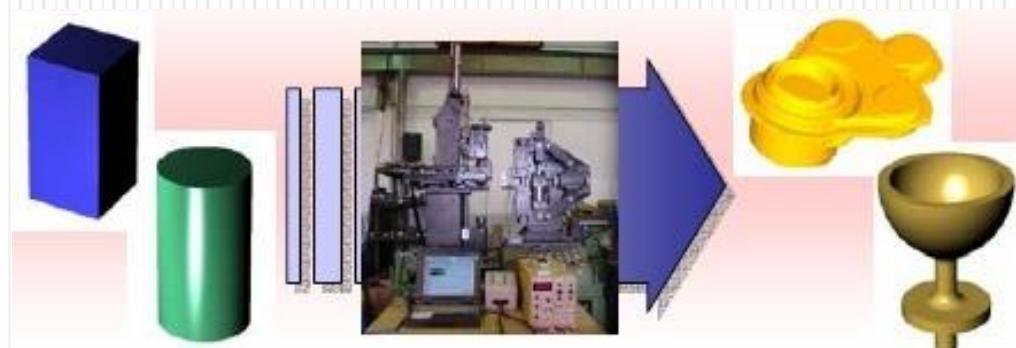


TEHNOLOGIJA MAŠINOGRADNJE

deo: TEHNOLOGIJA PLASTIČNOG DEFORMISANJA

Doc. dr Mladomir Milutinović



RAZDVAJANJE

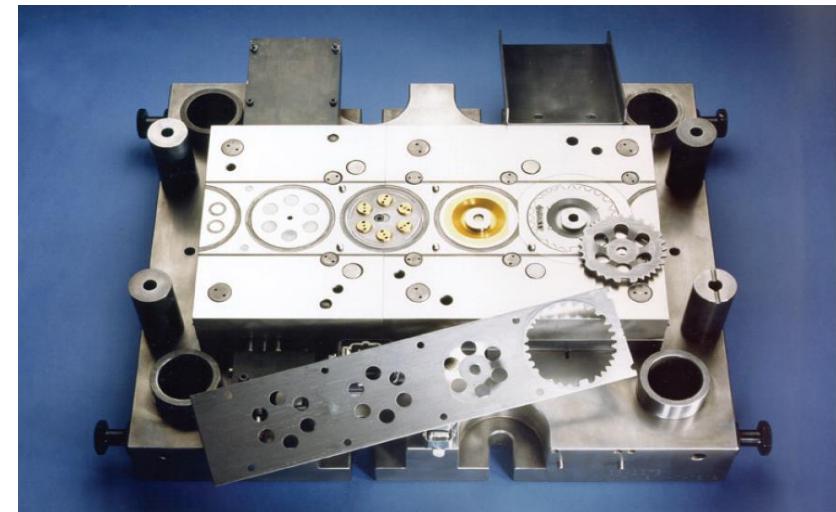
Kod ove obrade fizički se razdvaja jedna celina u dva ili više delova, pri čemu ne nastaje strugotina već se proces razdvajanja ostvaruje smicanjem po površinama na kojima se pojavljuju maksimalni slijepi i naponi.

Razdvajanje se razlikuje od ostalih metoda obrade deformisanja u sledećem:

- Pri razdvajaju zapremina obratka manja je od zapremine pripremka.
- Cilj obrade razdvajanjem nije, kao kod svih ostalih TPD, promena oblika zapremine pripremka, nego podjela te zapremine na dva ili više delova
- Pri razdvajaju, zona obrade koncentrisana je na usku oblast, dok je kod ostalih metoda obrade TPD najčešće cela zapremina dela u plastičnom stanju.
- Sustina procesa razdvajanja je ostvarivanje tangencijalnih (slijepih) napona u određenim ravnima. Kada ti naponi dostignu maksimalnu vrednost po toj ravni nastaje razdvajanje

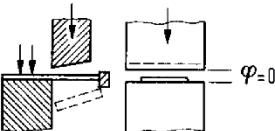
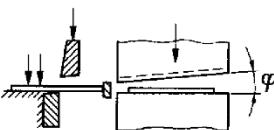
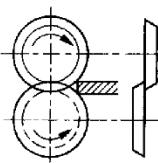
Metode razdvajanja se dele na:

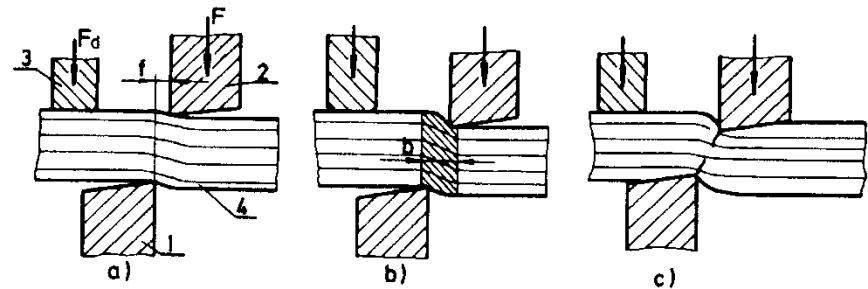
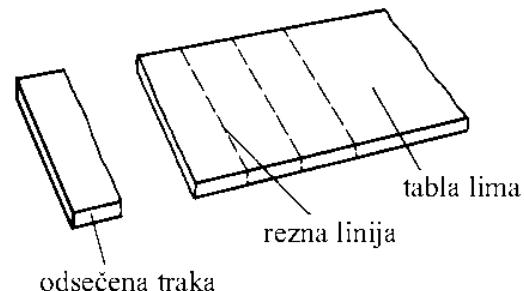
- razdvajanje odsecanjem
- razdvajanje prosecanjem i probijanjem
- razdvajanje lomljanjem
- razdvajanje seckanjem
- fino razdvajanje presovanjem



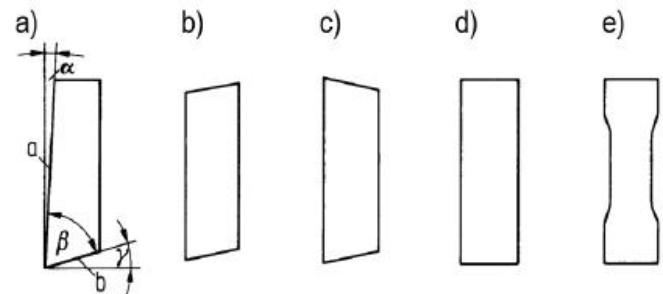
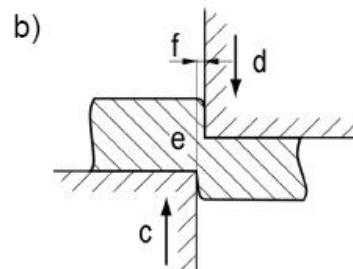
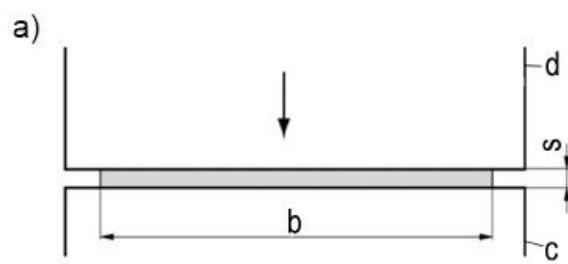
Razdvajanje odsecanjem

Odsecanjem se obrađuju limene table, trake, zipke, cevi i profili. To je pripremna operacija i služi za dobijanje polufabrikata koji se zatim nekom od sekundarnih obrada deformisanjem dalje obrađuju. Rezna linija kod operacije odsecanja je uvek prava.

