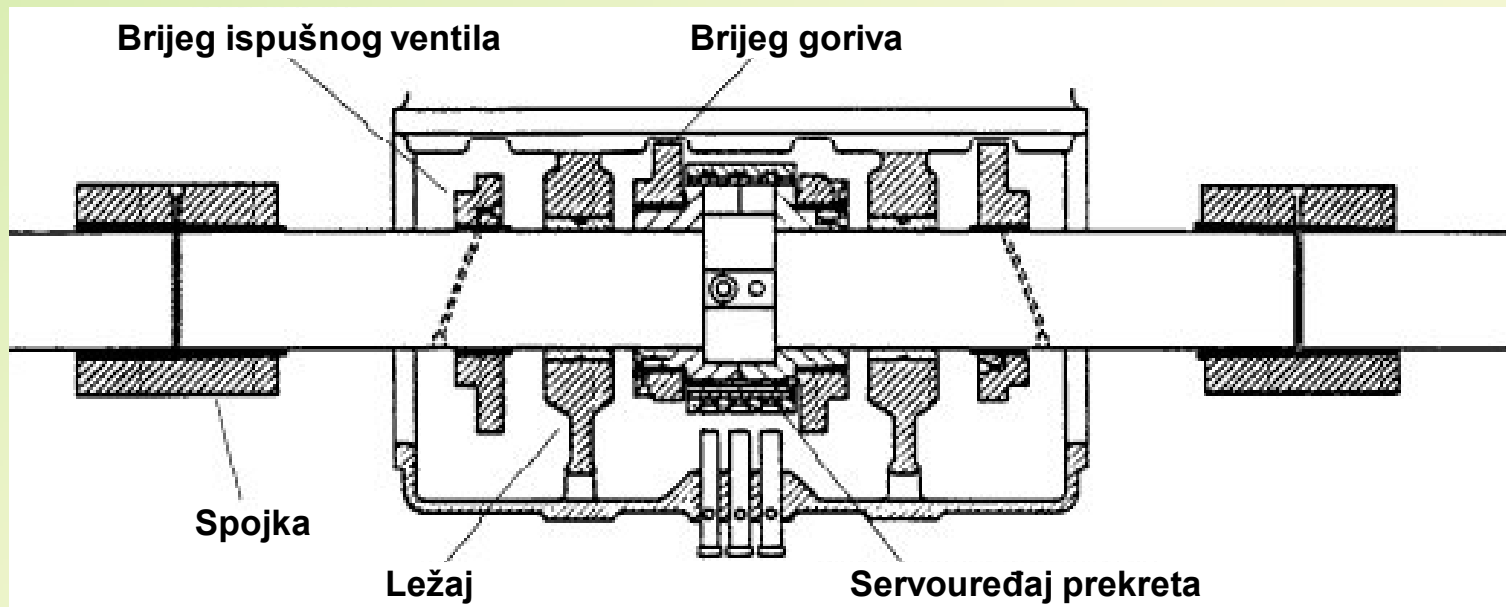
Pogon zupčanicima :

- zauzimaju “puno” mjesta
- šumni
- točan razvod
- plastični materijali

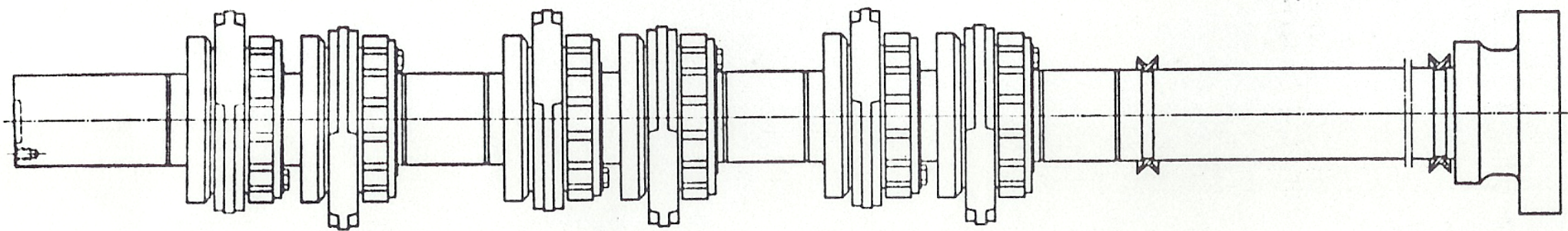
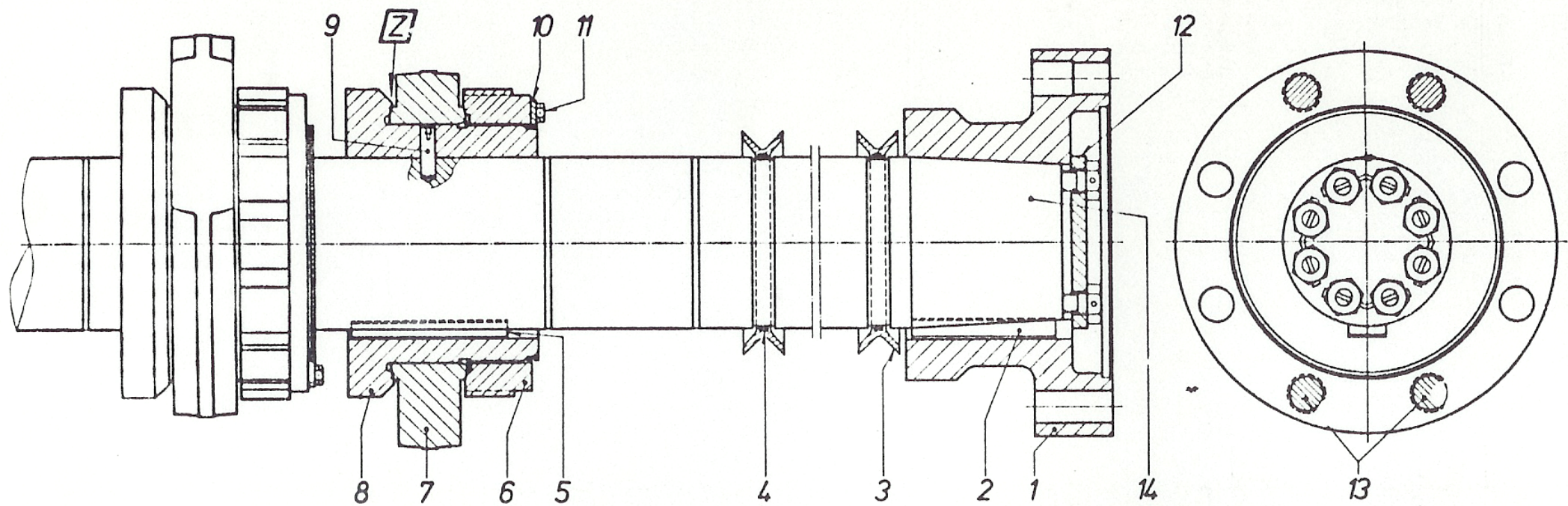
Nazubljenim remenom:

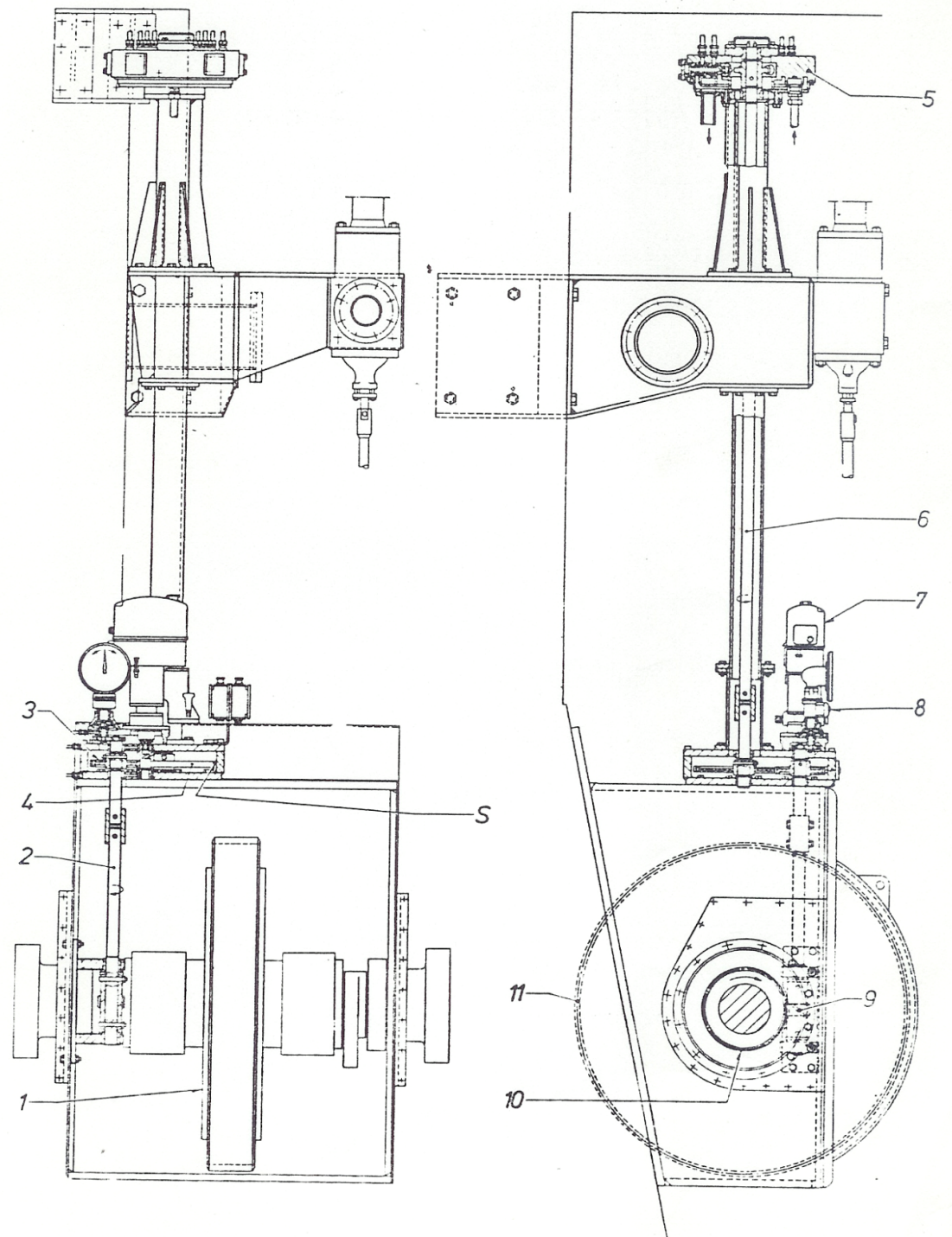
- tihi
- ne podnose ulje i visoke temperature

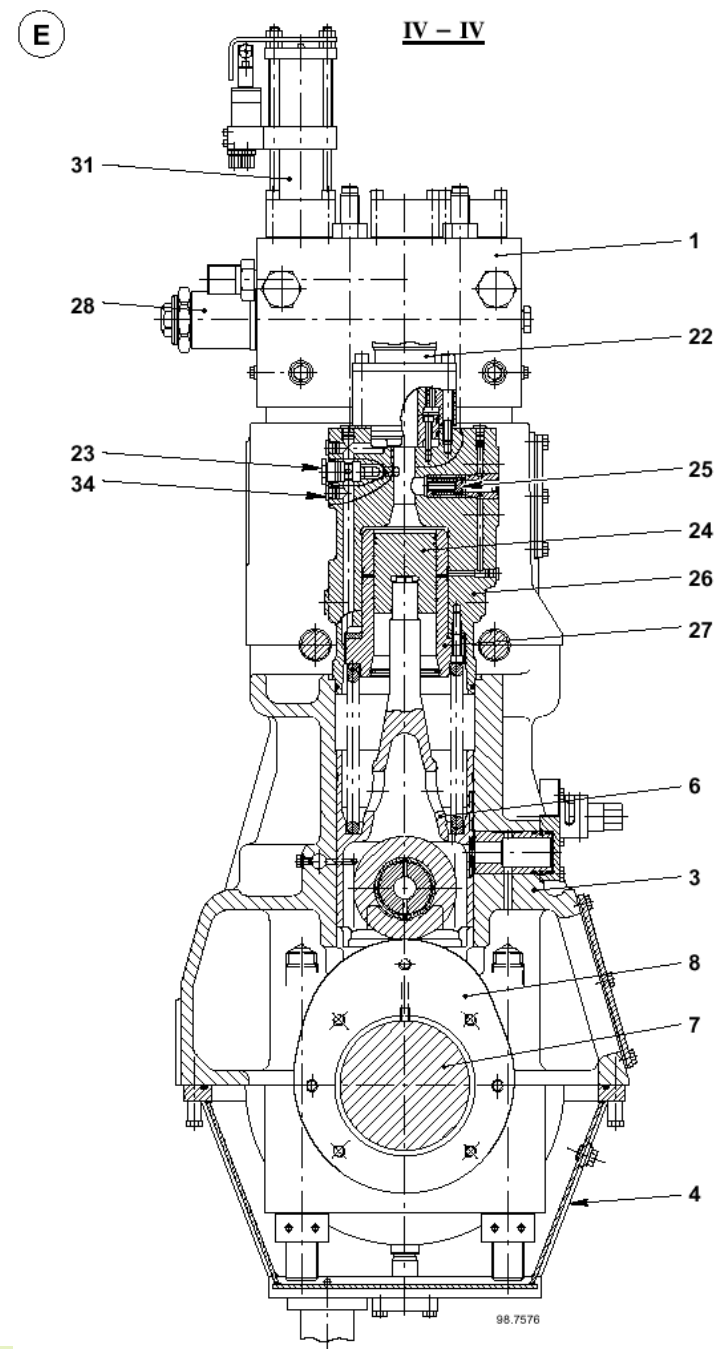
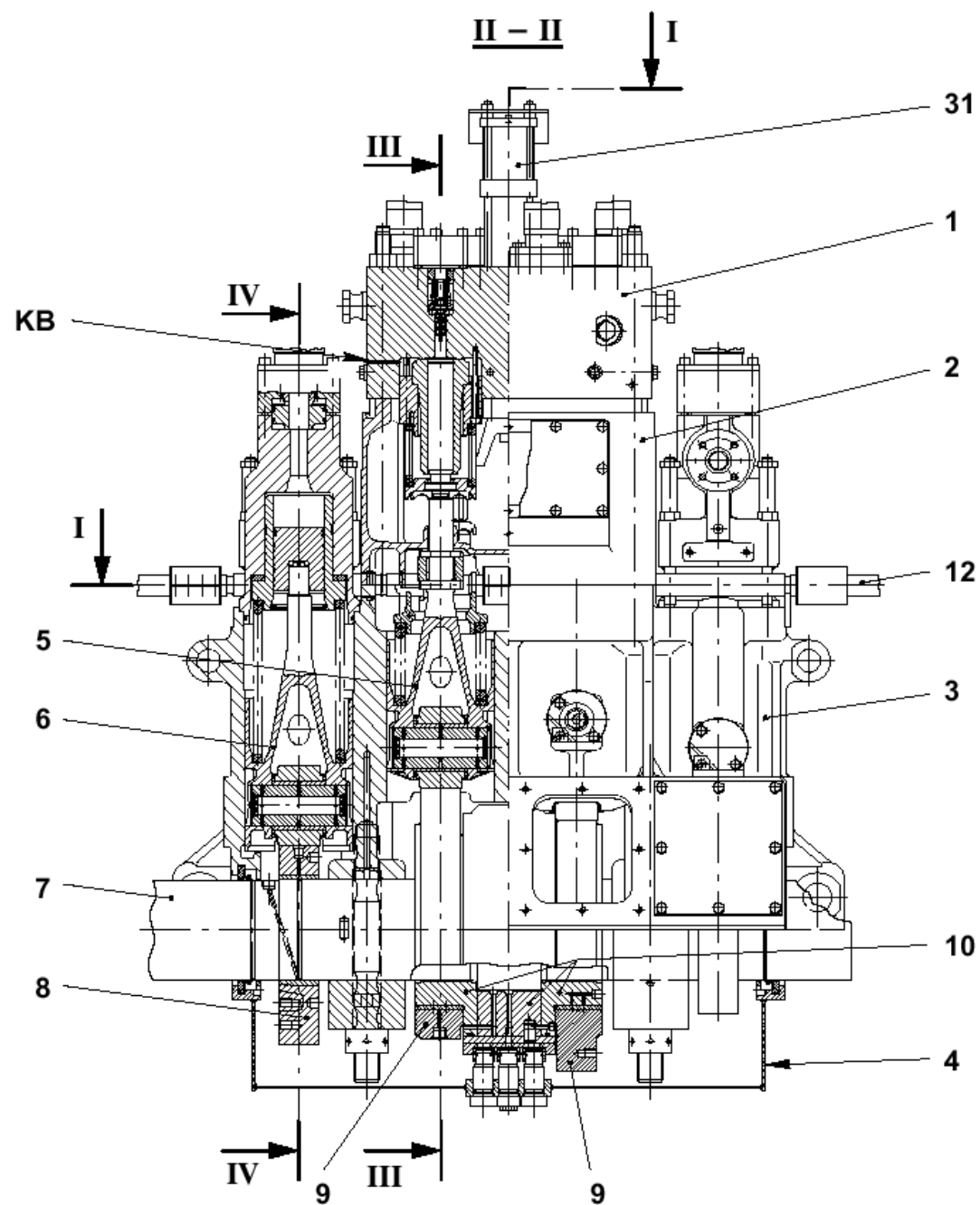




Bregasta osovina se izvodi sastavljanjem dijelova. Brijegovi se izrađuju zasebno i steznim spojem se vežu s osovinom. Bregasta osovina dvotaktnih brodskih motora na sebi imaju brijegove za pogon ispušnih ventila i brijegove za ubrizgavanje goriva. Svaki cilindar motora ima jedan takav par brijegova. Brijegovi su simetrični, kako bi mogli poslužiti i za rad motora u suprotnom smjeru (u preketu).





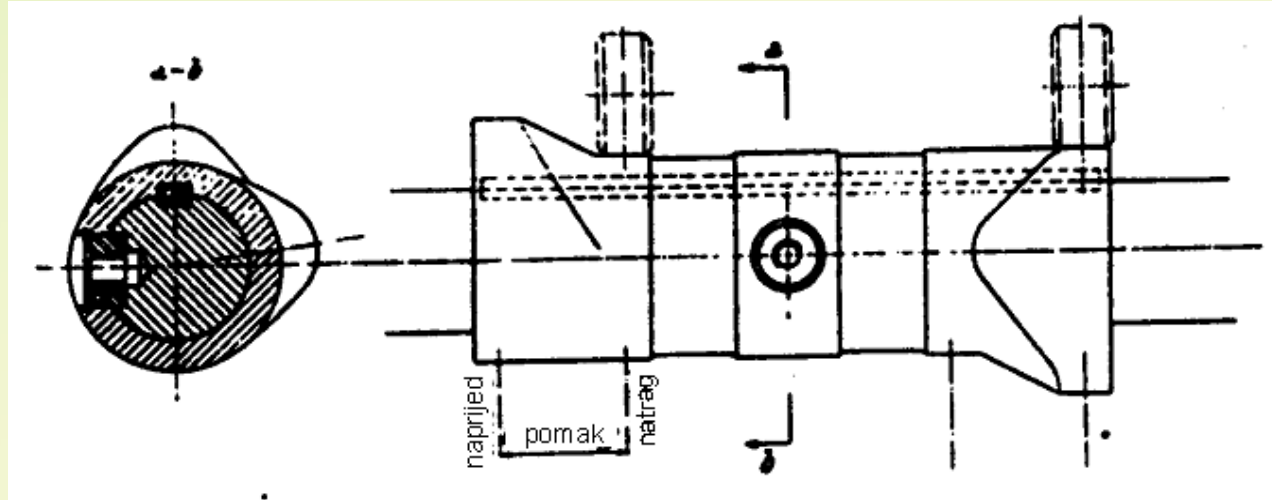


Hidraulička pumpa za pogon ventila i VT pumpa

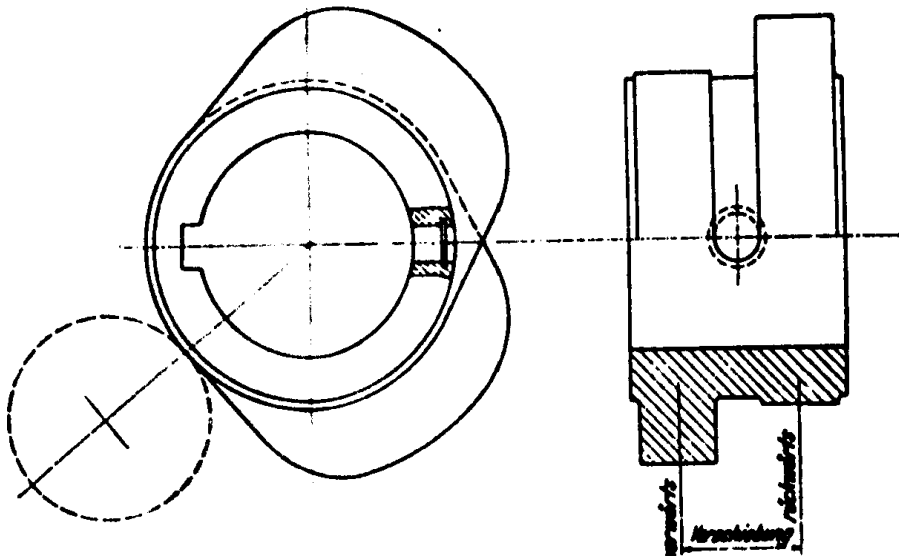
PREKRET MOTORA -4T

Razvodna osovina 4T
prekretnog motora

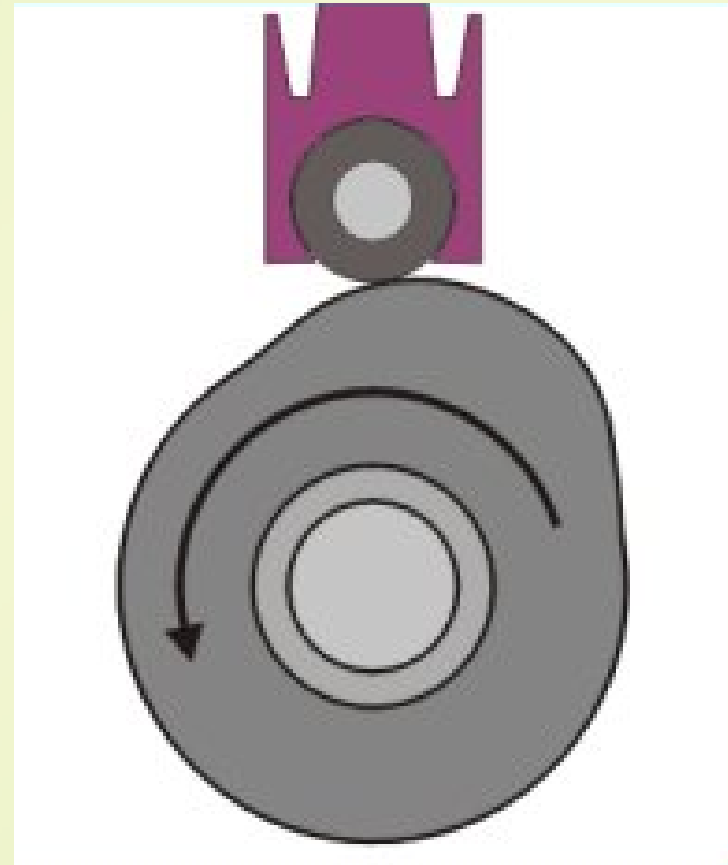
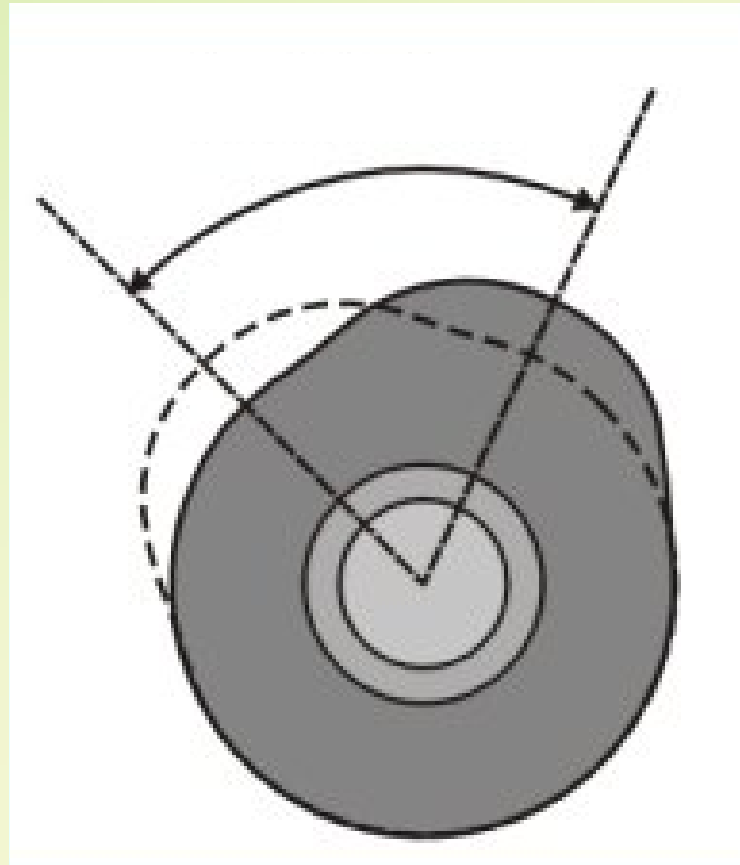
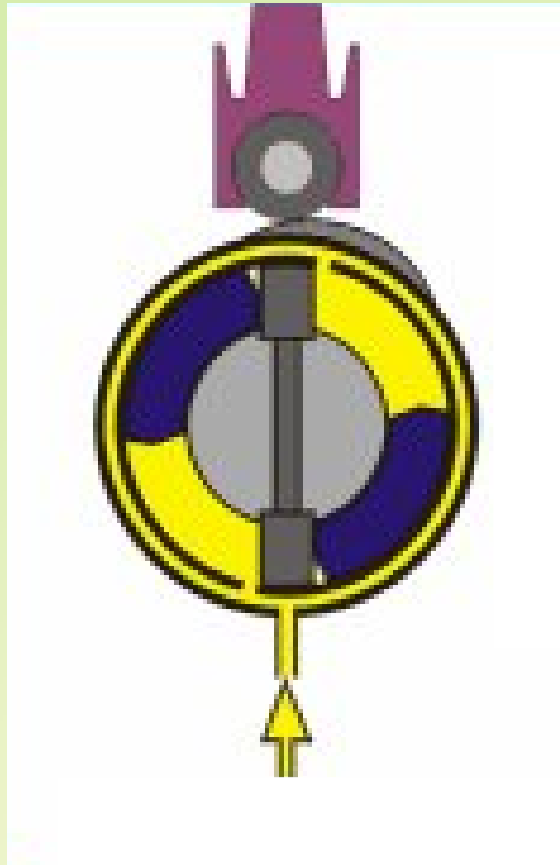
Brijeg za
vožnju
natrag

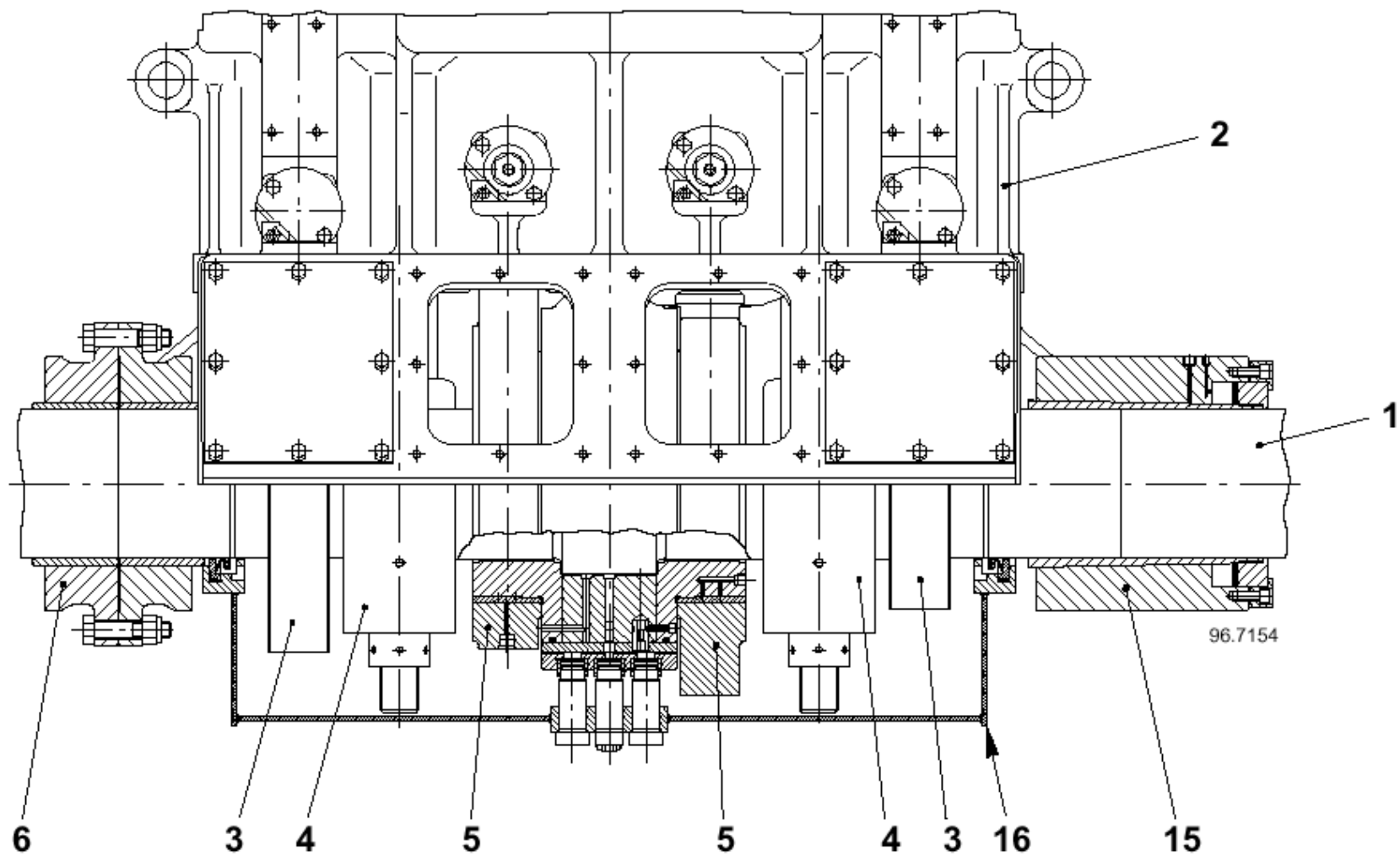


Brijeg za
vožnju
naprijed

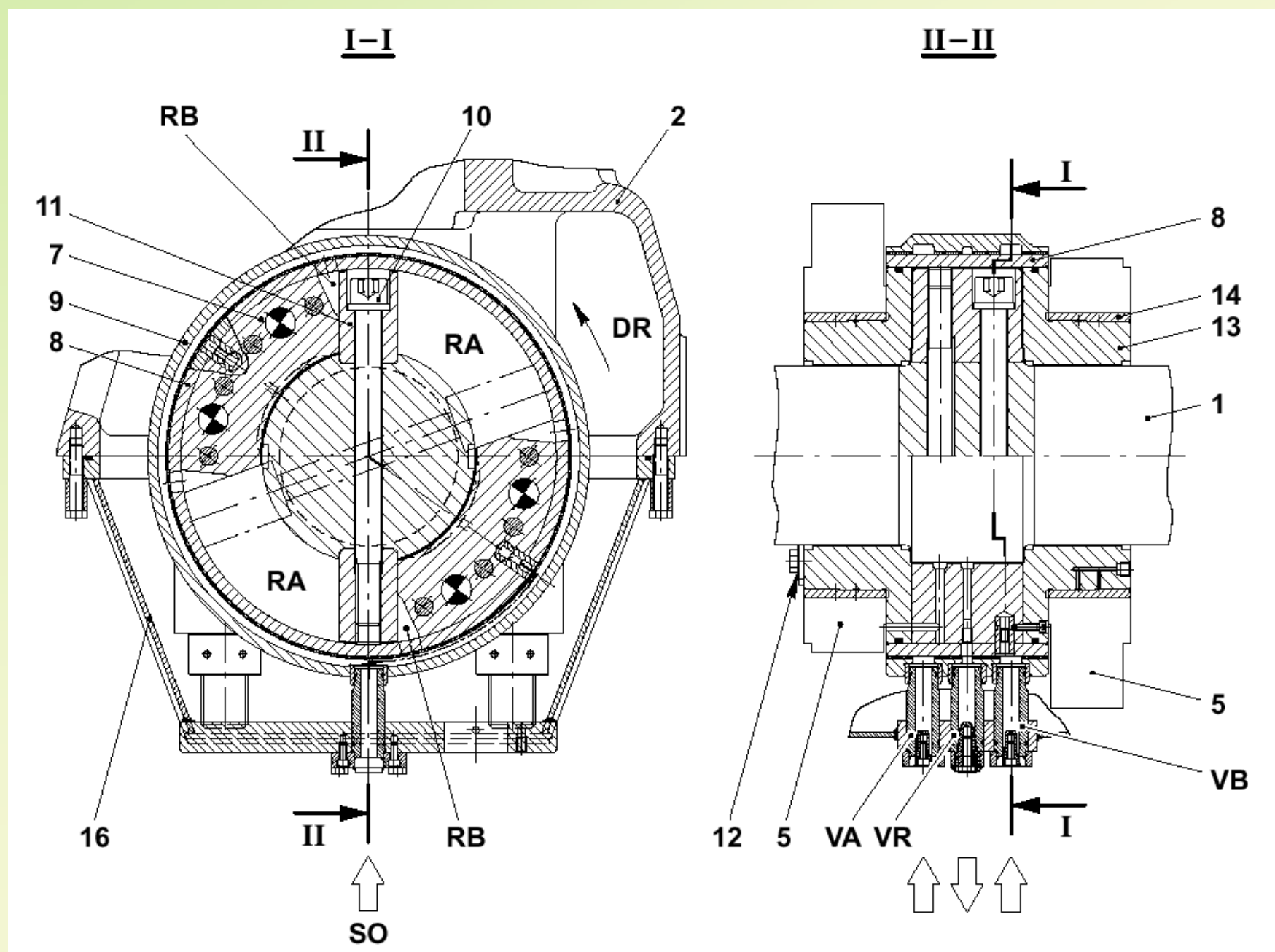


Uređaj za prekret s uzdužnim
pomicanjem bregastog vratila i
dvostrukim brijegovima kod 4T DM



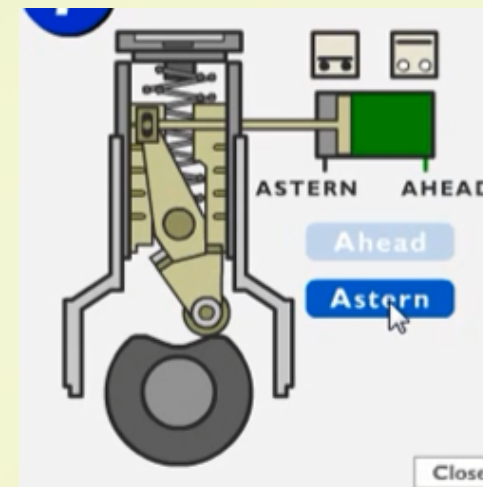
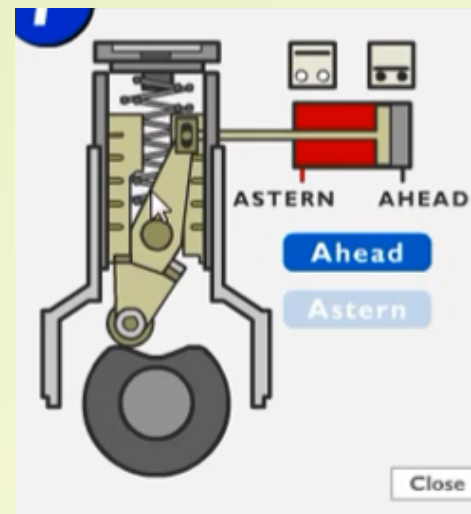
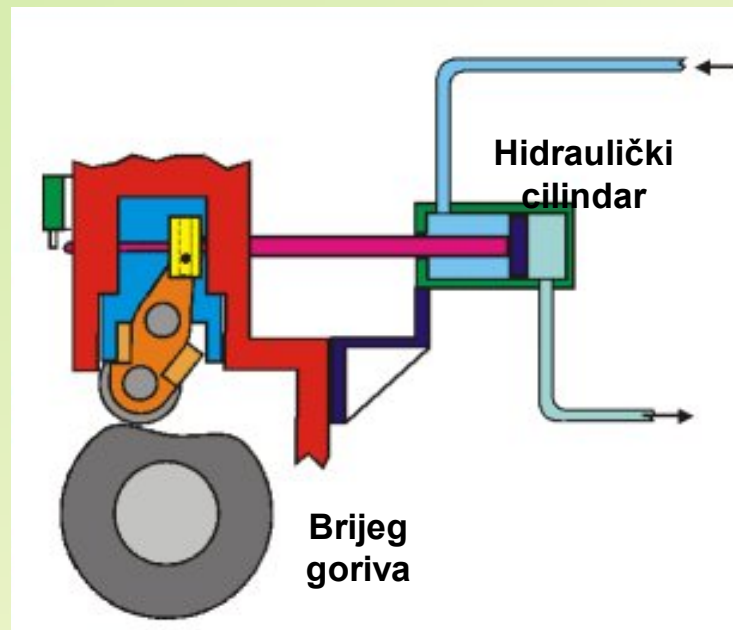


Uređaj za preket (Wartsila RTA48)

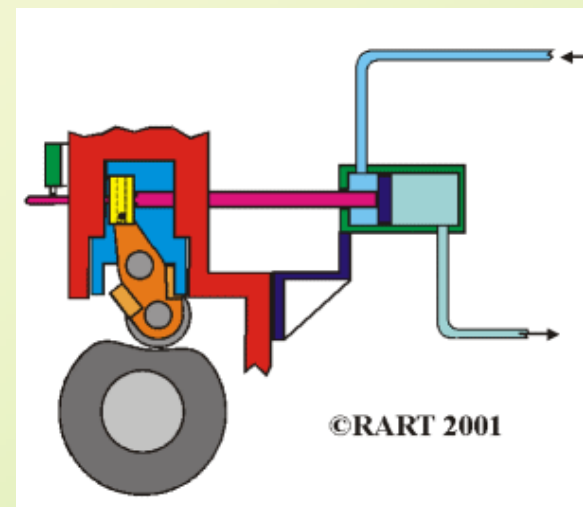


Uređaj za prekret (Wartsila RTA48)

Prekret na pogonu pumpe goriva



Prekret se vrši pomoću hidrauličkog cilindra s desne strane. S njim se vrši preklapanje valjčića za pogon klipa pumpe