Alat	Vrsta reza	Šematski prikaz
Ravni noževi	paralelni rez	
	kosi rez	
Kružni noževi	kružni rez	



Odsecanje na makazama s pravim paralelnim noževima



$$F_u = A \cdot \tau_{max} \quad A = b \cdot s$$

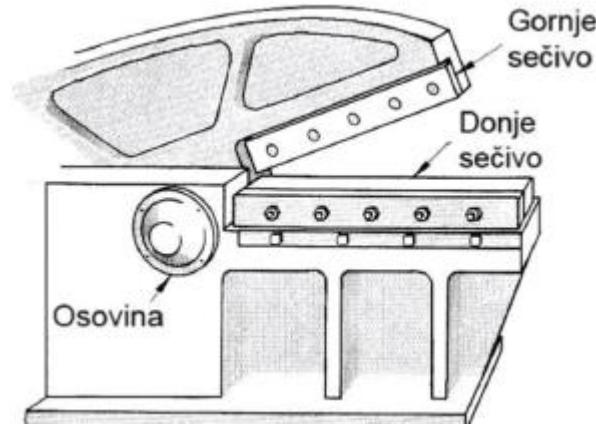
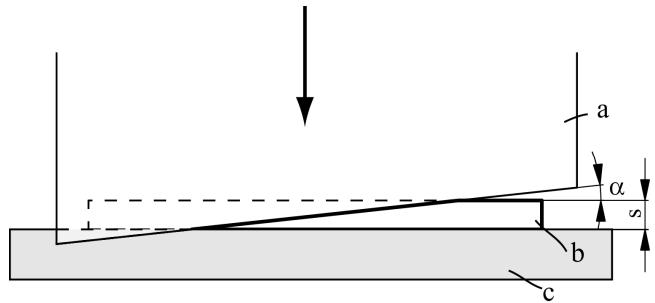
$$F_{stv} = 1,3 \cdot F_u$$

$$W = 0,6 \cdot \sigma_m \cdot \varepsilon_1 \cdot A \cdot s$$

	τ_m [daN/mm ²]	Debljina materijala s [mm]			
		< 1	1 ó 2	2 ó 4	> 4
Meki elik	25 ó 35	0,75 ó 0,70	0,70 ó 0,65	0,65 ó 0,55	0,50 ó 0,40
elik srednje tvrdi e	35 ó 50	0,65 ó 0,60	0,60 ó 0,55	0,55 ó 0,48	0,45 ó 0,35
Tvrdi elik	50 ó 70	0,50 ó 0,47	0,47 ó 0,55	0,44 ó 0,38	0,35 ó 0,25
Al i Cu (flaren)	ó	0,80 ó 0,75	0,75 ó 0,70	0,70 ó 0,60	0,60 ó 0,50



Odsecanje na makazama s pravim nagnutim noževima



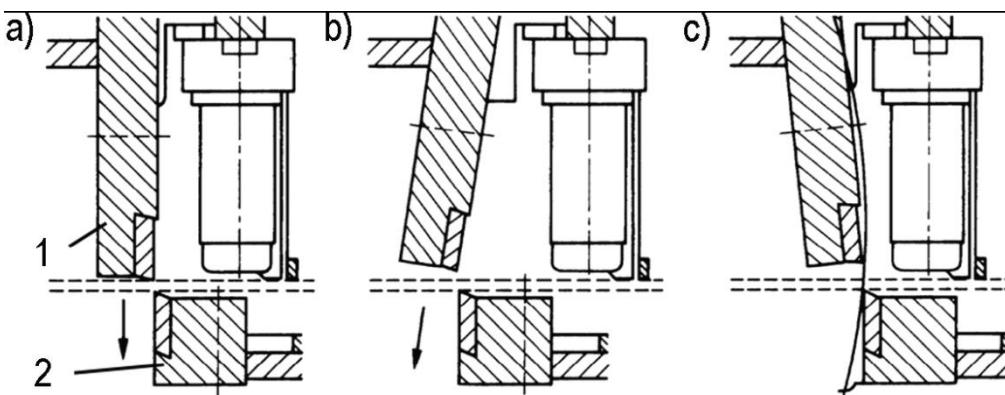
$$F_{\max} = 0,6 \sigma_m \varepsilon_1 \frac{s^2}{\operatorname{tg}\alpha}$$

$$W = 0,6 \sigma_m \cdot \varepsilon_1 \cdot A \cdot s$$

$$\alpha < \rho_1 + \rho_2$$

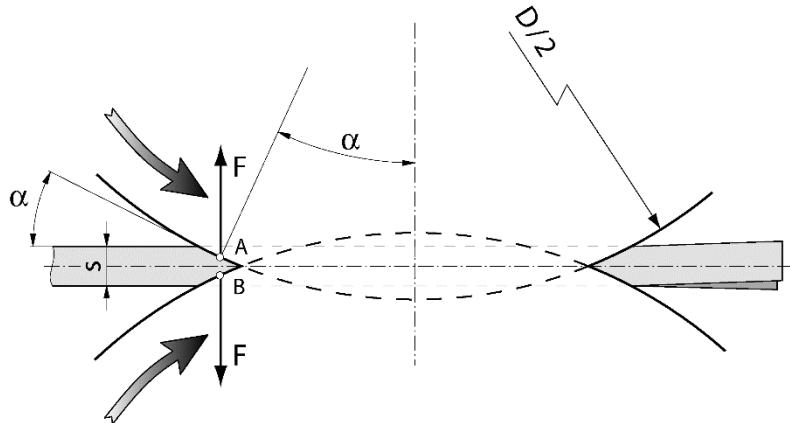
$$\rho = \operatorname{arctg}\mu$$

$$\mu = 0,1 \Rightarrow \alpha < 2 \cdot 5^\circ 40' \approx 12^\circ$$



$$\beta = 2^\circ \div 3^\circ$$

Odsecanje na makazama s kružnim noževima

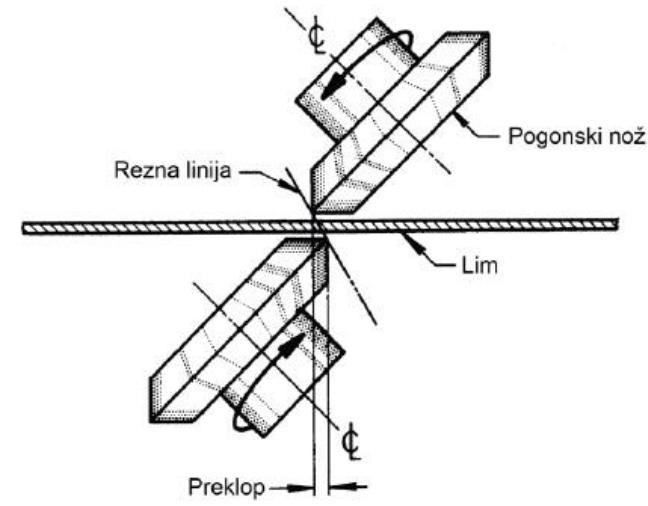
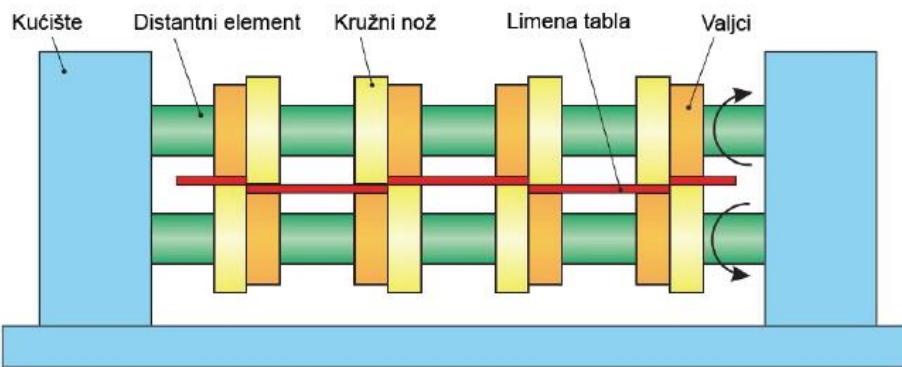
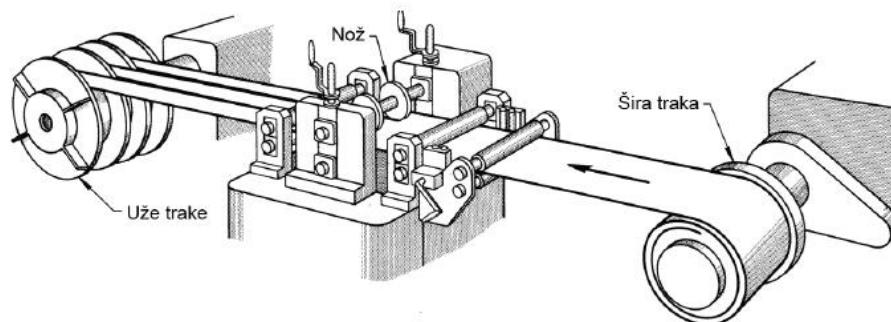


$$F_{\max} = 0,6 \cdot \sigma_m \cdot \varepsilon_1 \frac{s^2}{2 \cdot \operatorname{tg} \alpha}$$

$$M = F_{\max} \cdot \frac{D}{2} \sin \alpha$$

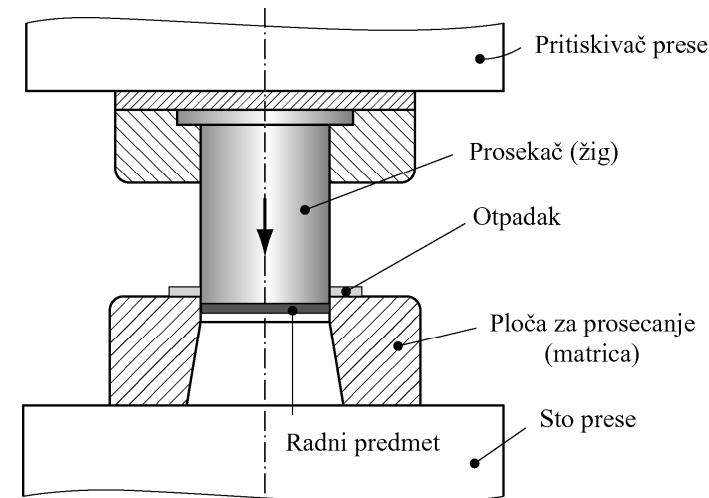
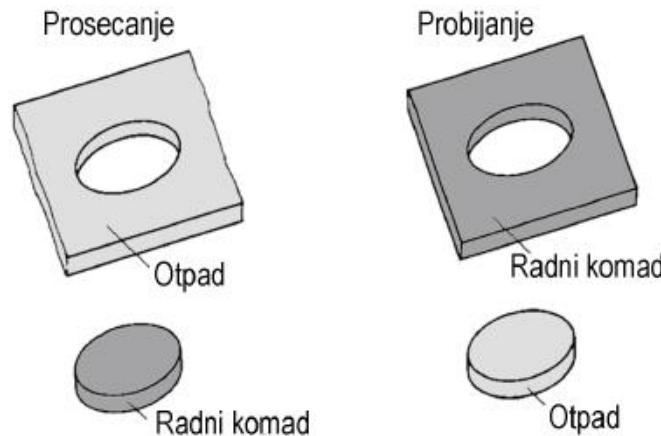
$$2\alpha < \rho_1 + \rho_2$$

$$\mu = 0,1 \Rightarrow 2\alpha < 2 \cdot 5^\circ 40' \approx 12^\circ$$

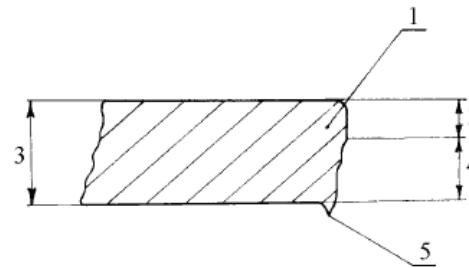
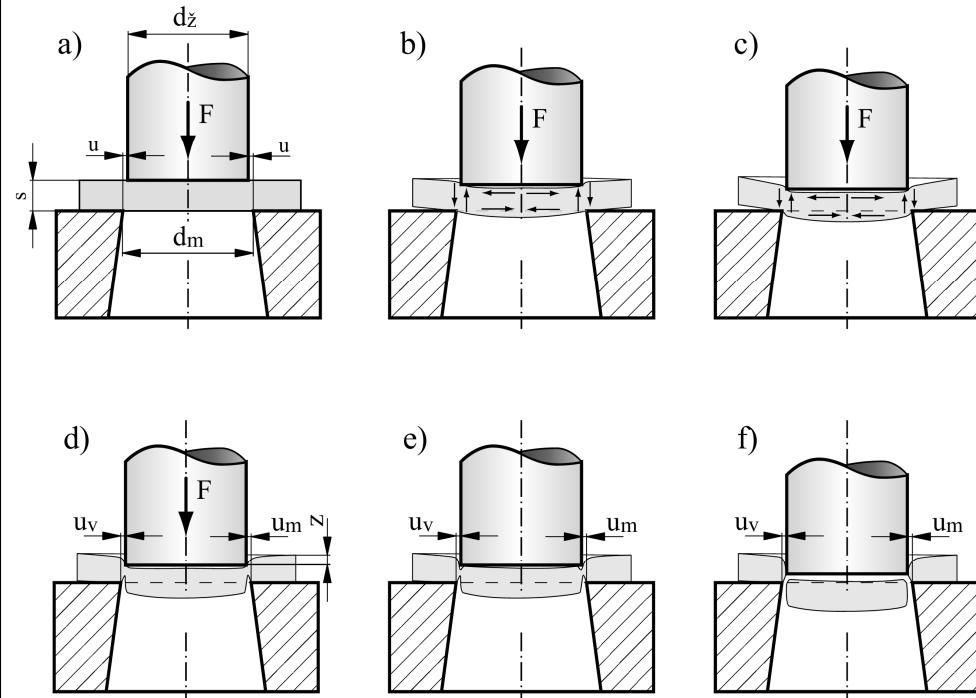
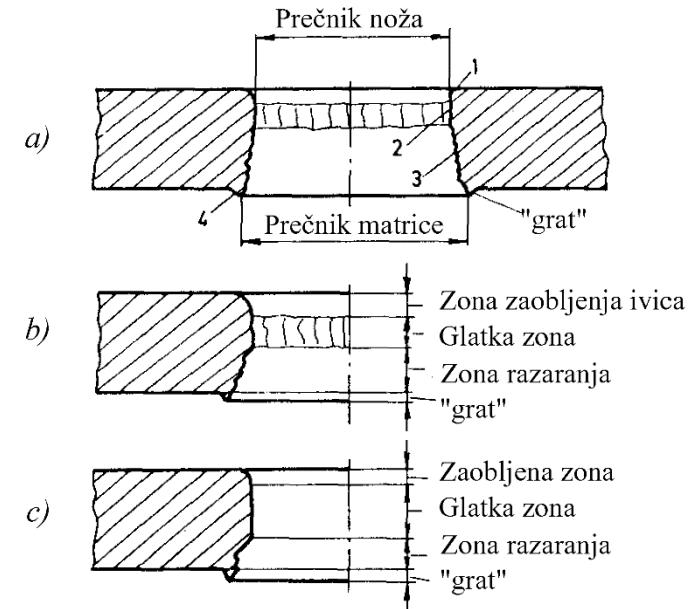
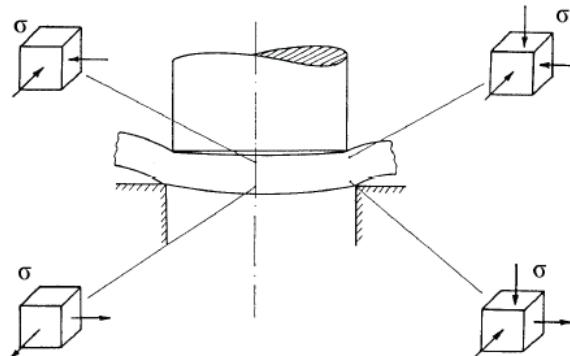
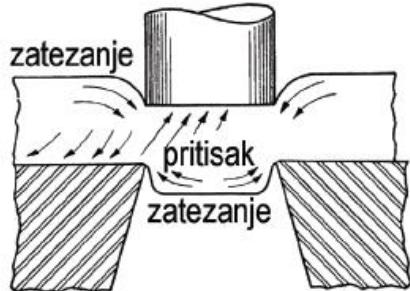


Razdvajanje lima prosecanjem i probijanjem

Prosecanje i probijanje lima su metode obrade razdvajanjem po zatvorenoj konturi uz pomoć specijalnog alata.