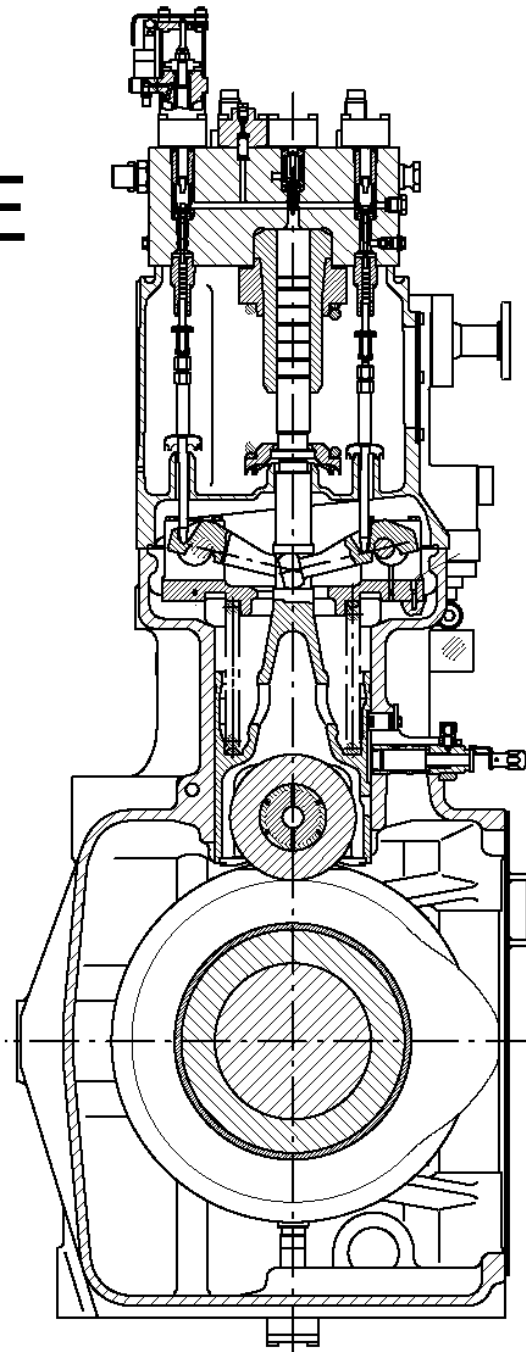
Kraj -> Sustav pripreme goriva

Brodski motori

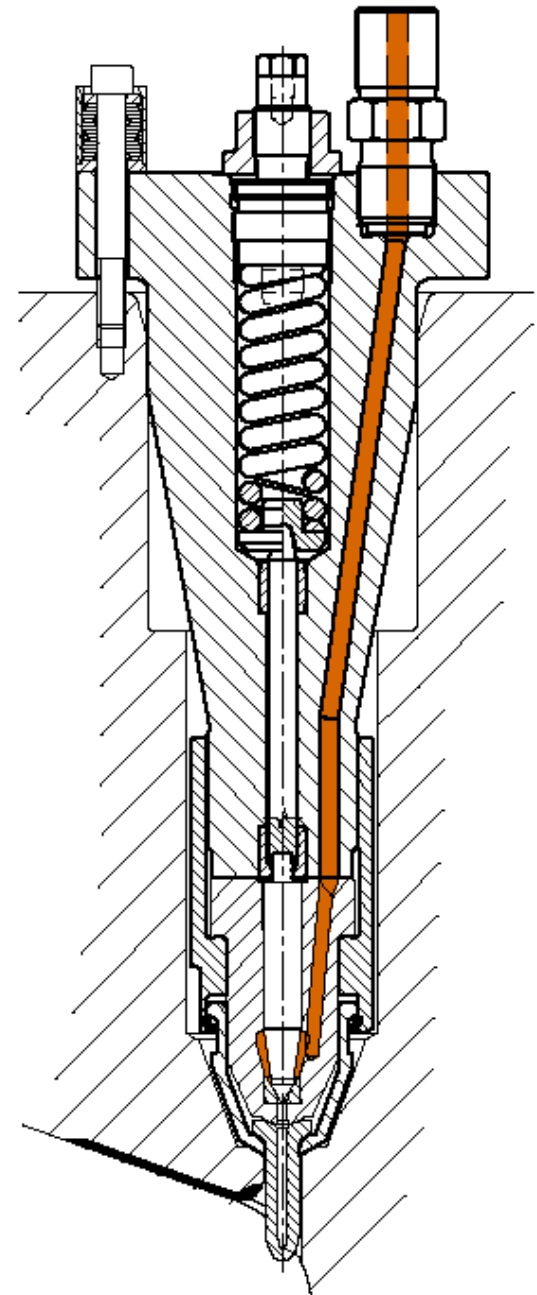
IX

Prof.dr.sc. Ivica Šegulja

SUSTAV PRIPREME GORIVA

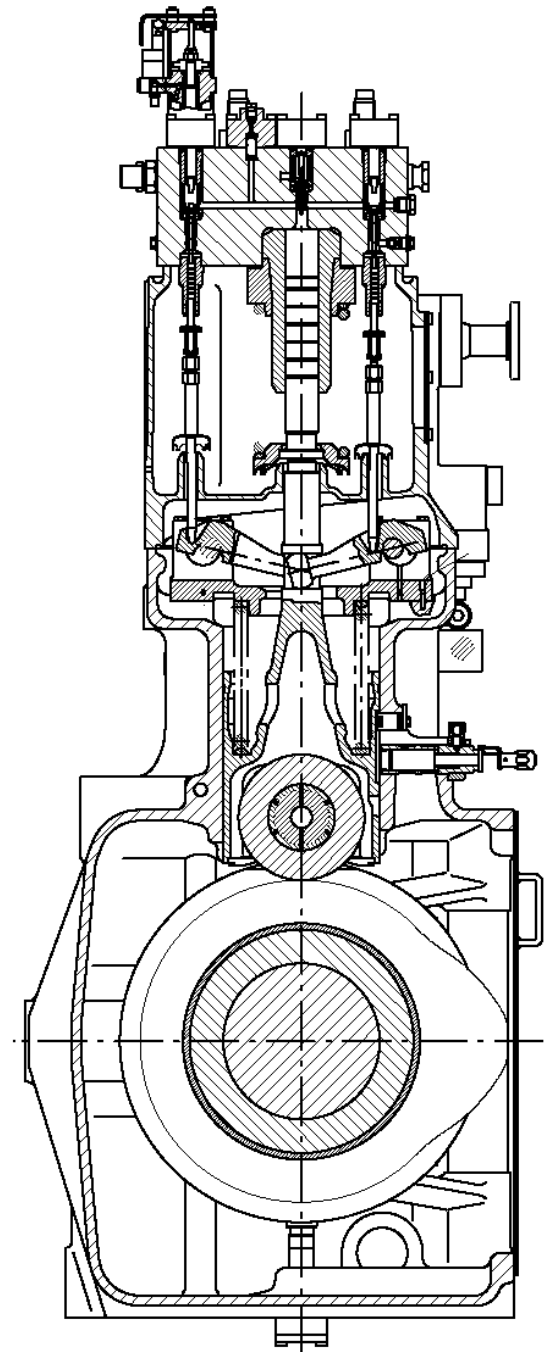
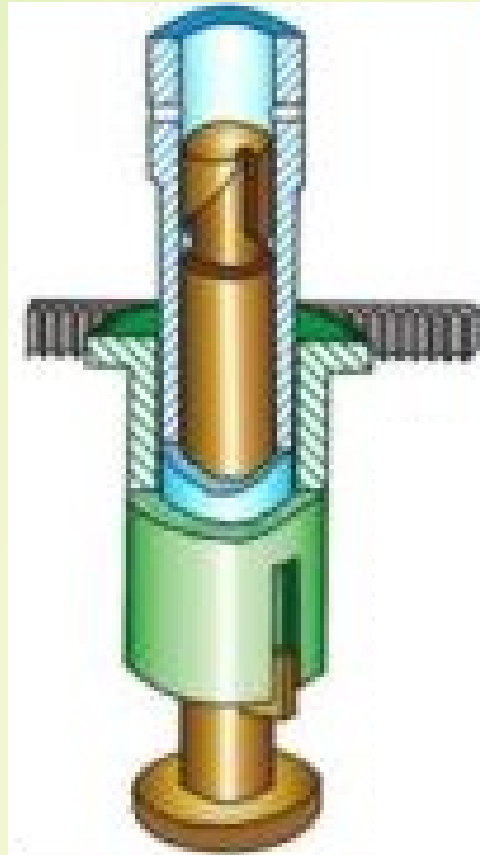
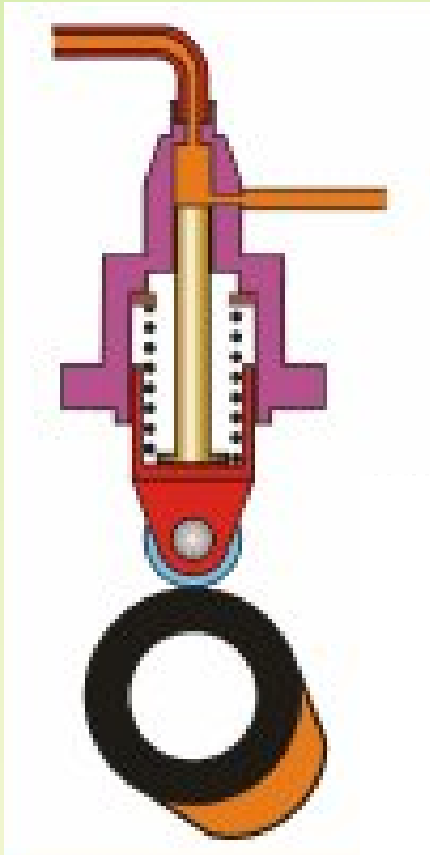


Fuel injection pump with double control valves



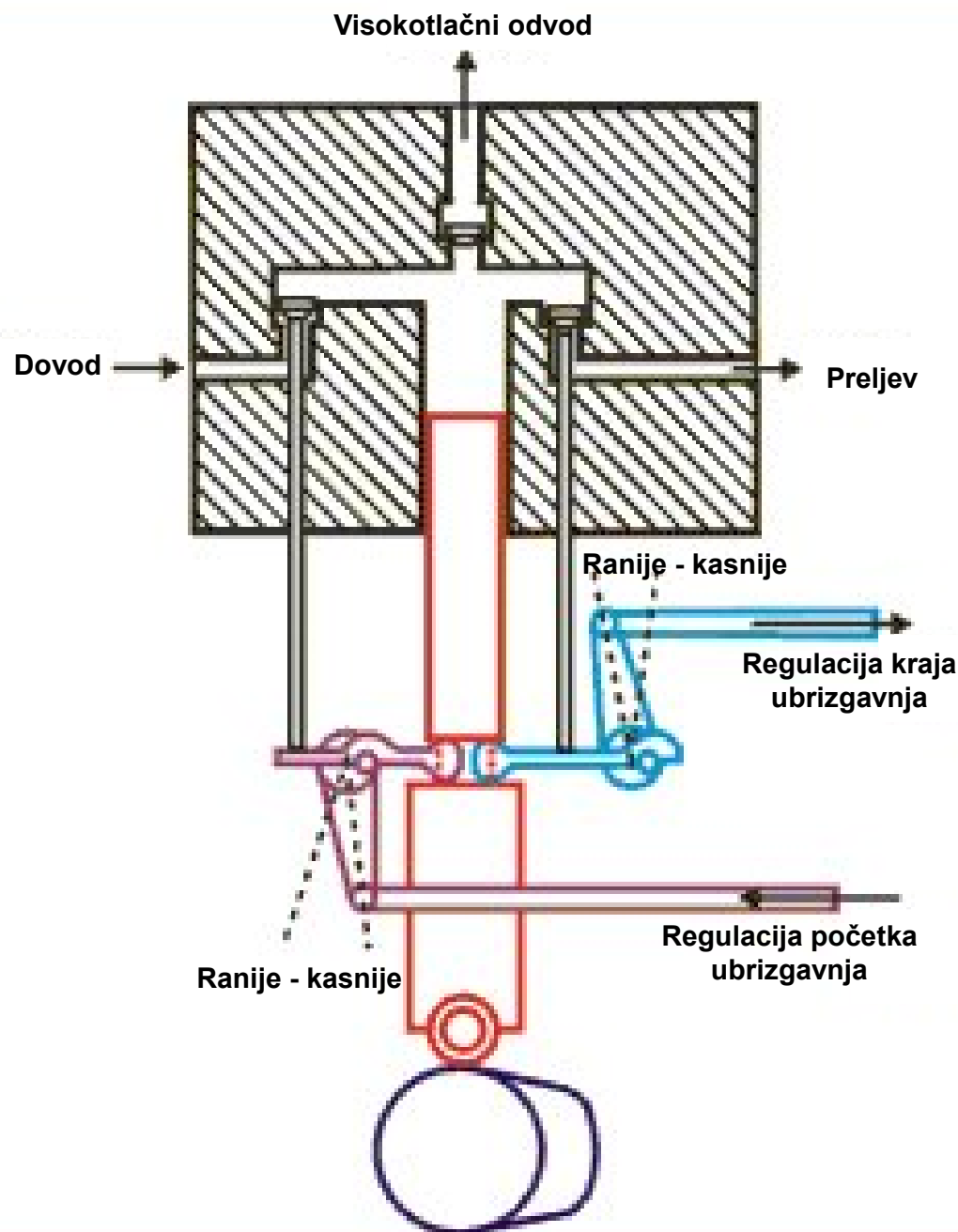
Fuel injection valve. The nozzle is not exposed to the combustion thereby avoiding material burning off

VT PUMPE

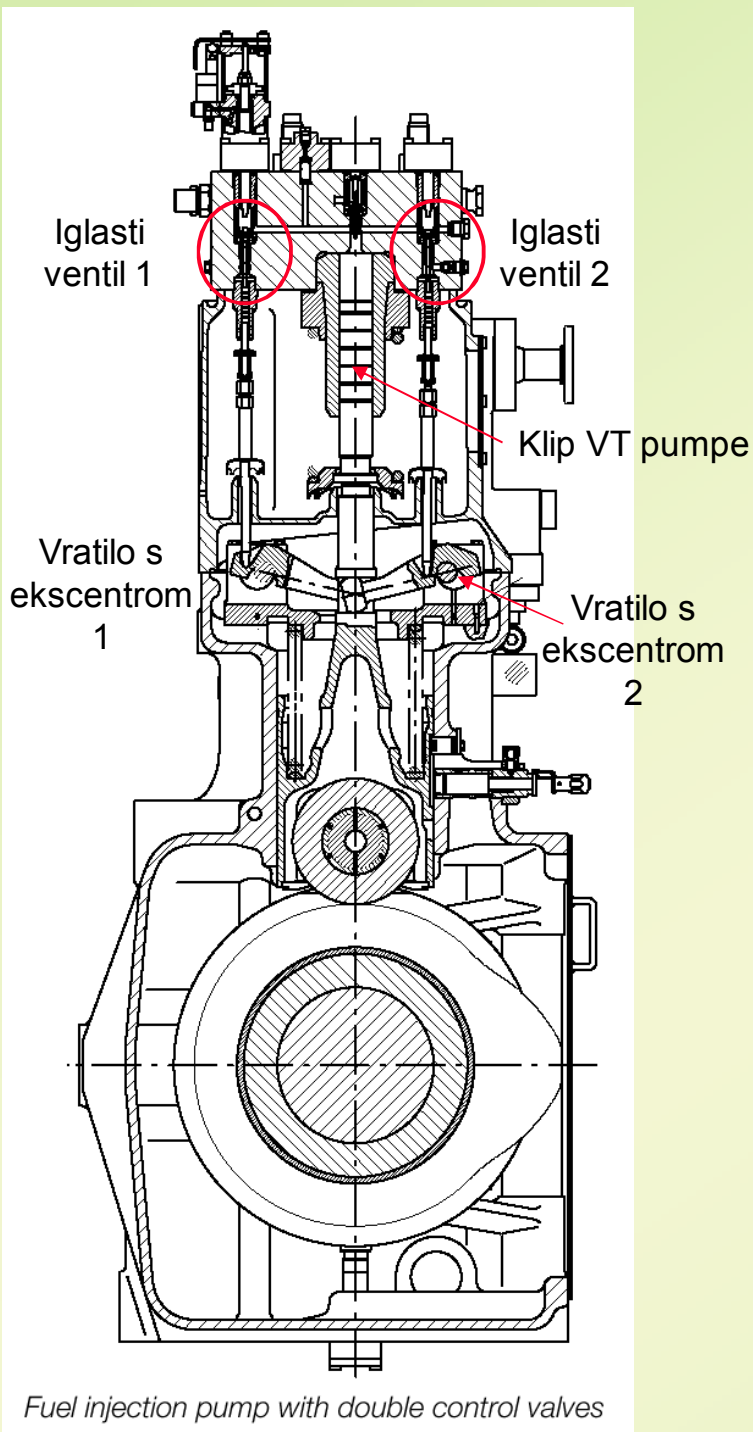


Fuel injection pump with double control valves

Ubrizgavanje goriva



Regulacija količine goriva kod dizelskih motora Wartsila (Sulzer) vrši se otvaranjem ventila. Podizanjem klipa dolazi do pomicanja krajeva poluga. Okretišta tih poluga namještaju se rotacijom ekscentra preko vanjskih poluga kojima upravlja regulator. Uzajamnim djelovanjem poluga regulira se trenutak početka i trajanje ubrizgavanja (tj. količine goriva). Podizajem klipa podižu se krajevi poluga (ljubičaste i plave). Lijeva vertikalna šipka će se spuštati, a desna šipka će se podizati. Lijeva šipka će otpustiti nepovratni ventil i zatvoriti prostor pumpe, te će početi ubrizgavanje. Ono će trajati dok desna šipka podizanjem ne podigne desni nepovratni ventil i poveže prostor pumpe s preljevom goriva.



Fuel injection pump with double control valves

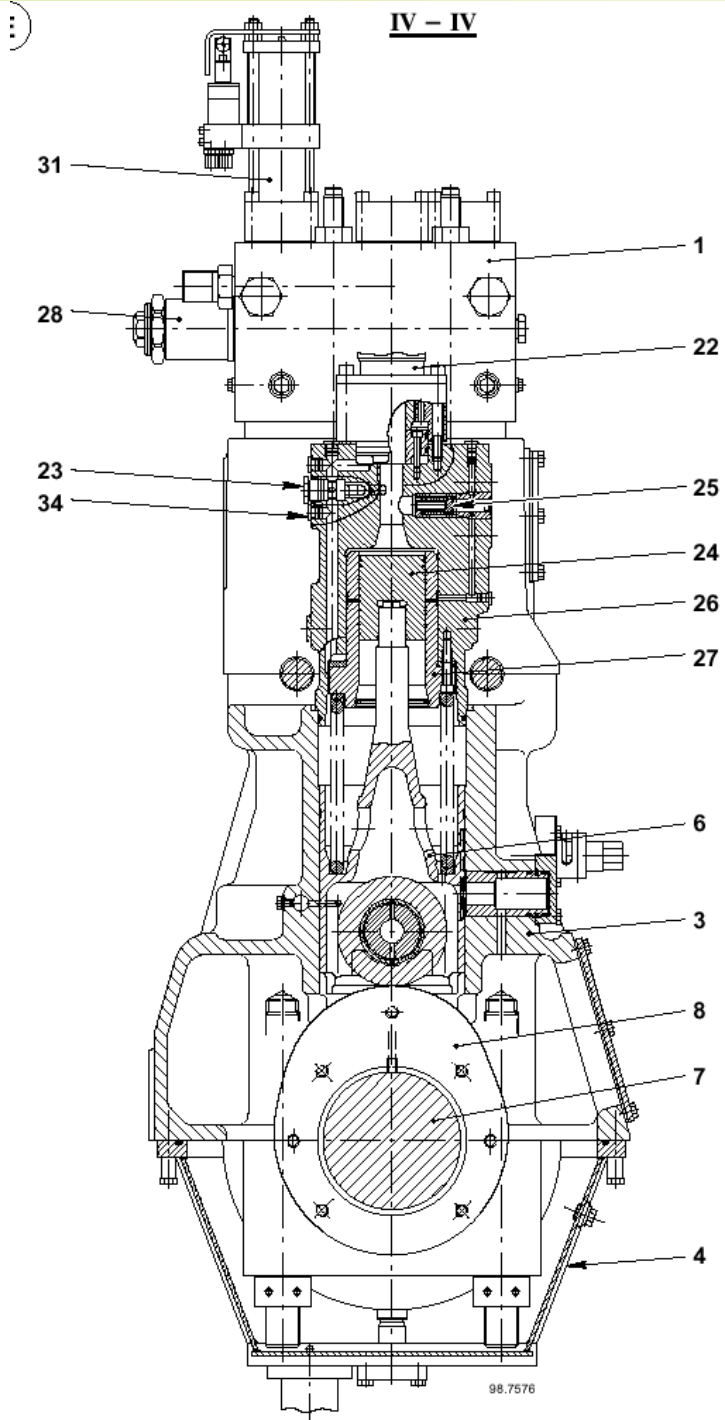
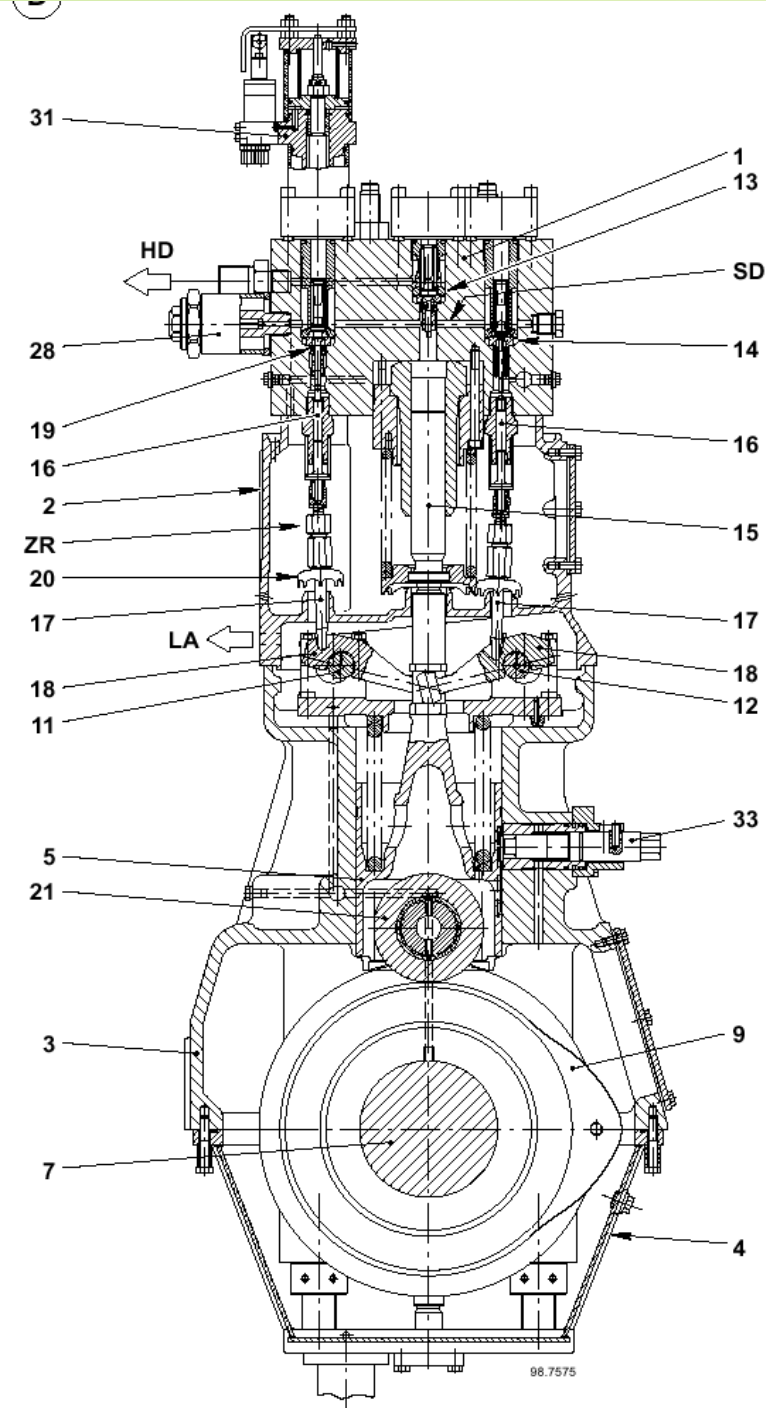
Princip rada visokotlačne pumpe goriva

Odvaljivanjem valjčića po brijegu goriva, klip VT pumpe se podiže i smanjuje volumen u cilindru VT pumpe. Na početku hoda klipa, iglasti ventil 2 je zatvoren a iglasti ventil 1 goriva je otvoren i gorivo se prelijeva prema strani niskoga tlaka. Gibanjem klipa na gore, zajedno s klipom se pomiču krajevi klackalice koje se vrte oko ekscentara na vratilima 1 i 2. Kod lijeve klackalice se prilikom gibanja klipa na gore spušta poluga koja djeluje na iglasti ventil 1 (koja ga na početku hoda drži u otvorenom položaju). Kod desne klackalice se prilikom hoda klipa na gore podiže i poluga koja će djelovati na iglasti ventil 2. Ona na početku hod klipa ne djeluje na ventil 2, tako da on sjedi zatvoren na svom sjedištu.

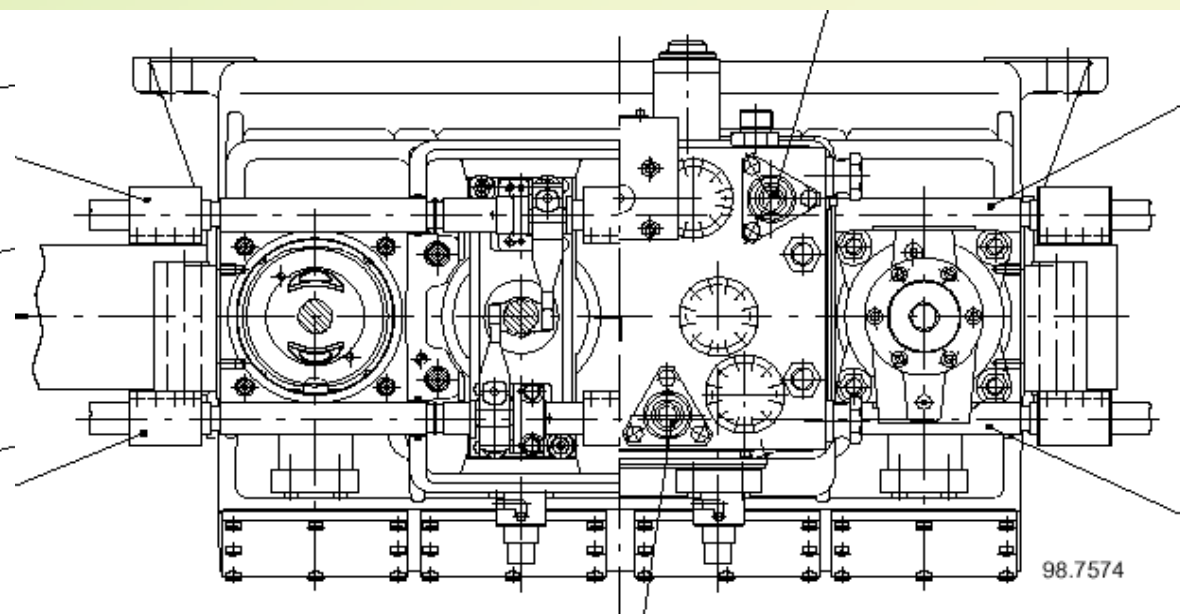
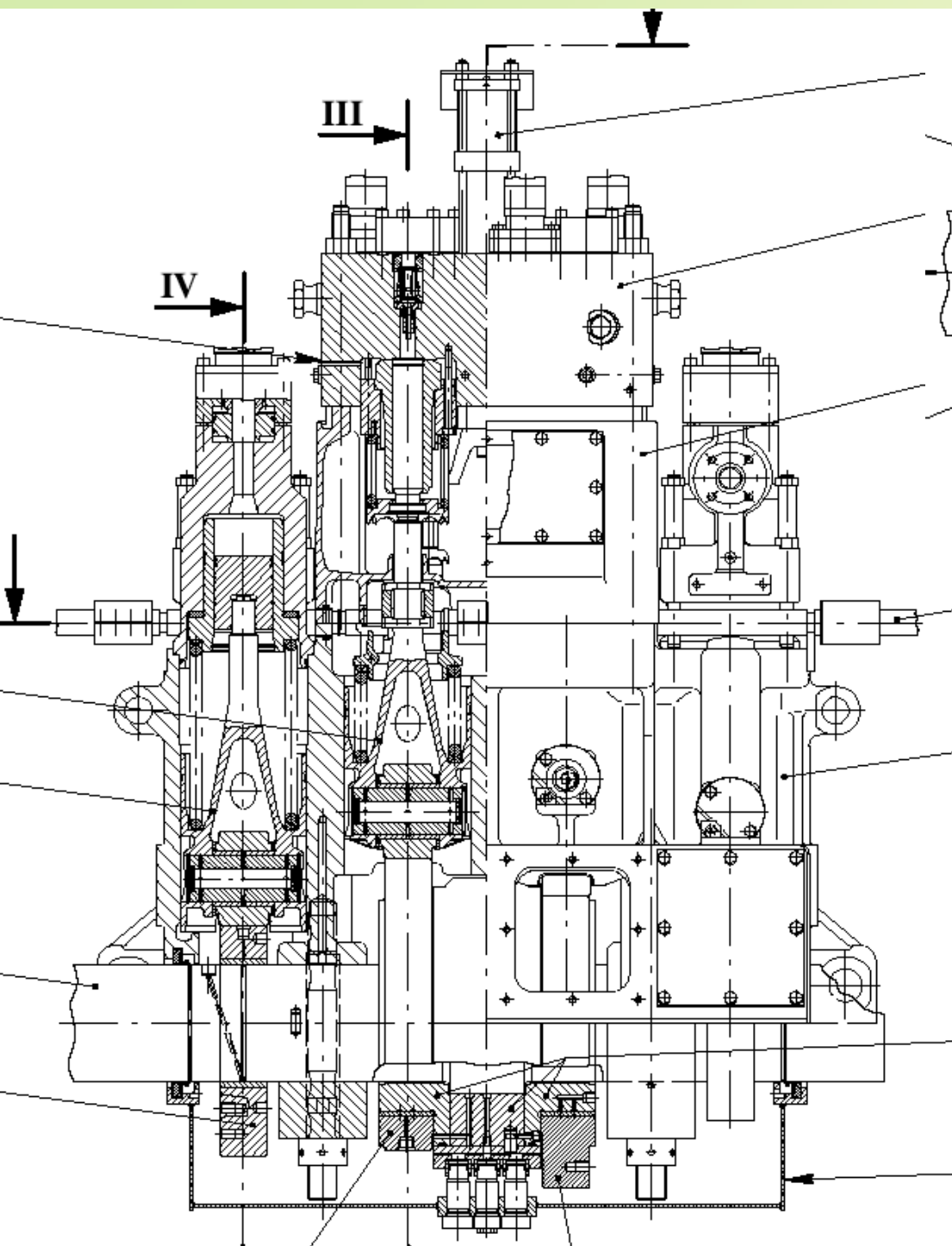
Pri hodu klipa VT pumpe na gore, najprije će se zbog gibanja klackalice i odgovarajućih poluga zatvoriti iglasti ventil 1. Tada će prestati preliv goriva iz cilindra pumpe i u cilindru će naglo početi rasti tlak goriva i započeti će ubrizgavanje goriva u cilindar motora. Ubrižgavanje će potrajati dotle dok se desna poluga zbog gibanja desne klackalice ne podigne dovoljno da otvori iglasti ventil 2. Njegovim otvaranjem gorivo će početi preliv prema povratu goriva, tlak u cilindru pumpe će pasti i ubrizgavanje goriva u cilindar će se prekinuti.

Spuštanjem ekscentra 1 na lijevoj strani postiže se raniji početak ubrizgavanja. Spuštanjem ekscentra 2 na desnoj strani postiže se kasniji završetak ubrizgavanja. Uzajamnim djelovanjem oba ekscentra može se postići regulacija količine ubrizganog goriva i pomicanje ukupnog ubrizgavanja goriva na ranije ili kasnije ubrizgavanje.

Klasična oprema za ubrizgavanje goriva na 2T motorima Wartsila



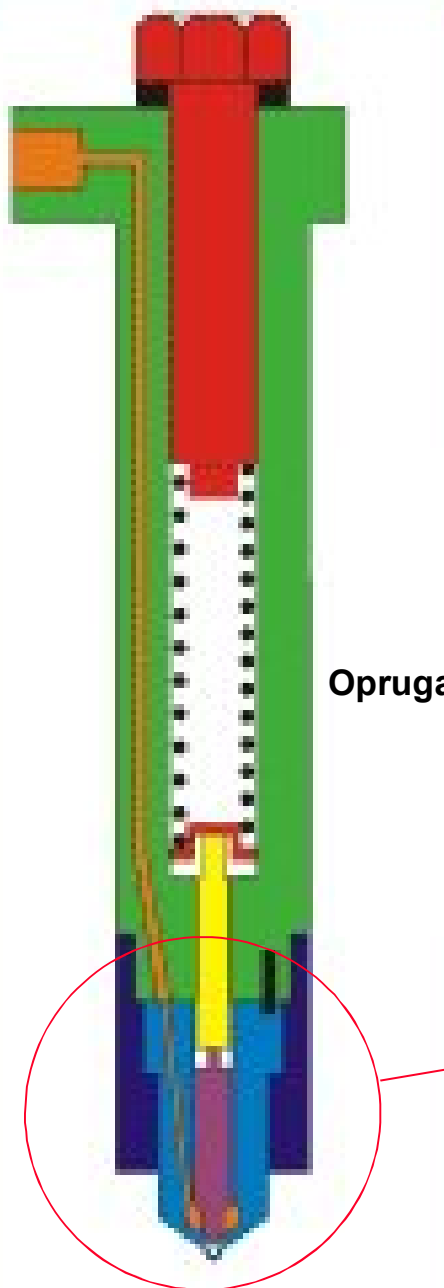
Poprečni presjek kroz visokotlačnu pumpu za ubrizgavanje goriva i pumpu za pogon ispušnog ventila



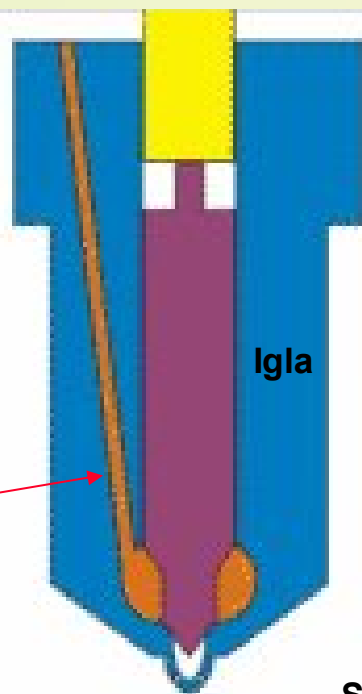
98.7574

Uzdužni presjek
visokotlačne pumpe za ubrizgavanje
goriva i pumpe za pogon ispušnog
ventila

RASPRSKAČI

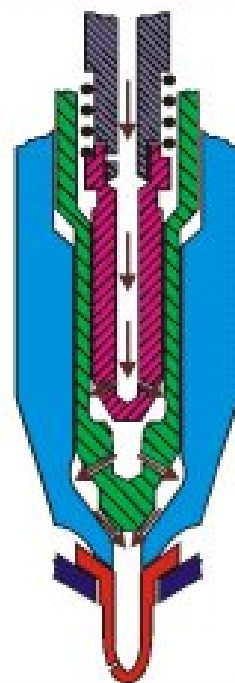


Opruga

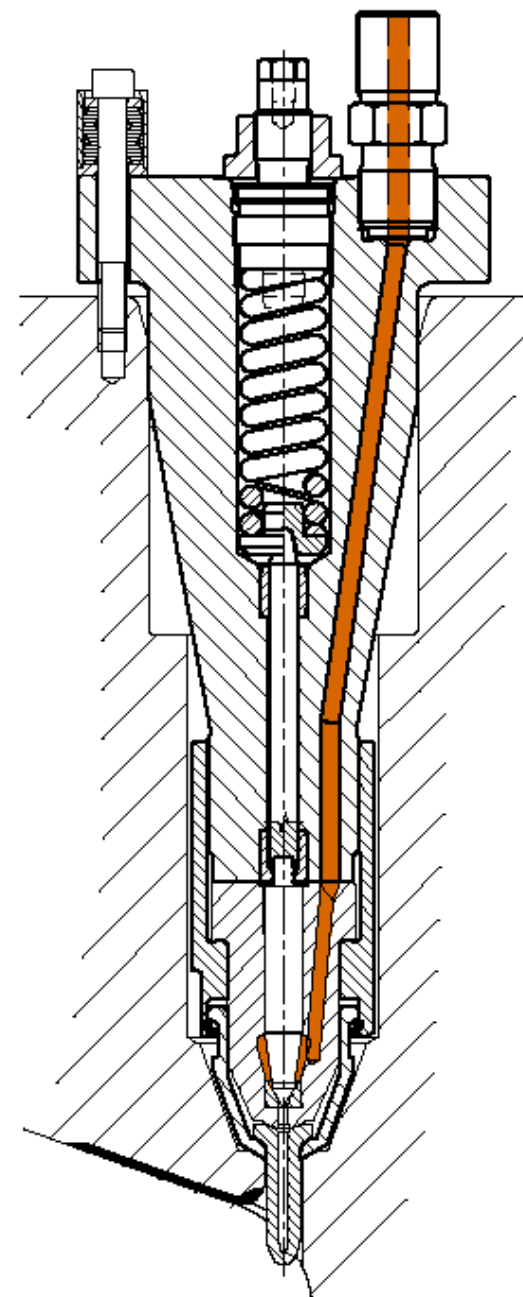


Igla

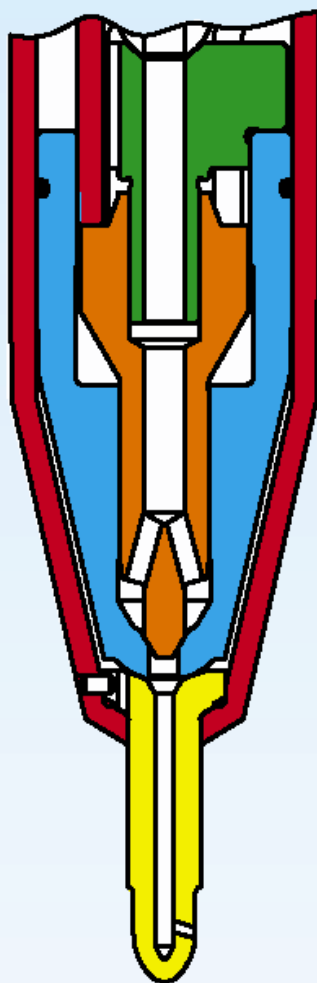
Sa



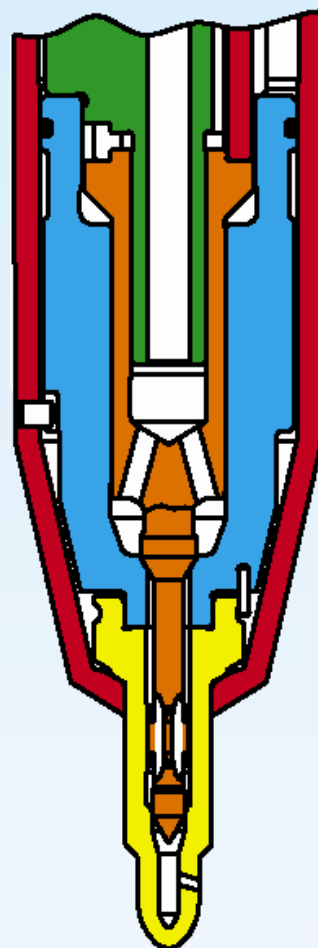
Izvedba rasprskача
kod motora Wartsila
(Sulzer) serije RTA



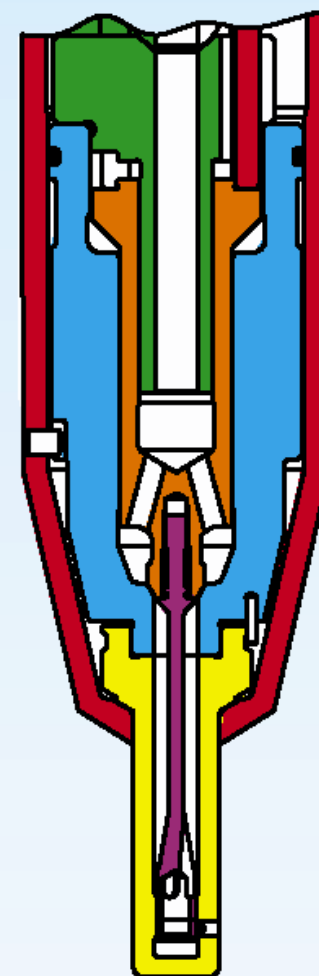
Fuel injection valve. The nozzle is not exposed to the combustion thereby avoiding material burning off