Deformacije u zoni razdvajanja



konvencionalni kvalitet rezne površine

$$s \leq 3 \text{ mm} \Rightarrow u = (0,03 \div 0,06) \cdot s$$

za **povišeni kvalitet** rezne površine

$$\text{za } s \leq 3 \text{ mm} \quad u = (0,02 \div 0,04) \cdot s$$

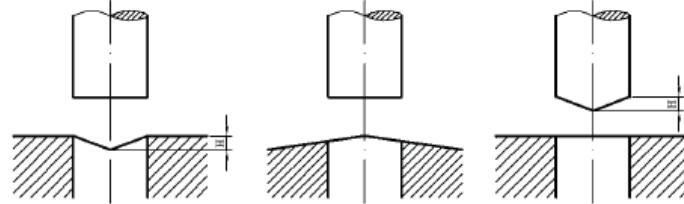
$$\text{za } 10 \leq s \leq 25 \text{ mm} \quad u = (0,06 \div 0,08) \cdot s$$

Deformaciona sila i deformacioni rad

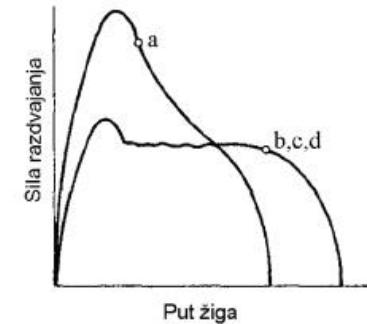
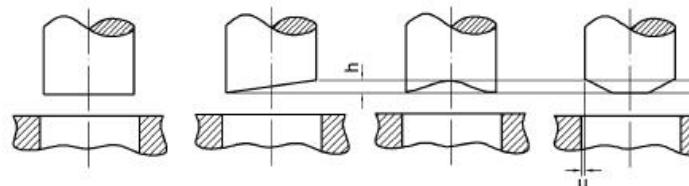
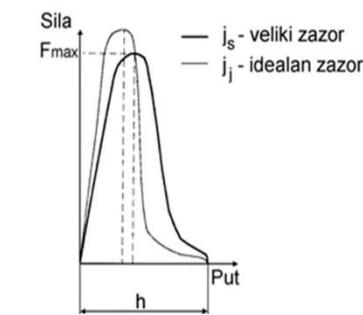
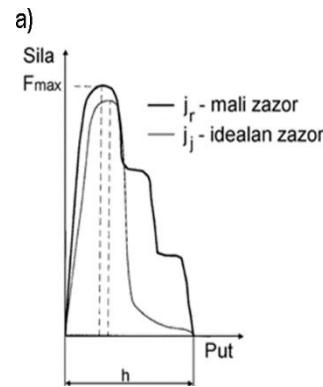
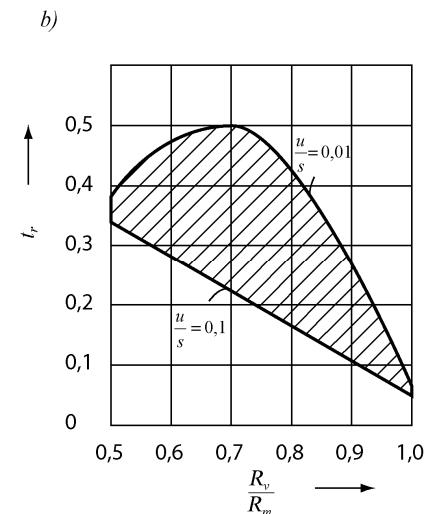
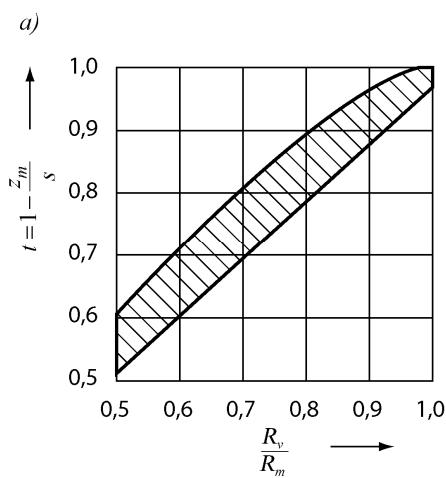
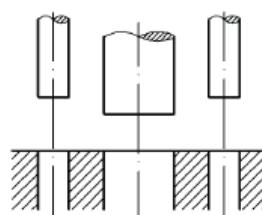
$$F = l_r \cdot s \cdot t \cdot R_m$$

$$W = t_r \cdot l_r \cdot s^2 \cdot R_m$$

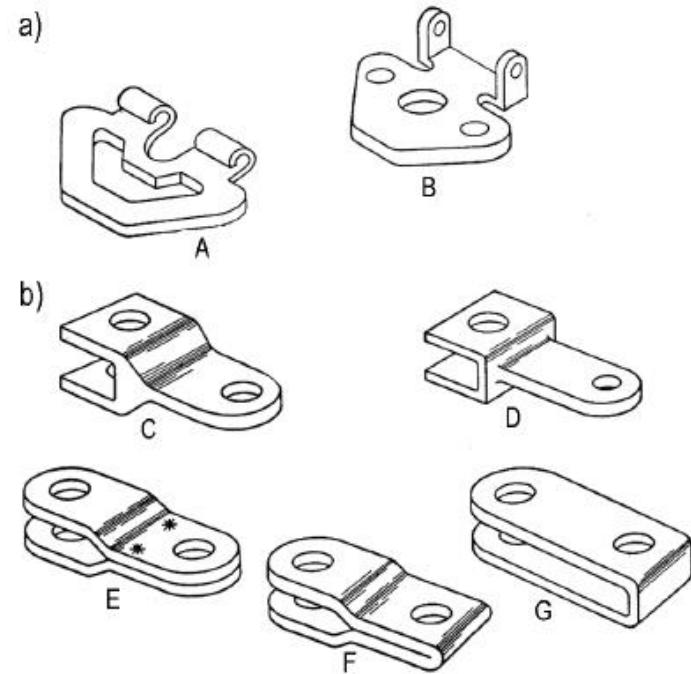
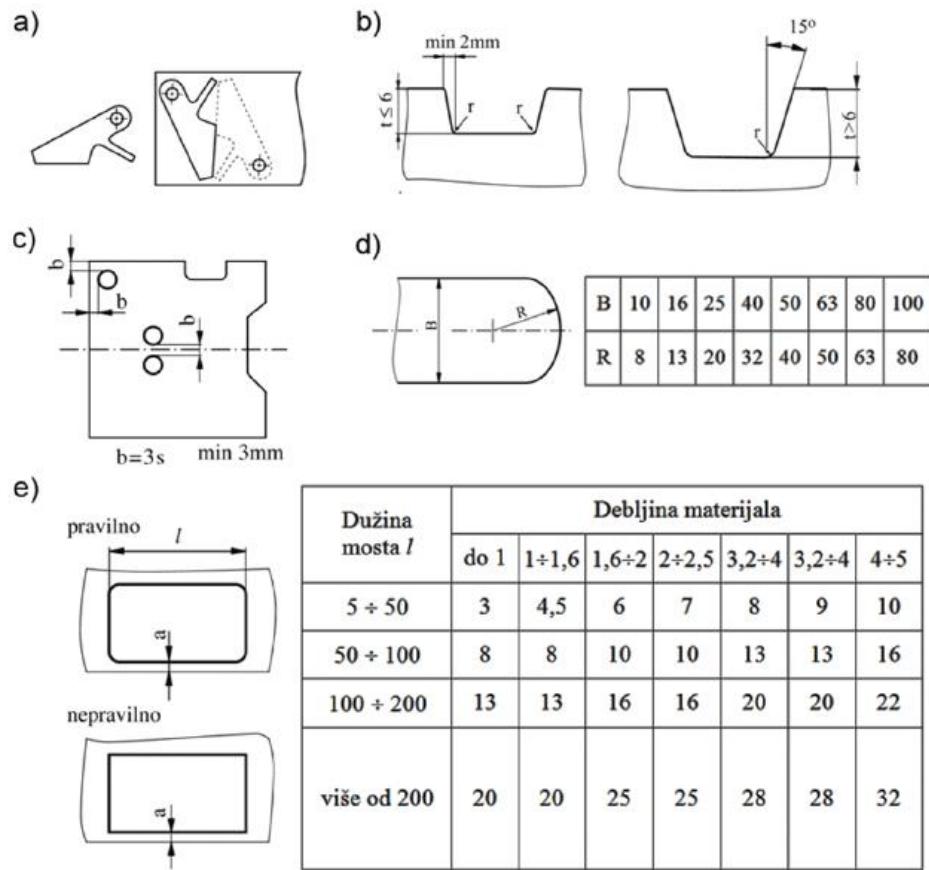
A



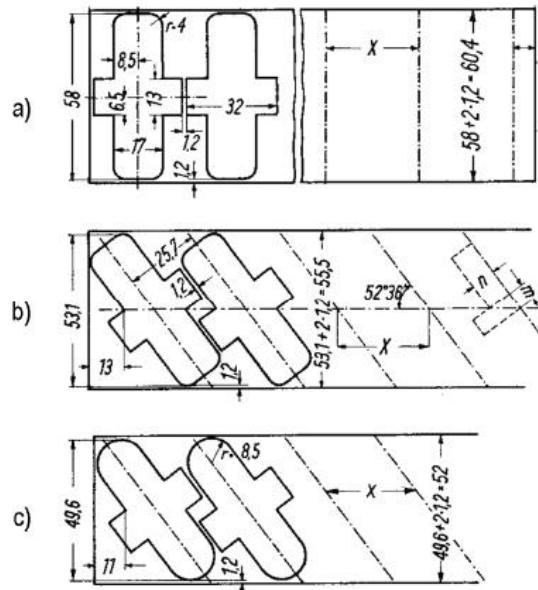
B



Tehnologičnost obratka



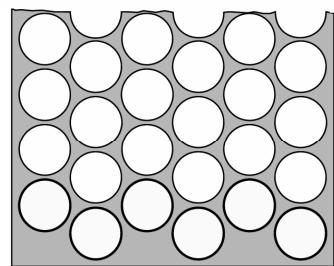
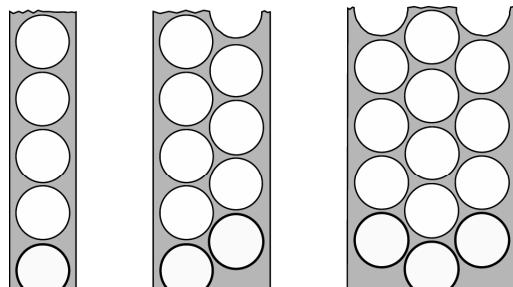
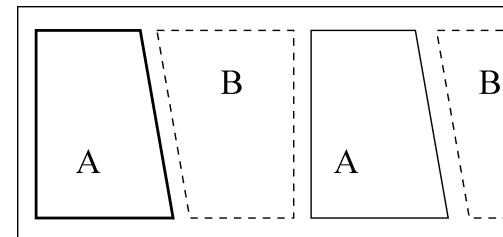
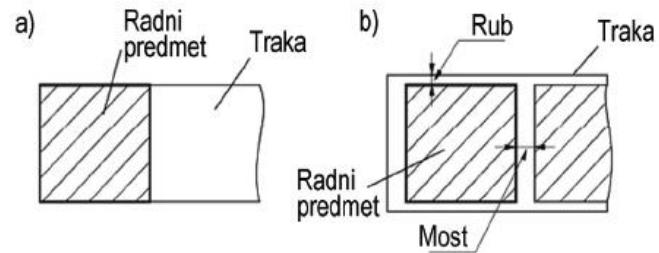
Položaj obratka u traci i stepen iskorišćenja trake



$$\eta = \frac{n \cdot A_o}{A_{t_i}}$$

Diagram showing a circle with radius d and area $A = \pi d^2$.

$$\eta = \frac{n \cdot A_0}{A_{t_i}} = \frac{d^2 \cdot \pi}{4 \cdot a^2} = 78,5\%$$



56,8%

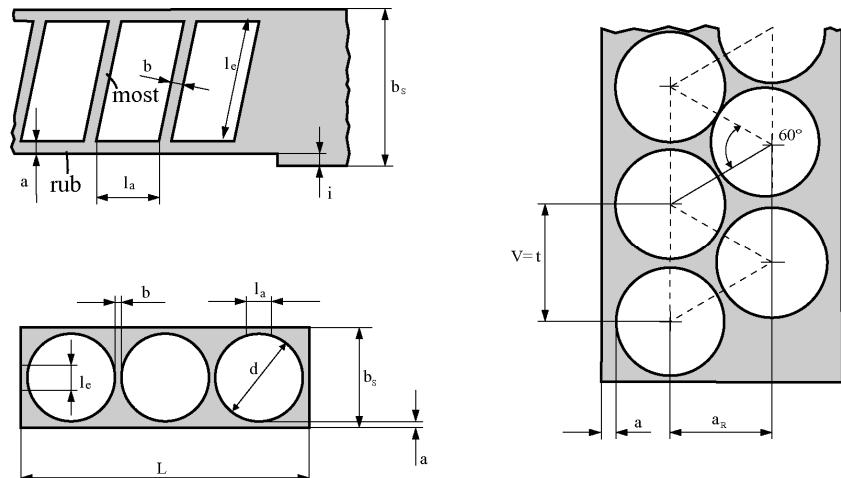
65%

67,4%

73,2%

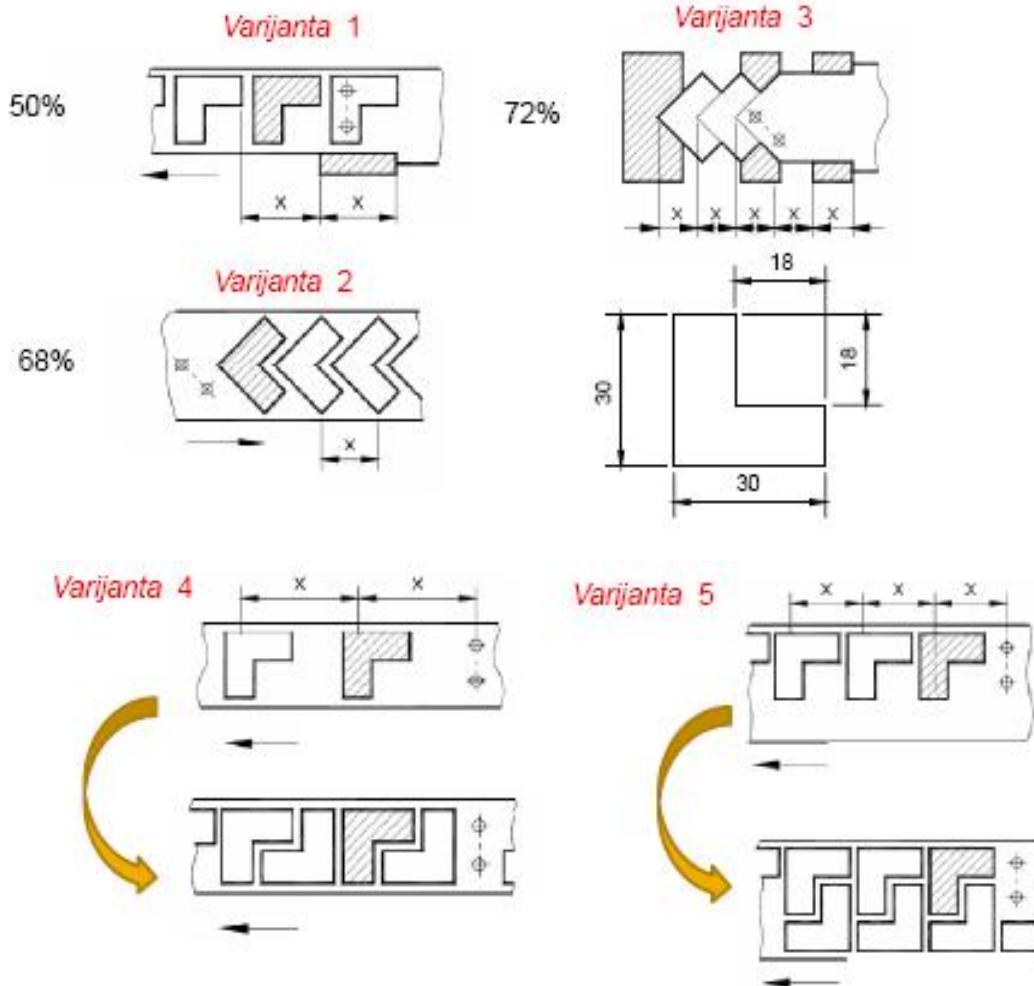
Položaj obratka u traci i stepen iskorišćenja trake