Conventional fuel valve
Sac volume 1690 mm³



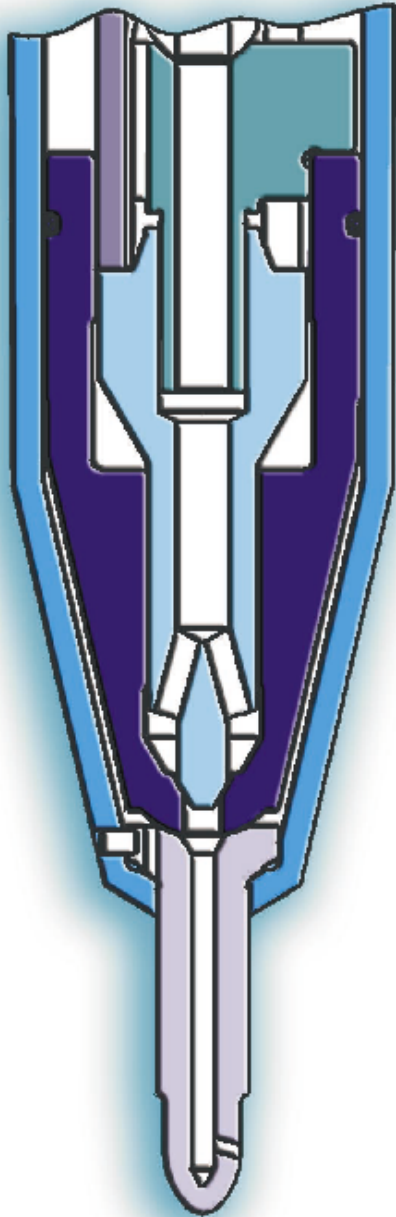
Mini-sac valve
Sac volume 520 mm³



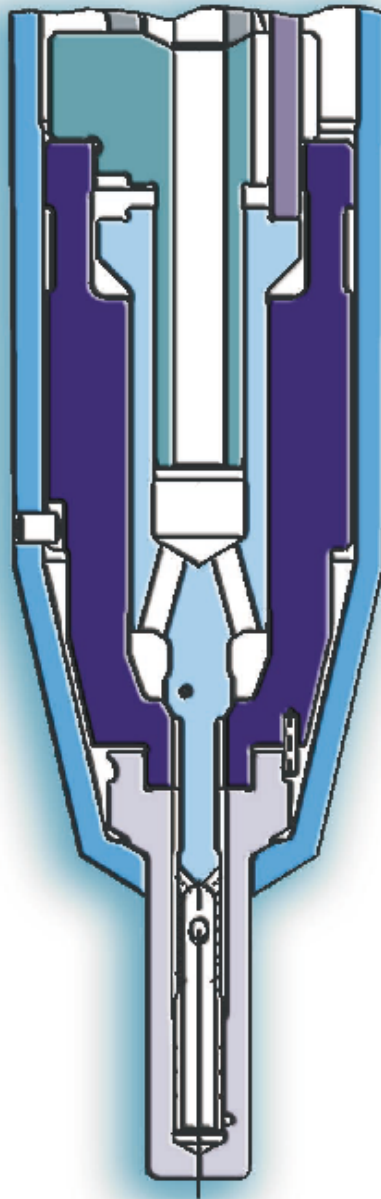
Slide-type fuel valve
Sac volume volume 0 mm³

Izvedbe rasprskaa (MAN B&W) za smanjenje volumena ispod igle
rasprskaa (sac volume)

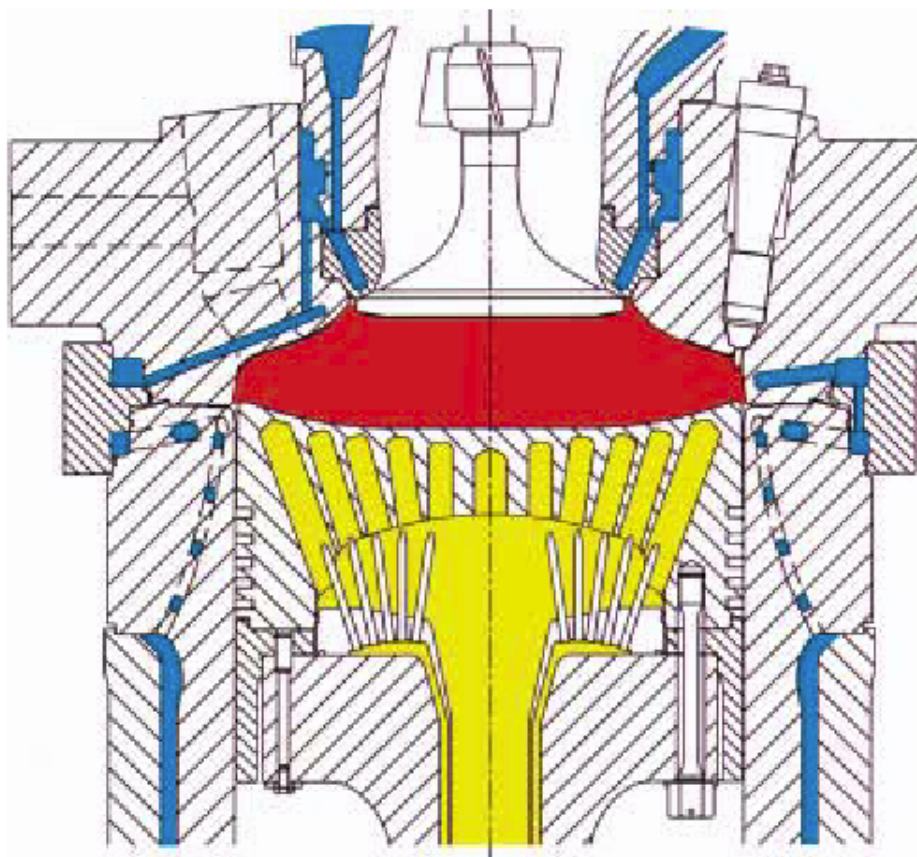
Conventional fuel valve



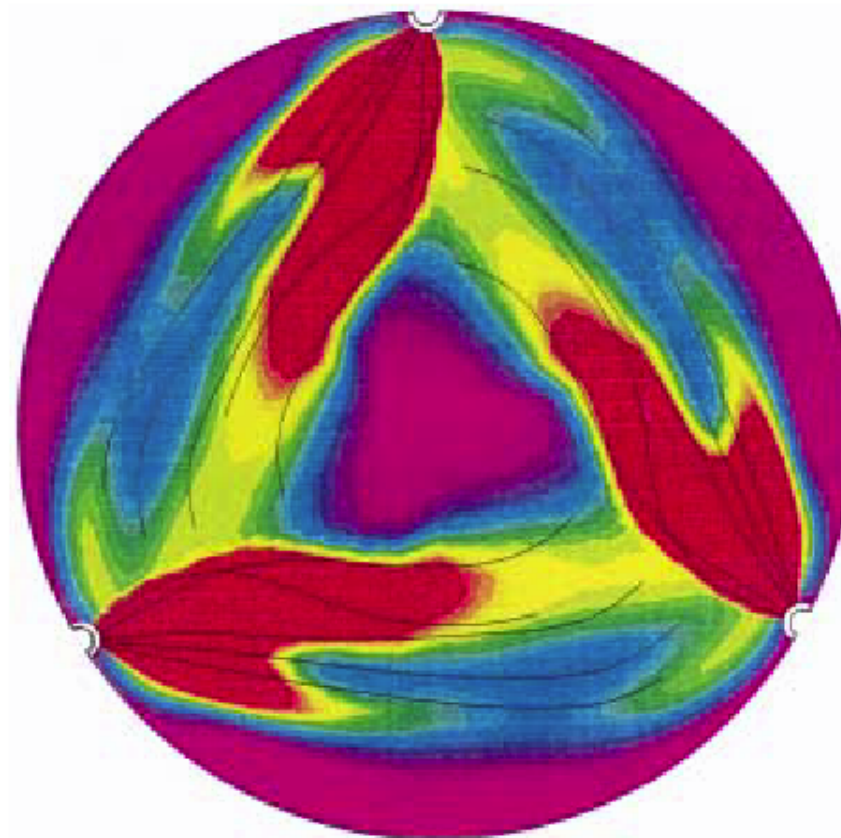
Slide fuel valve



Klasična izvedba rasprskача (lijevo) i izvedba rasprskача s klizačem (desno), kako bi se poništio volumen ispod igle rasprskача (MAN B&W)



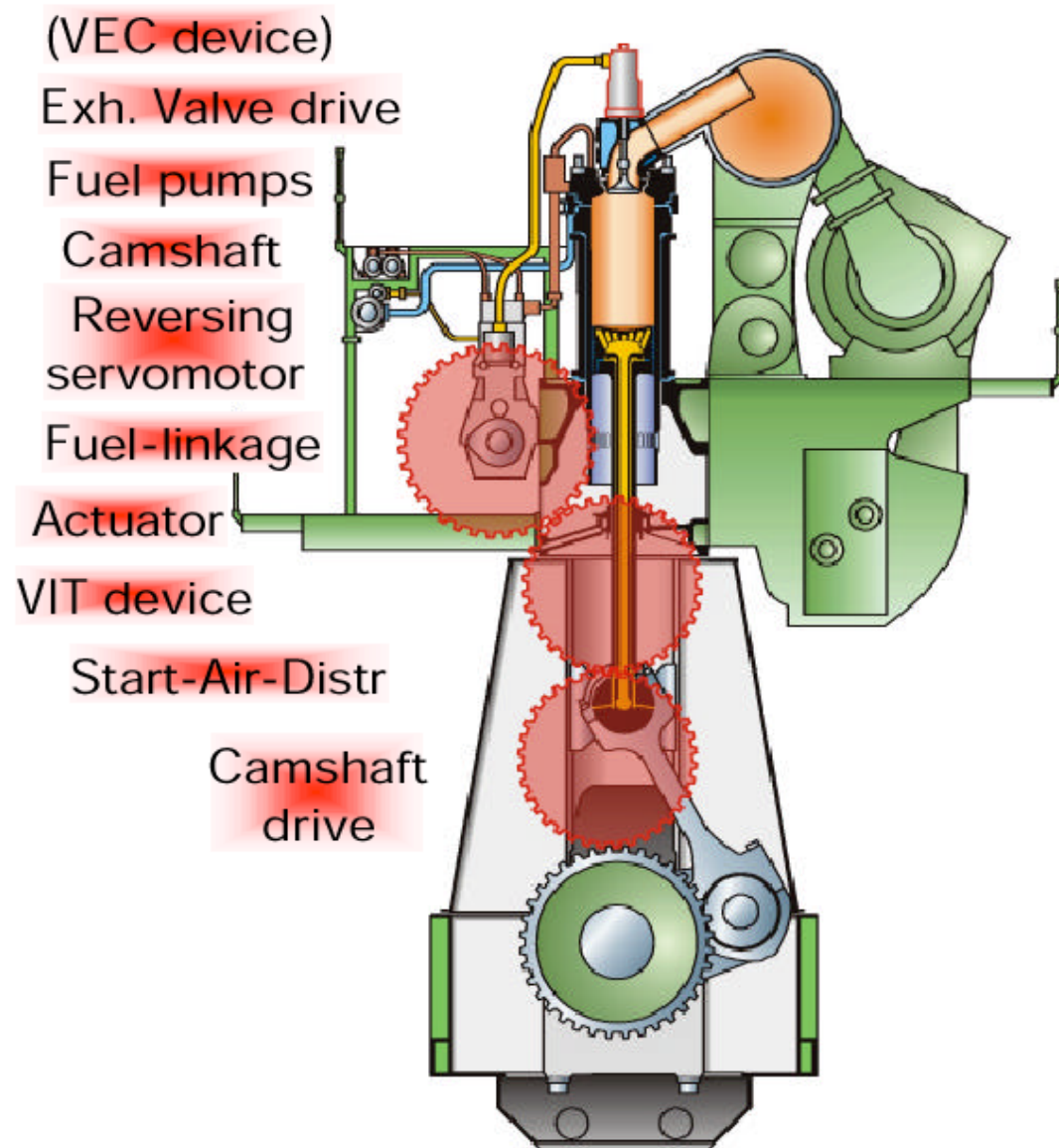
Fully bore-cooled combustion chamber.



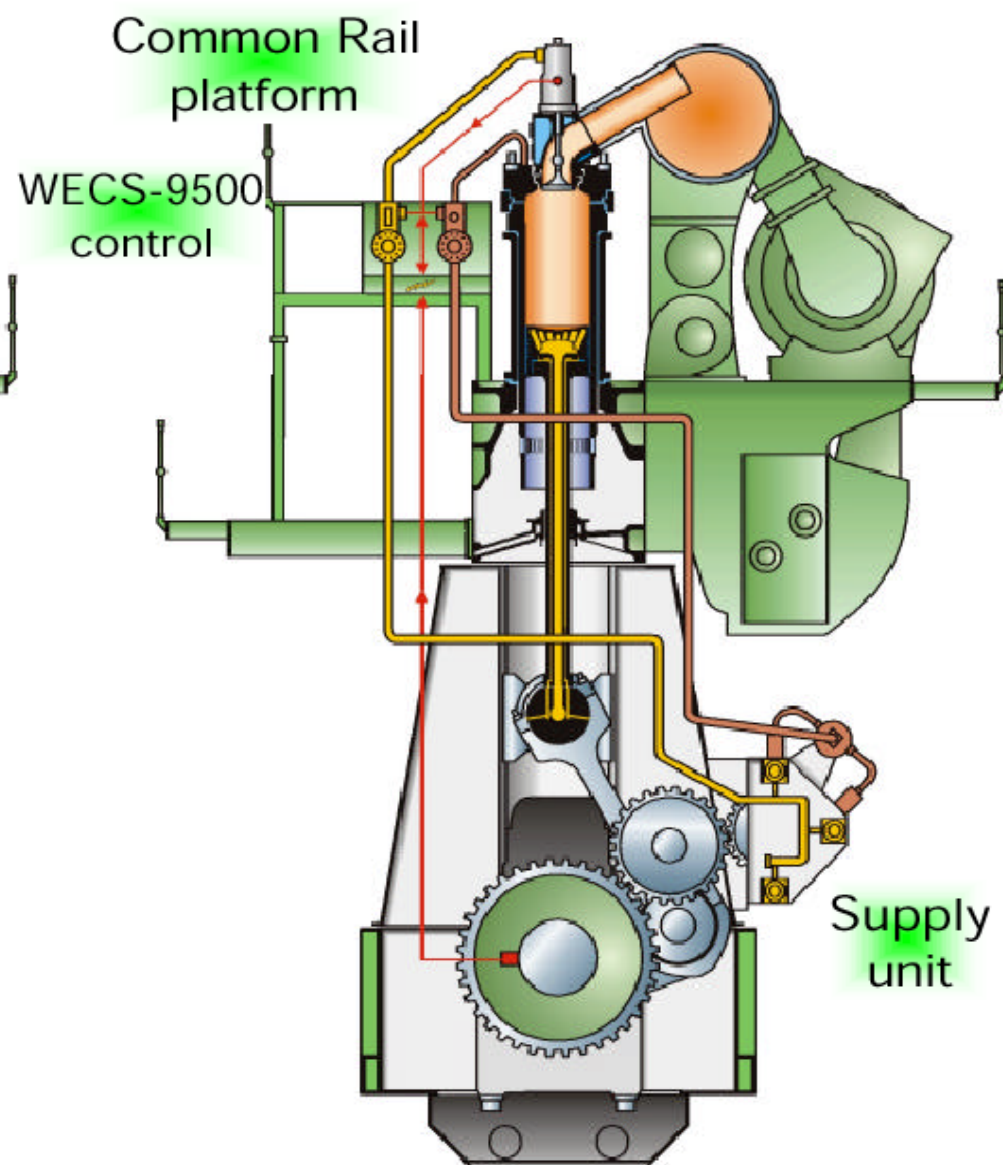
Analysis of fuel distribution and injection trajectories in the RTA96C cylinder. Colours indicate concentration with blue/green for the stoichiometric mixture. No combustion calculated.

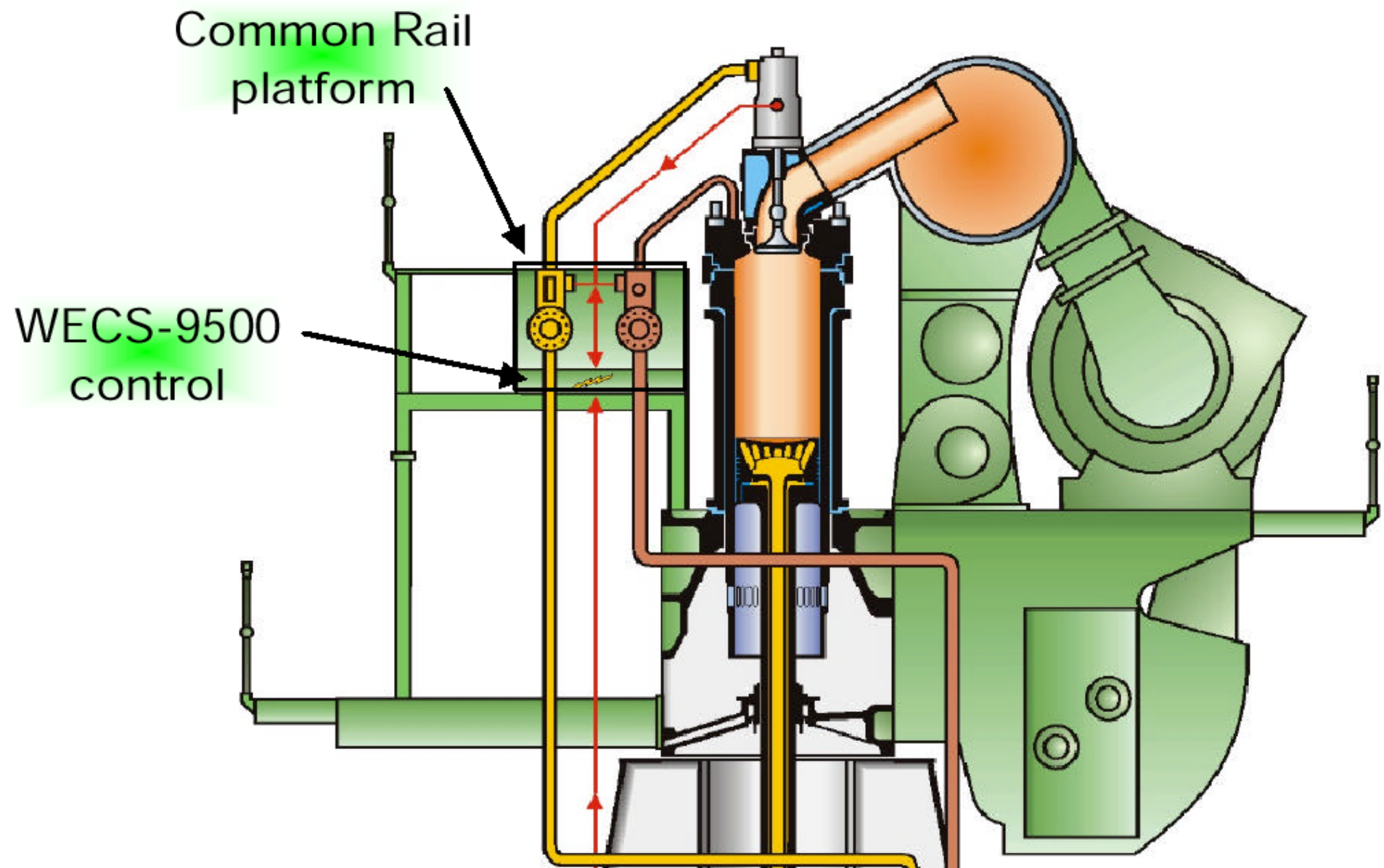
Obzirom da se kod 2T DM s uzdužnim ispiranjem koristi ispušni ventil u osi motora, rasprskачи (2 ili 3) se smještaju po obodu. Mlazovi goriva se kao lepeze usmjeruju tako da čim više obuhvate prostor izgaranja. Ubrizgano gorivo slijedi smjer vrtložnog strujanja zraka u cilindru.

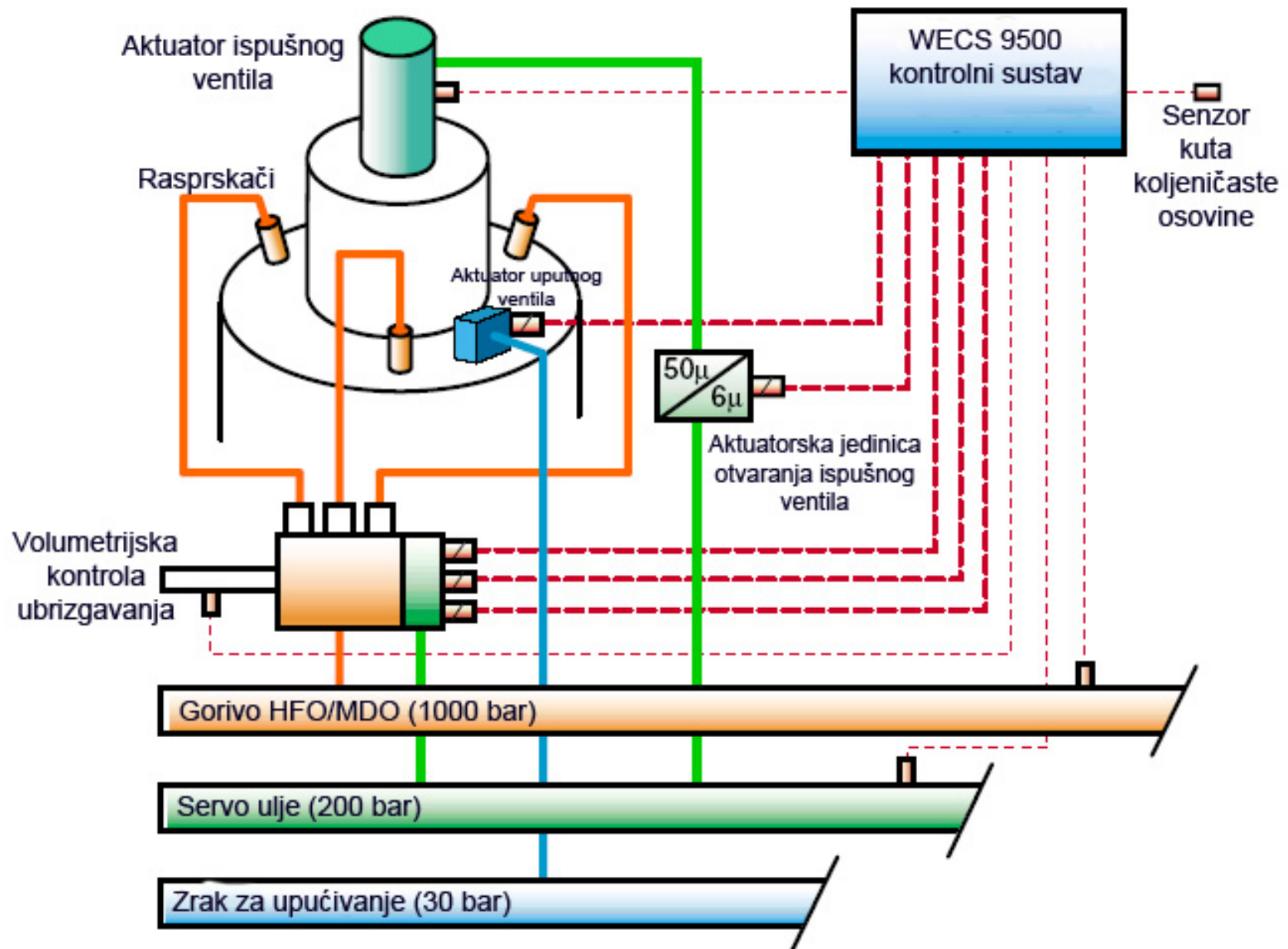
Dizelski motor s bregastim vratilom



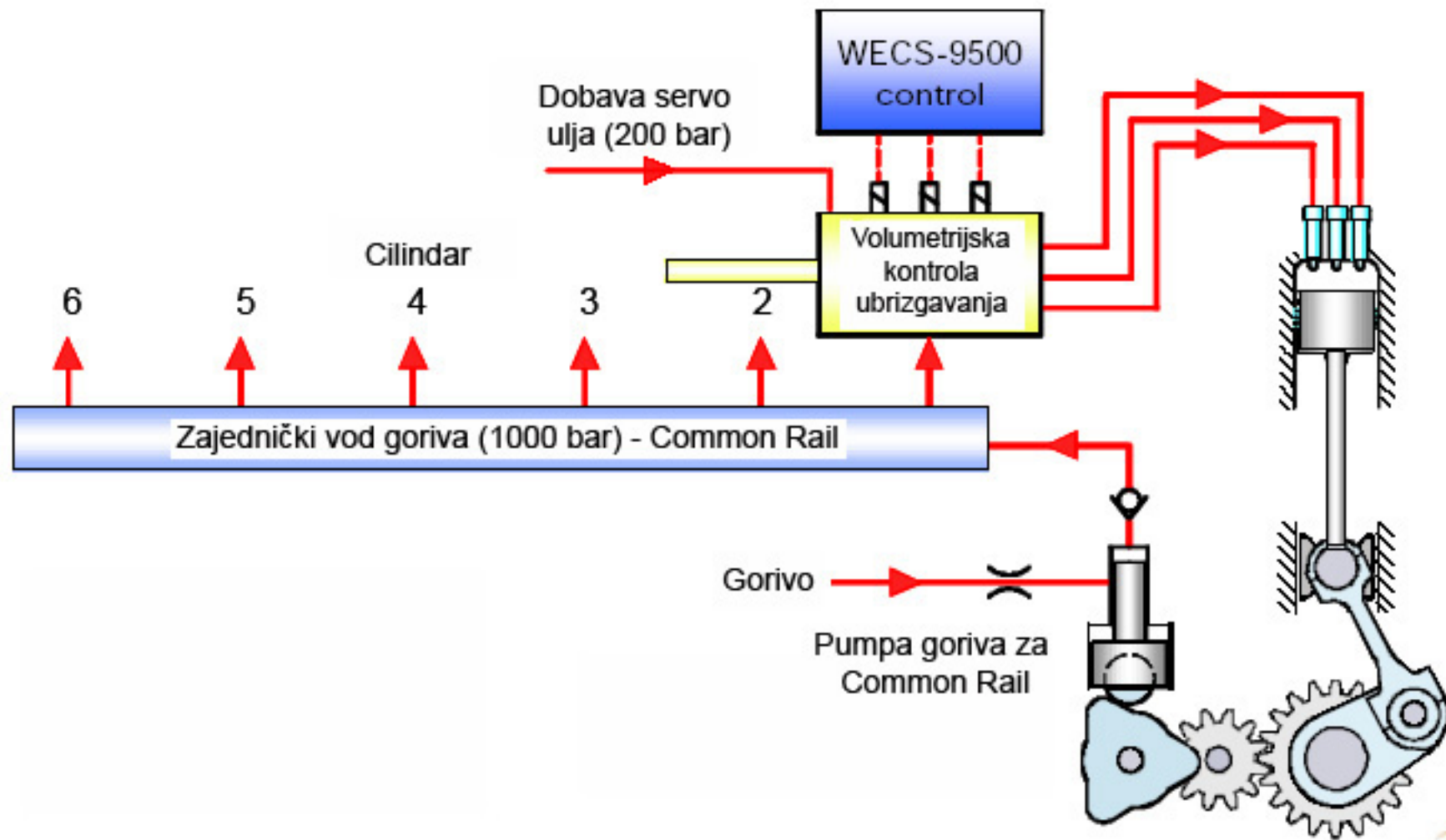
Dizelski motor bez bregastog vratila







Sustav ubrizgavanja goriva Wartsila RT-Flex



Sustav ubrizgavanja goriva Wartsila RT-Flex

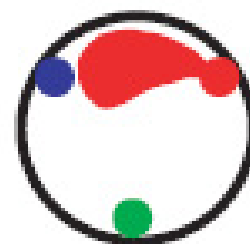
Selektivno isključivanje pojedinih rasprkača
Bezdimni rad na malim brojevima okretaja



Normalan rad:
Svi rasprskači rade
u jednom taktu



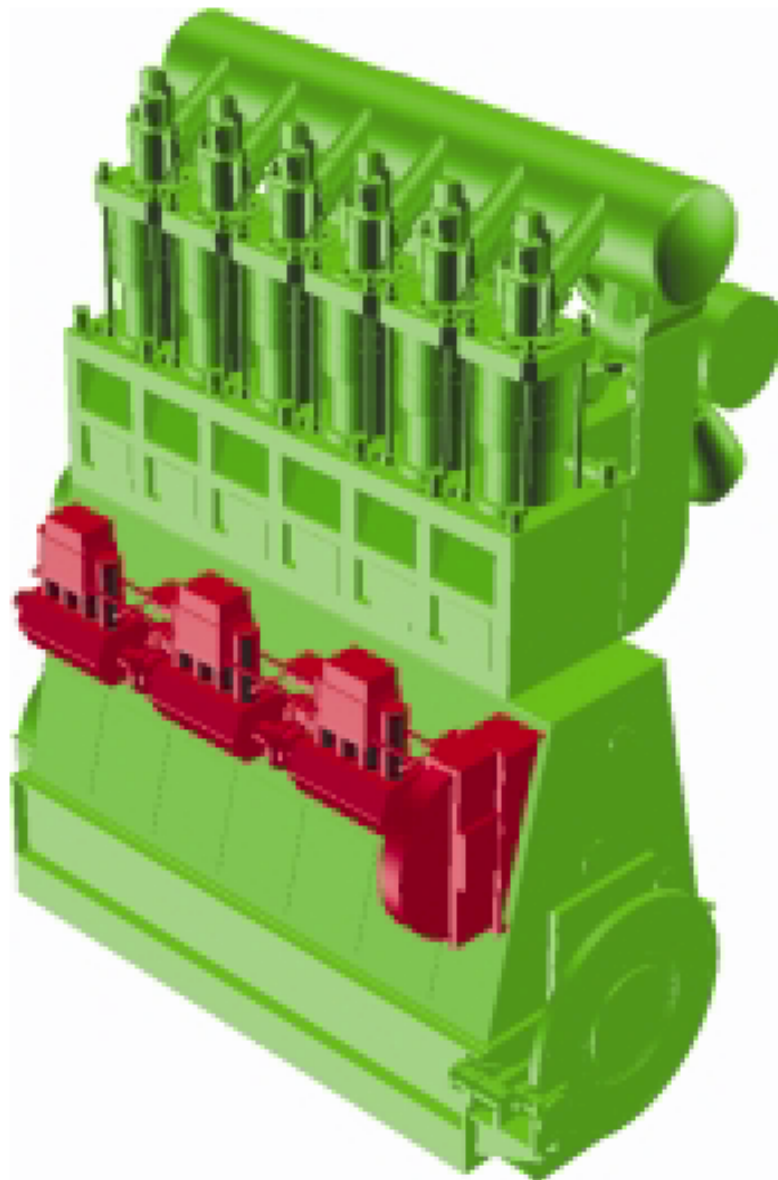
Rad s dva
rasprkača



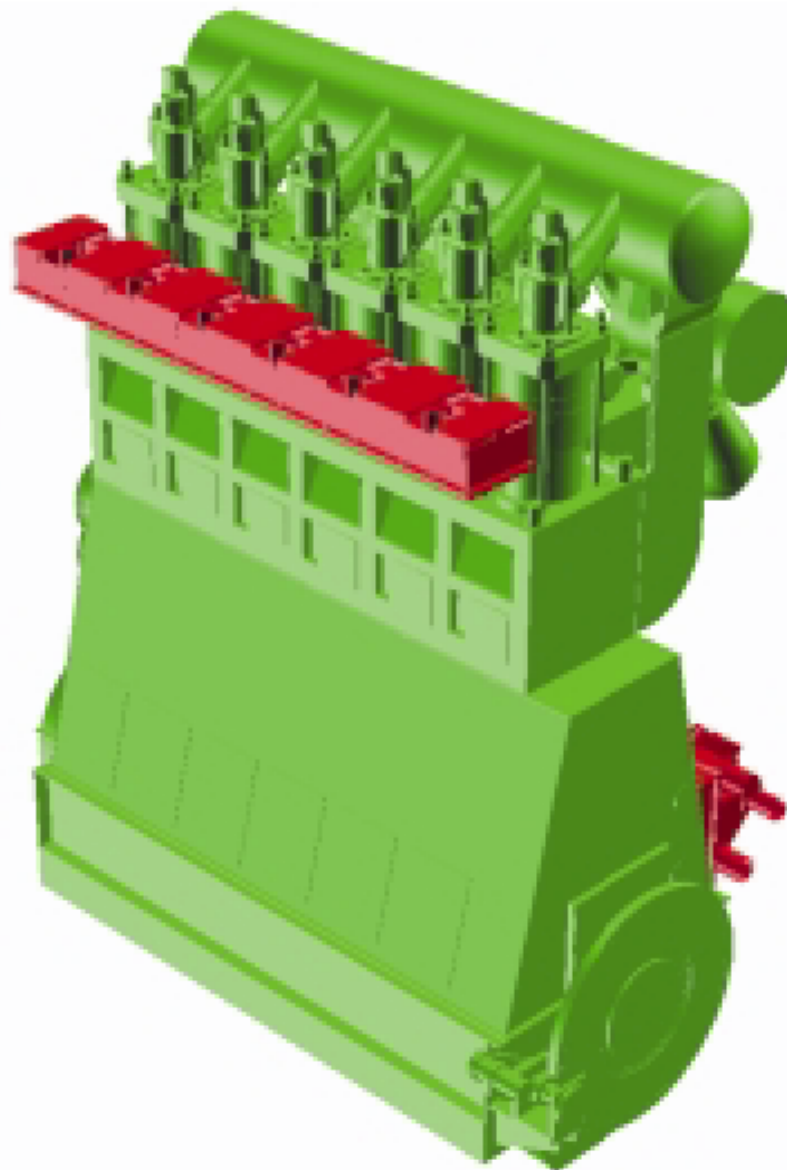
Rad s jednim
rasprkačem

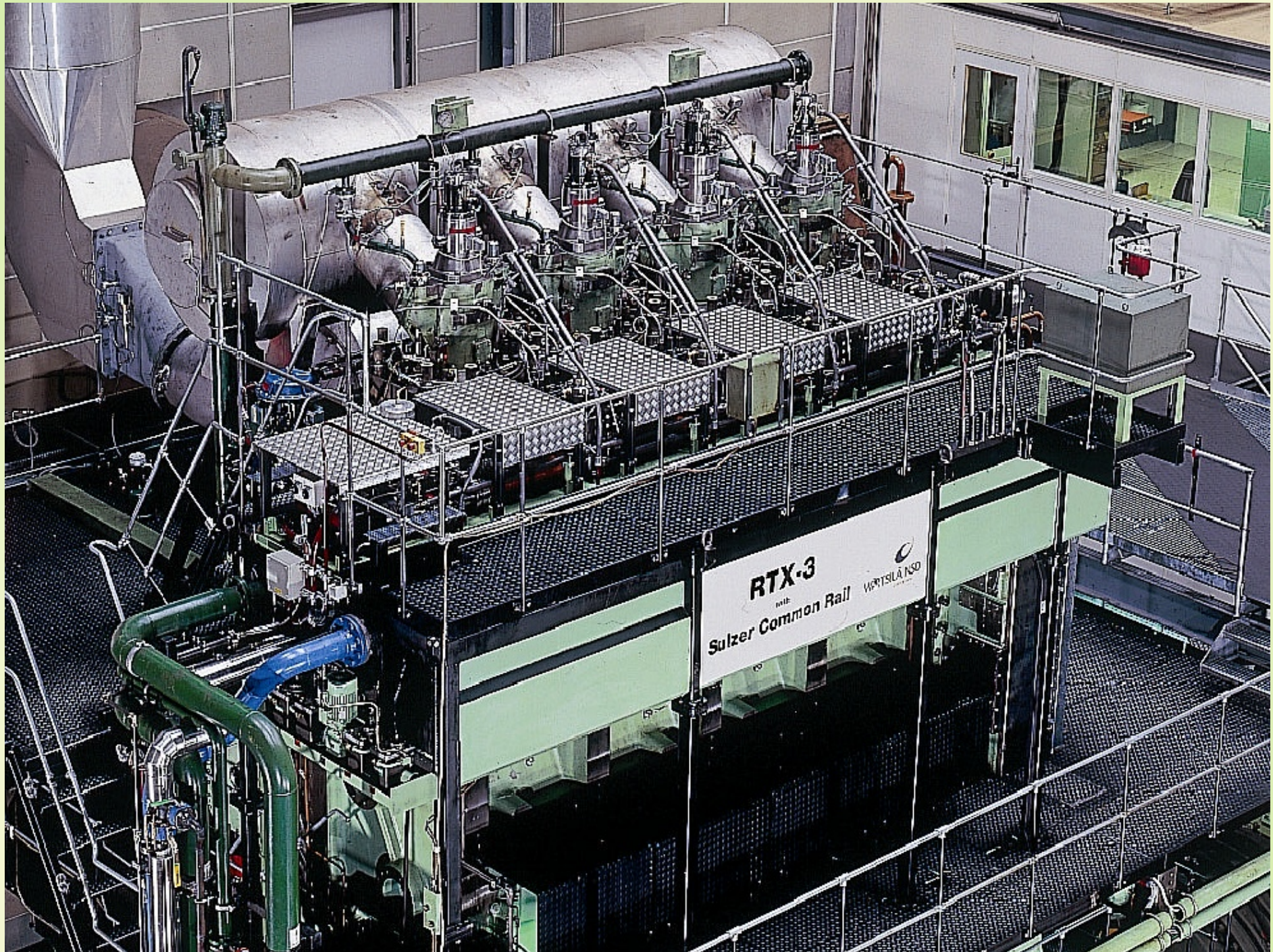
→ Vrijeme

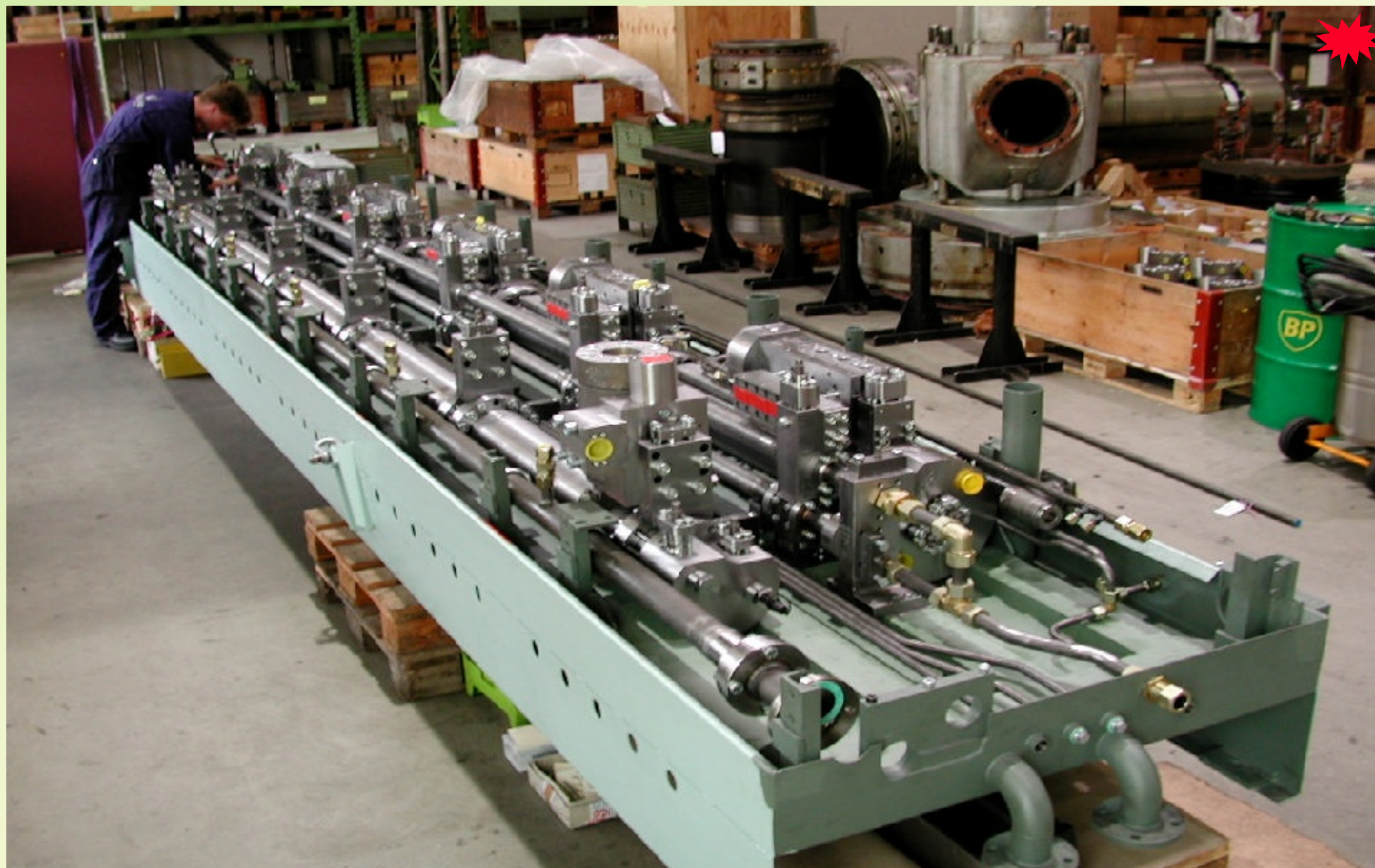
DM s bregastim vratilom

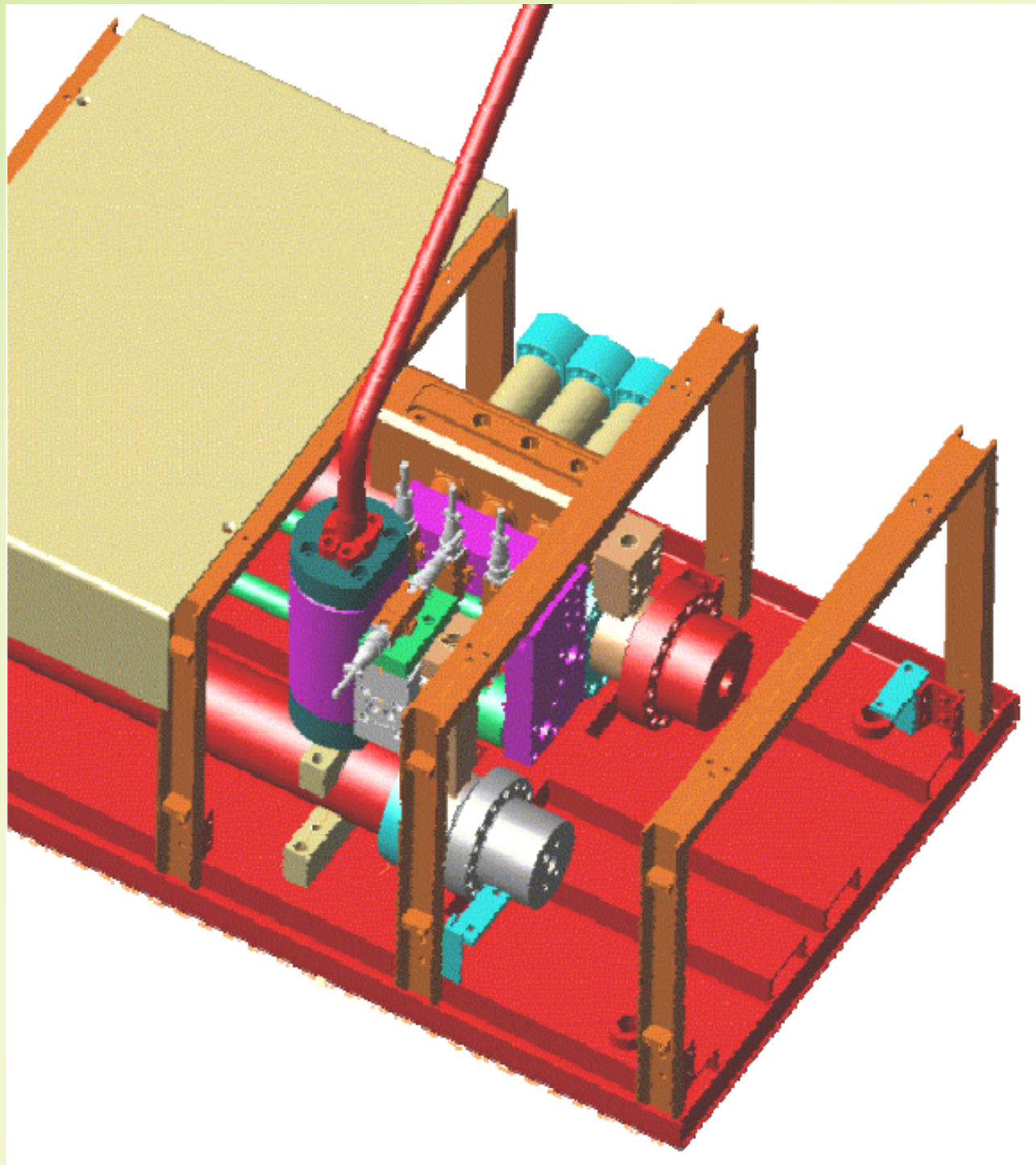


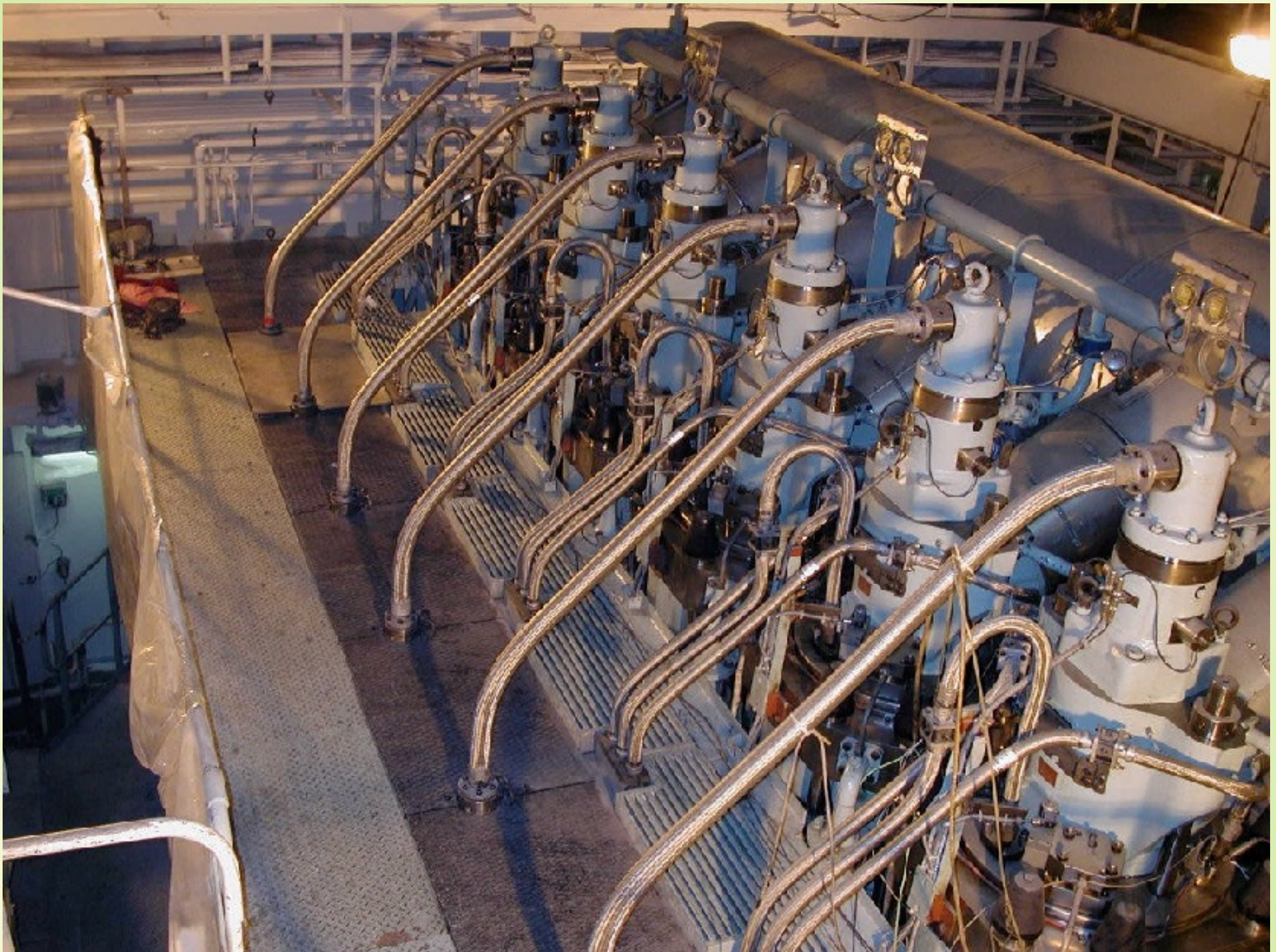
DM bez bregastog vratila



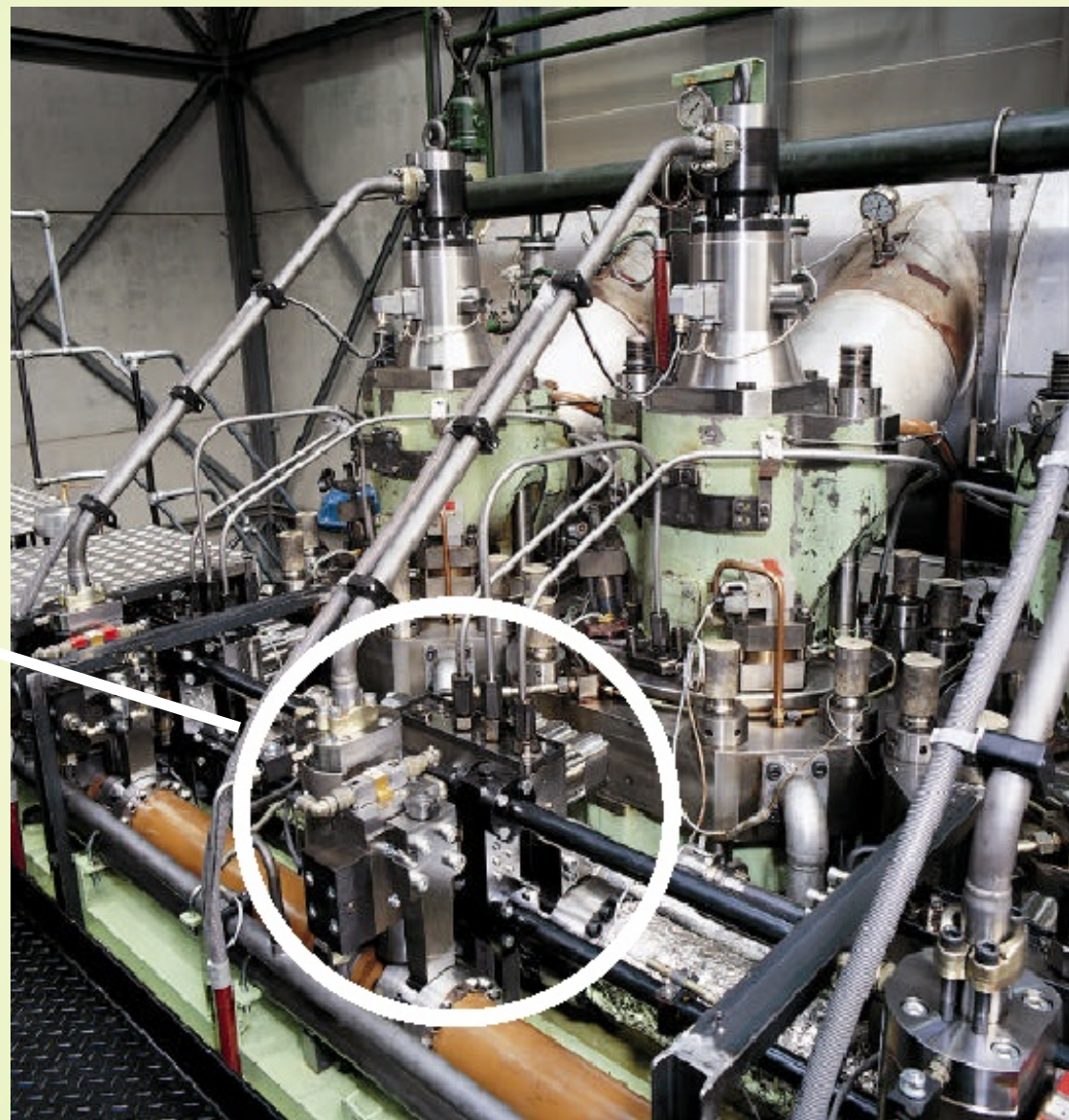
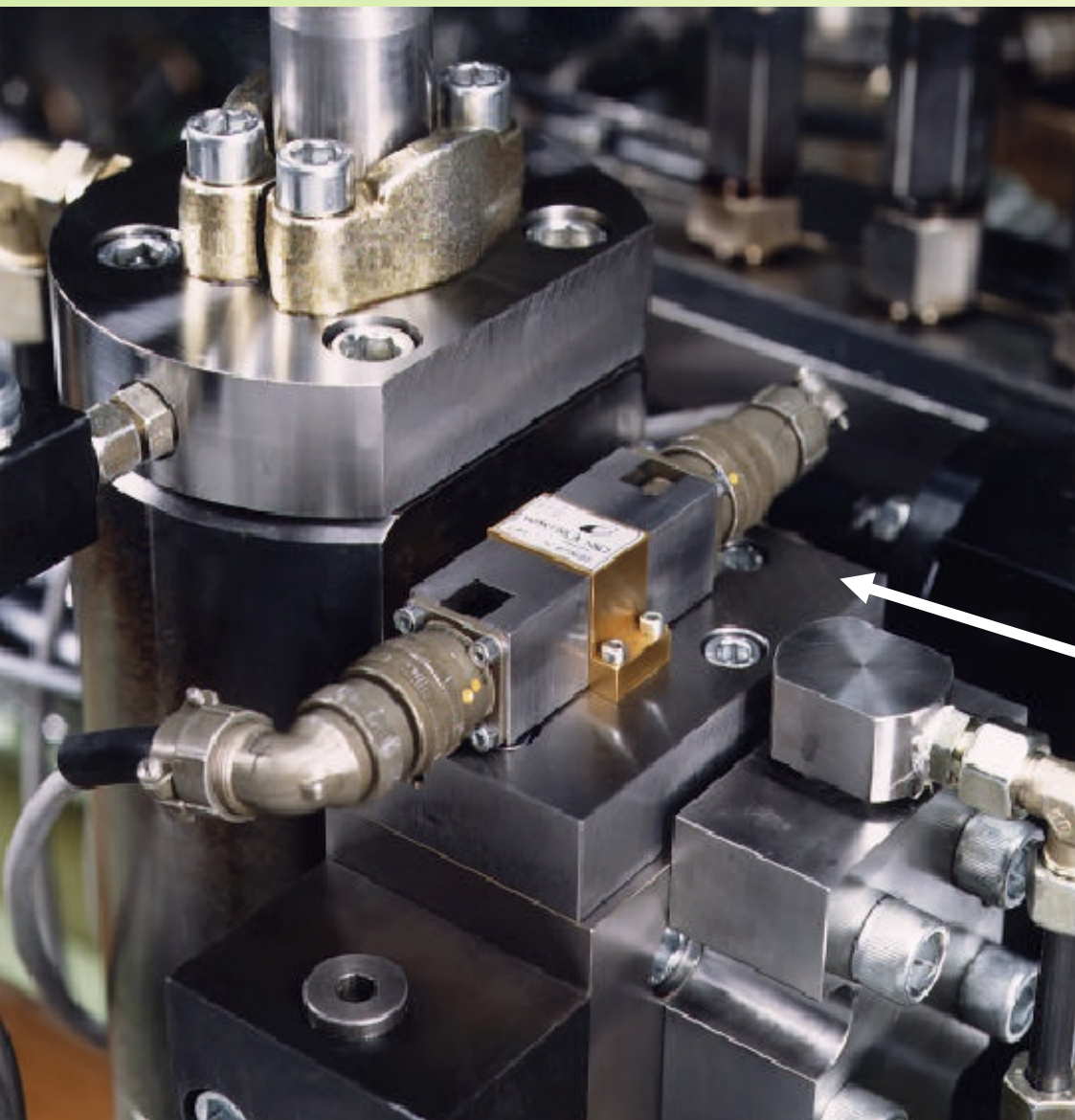


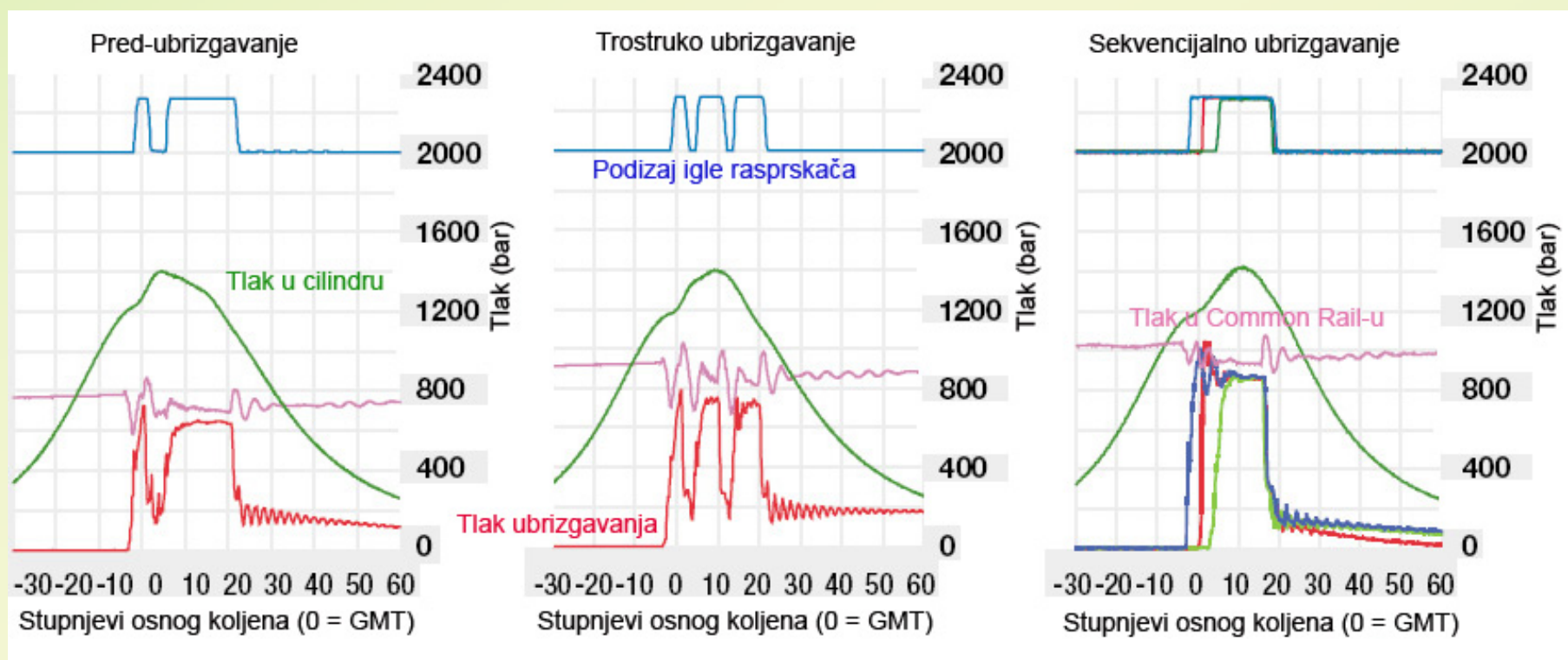
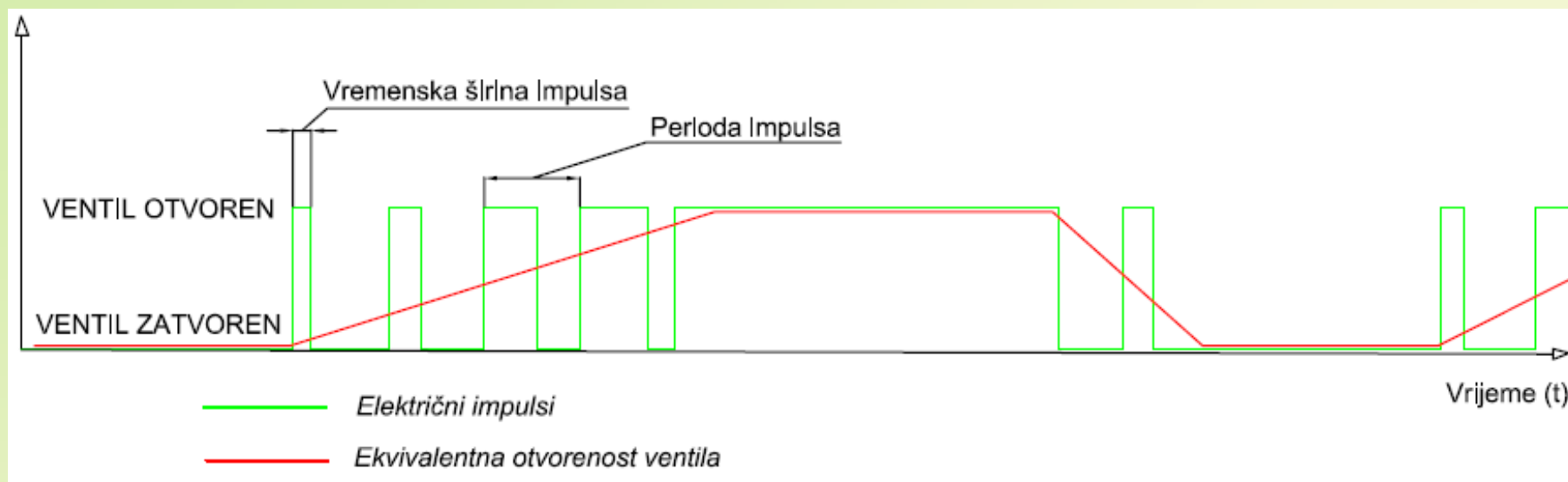




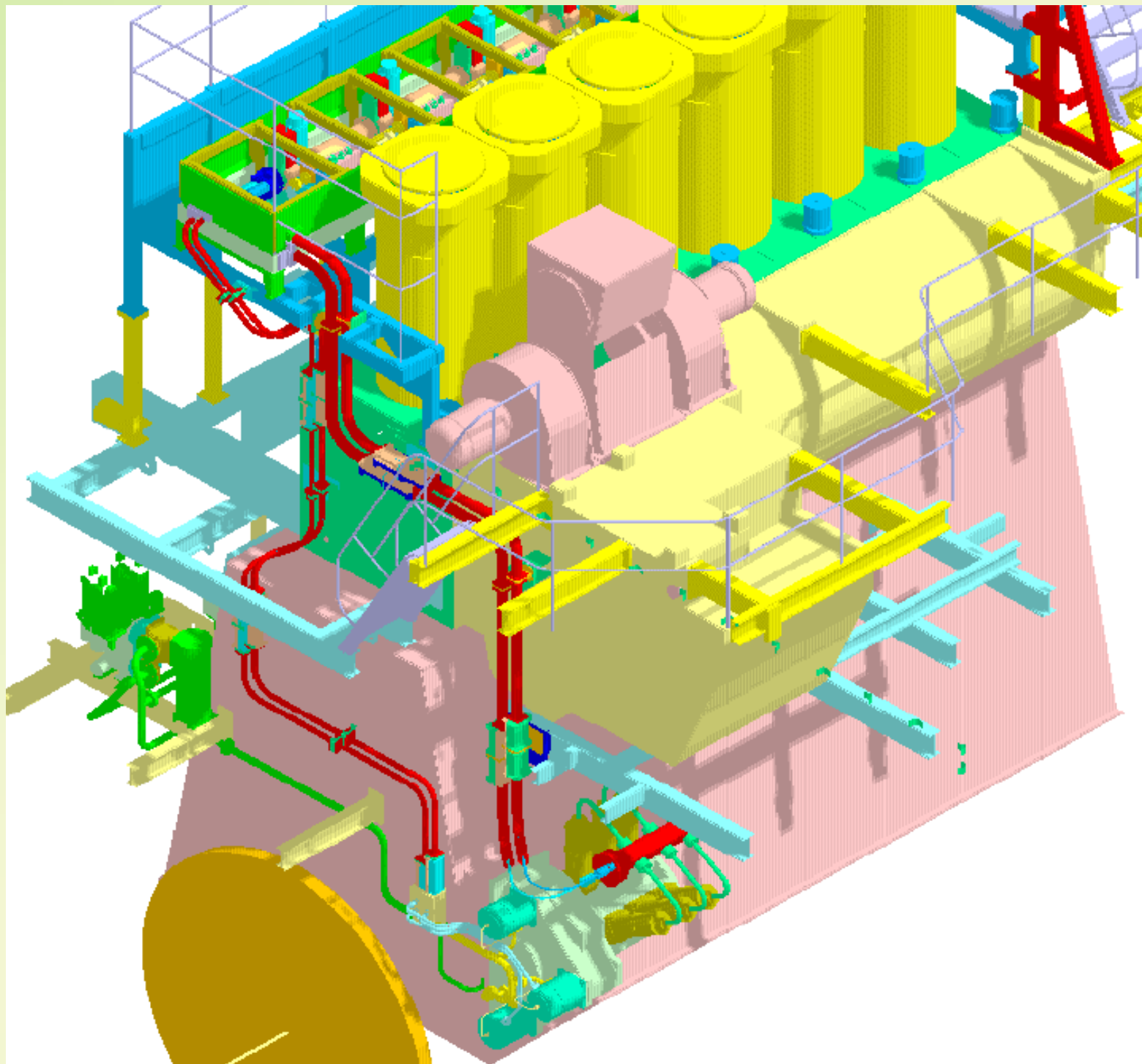


Brzi elektromagnetski ventil

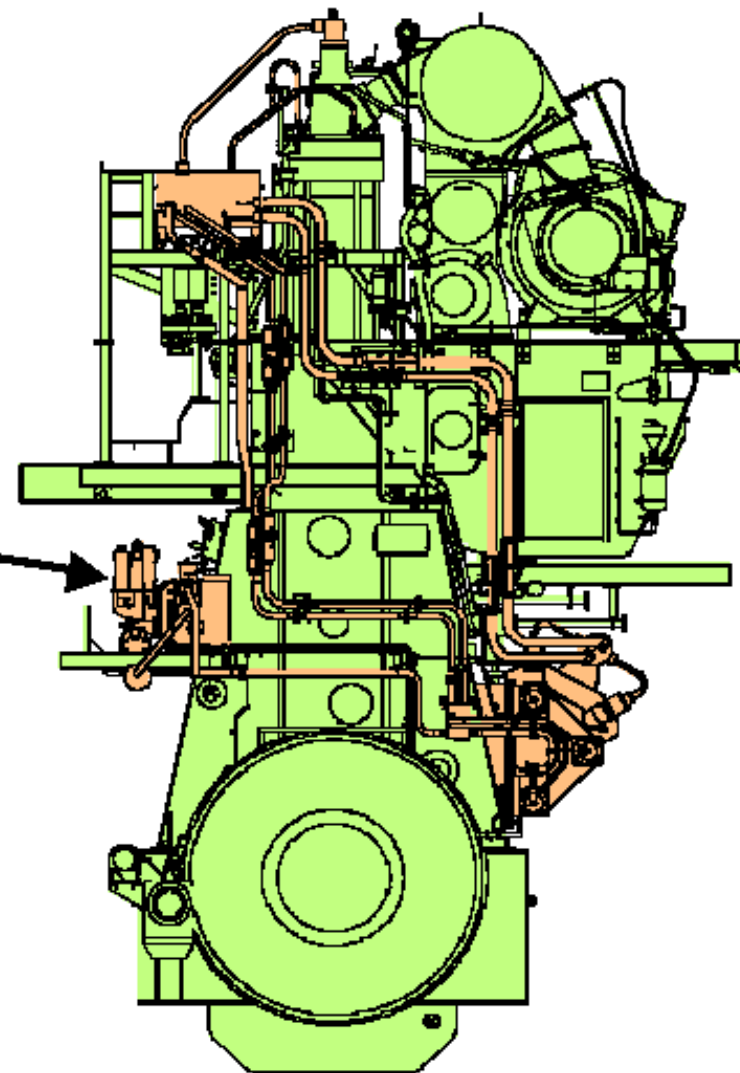
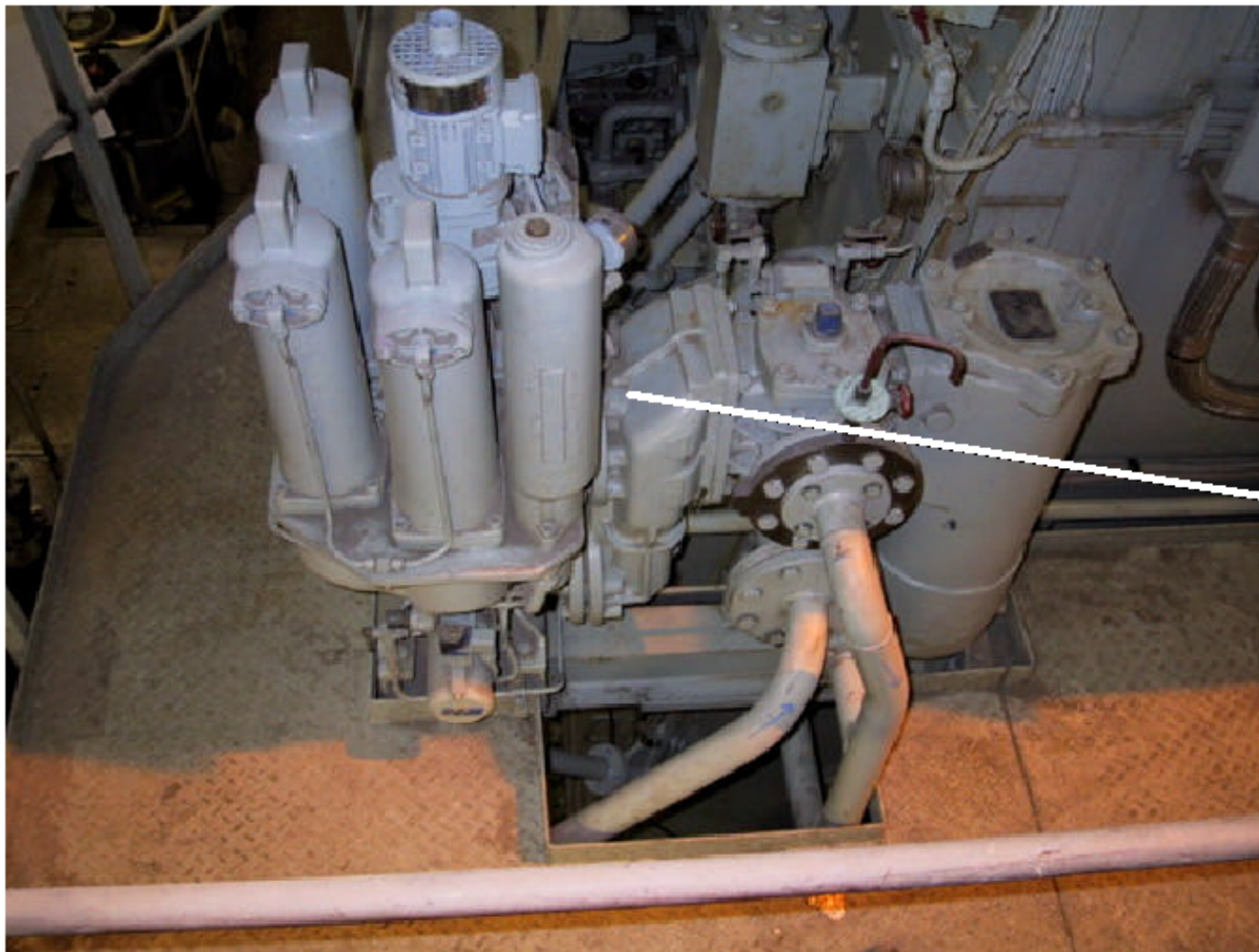


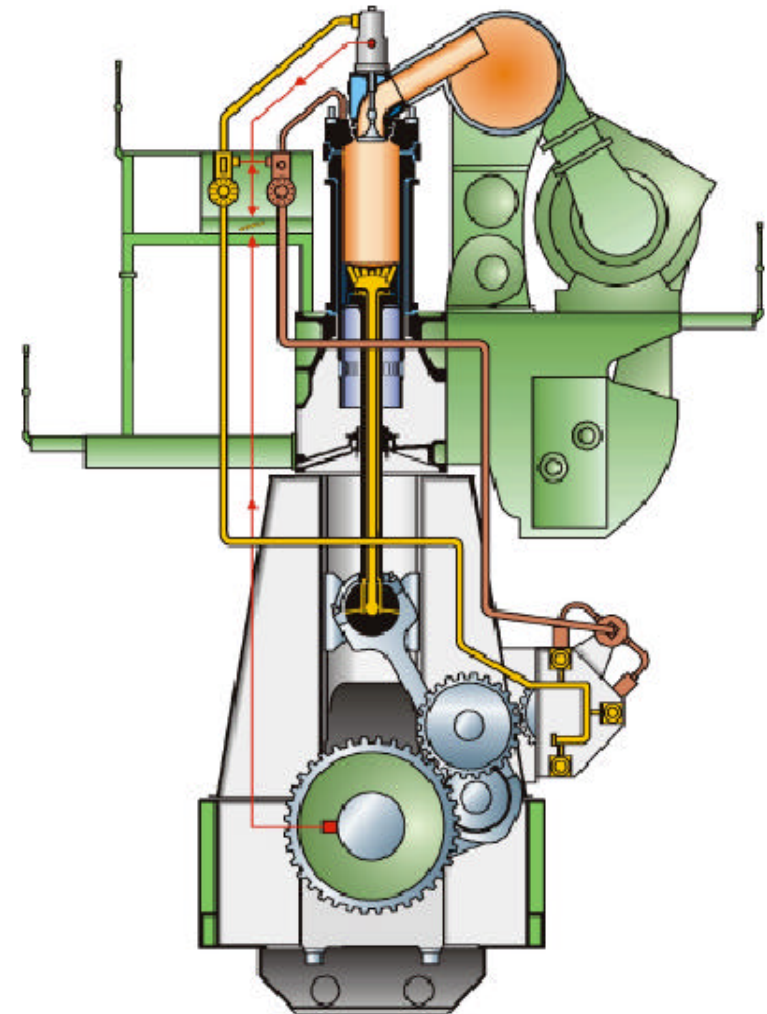
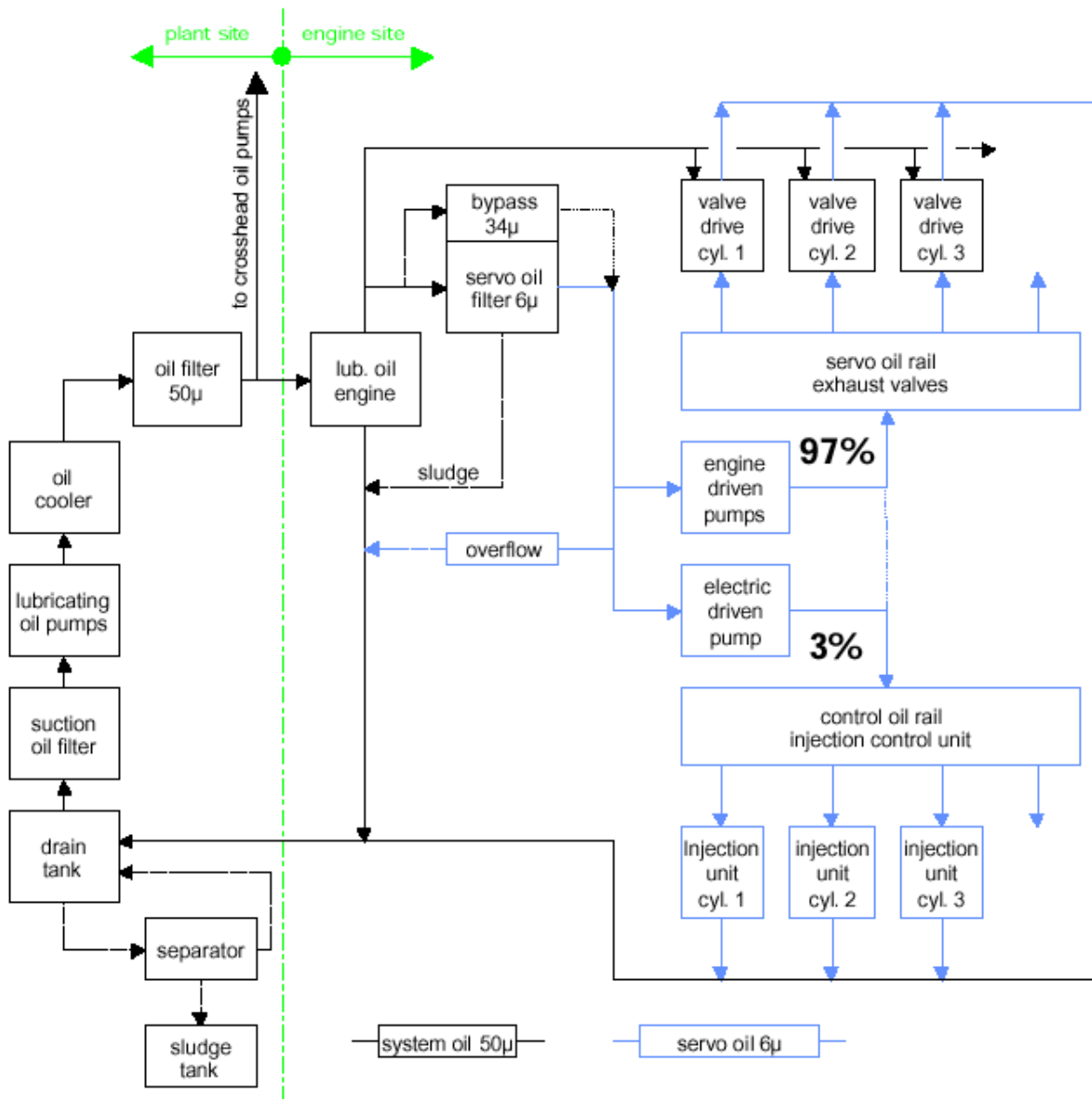


Ubrizgavanje goriva na motorima serije ME



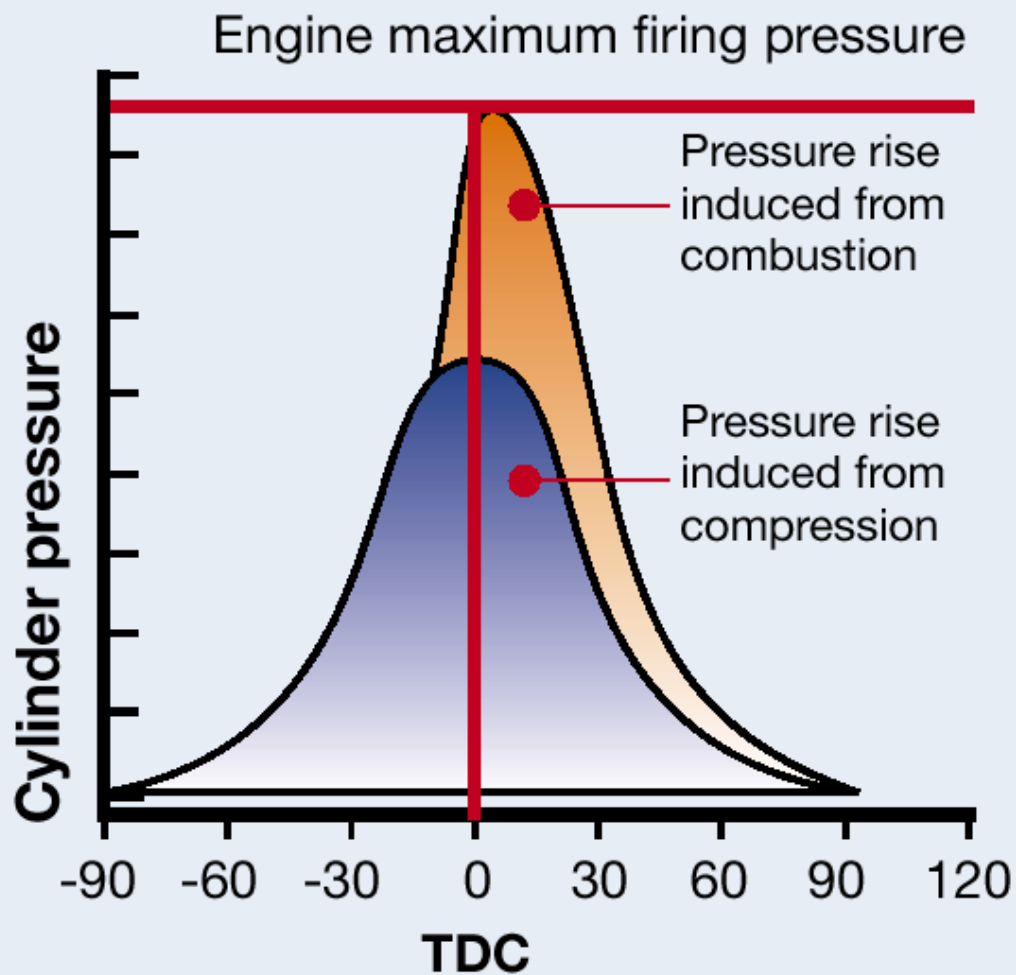
Jedinica za pročišćavanje upravljačkog ulja