Širina trake	Dužina mosta	Širina mosta i ruba	Debljina lima [mm]						
			0.1	0.5	1	1.5	2	2.5	3
do 100 mm	do 10	b a	0.8 1	0.8 0.9	1	1.3	1.6	1.9	2.1
	11... 50	b a	1.6 1.9	0.9 1.0	1.1	1.4	1.7	2	2.3
	51... 100	b a	1.8 2.2	1.0 1.2	1.3	1.6	1.9	2.2	2.5
	više od 100	b a	2.0 2.4	1.2 1.5	1.5	1.8	2.1	2.4	2.7
	širina bočnog noža		1.5			2.2	3	3.5	4.5
više od 100 mm	do 10	b a	0.9 1.2	1.0 1.1	1.1	1.4	1.7	2	2.3
	11... 50	b a	1.8 2.2	1.0 1.2	1.3	1.6	1.9	2.2	2.5
	51... 100	b a	2.0 2.4	1.2 1.5	1.5	1.8	2.1	2.4	2.7
	više od 100	b a	2.2 2.7	1.4 1.7	1.7	2	2.3	2.6	2.9
	širina bočnog noža		1.5			2.5	3.5	4	5



Bočni nož služi za obezbeđivanje tačnosti pomaka i prilikom određivanja potrebne zirine trake potrebno je uzeti u obzir i zirinu bočnog noža

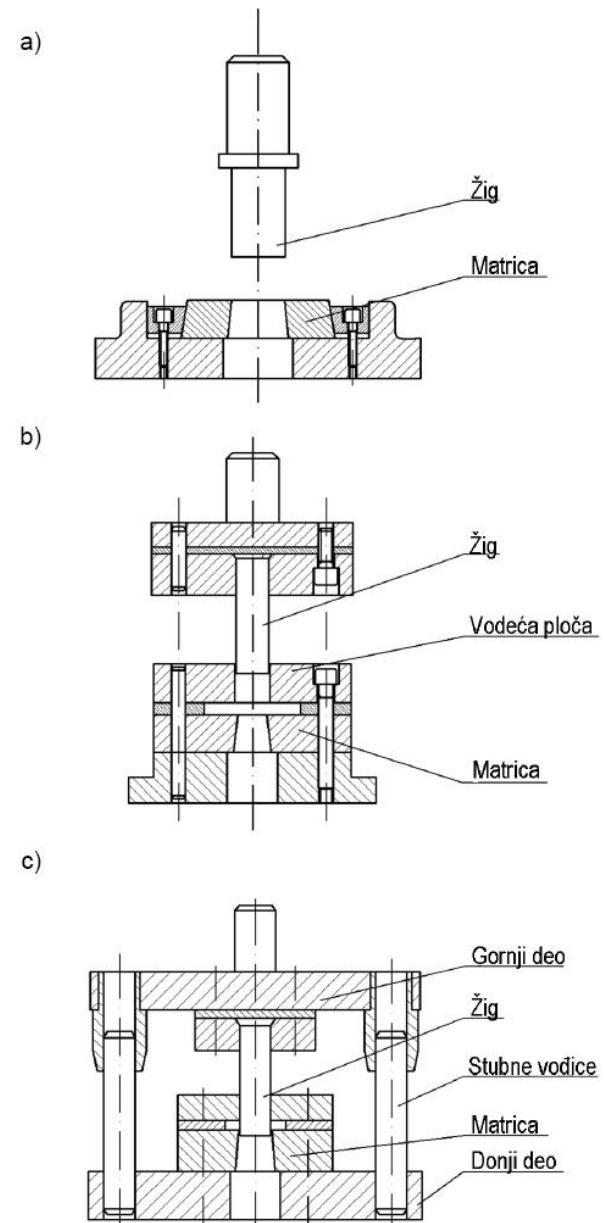
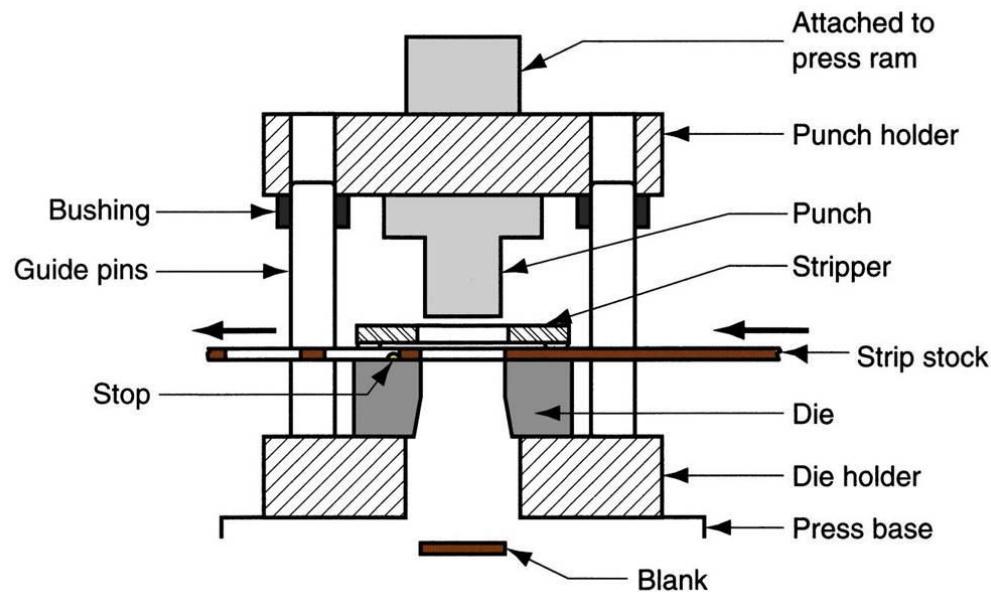
Položaj obratka u traci i stepen iskorišćenja trake

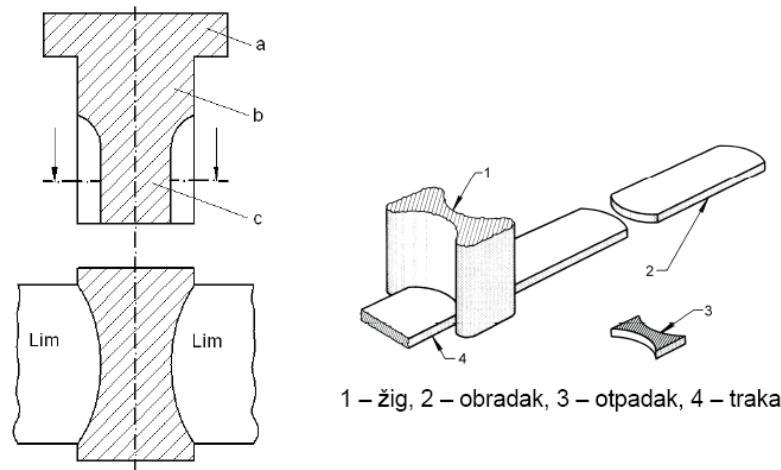
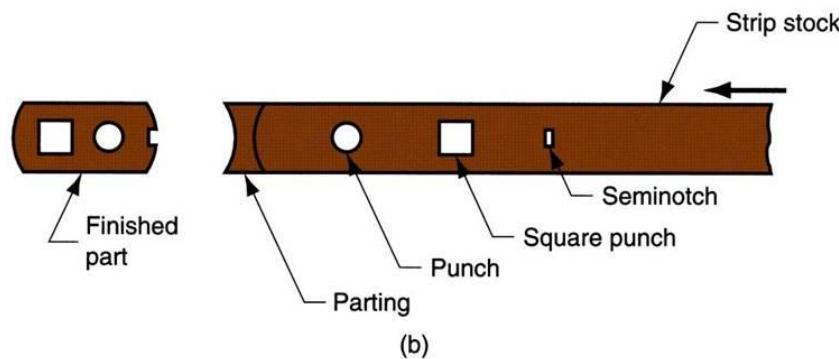
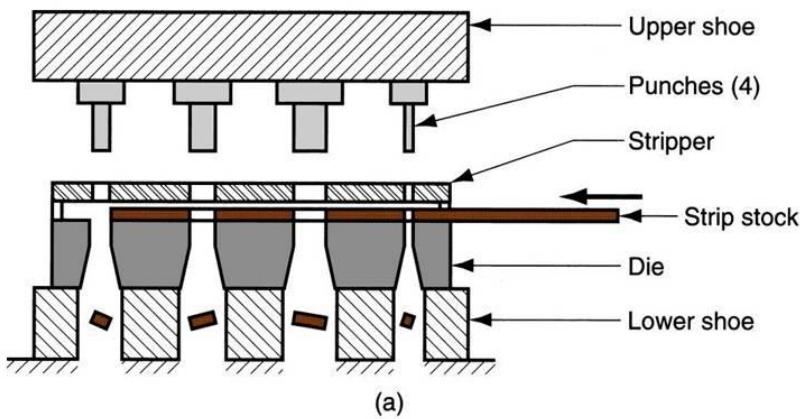
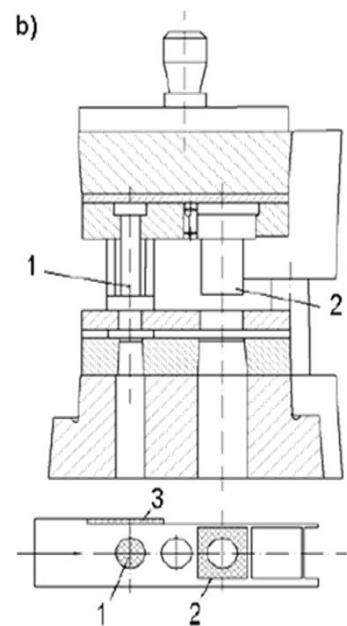
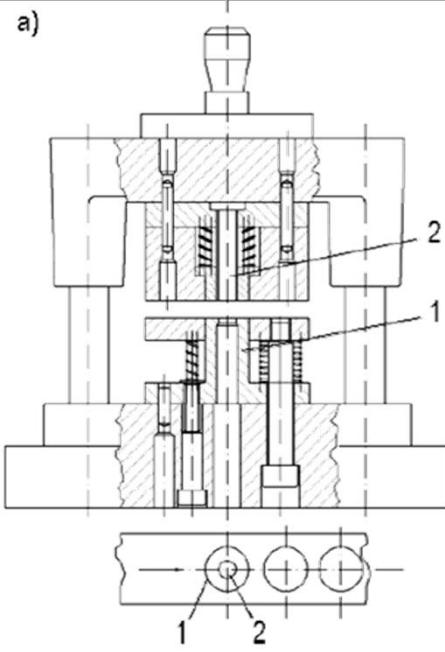