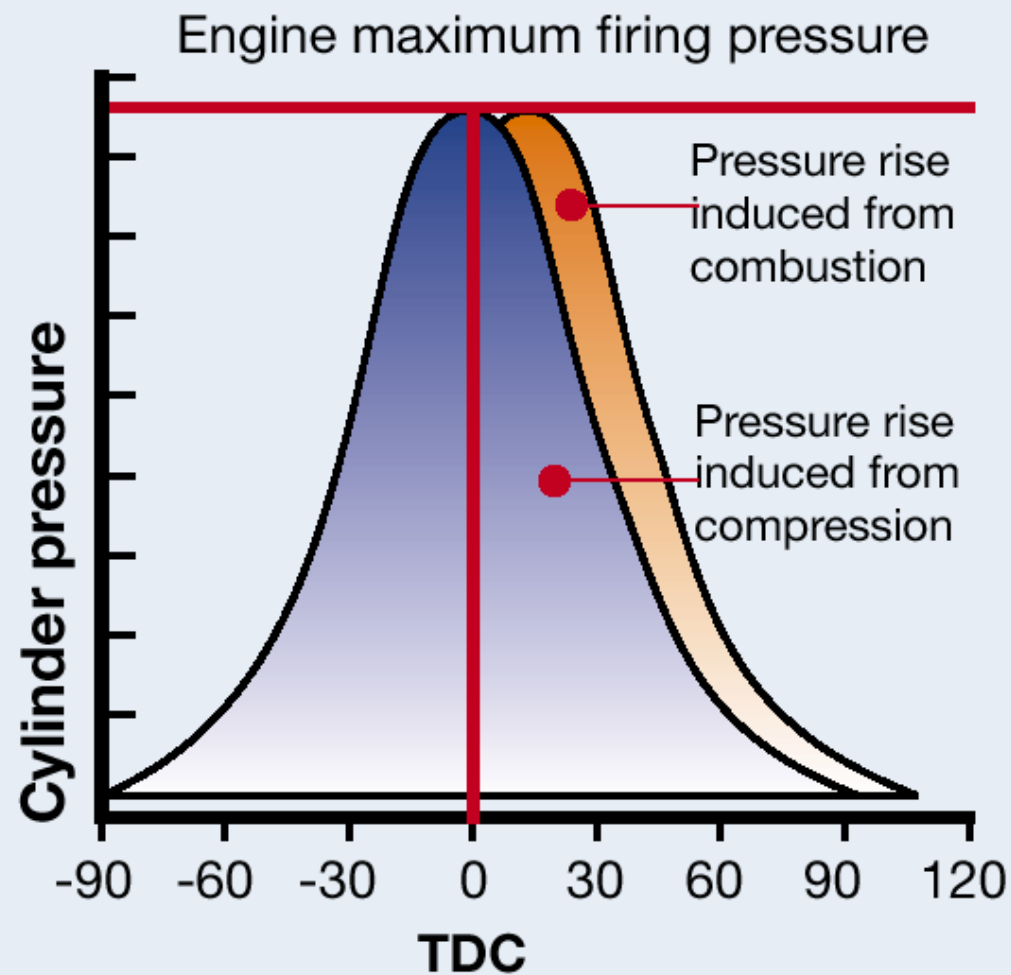


Vođenje procesa kod Wartsila VASA motora za smanjenje emisije NO_x

Conventional design



Low NO_x design



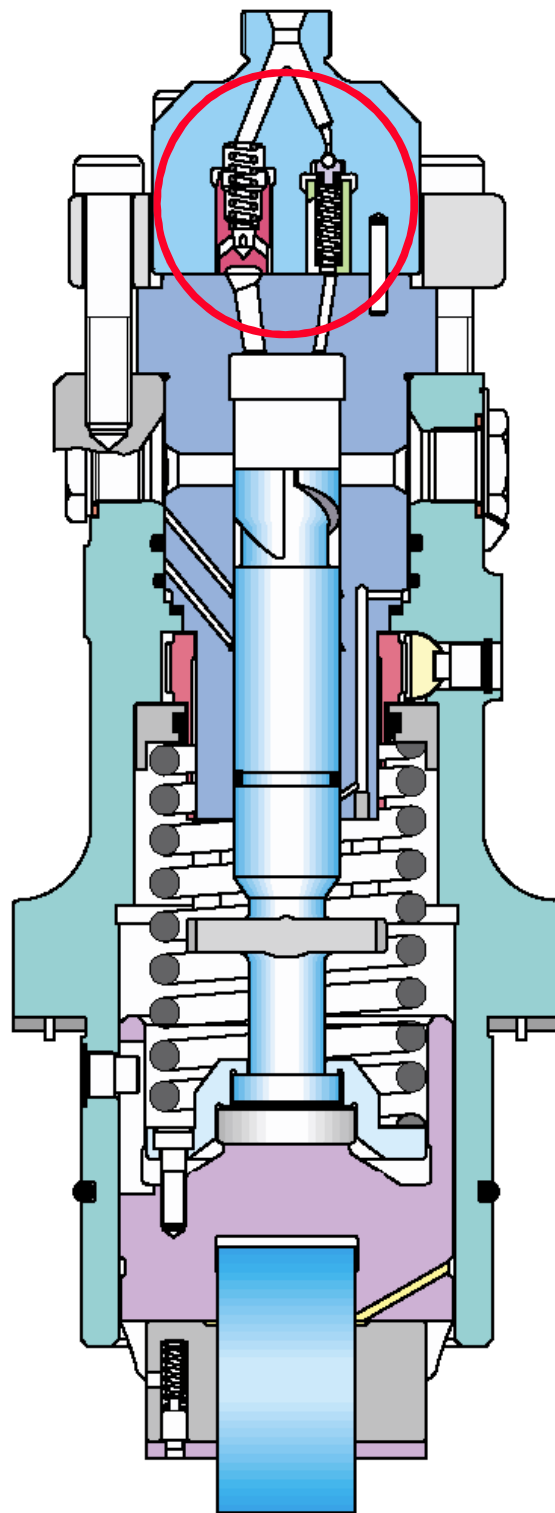
VT pumpa za ubrizgavanje goriva i rasprskач kod motora Wartsila VASA



Fuel system



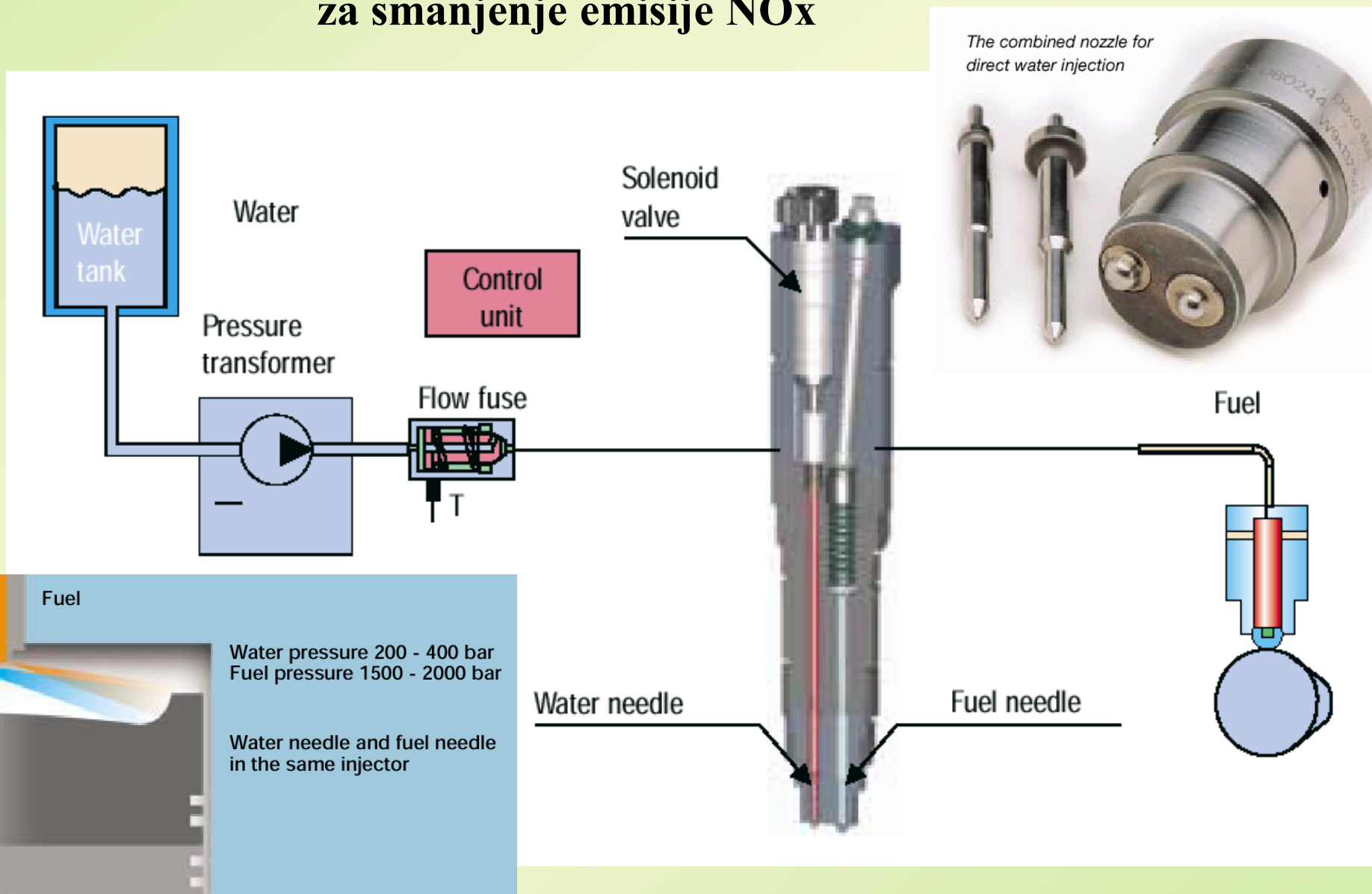
Fuel injection system



**Visokotlačna pumpa za
ubrizgavanje goriva s
konstantnim preostalim
tlakom u VT cjevovodu**

SISTEM UBRIZGAVANJA GORIVA I VODE

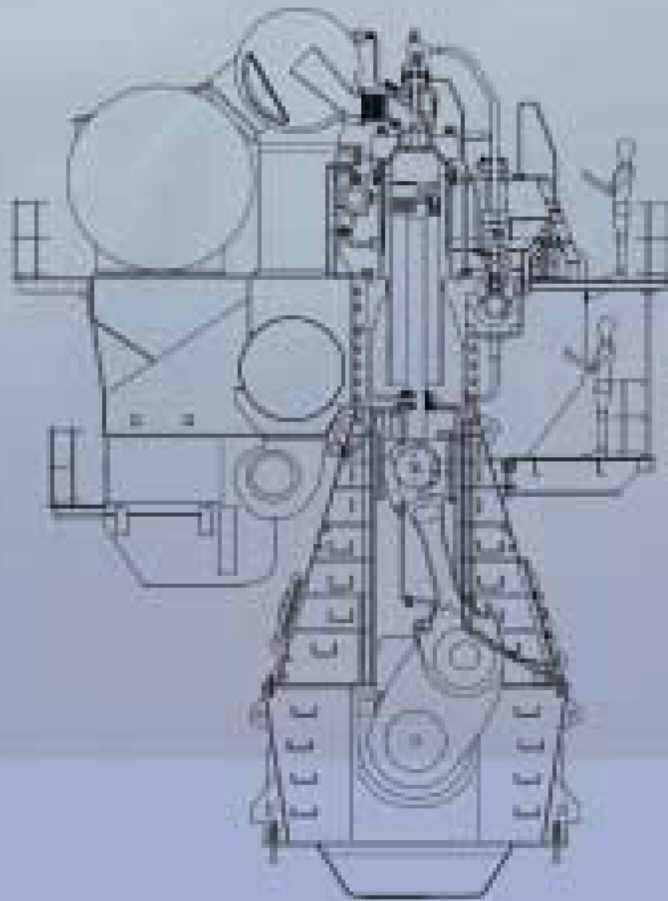
za smanjenje emisije NO_x



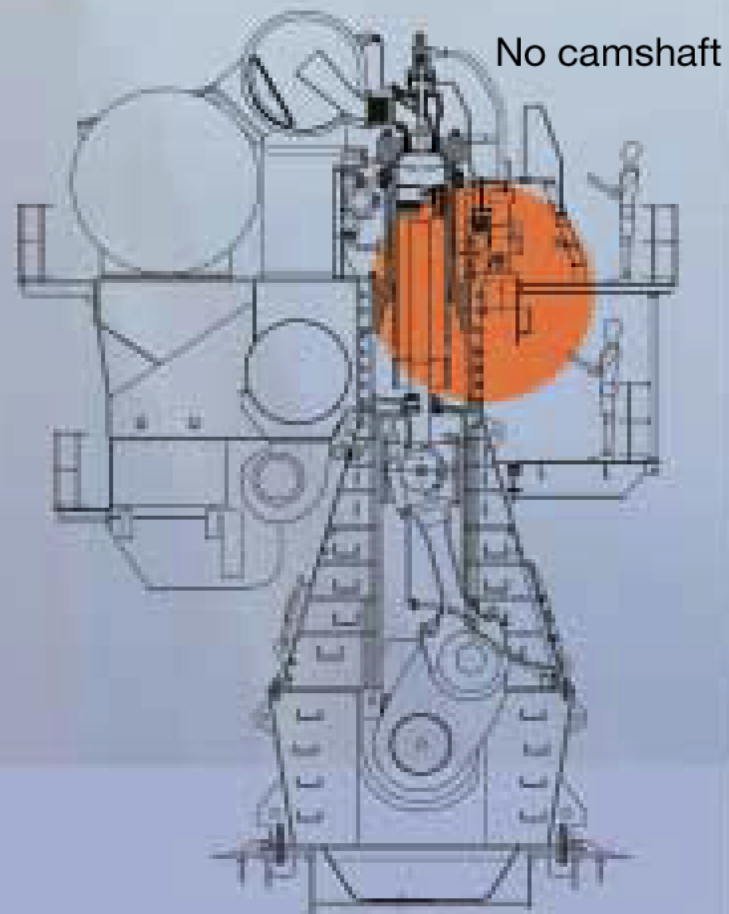
Sporokretni dizelski motorji MAN B&W

Odgovor na izazov: Intelligent Engine

MC engine
Conventional engine



ME engine
With electronic control



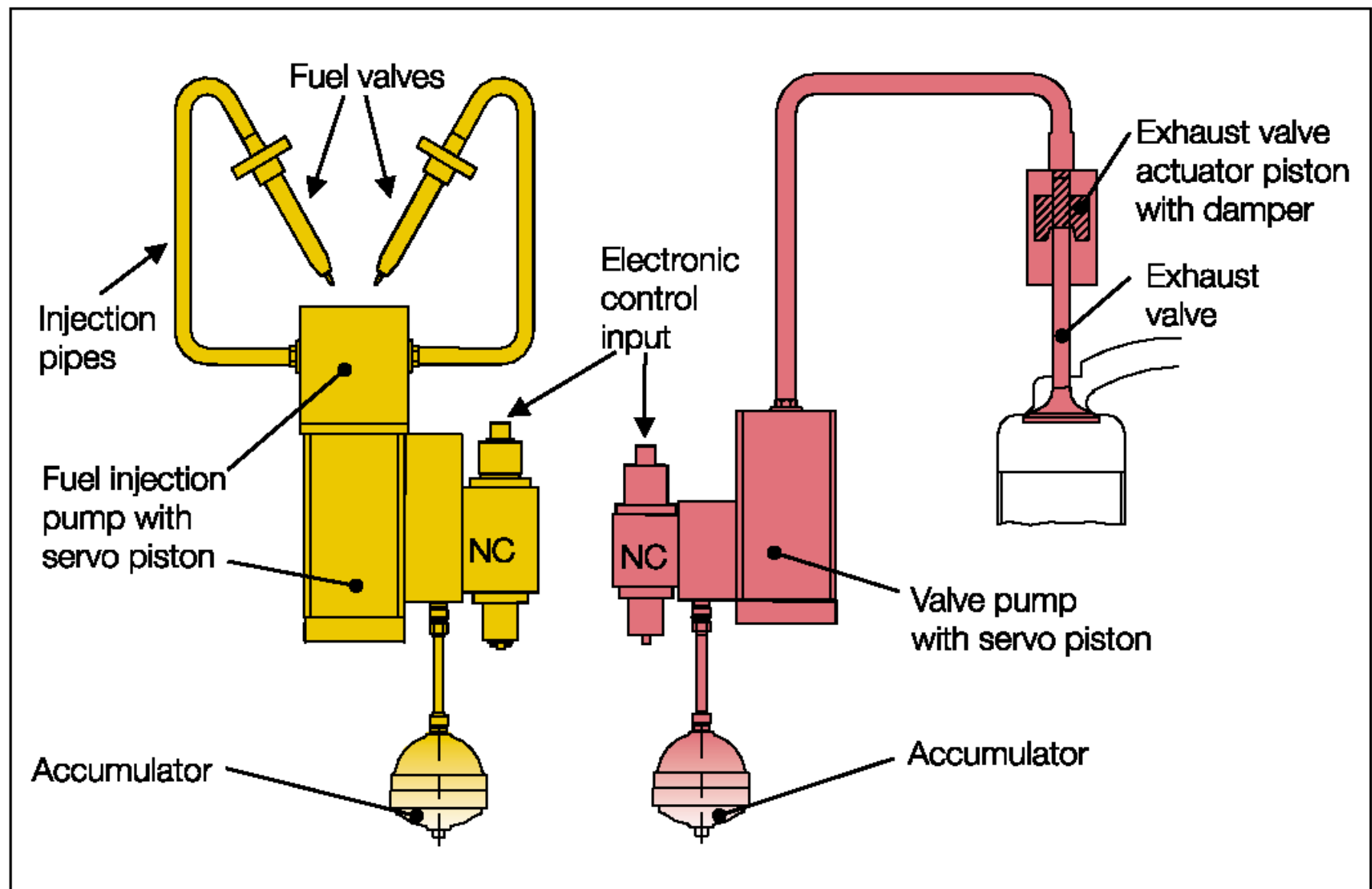
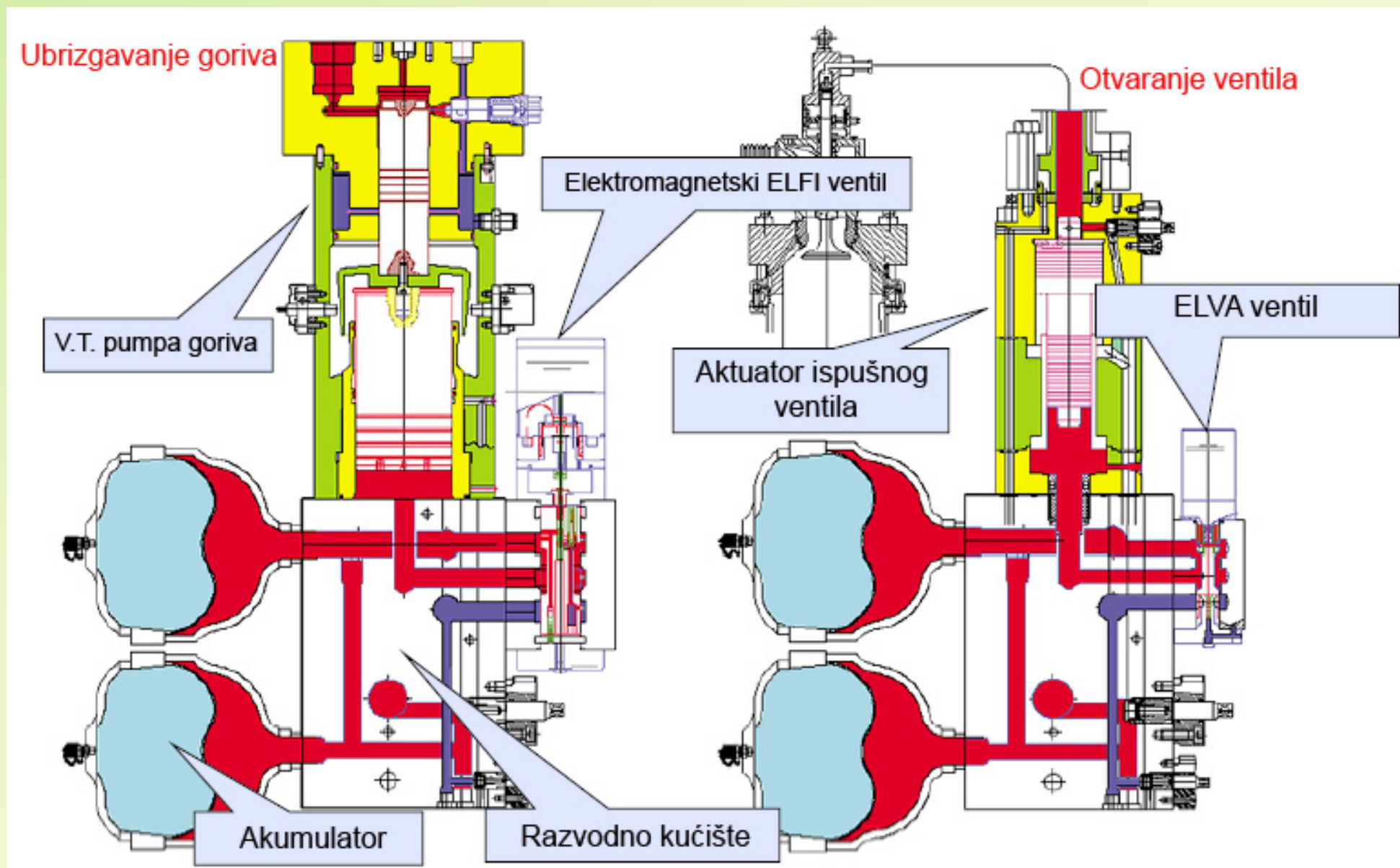
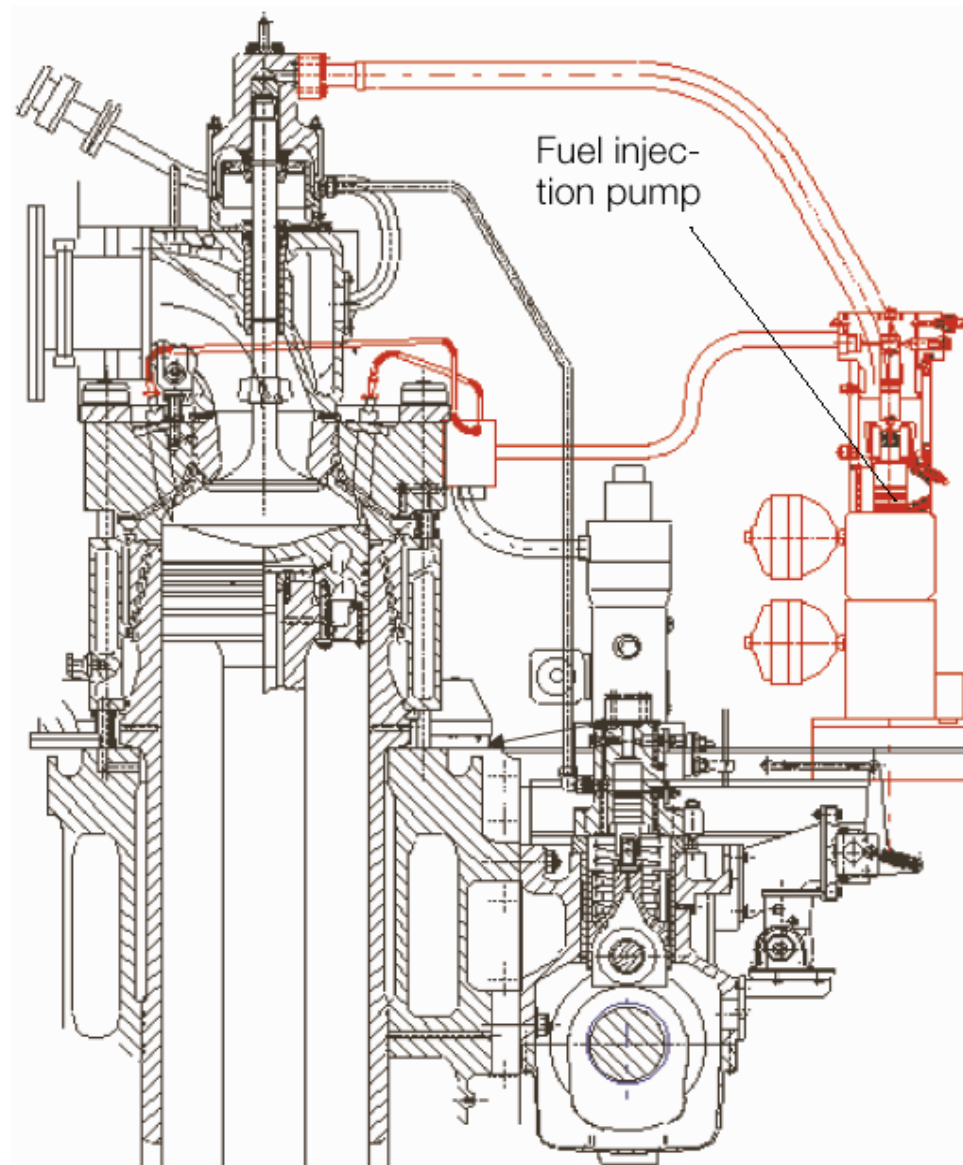


Fig. 4: General system layout for fuel injection and exhaust valve actuation systems

Sustav elektrohidrauličkog upravljanja ubrizgavanjem goriva (lijevo) i ispušnih ventila (desno)

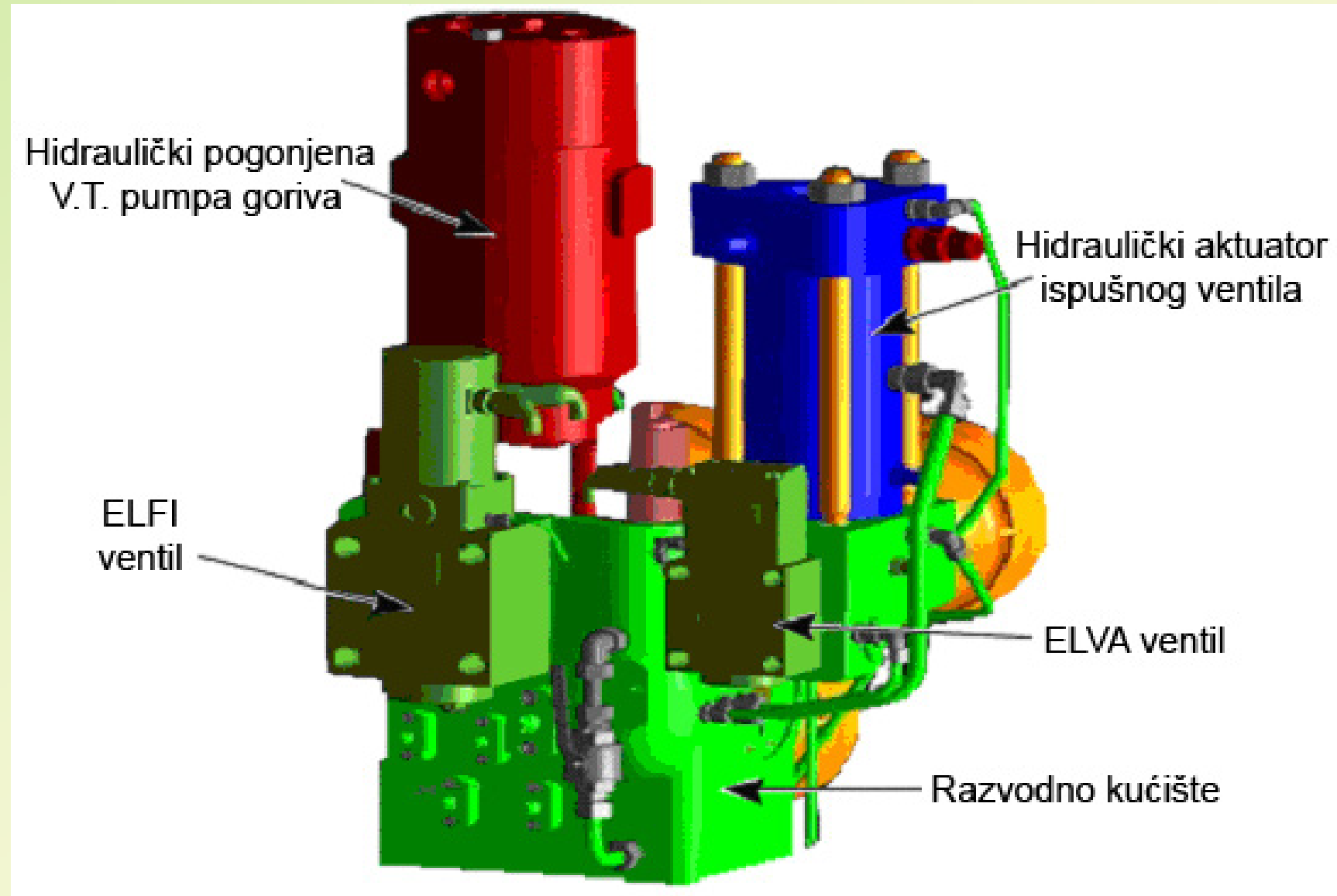


Sustav ubrizgavanja goriva MAN B&W serija ME

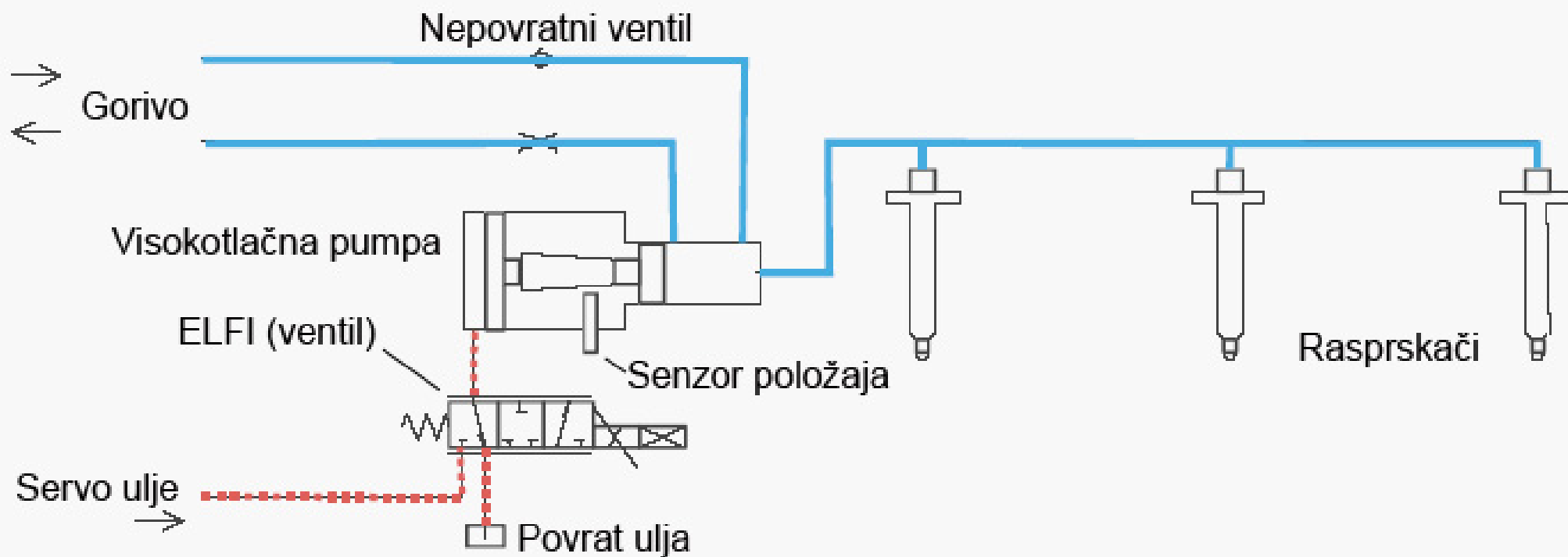


Usporedba klasičnog pogona ventila
i ubrizgavanja goriva s novim
elektrohidrauličkim upravljanjem
(crveno) (MAN B&W)

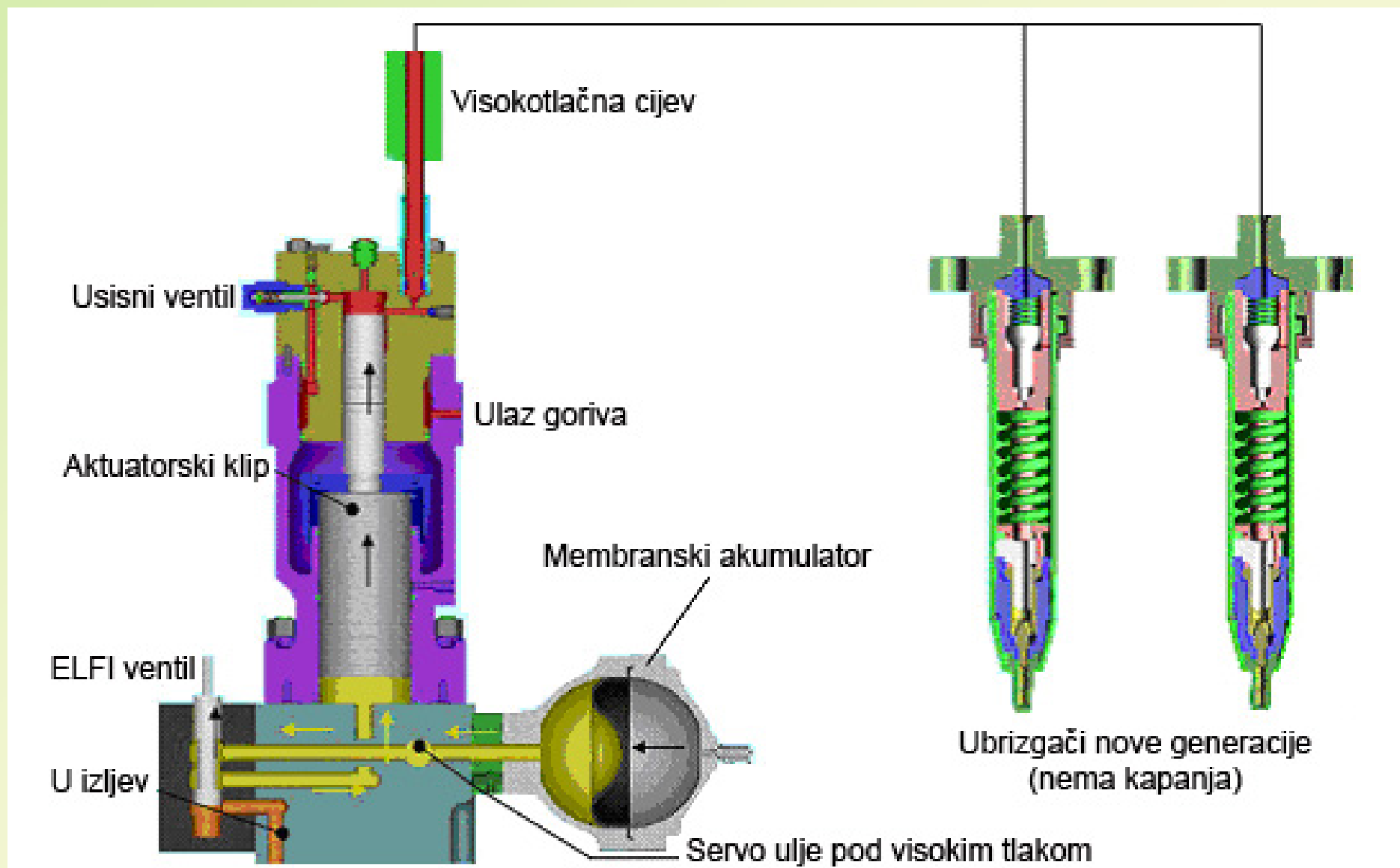
Fig. 17: Installation of the IE fuel injection and exhaust valve control systems in parallel with the conventional camshaft of the 6L60MC main engine of M/T Bow Cecil



Izvedba jedinice za ubrizgavanje goriva MAN B&W serija ME



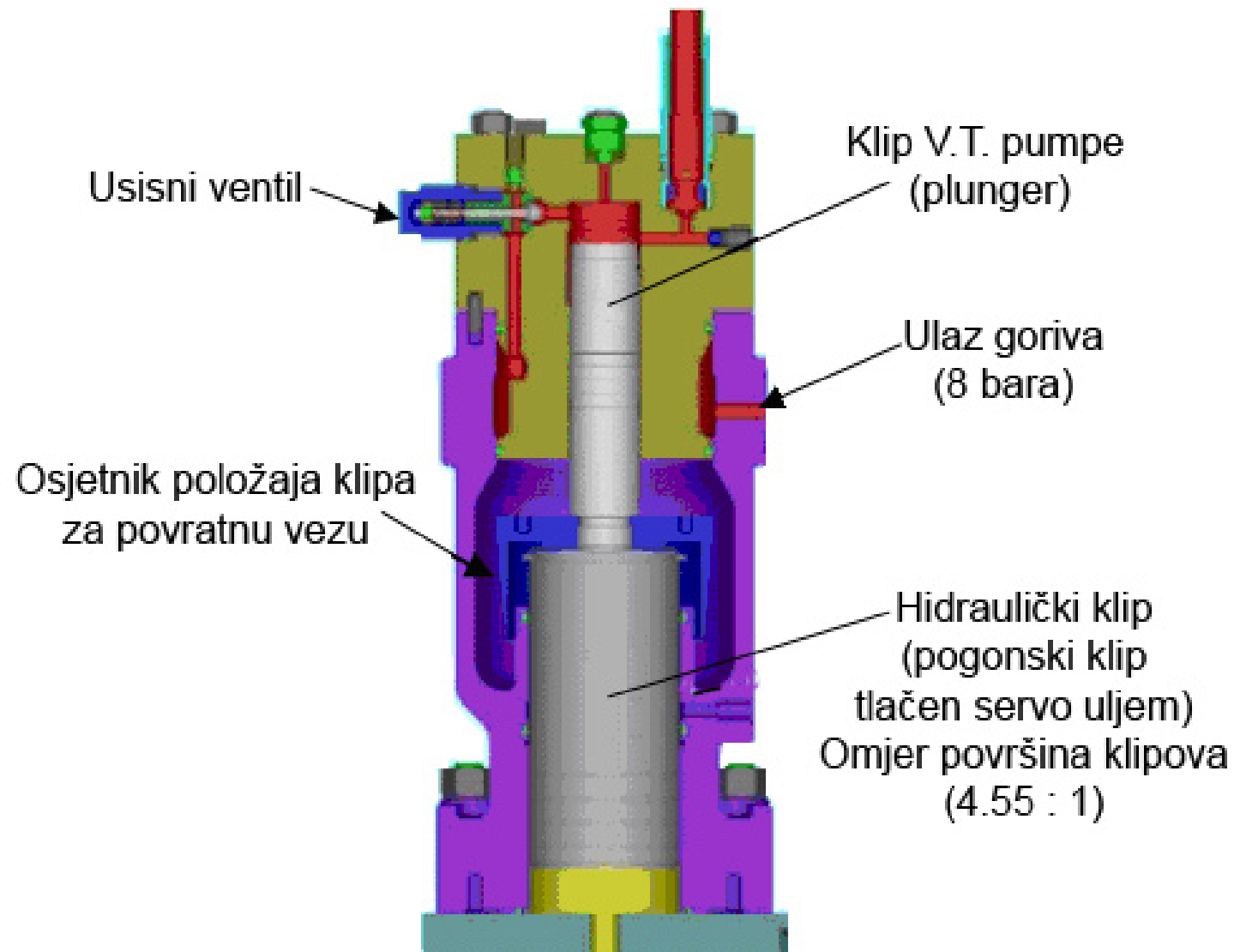
Sustav ubrizgavanja na MAN B&W motoru serije ME



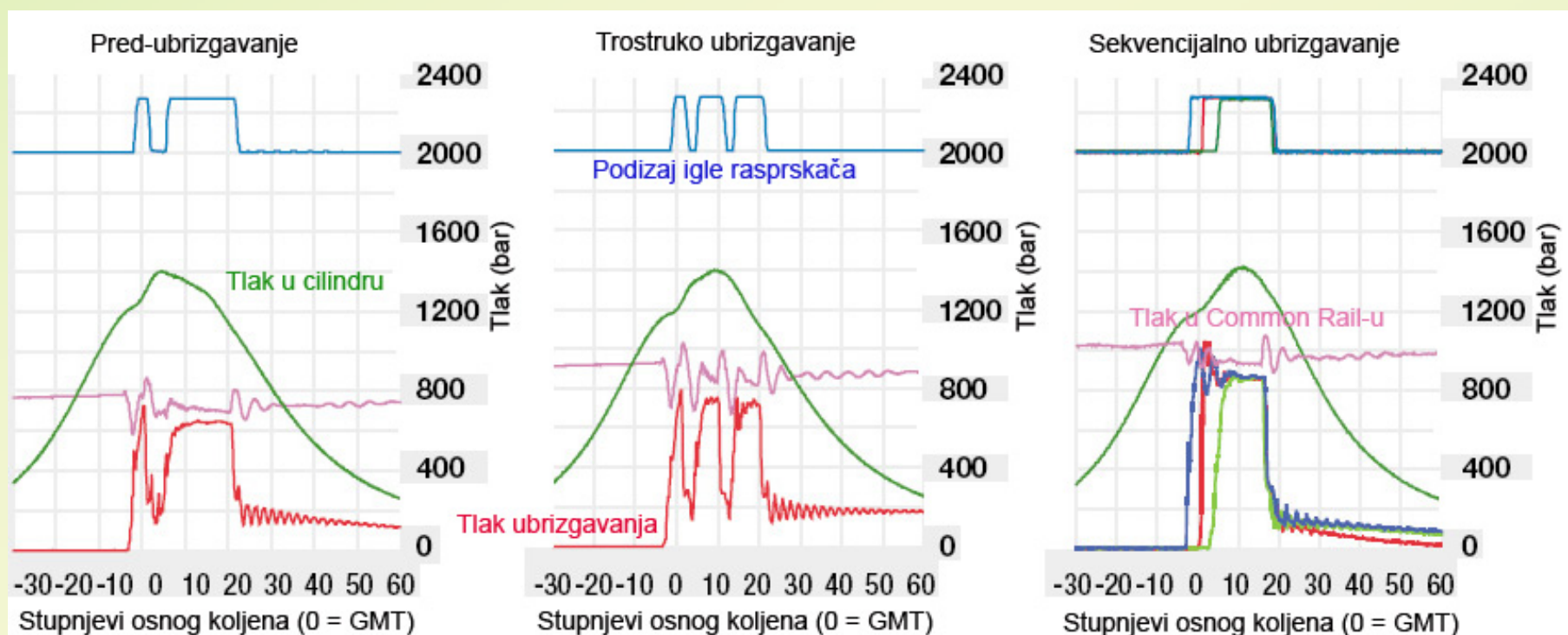
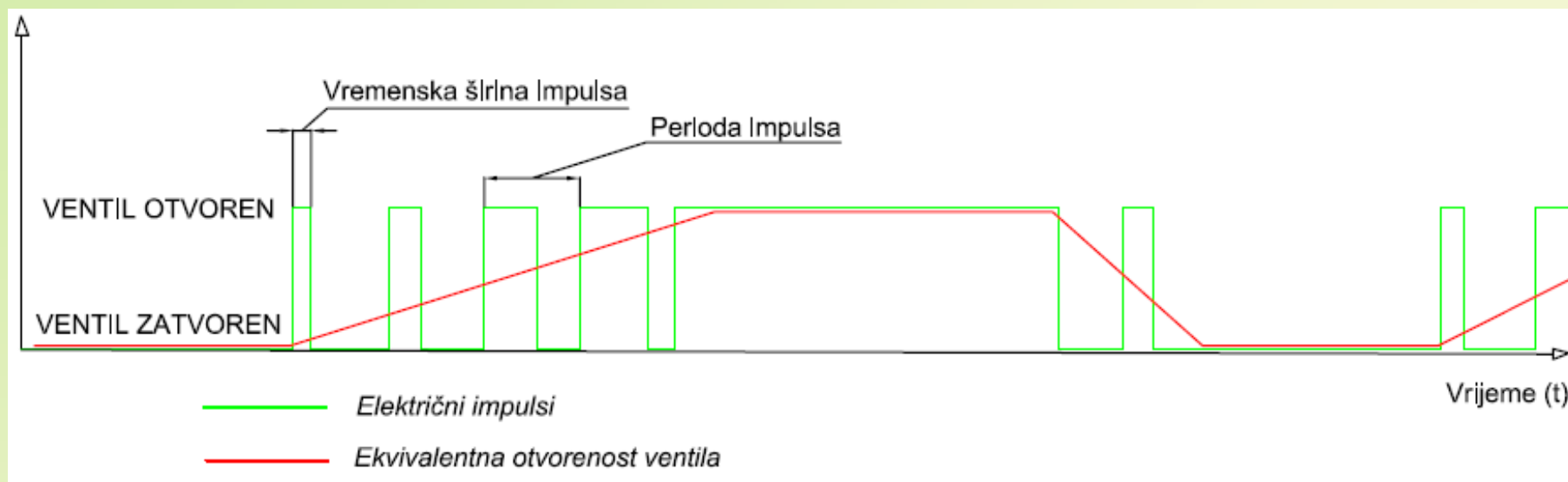
Princip ubrizgavanja na ME seriji



S50ME-C



Visokotlačna pumpa s
aktuatorom



Ubrizgavanje goriva na motorima serije ME

PLIN kao gorivo

LNG – liquefied natural gas

CNG - compressed natural gas

- Methan CH_4 , kao glavni sastojak (80-90%), razlika u temperaturi LNG - $163\text{ }^{\circ}\text{C}$, a CNG na povišenom tlaku.