Alati za prosecanje i probijanje

Glavni elementi alata za probijanje i prosecanje su :

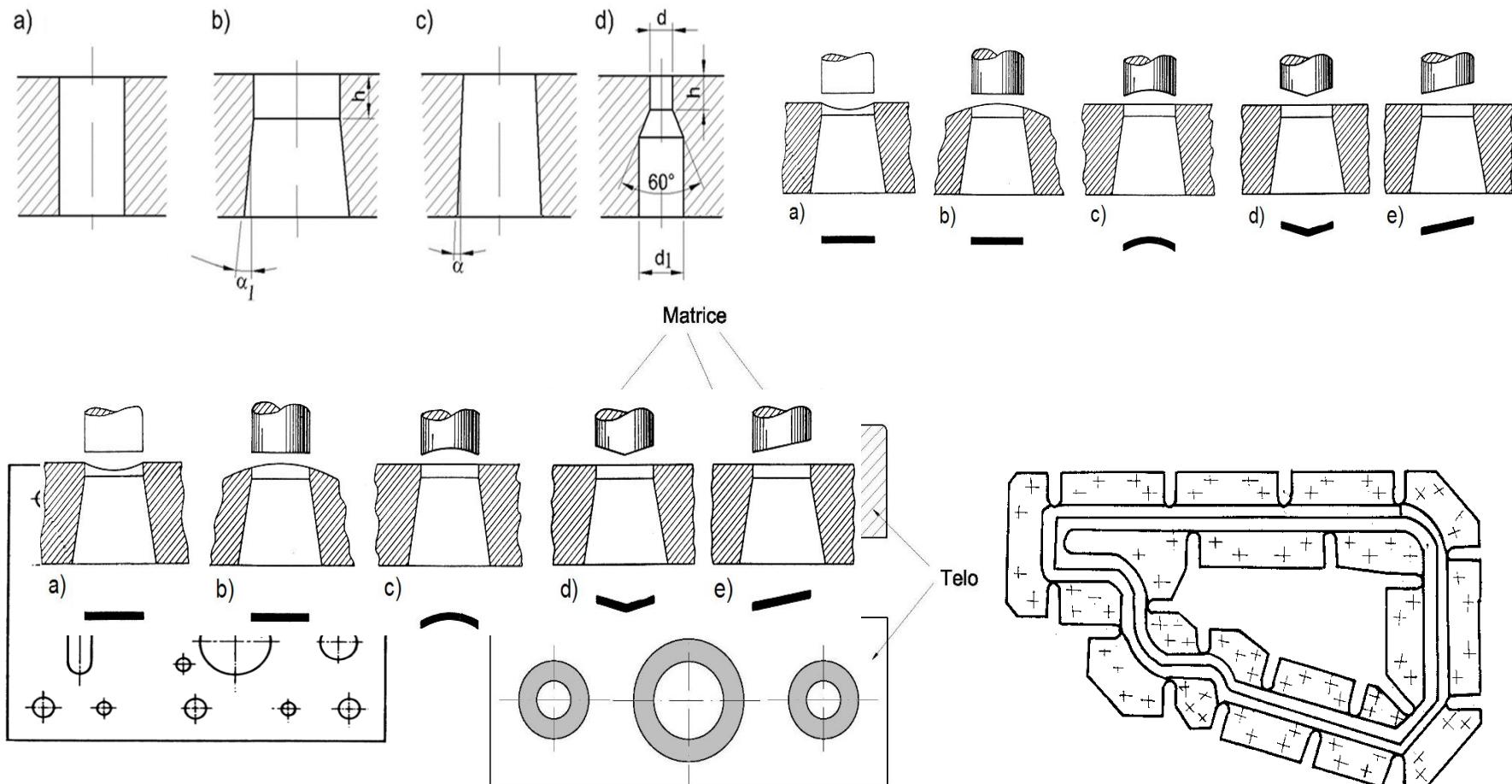
- „ matrica
- „ Oig
- „ ku izte sa vo icama
- „ elementi za vo enje i centriranje trake
- „ elementi za regulisanje pomaka trake
- „ elementi za pri vrz ivanje alata za sto mazine
- „ pomo ni elementi





Matrica

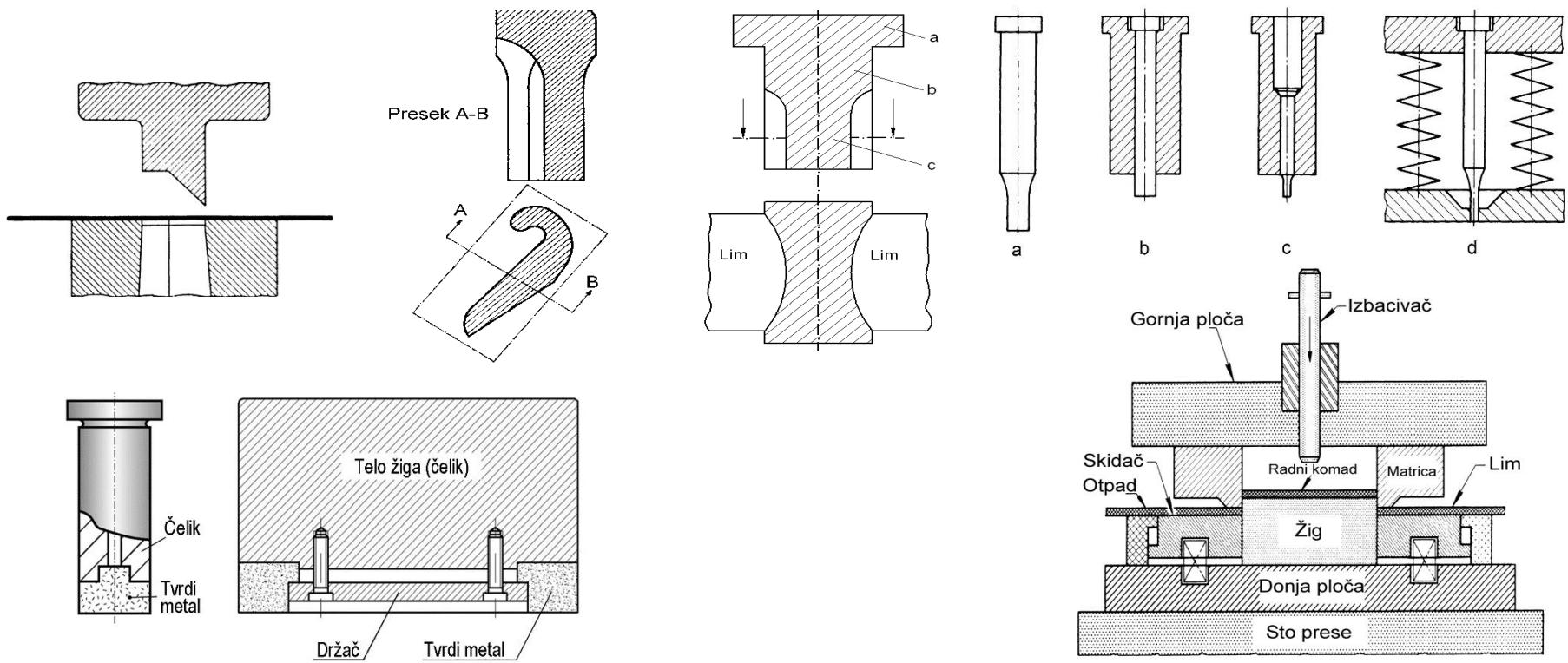
- Matrica (rezna ploča) najčešće je smještena u donji deo alata
- Oblik rezne linije matrice odgovara obliku radnog predmeta