Prirodni plin ima svojstva:

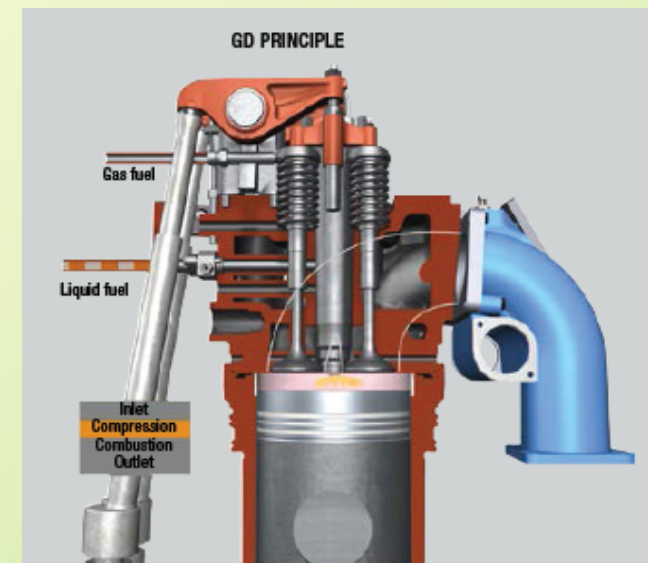
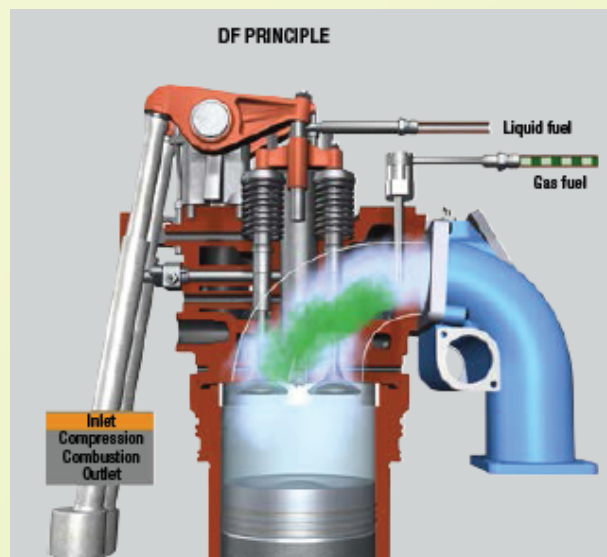
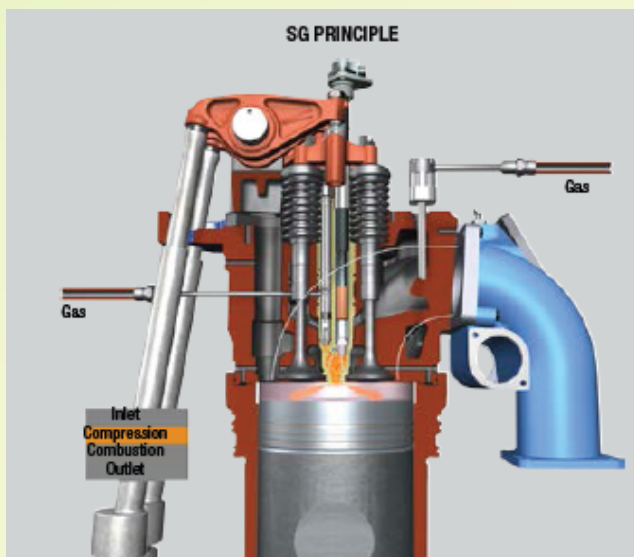
- ne sadrži nečistoće
- ne prlja ulje
- dobro se miješa sa zrakom
- visoku temperaturu samozapaljenja ($540\text{ }^{\circ}\text{C}$) i smanjeno područje zapaljivosti (5–15 %; $\lambda=0.59-1.95$)
- manje zagađuje
- sklon detonaciji : metanski broj – otpornost na detonaciju

OG – Otto Gas. Homogena smjesa plina i zraka. Paljenje svjećicom.

- jednokomorni prostor: Stehiometrijska smjesa = visoki NOx.
- pretkomora: stehiometrijska smjesa, a u glavnoj komori siromašna smjesa = niski NOx (lean-burn engines)

DG – Diesel Gas. Homogena smjesa siromašne smjese plina i zraka, pali se ubrizgavanjem PILOT goriva (do 5%) . Radi na principu Otto procesa.

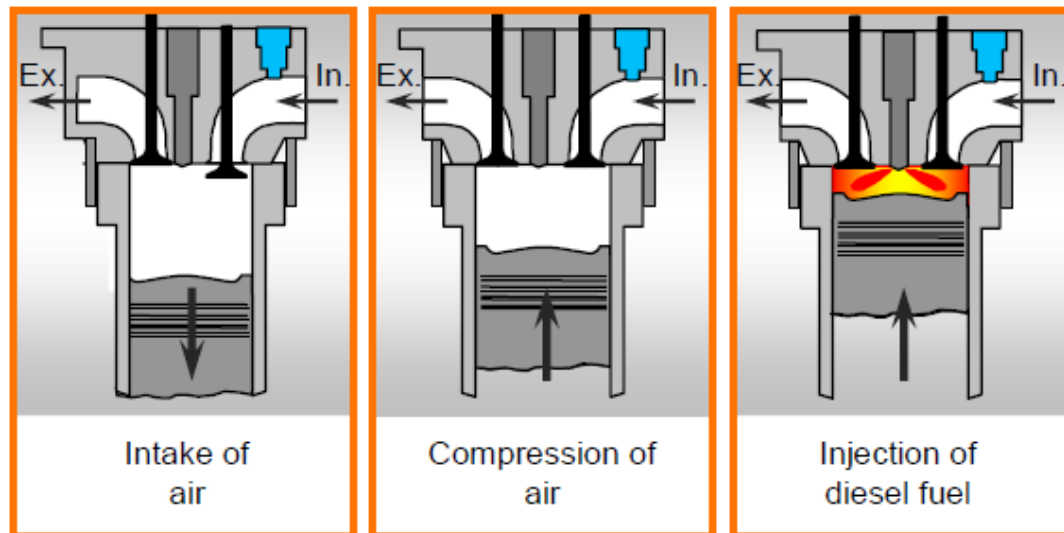
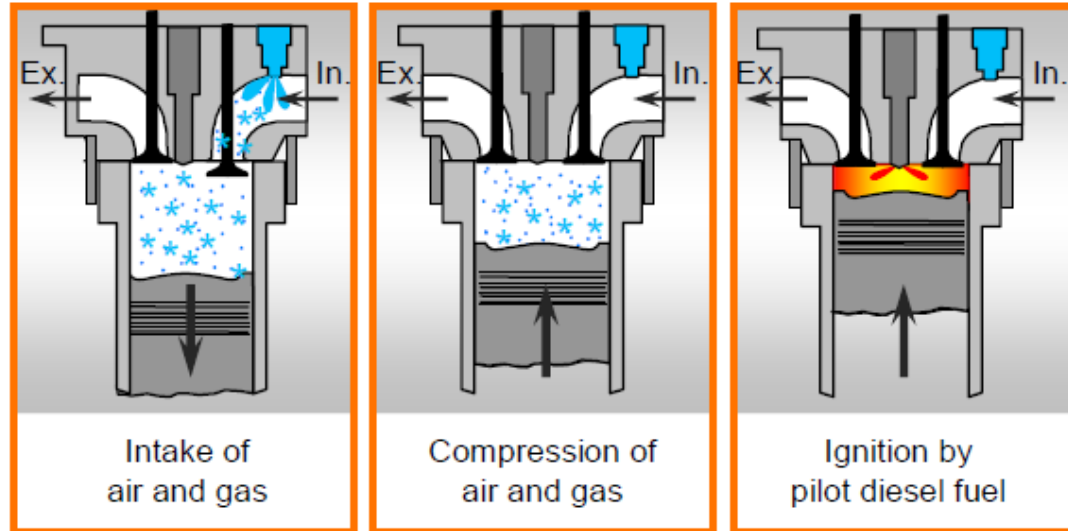
GD – Gas Diesel. Ubrižgavanje tekućeg plina u prostor za izgaranje. Paljenje putem PILOT goriva. Tlak ubrizgavanja 250 do 350 bara.



DUAL FUEL – OG

Gas mode:

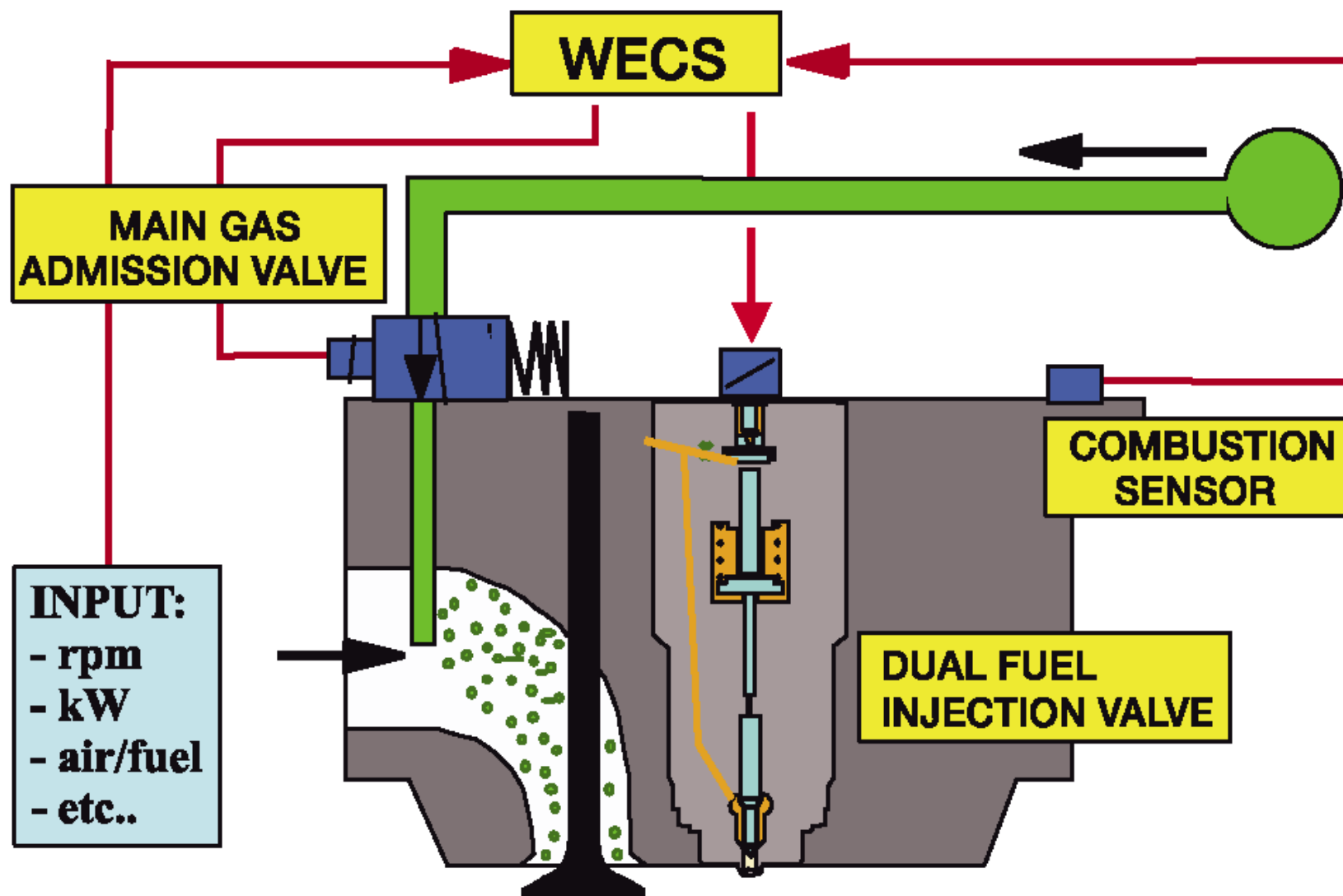
- Otto principle
- Low-pressure gas admission
- Pilot diesel injection



Diesel mode:

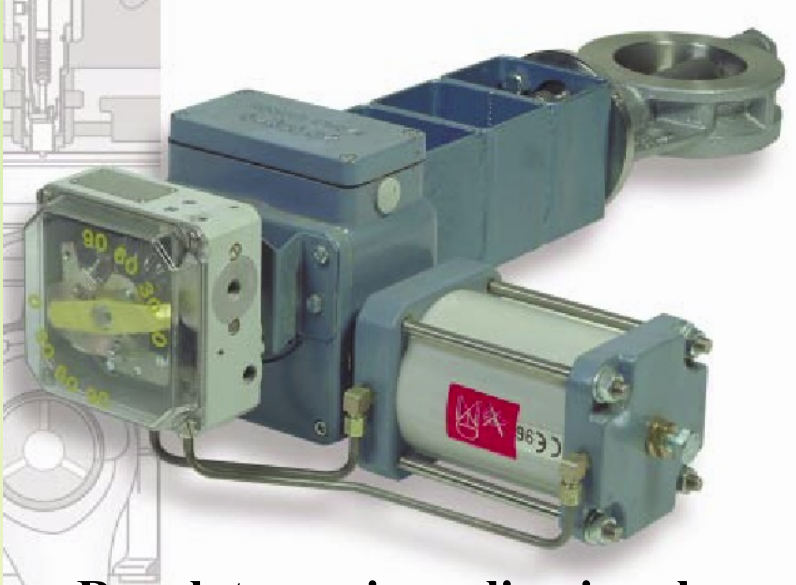
- Diesel principle
- Diesel injection

PRIPREMA GORIVE SMJESE za DF motor (plin i dizel) Wartsila VASA





OPREMA ZA PRIPREMU GORIVE SMJESE za DF motor (plin i dizel) Wartsila VASA



Regulator smjese plina i zraka



Dovod plina



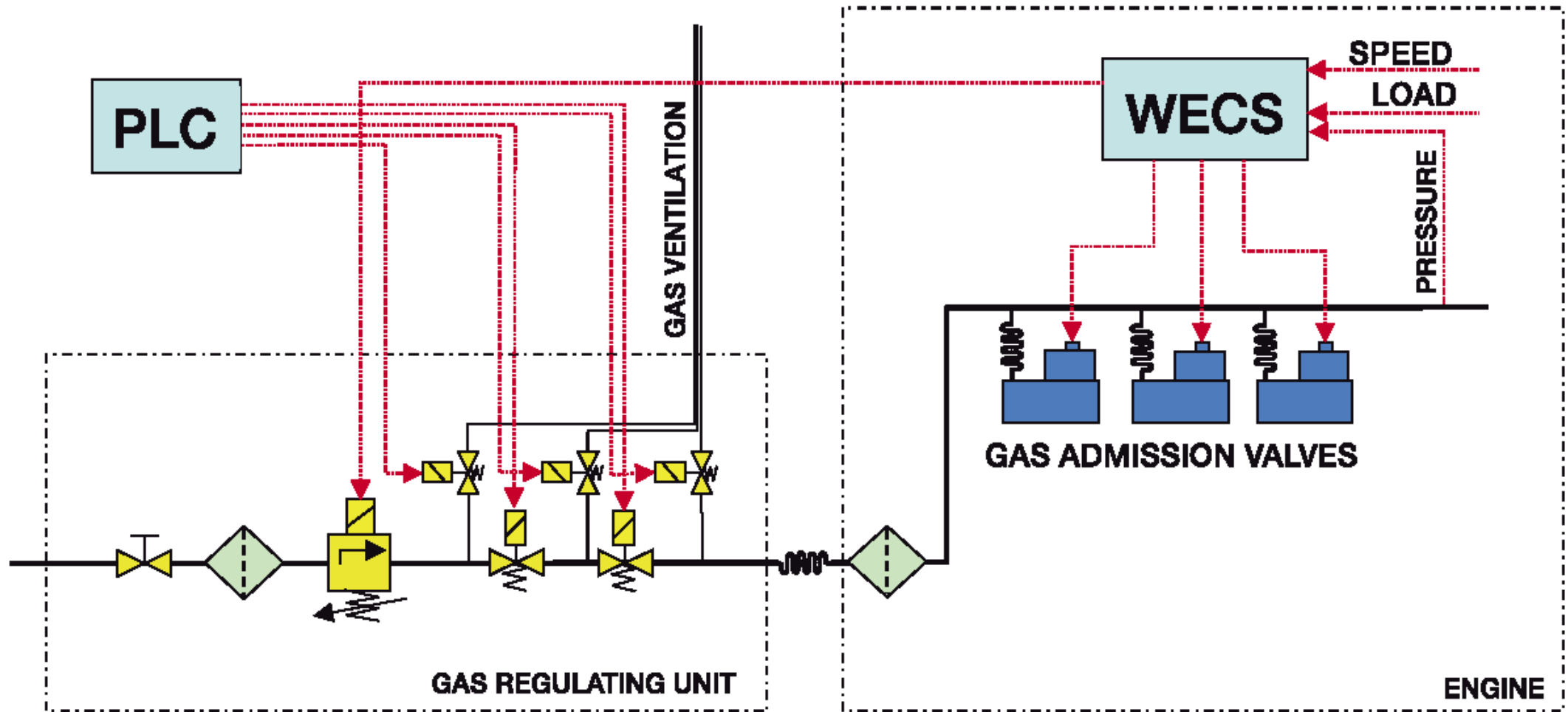
Rasprskач



VT pumpa



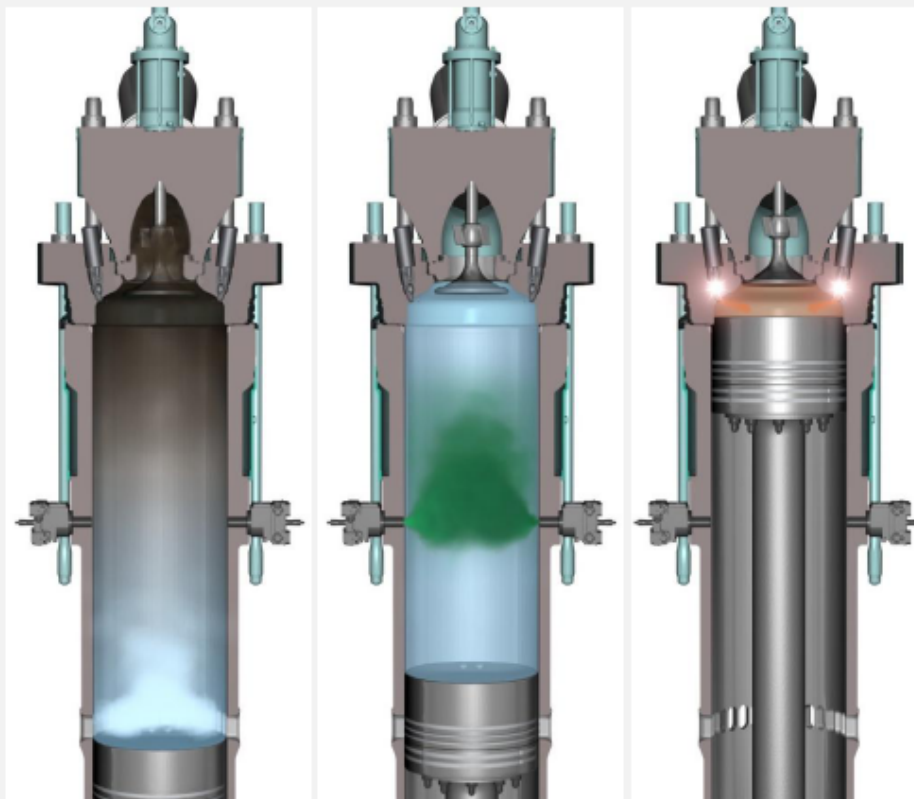
SISTEM ZA DOVOD PLINA



The 2-stroke DF concept

low pressure Dual Fuel

'Pre-mixed lean-burn' combustion



Scavenging

Compression/
gas admission

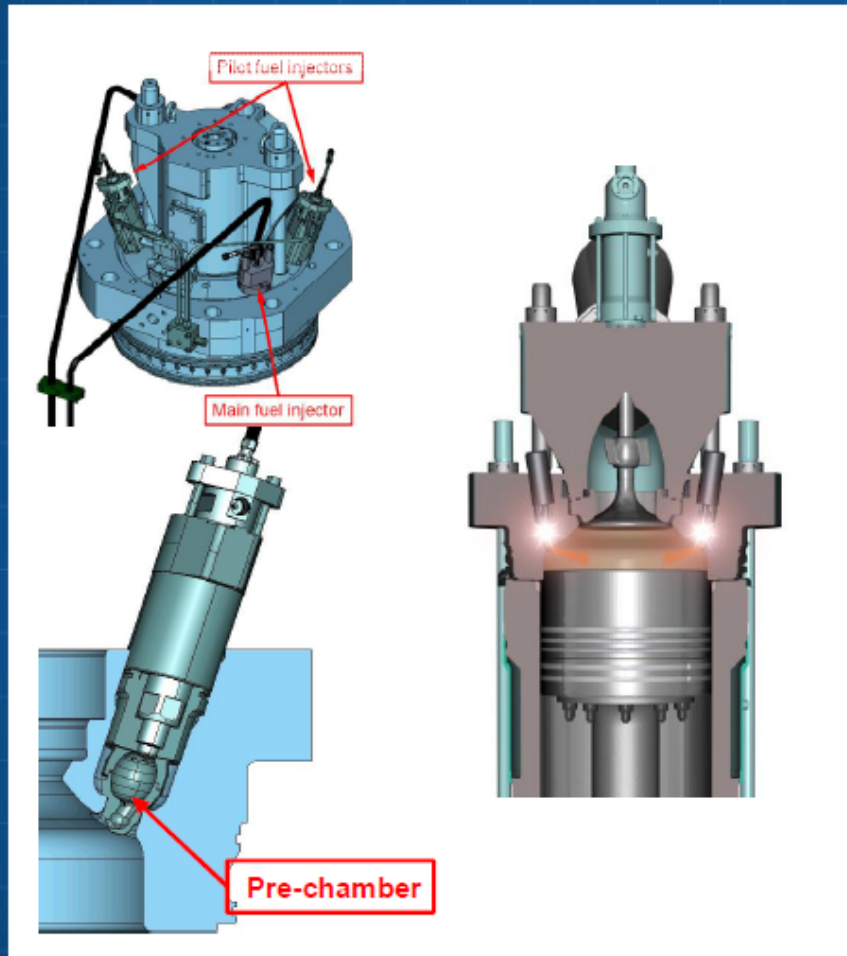
Ignition →
expansion

The Principle:

- Engine operating according to the Otto process
- Pre-mixed 'Lean burn' technology
- Low pressure gas admission at 'mid stroke'
- Ignition by pilot fuel in prechamber

2-stroke DF - Key Technologies

2STROKE
DEBUT OF DUAL-FUEL
ENGINE TRIESTE 12/11/2013

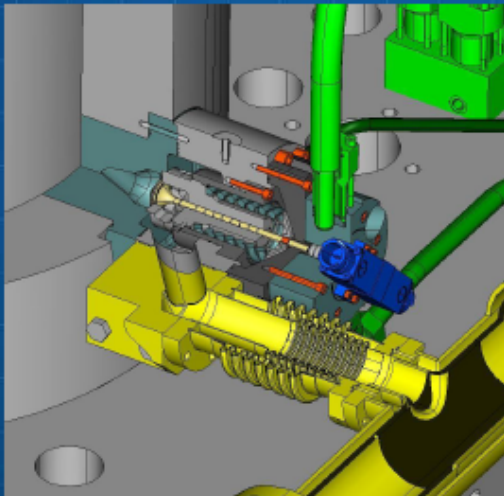
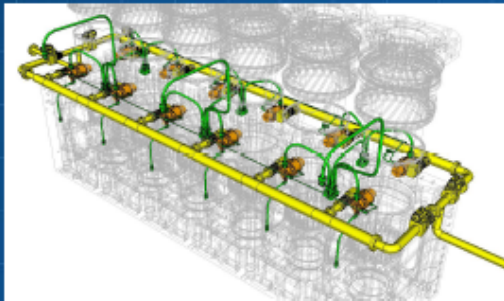


Micro pilot' and Pre-chamber technology

- Electronically controlled injectors + Common Rail fuel supply
- Pilot fuel (for ignition) only 1% - minimizing **fuel costs**
- Pre-chamber technology for best combustion stability and **reduced emissions**
- Technology developed and **proven** on 4-stroke
- Option for HFO as pilot will be available

2-stroke DF - Key Technologies

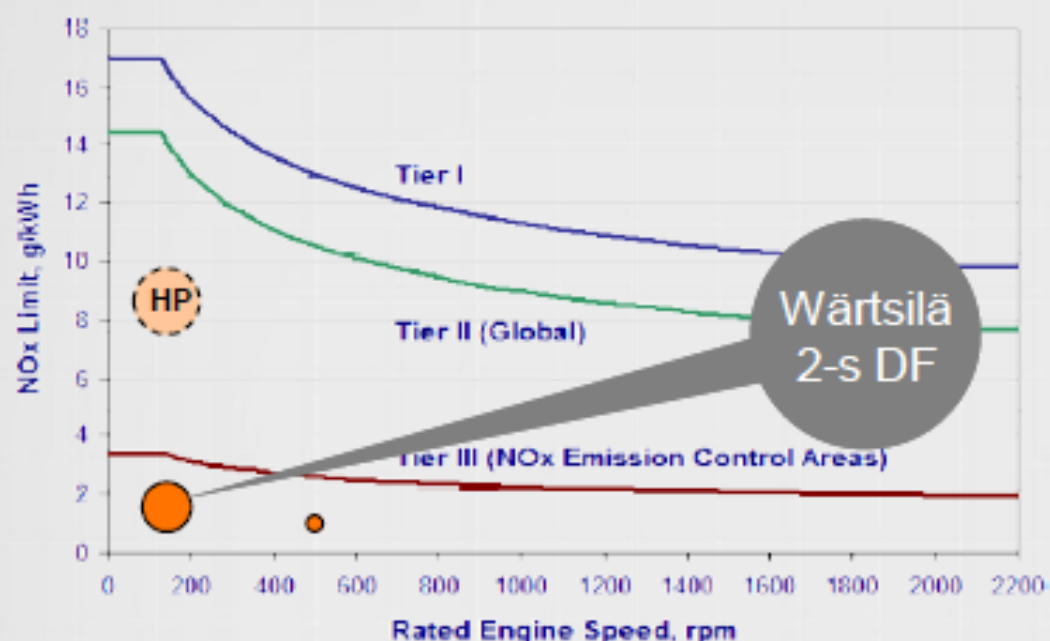
2STROKE
DEBUT OF DUAL-FUEL
TWIN ENGINE THIRSTE 12/11/2013



Gas admission system

- 2 x GAV (Gas Admission Valve) per cylinder
- GAV actuated hydraulically
- Hydraulic power supply from exhaust valve servo oil system
- **Precise gas admission control – from full load to 'idling'**
- The key to optimized fuel/air mixture formation – engine performance
- Double walled piping for enhanced **safety**

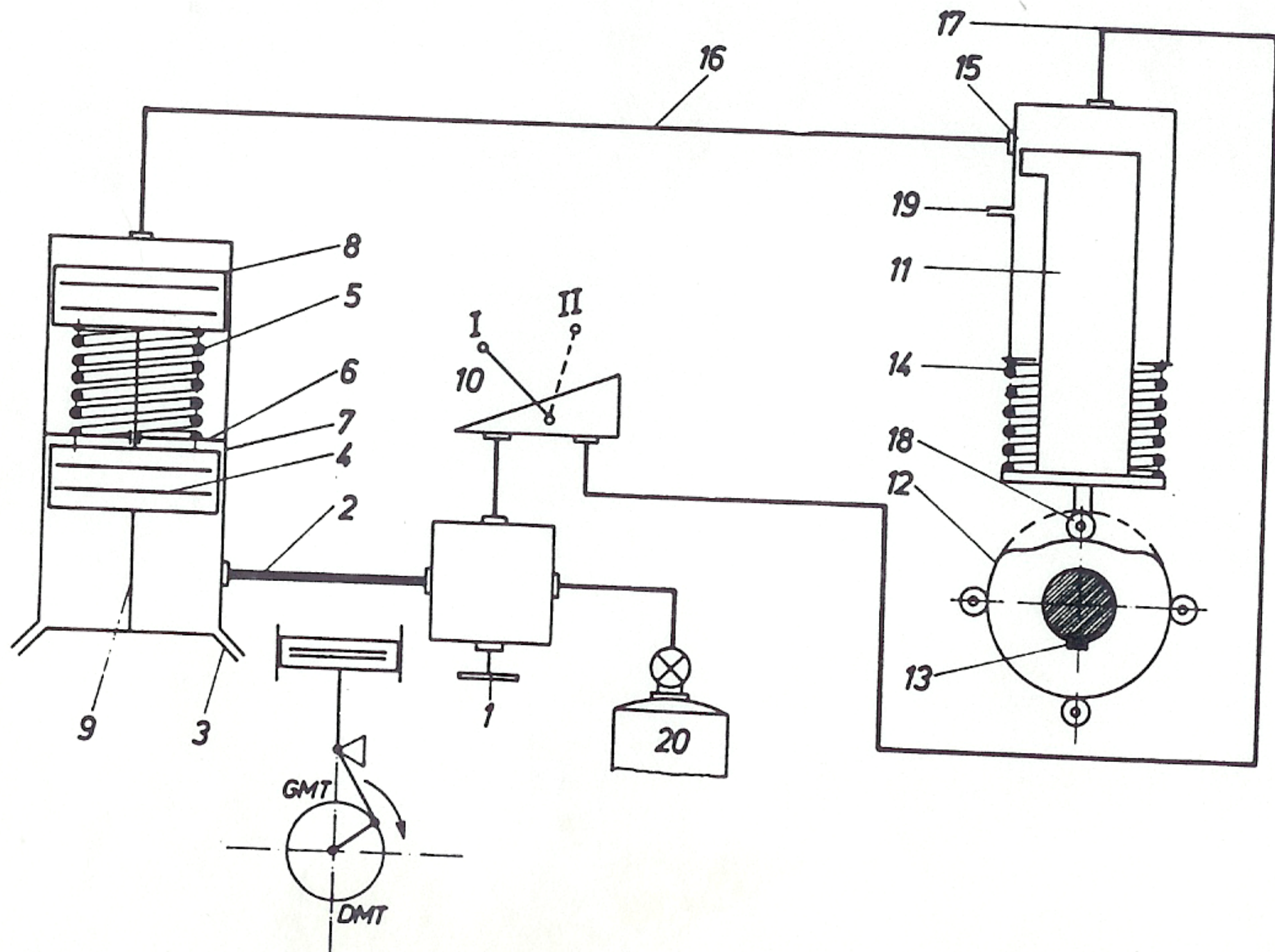
2-stroke DF - NO_x Emissions



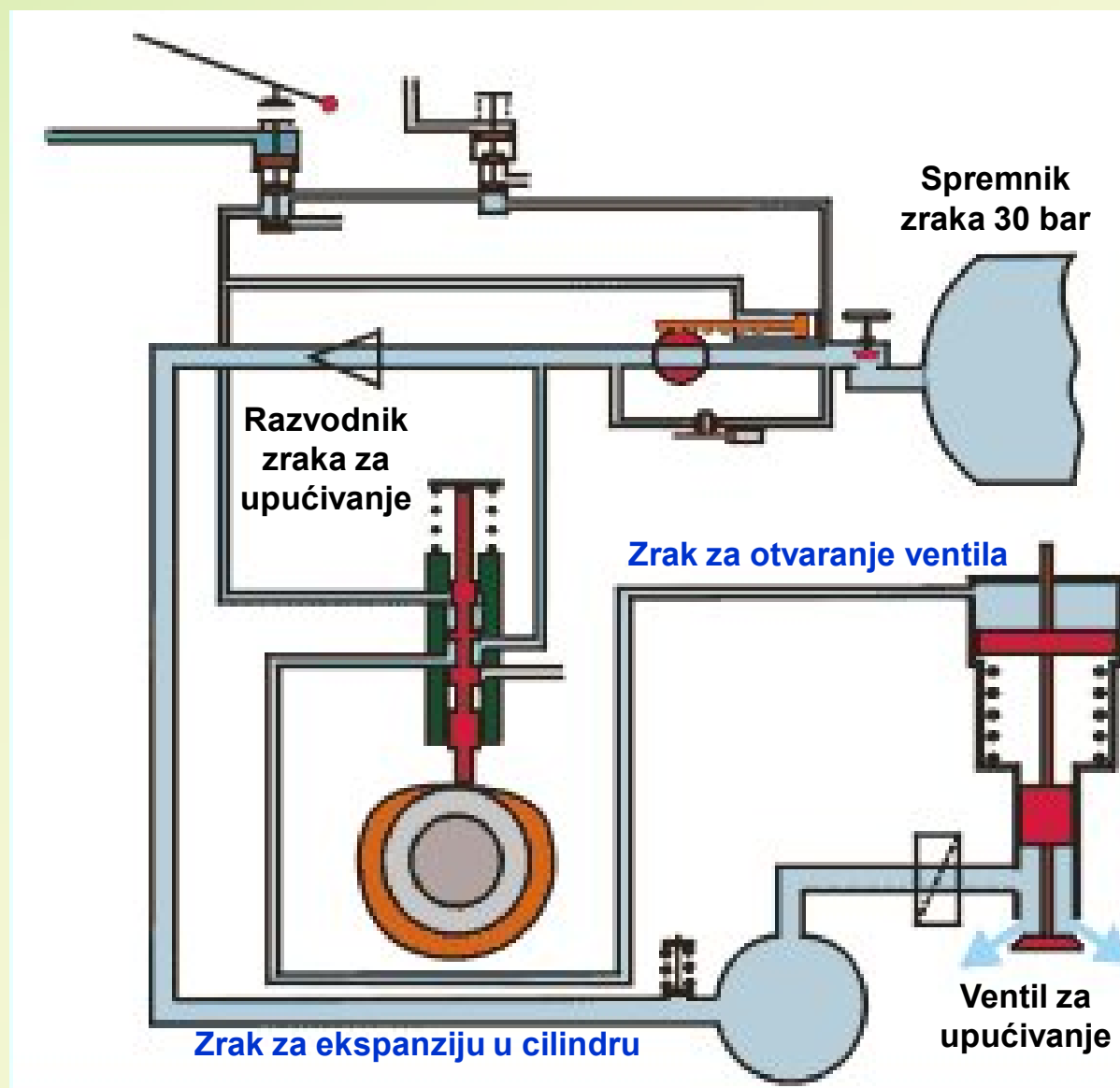
- Significant reduction of NO_x emissions due to the low pressure DF technology
 - clearly below IMO Tier III
 - without exhaust gas after treatment

UPUĆIVANJE BRODSKIH MOTORA

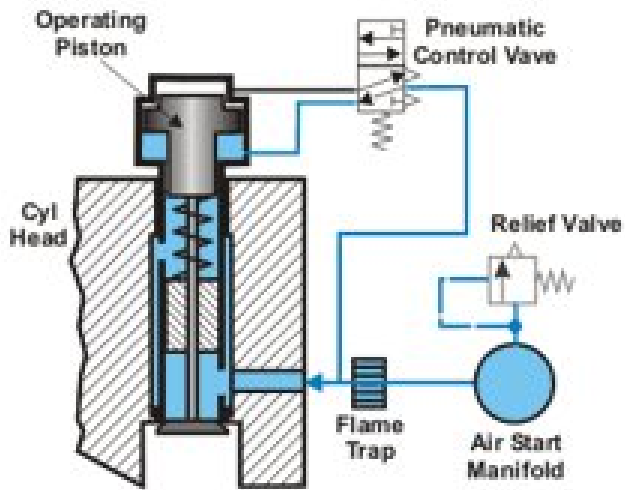
- ručno
- električno
- tlakom zraka : boce 30 bara



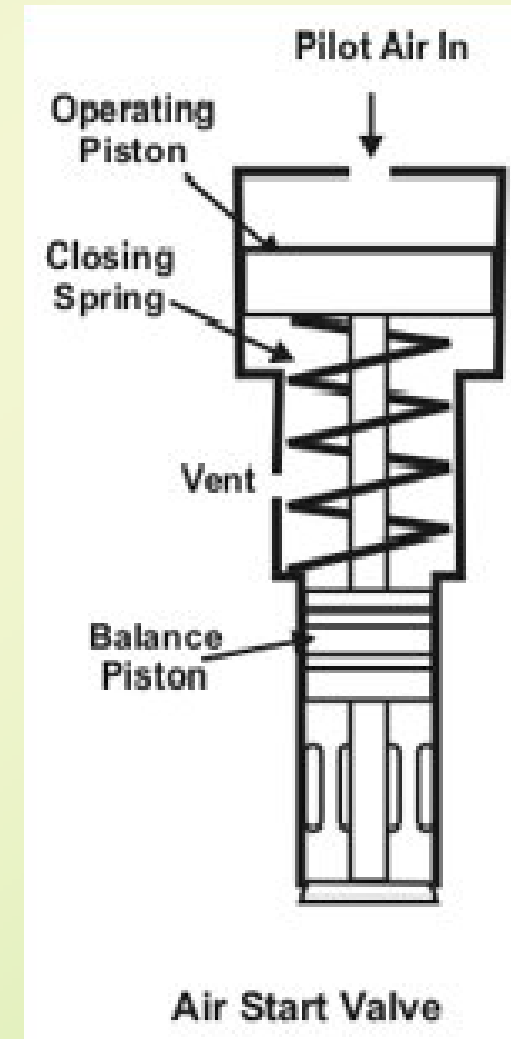
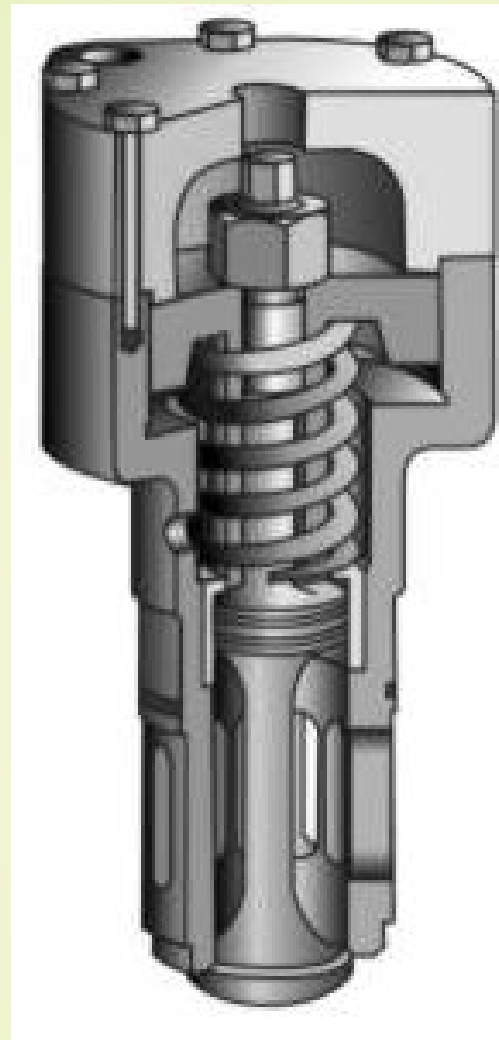
Glavni dijelovi sistema za upućivanje motora



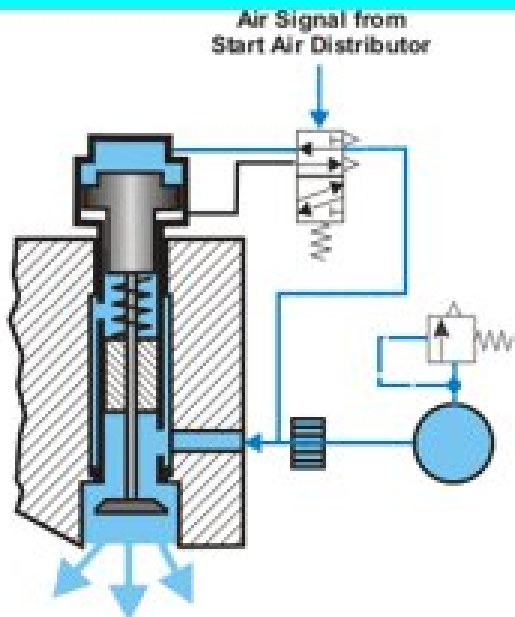
Uputni ventil



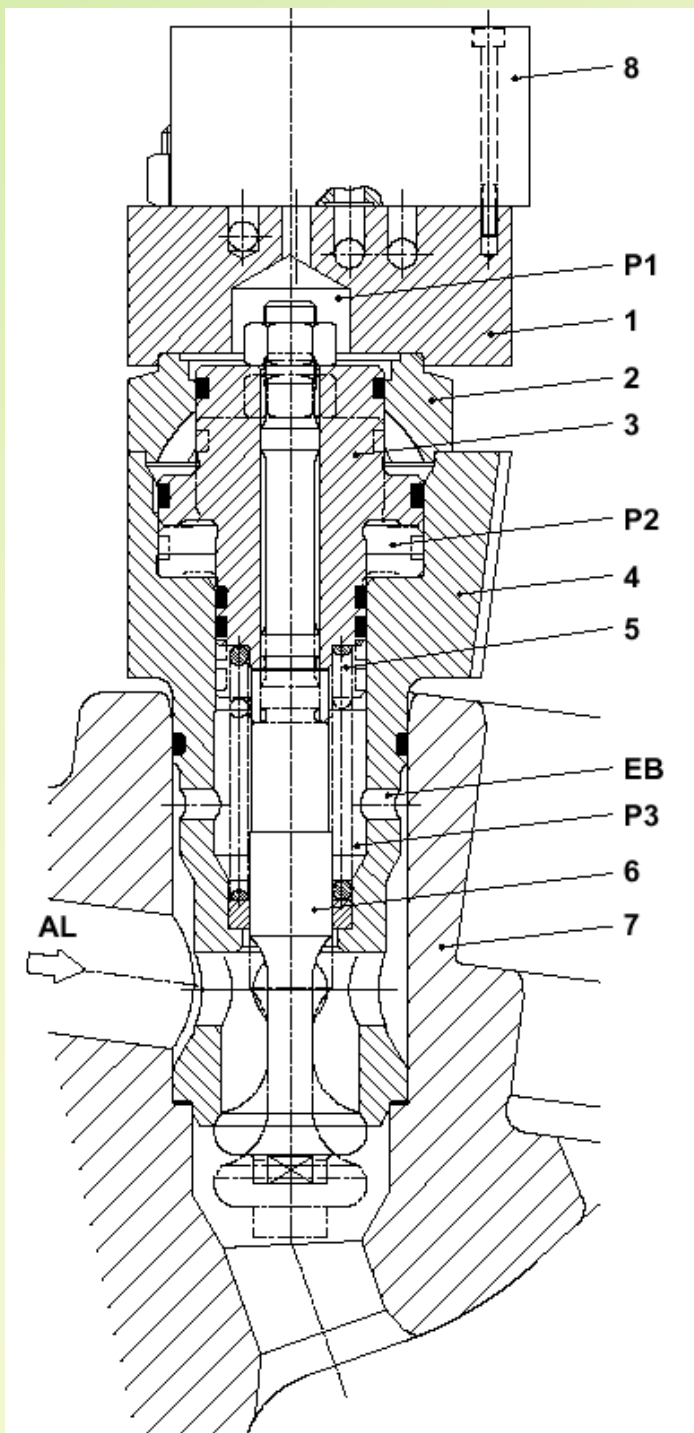
AIR START VALVE - SULZER RTA
(Automatic Valve Open, Valve Closed)



Air Start Valve

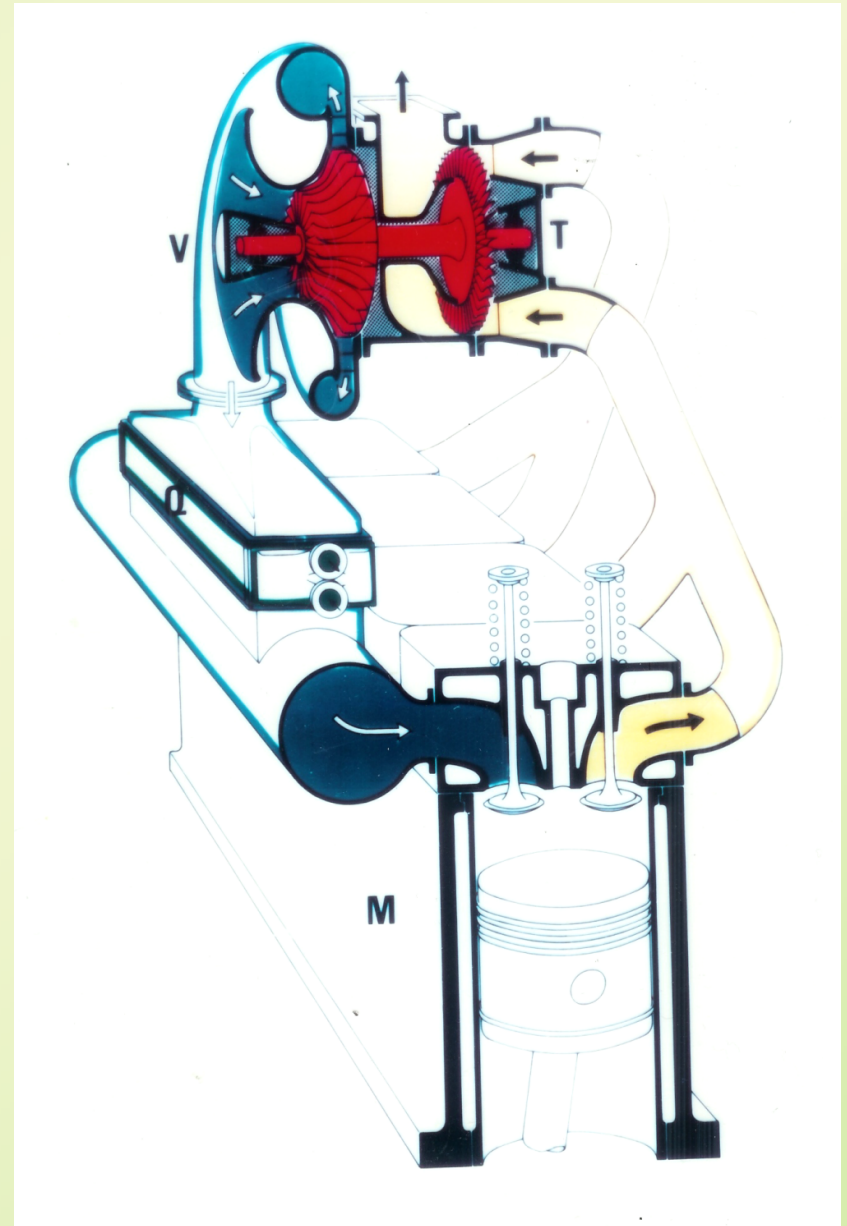
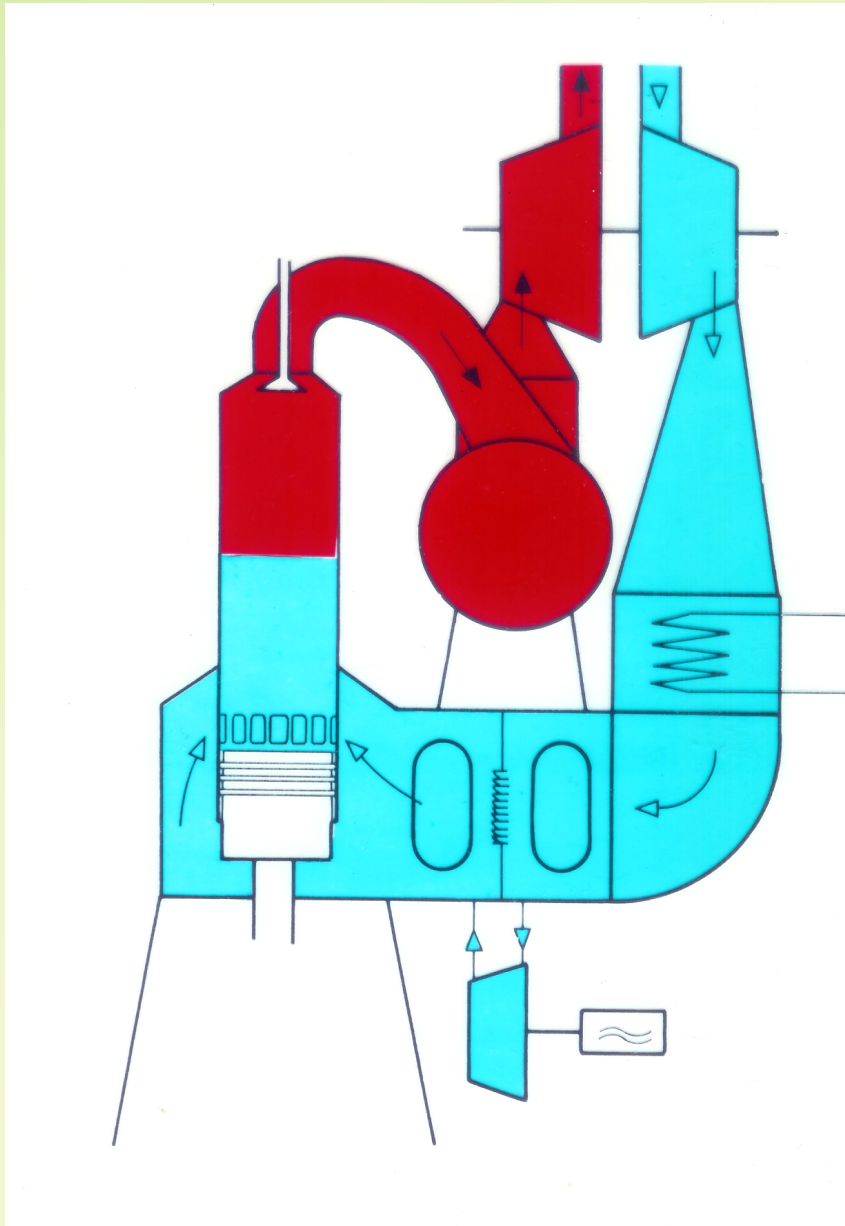


AIR START VALVE - SULZER RTA
(Valve Opened By Signal From Distributor)



Uputni ventil

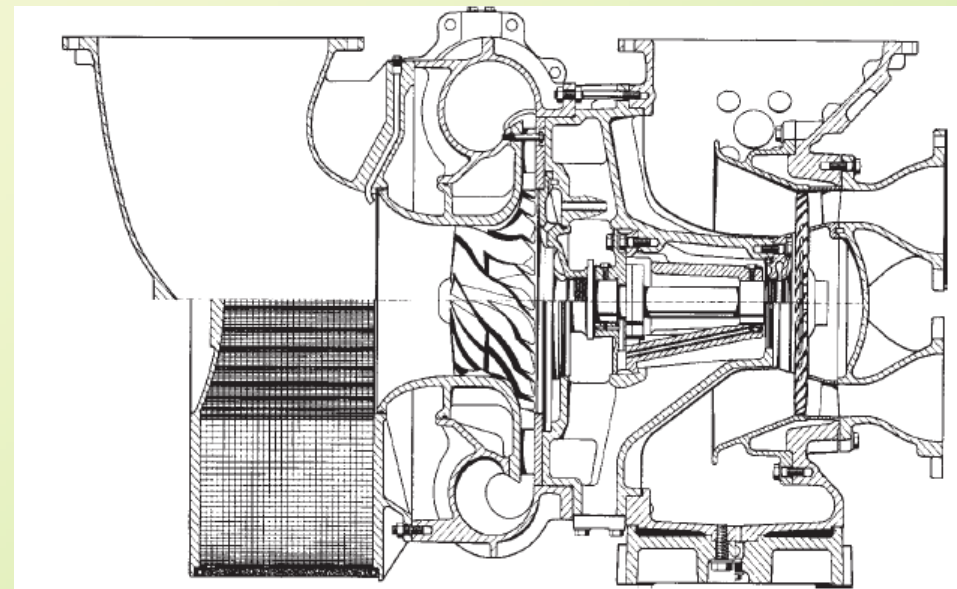
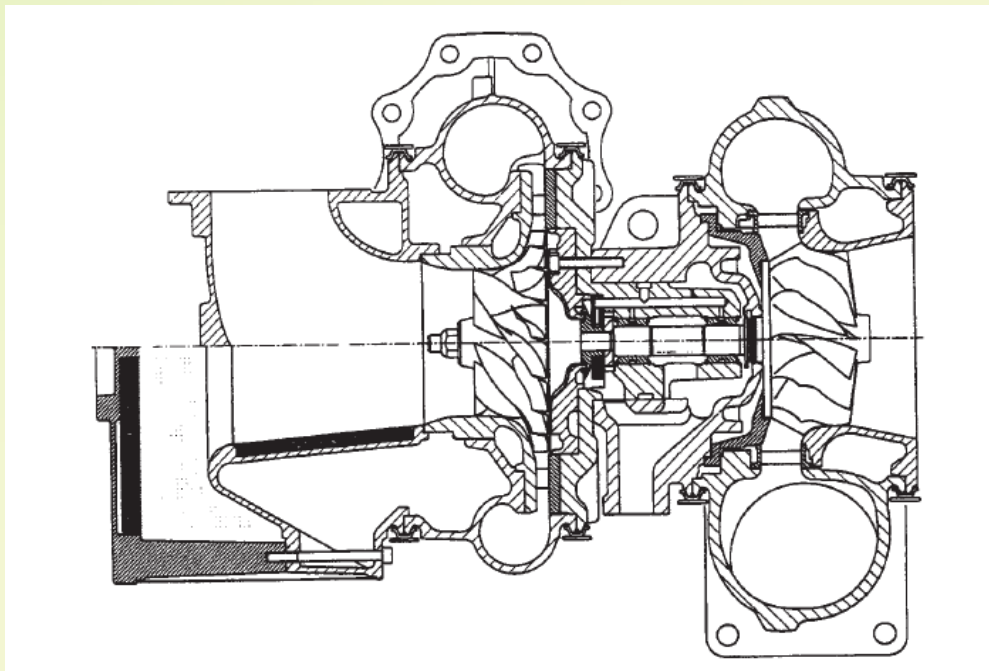
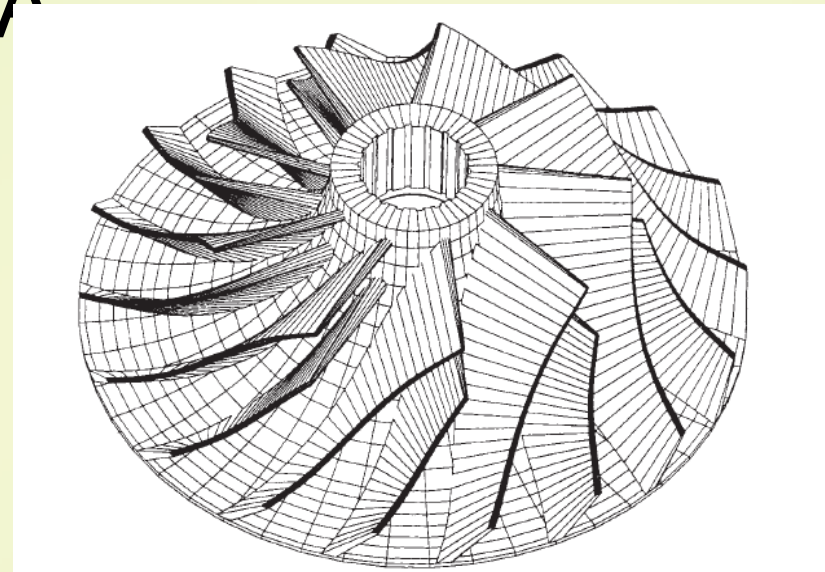
TURBOPUHALA



TURBOPUHALA

Dijelovi TP:

- kućište
- rotor s osovinom (rotor puhala, rotor turbine)
- sustav za podmazivanje



TURBOPUHALA

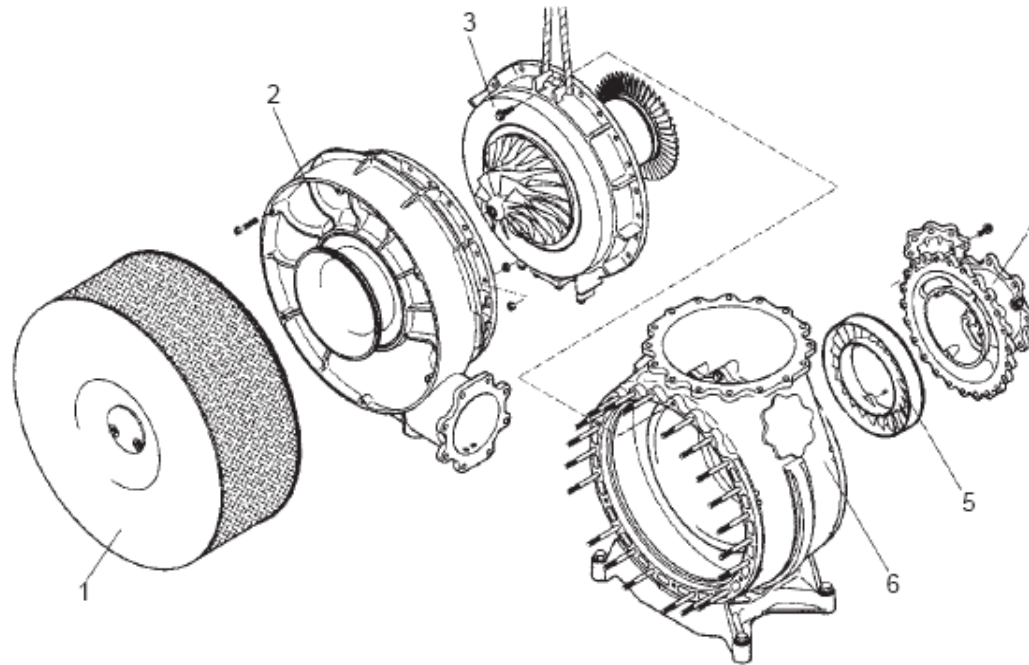
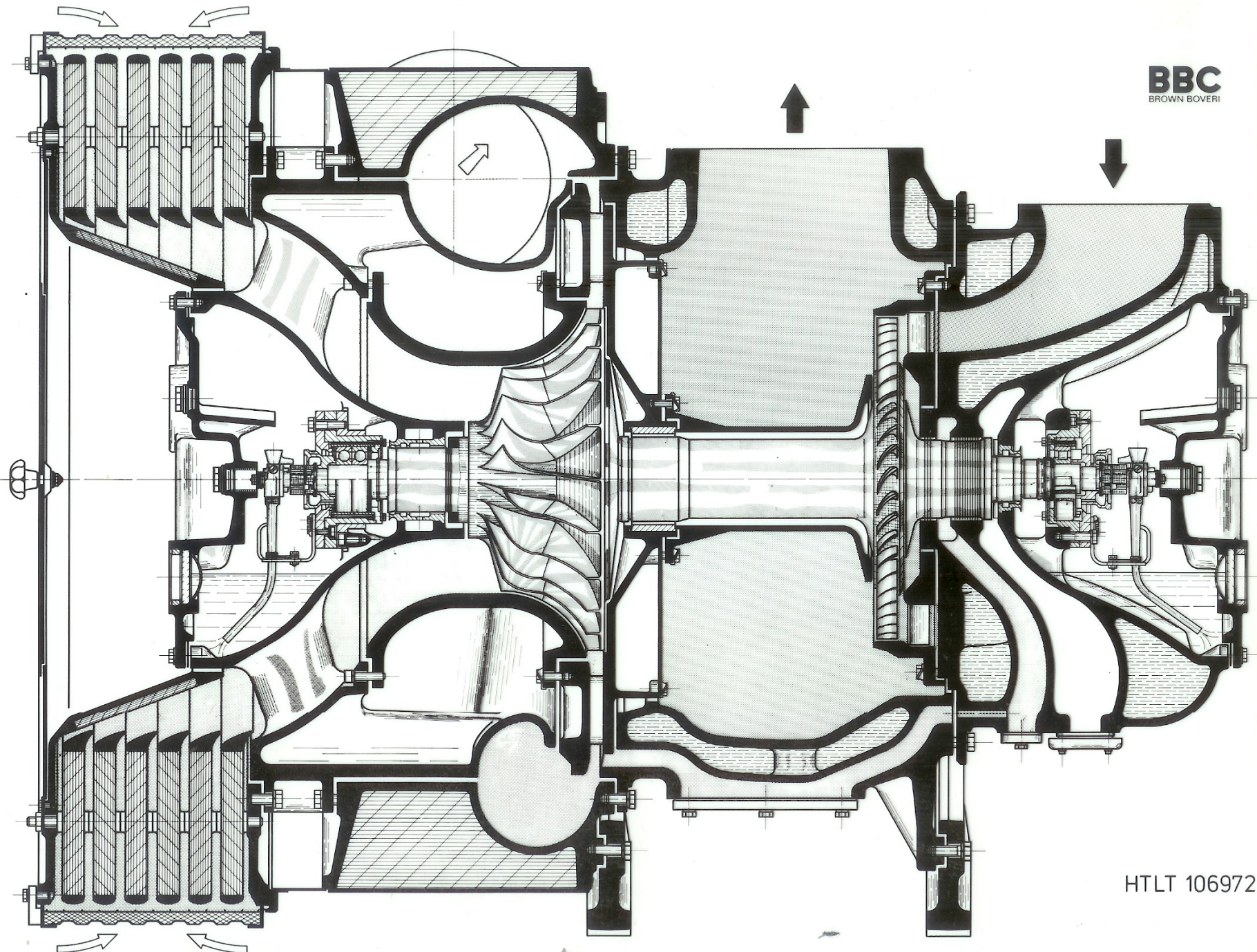


Figure 7.16 (c) Modular design concept of ABB TPL turbocharger: 1. Filter-silencer; 2. Air volute; 3. Rotor block; 4. Gas inlet casing; 5. Nozzle ring; 6. Gas outlet casing

Kućište se sastoji :

- zračnog kućišta
(usisni filter, usisno kućište, difuzor)
- pregradne stijene
- plinskog kućišta
(ulazno kućište, statorske lopatice, kućište izlaza plinova)



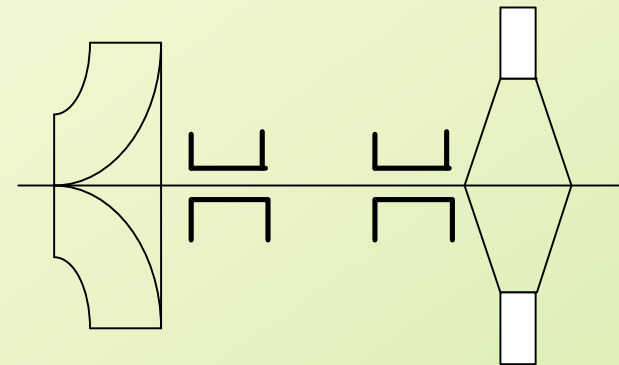
BBC
BROWN BOVERI

HTLT 106972

T-P

S unutarnjim ležajima :

- + jednodjelno kućište , lagano centriranje ležaja
- + mali promjer osovine
- rotor iz više dijelova, skupo za izradu
- nepristupačnost ležajima, teška kontrola



T-P

S vanjskim ležajima :

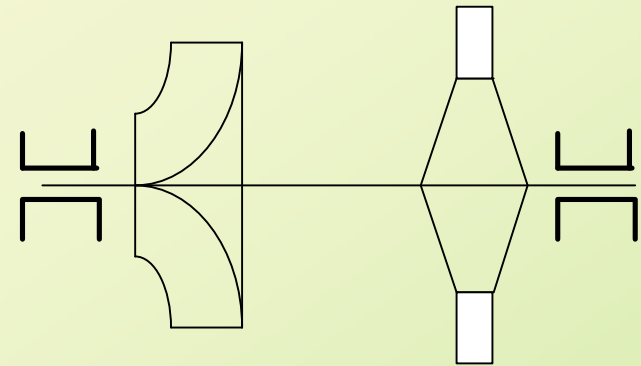
+ dostupnost ležaja

+ mali promjer ležaja, malo trenje

- višedijelno kućište, teško centriranje ležaja

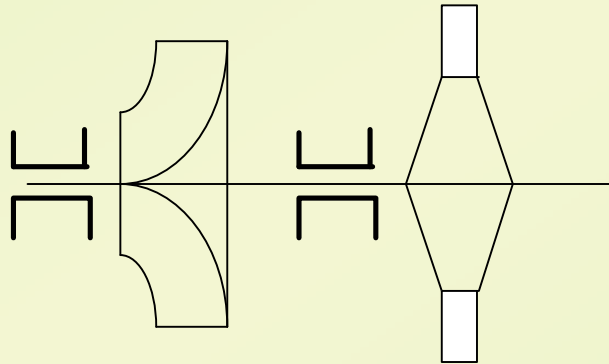
- zbog izlaza ispuha, osovina dugačka, velika inercija i lako vibrira

- brtvljnje plinske i zračne strane otežano



T-P

Mješana izvedba :



T-P

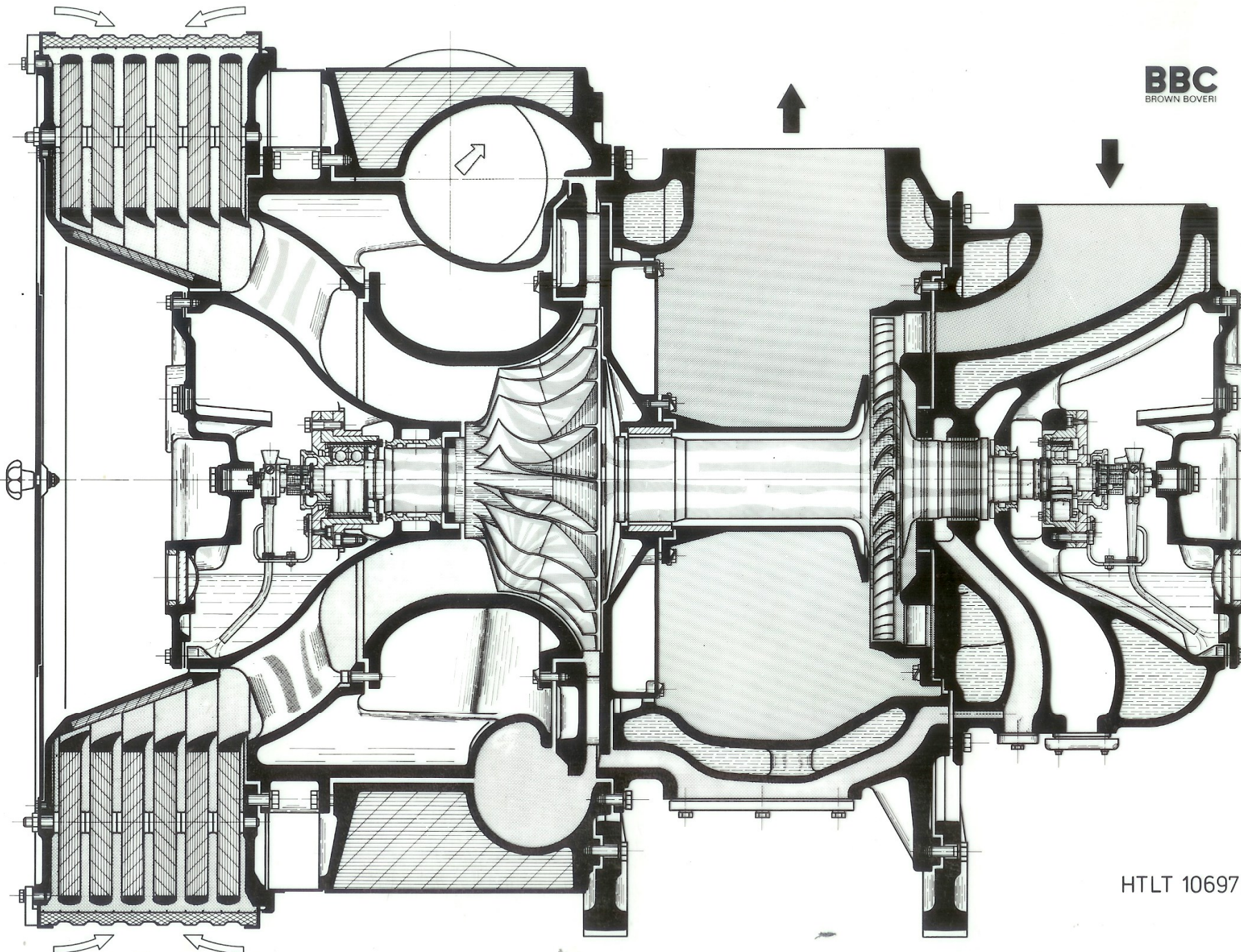
Ležaji :

- klizni kod manjih
- kotrljajući kod većih (kuglični - zračna strana, valjkasti - plinska strana)

Labiritna brtva - odvaja plinsku i zračnu stranu.

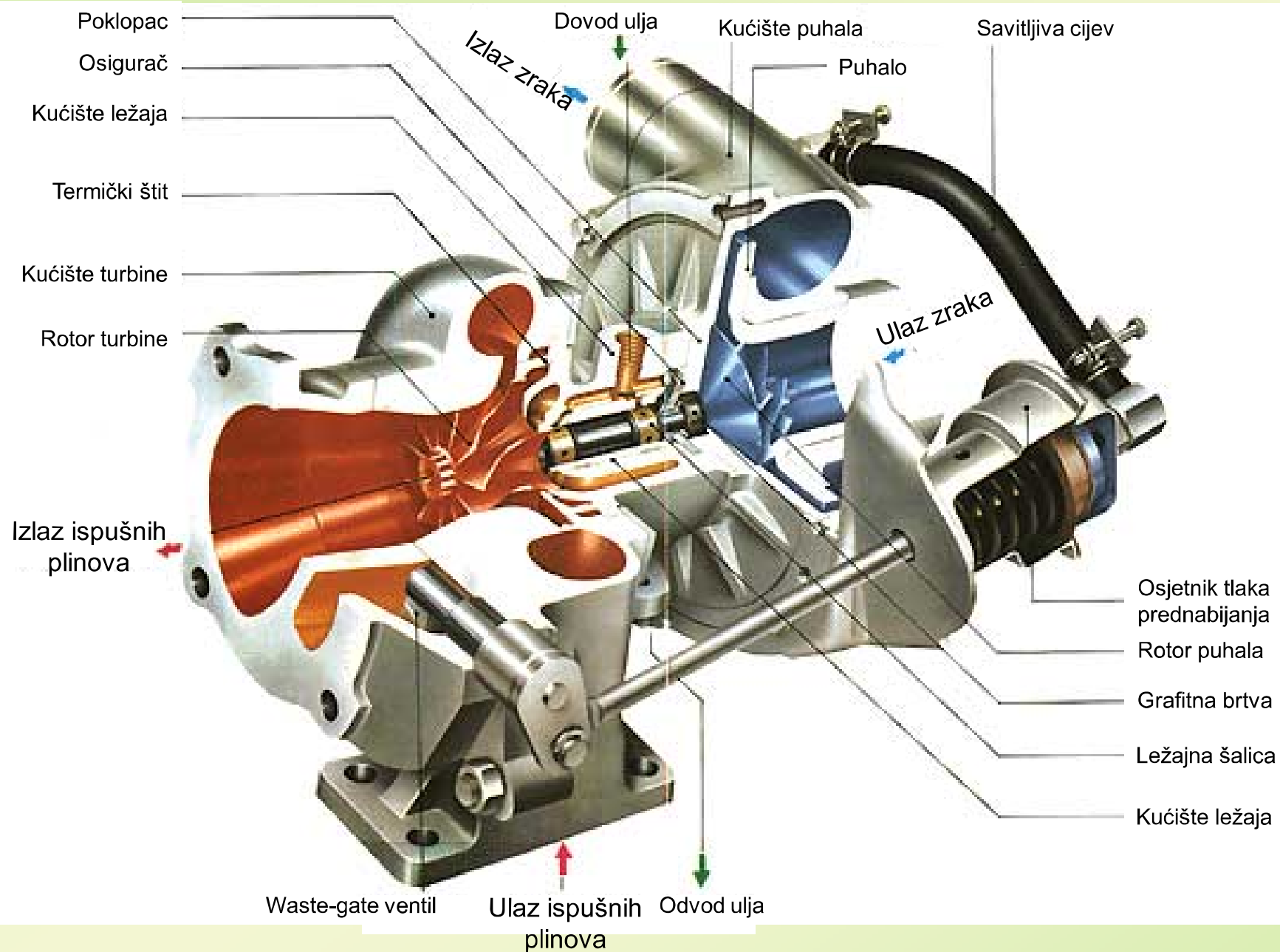
Sustav podmazivanja:

- nekada dio podmazivanja GM
- danas odvojeni sustavi : gravitacijski ili cirkulacijski s privješenom pumpom.

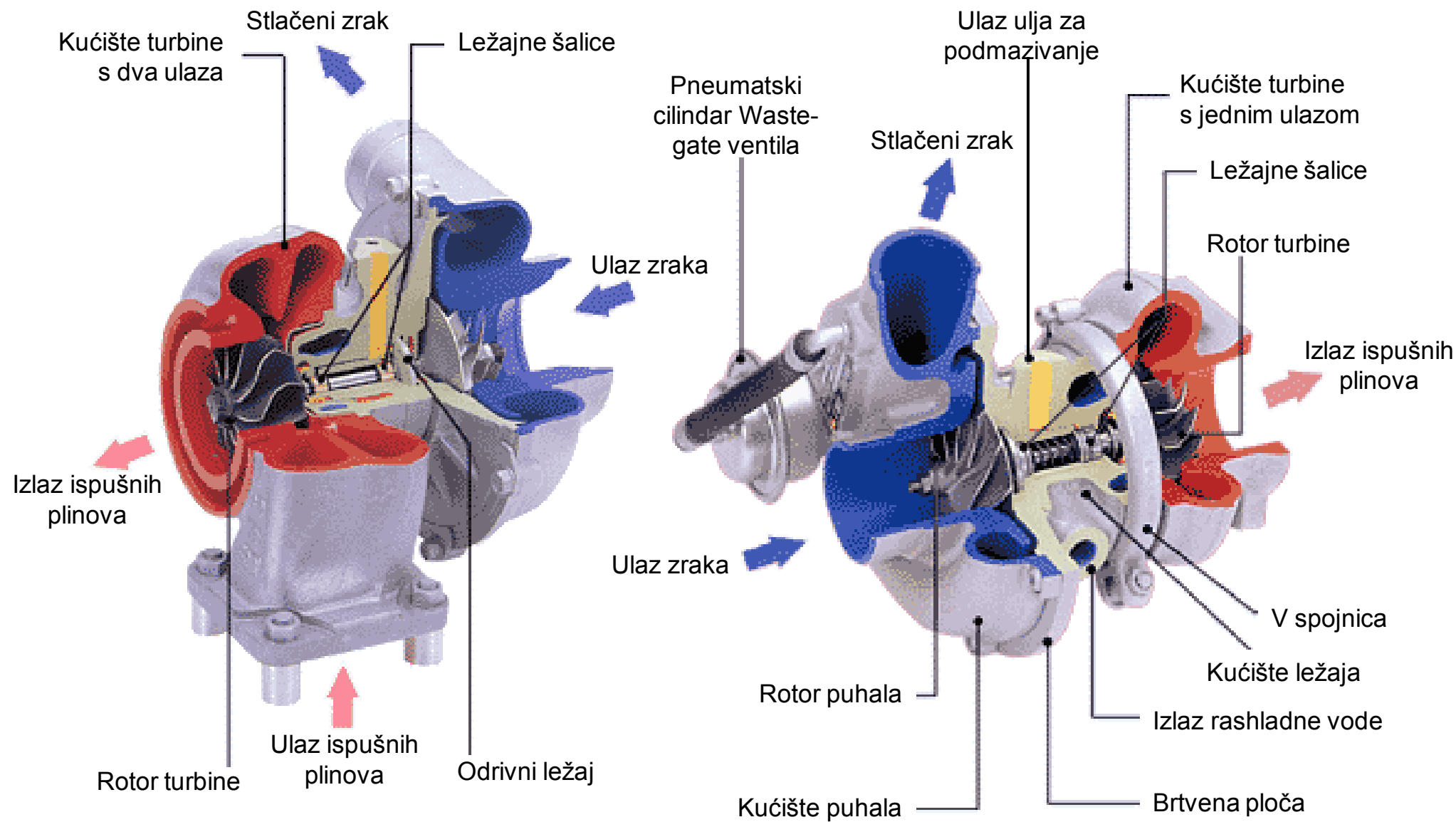


BBC
BROWN BOVERI

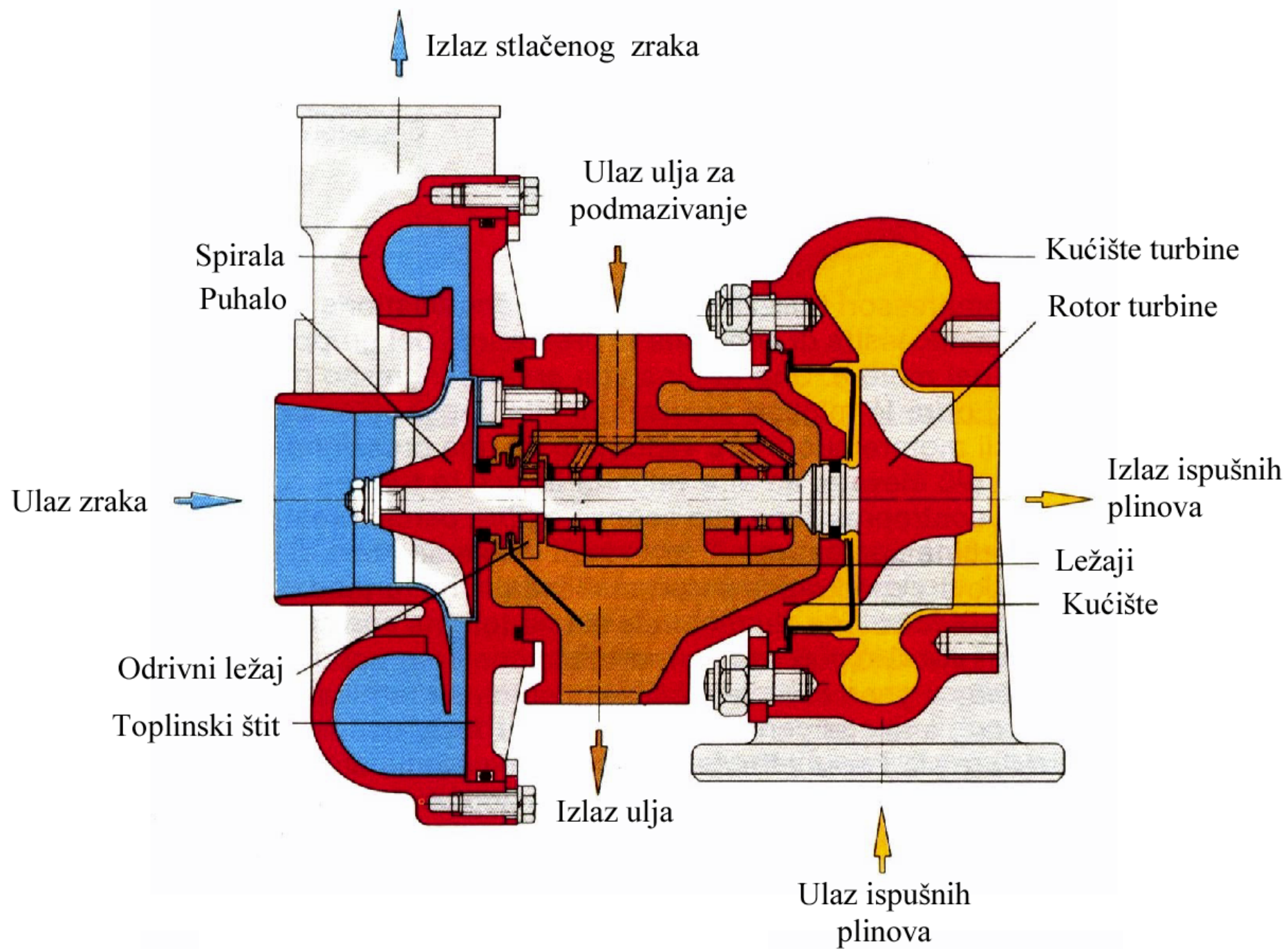
HTLT 106972



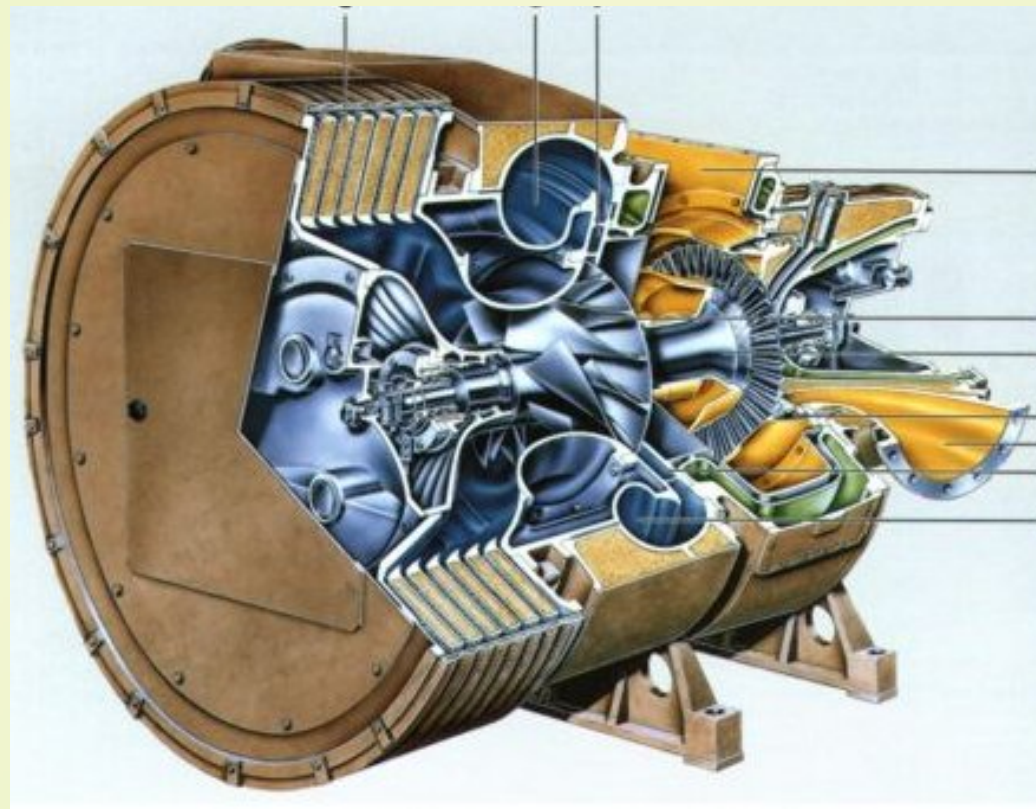
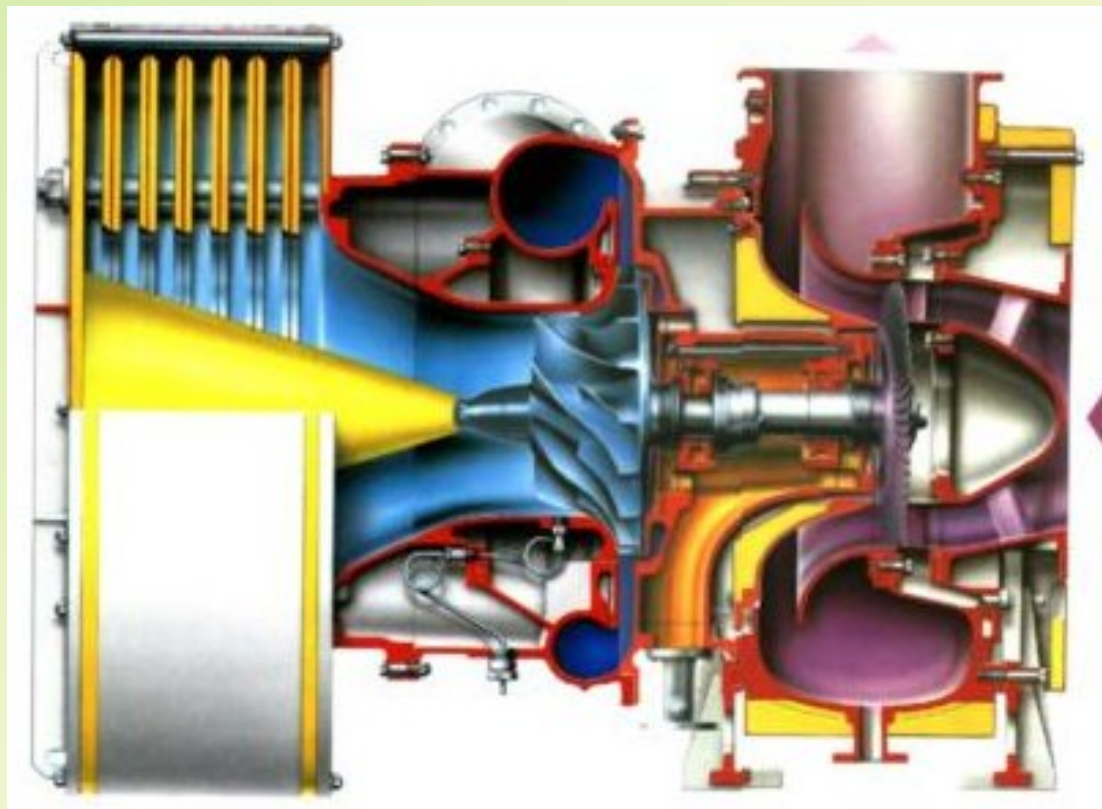
Turbopuhalo s Waste-gate ventilom



Dijelovi malih turbopuhala

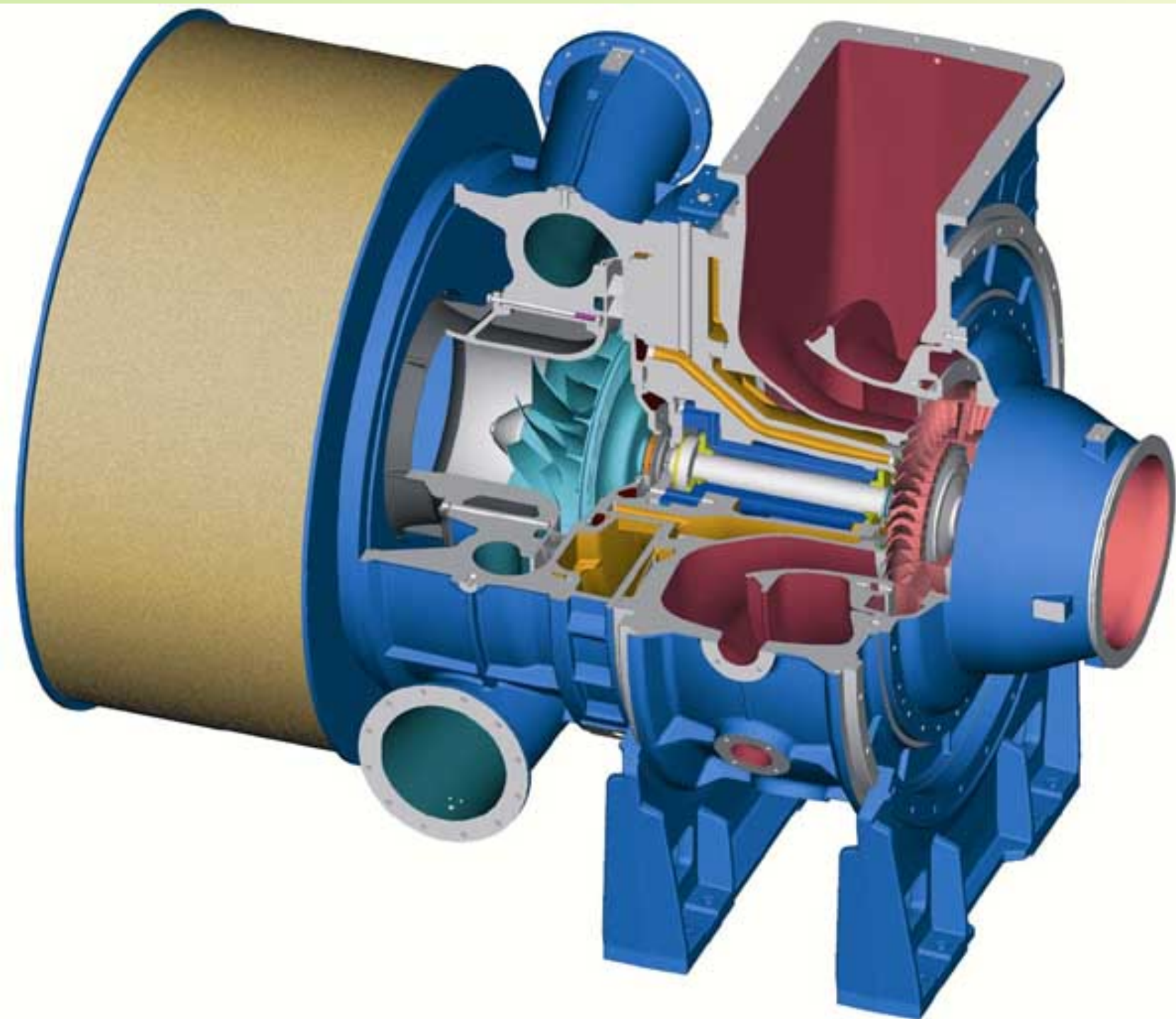


Turbopuhala s aksijalnom turbinom





Vanjski izgled velikog turbopuhala serije TCA (MAN)



Presjek turbopuhala
iz serije MAN TCA

ODRŽAVANJE T-P

Taloženje naslaga na lopatice uzrokuje :

- debalans rotora
- oštećenje ležaja
- oštećenje lopatica
- “pumpanje” t-p

Zbog toga se vrši “PRANJE” T-P.

ZRAČNA STRANA :

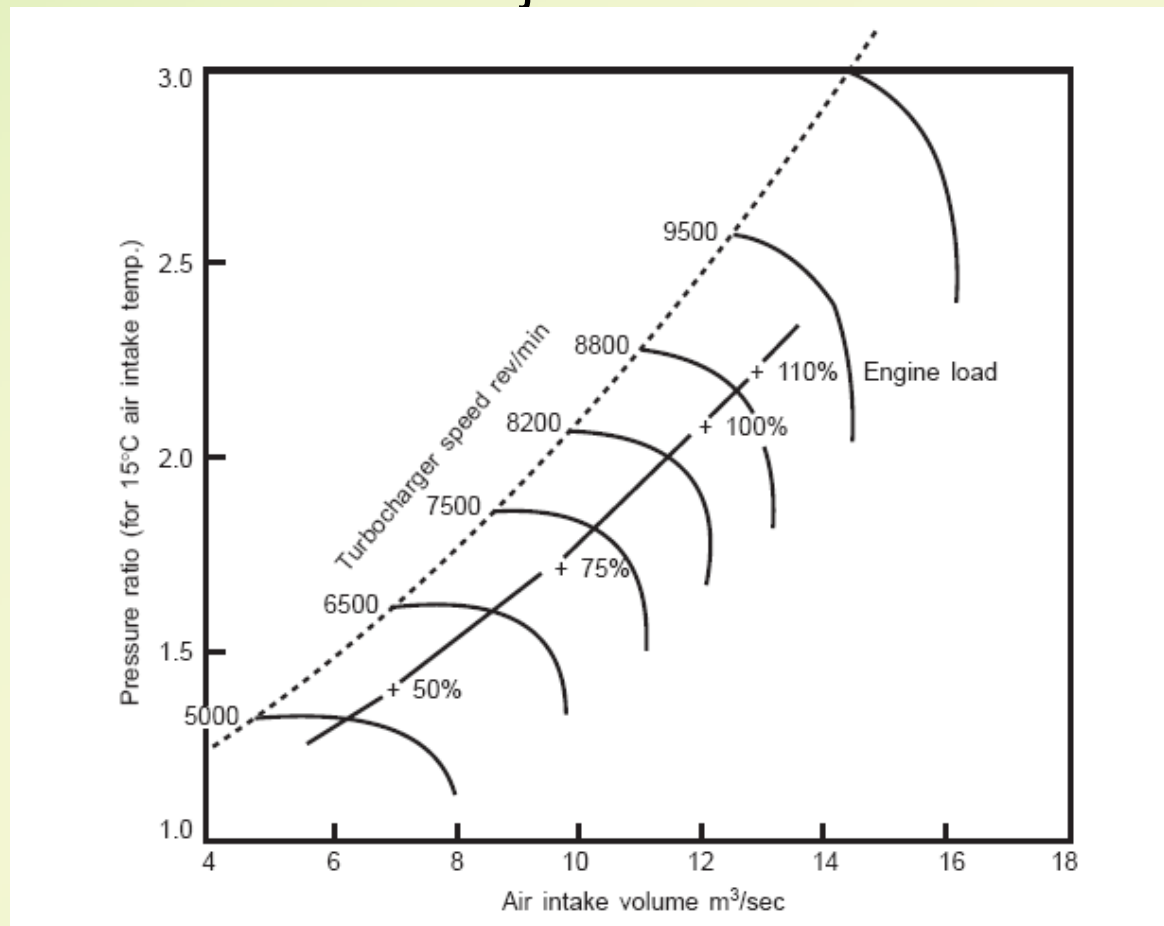
- čista voda + aditivi
- svaki dan
- 100% snage

PLINSKA STRANA:

- zagrijana voda + aditivi ili granule ugljika
- 50 % snage
- jednom tjedno

“PUMPANJE” T-P

Karakteristika T-P- funkcionalna ovisnost tlačnog omjera i kapaciteta dobave pri raznim brzinama vrtnje.



Pumpanje je pojava nestabilnog rada T-P koje u dugotrajnom radu može oštetiti lopatice rotora i ležajeve

REGULATORI BROJA OKRETAJA

Zbog promjene opterećenja, a konstantne dobave goriva u motor mijenjao bi se broj okretaja. Te promjene uzrokuje ubrzanja i usporenja, tj. dodatna opterećenja za motor, a postoji i opasnost od prekoračenja max. dozvoljenog broja okretaja.

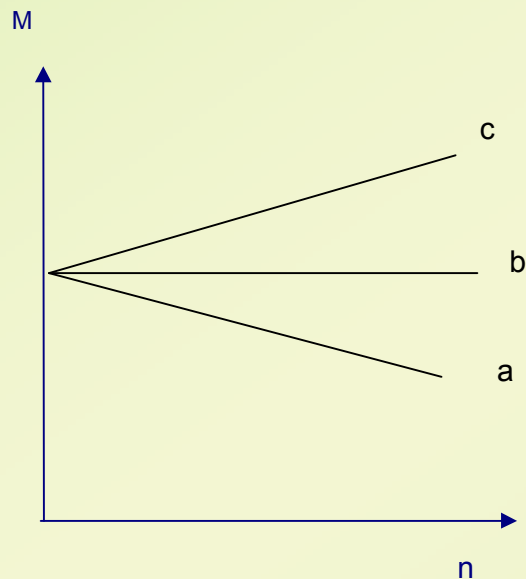
Regulatore dijelimo na:

- granične ili sigurnosne : sprečavaju povećanje broja okretaja preko max. dozv. broja okretaja
- sverežimske regulatore : omogućavaju održavanje zadanog broja okretaja
- jednorežimski regulatori : omogućavaju održavanje točno određenog broja okretaja.

REGULATORI BROJA OKRETAJA

SIGURNOSNI ILI GRANIČNI REGULATORI

U stacionarnom radu moment motora je jednak momentu otpora. Ako moment otpora padne, moment motora će uzrokovati zalet motora, tj. povećanje brzine vrtnje.



- a) padajuća karakteristika - atmosferski benzinski motori
- b) konstantna karakteristika - dizelski motori
- c) rastuća karakteristika - motori s prednabijanjem

Kod a imamo samoregulaciju, dok kod b i c trebamo sigurnosni regulator.

REGULATORI BROJA OKRETAJA

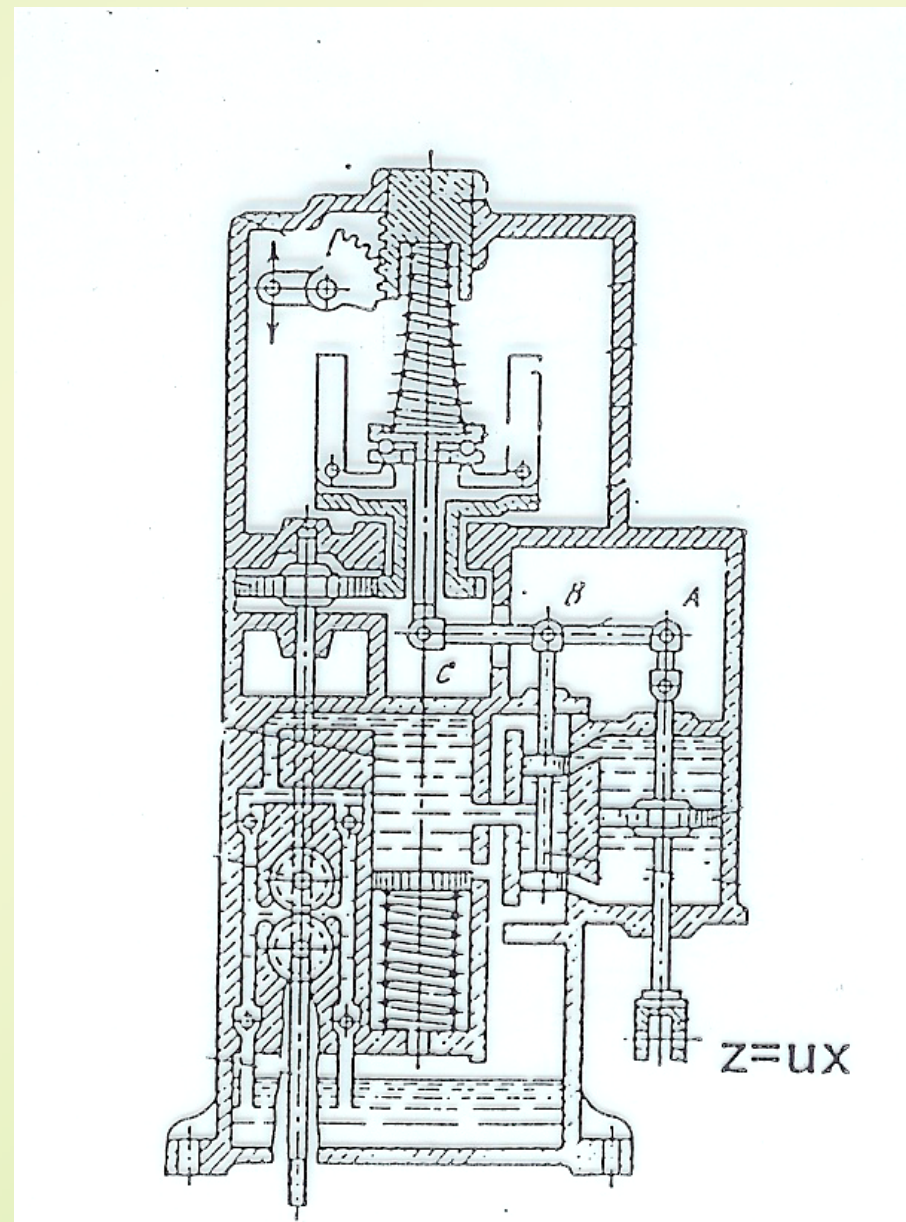
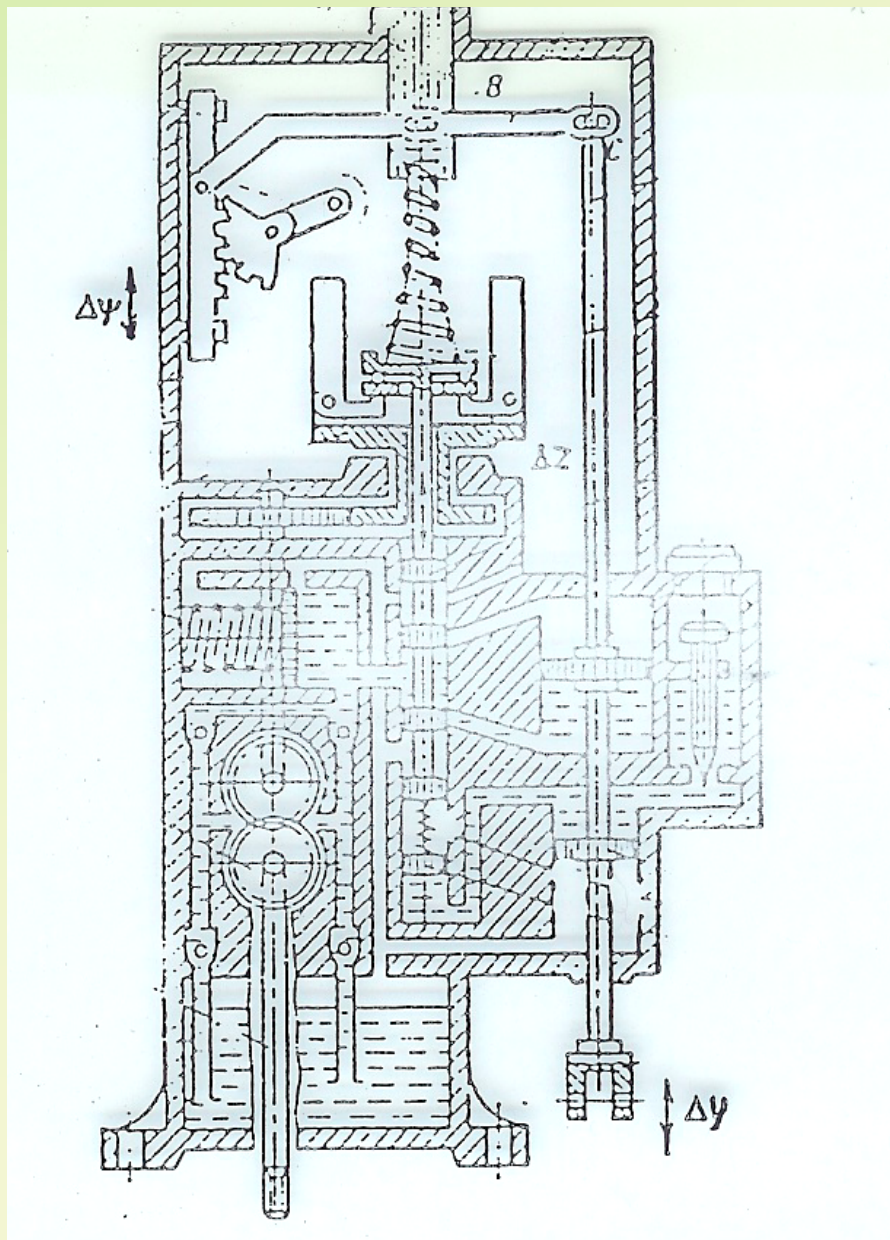
Dijelovi regulatora:

- mjerni davač ili osjetnik brzine vrtnje
- upravljačka jedinica
- postavni član
- (pojačalo izlaznog signala)

Tehnologija izrade regulatora:

- mehanički
- mehaničko hidraulični
- mehaničko hidraulično elektronski

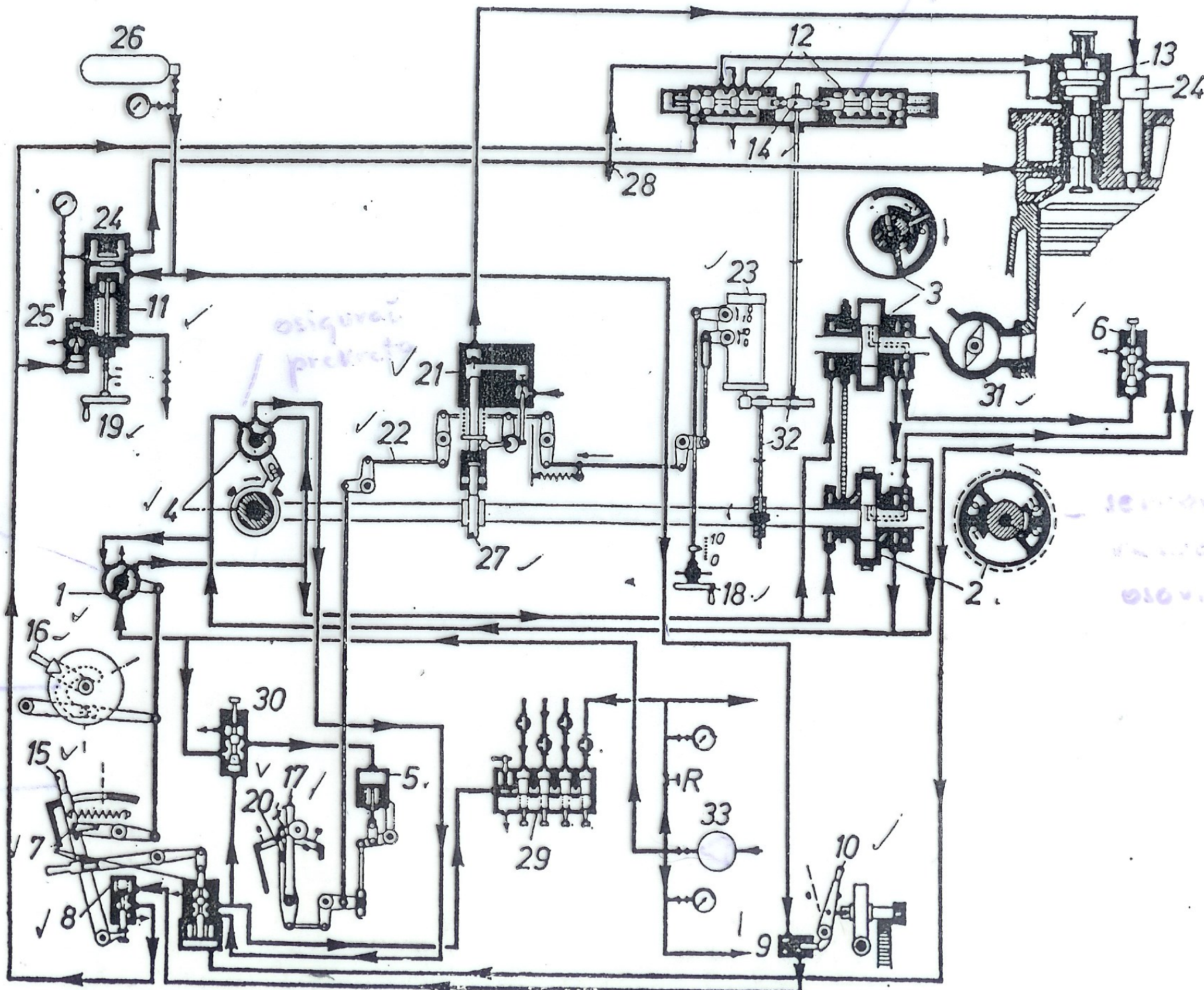
REGULATORI BROJA OKRETAJA



MANEVARSKI UREĐAJ ili REGULACIJSKI UREĐAJ PREKRETA, UPUĆIVANJA, ZAUSTAVLJANJA I ZAŠTITE MOTORA

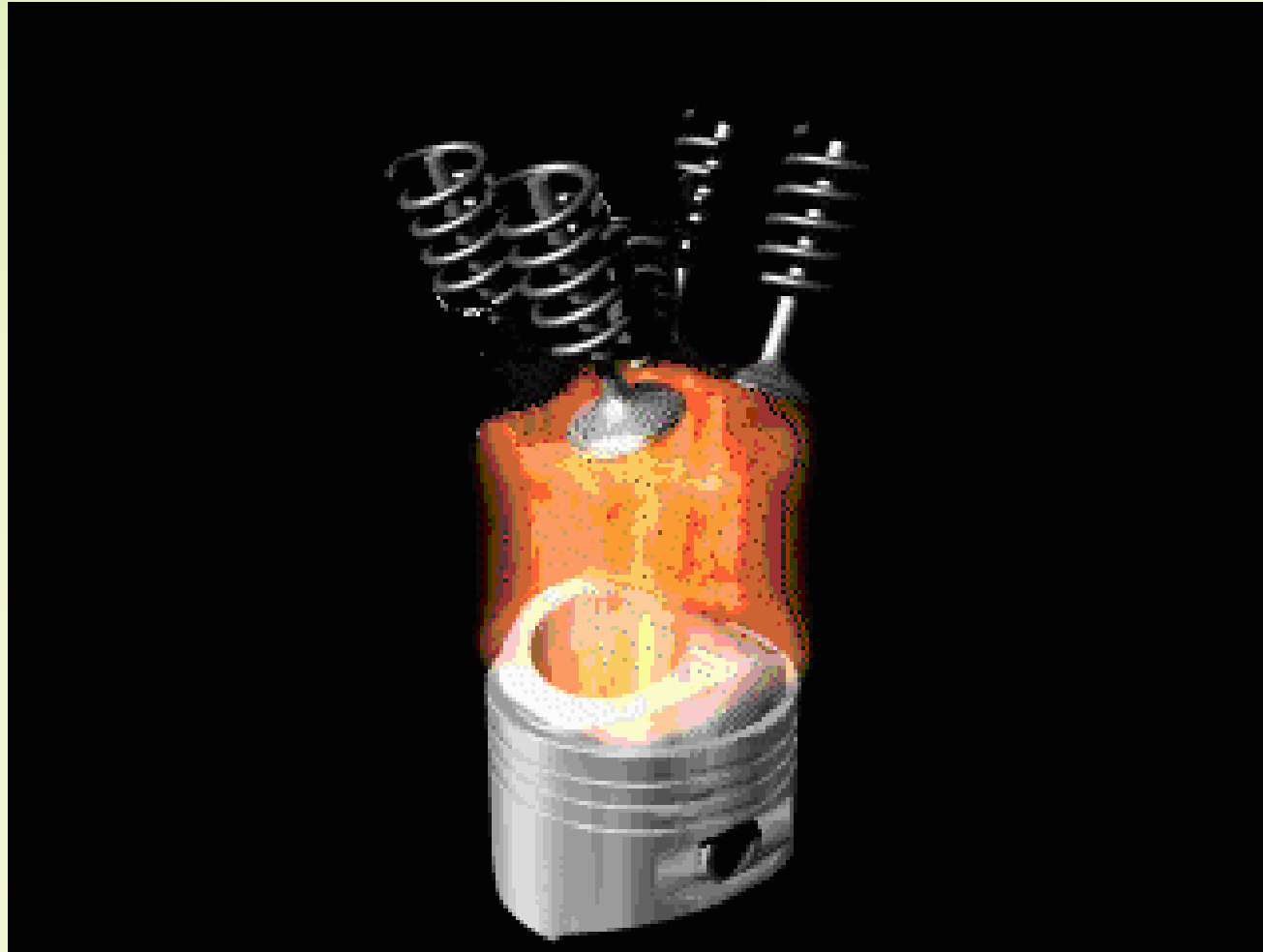
Funkcija:

1. Osigurati obavljanje operacija upućivanja, preketanja, zaustavljanja i reg.broja okretaja
2. Zaštititi motor od pogrešnih manevara:
 - preketanje samo kod zaustavljenog motora
 - uputiti motor tek kada su sve predradnje izvršene (preket, podmazivanje...)
 - kontrolirano upućivanje
 - kontrolirano opterećivanje
 - kontrolirano rasterećivanje





KRAJ



Katalizator trostrukog djelovanja

CO

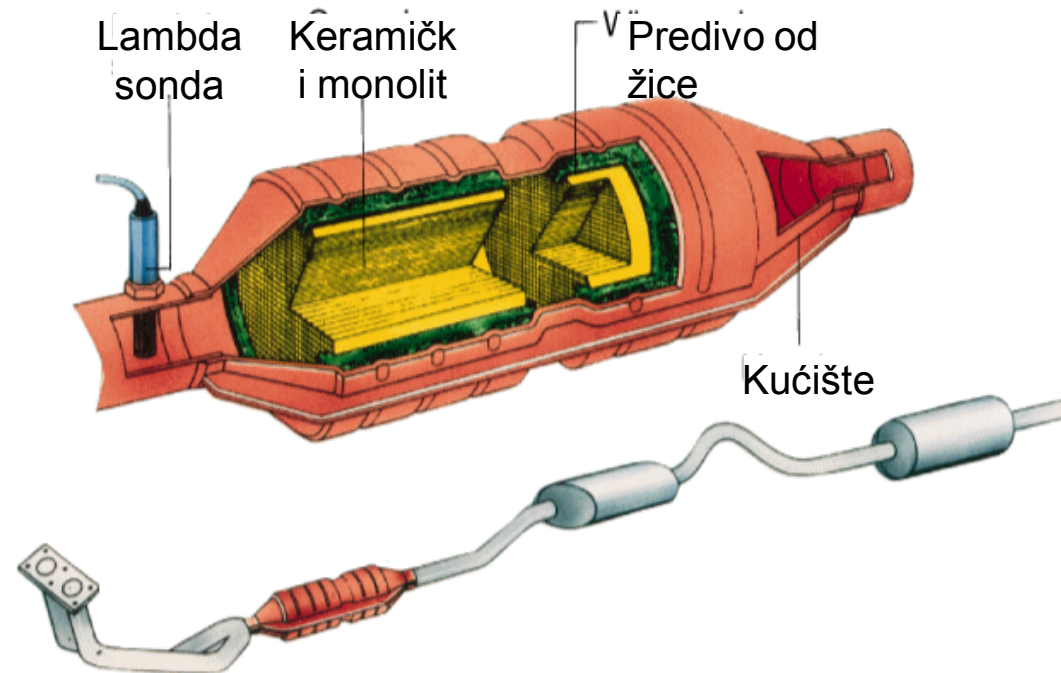
Ugljični monoksid

HC

Ugljikovodici

NOx

Dušikovi oksidi



CO₂

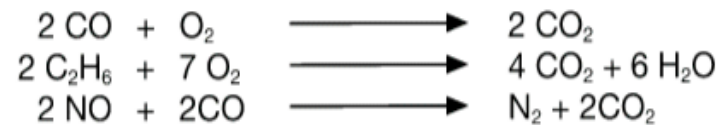
Ugljični dioksid

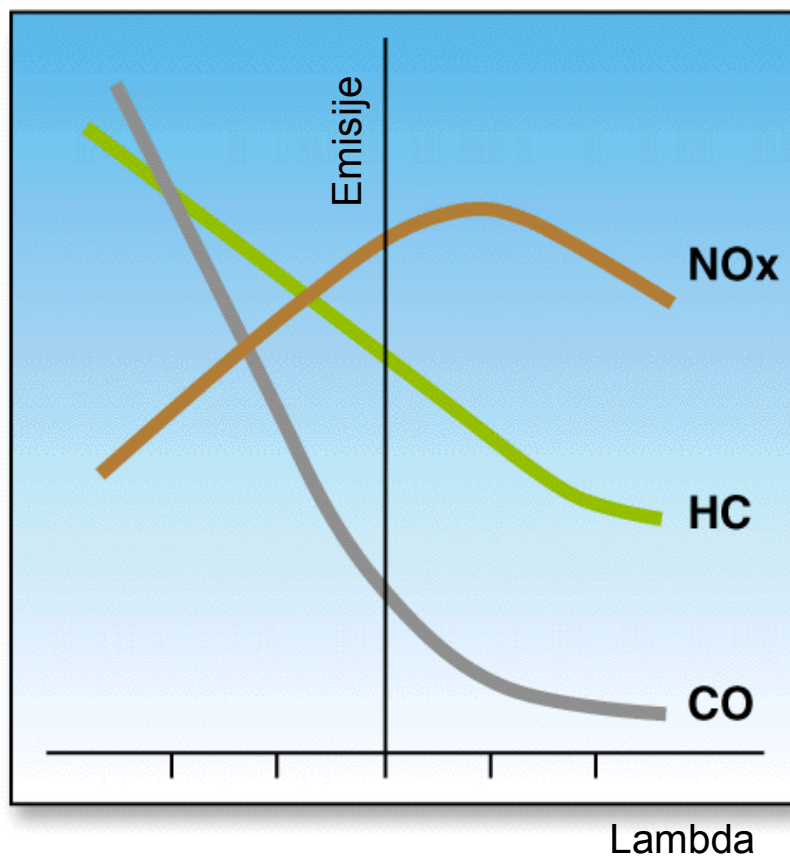
H₂O

Vodena para

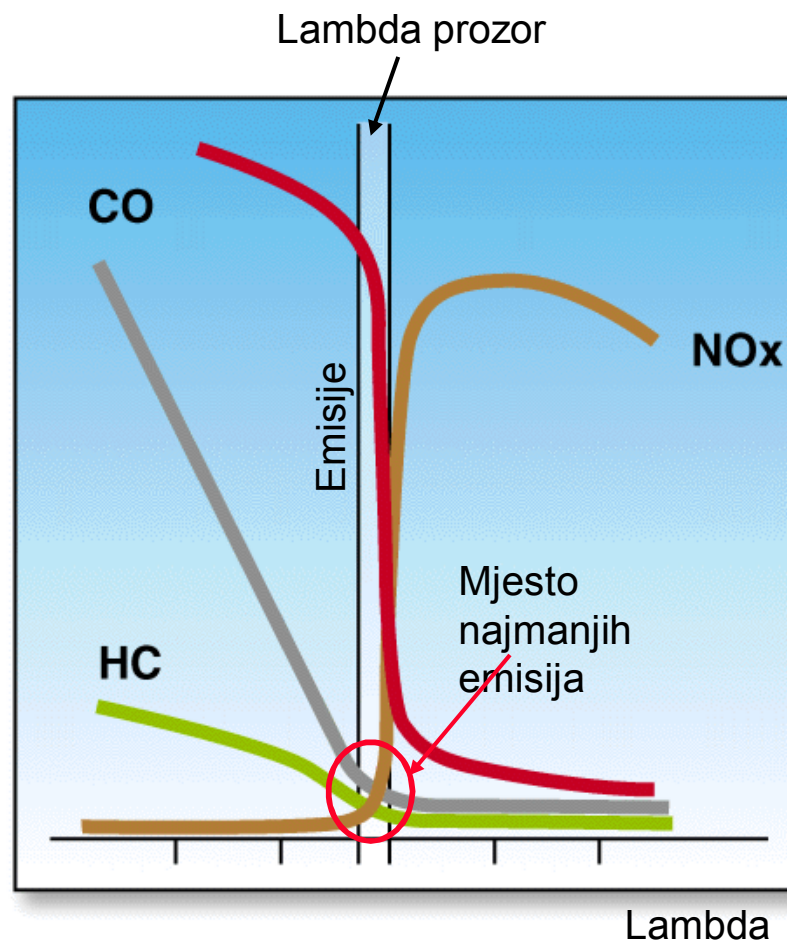
N₂

Dušik





Emisije iz motora bez katalizatora



Emisije iz motora iza katalizatora