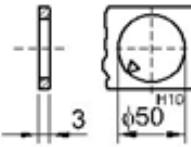
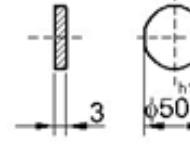
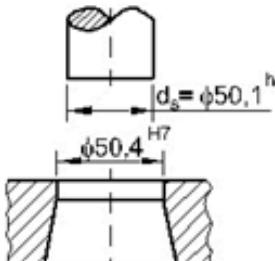
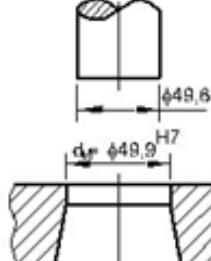


Žig

Svaki žig ima 3 funkcionalno različita dela

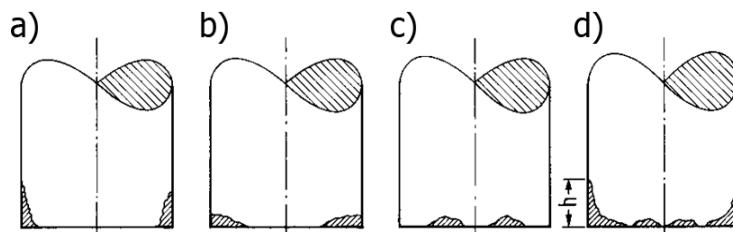
- a) osloni
 - b) srediznji
 - c) radni deo
- Oslonim delom žiga se oslanja na mazinu, srediznji deo prenosi potrebnu silu u zonu rezanja, a radni deo je u direktnom kontaktu sa materijalom i u sprezi sa matricom vrzi razdvajanje
 - žig treba da bude zato što je moguće kraće i kako bi bila otklonjena opasnost od njegovog izvijanja ($60 \div 100$ mm)



VELICINA		PROBIJANJE	PROSECANJE
SKICA-PREDMETA			
Nazivna mera predmeta		D = 50 mm	D = 50 mm
Izradna tolerancija predmeta (tabela br. 18)		$\Delta = +0,1 \text{ mm}$ (za H10 u području D = 30–50 mm)	$\Delta = +0,1 \text{ mm}$ (za h10 u području D = 30–50 mm)
Najveća i najmanja mera predmeta		$D_{\max} = D + \Delta = 50 + 0,1 = 50,1 \text{ mm}$ $D_{\min} = 50,1 \text{ mm}$	$D_{\min} = D - \Delta = 50 - 0,1 = 49,9 \text{ mm}$ $D_{\max} = 49,9 \text{ mm}$
NAZIVNE MERE ALATA		<p>Prečnik probajca je jednak najvećoj mjeri predmeta d_s = D_{max} = 50,1 mm</p> <p>Prečnik prstena za probijanje d_M = d_s + w = 50,1 + 0,3 = 50,4 mm</p>	<p>Prečnik prstena za prosecanje je jednak najmanjoj mjeri predmeta d_M = D_{min} = 49,9 mm</p> <p>Prečnik prosekača d_s = d_M - w = 49,9 - 0,3 = 49,6 mm</p>
SKICA ALATA			
Izradne tolerancije alata (tabela 18)	Prsten	$t_M = +0,025 \text{ mm}$ (za H7 u području D = 30–50 mm)	
	Probajac	$t_s = -0,016 \text{ mm}$ (za h6 u području D = 30–50 mm)	
Najveća mera prstena za probijanje, odnosno prosecanje		$d_{M(\max)} = d_M + t_M$ $d_{M(\max)} = 50,4 + 0,025 = 50,425 \text{ mm}$	$d_{M(\max)} = d_M + t_M$ $d_{M(\max)} = 49,9 + 0,025 = 49,925 \text{ mm}$
Najmanja mera probajca, odnosno prosekača		$d_{s(\min)} = d_s - t_s$ $d_{s(\min)} = 50,1 - 0,016 = 50,084 \text{ mm}$	$d_{s(\min)} = d_s - t_s$ $d_{s(\min)} = 49,6 - 0,016 = 49,584 \text{ mm}$

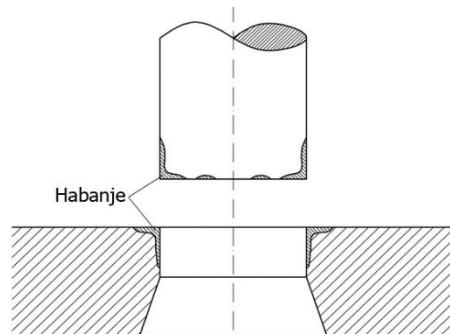
Eksplotacija alata

- “ Ozte enje alata može biti u vidu habanja, trajne neeljene deformacije ili loma alata
- “ Ako na Oigu ili matrici dođe do habanja, to habanje može se do određene mere eliminisati tzv. oztrenjem tj. skidanjem debljine sloja koji je zahvaćen habanjem.



Ukupna postojanost alata

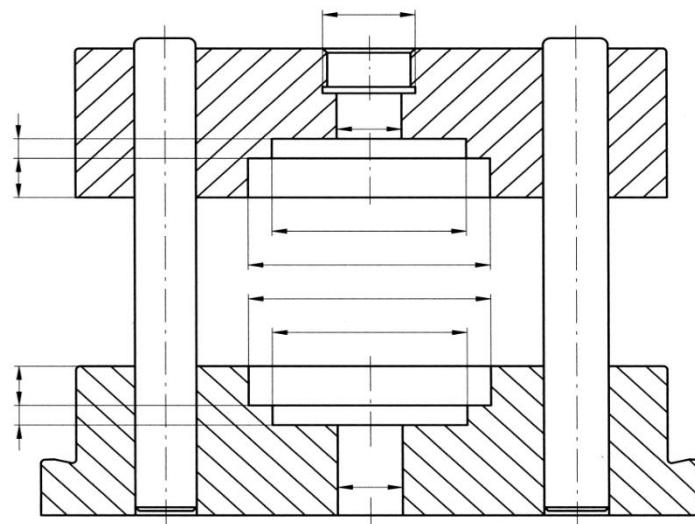
	Bez vojica	Vodenje pločom	Alat sa vodicama		Kugli no vedenje	
			elik	Tvrdi metal	elik	Tvrdi metal
Okrugli obl.	10.000	500.000	1.000.000	6.000.000	1.500.000	15.000.000
Ugaoni obl.	6.000	400.000	800.000	4.000.000	1.200.000	10.000.000
Tezki oblici	-	300.000	600.000	2.000.000	1.000.000	8.000.000



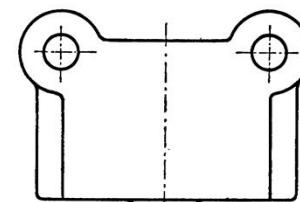
Postojanost po jednom oztrenju

	Bez vojica	Vodenje pločom	Alat sa vodicama		Kugli no vedenje	
			elik	Tvrdi metal	.2080	Tvrdi metal
Okrugli obl.	1.000	40.000	60.000	300.000	100.000	1.000.000
Ugaoni obl.	800	30.000	50.000	200.000	80.000	750.000
Tezki oblici	-	25.000	40.000	100.000	60.000	500.000

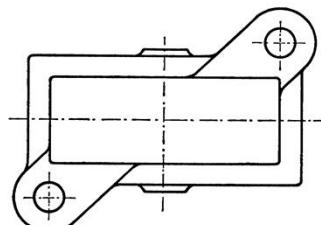
Kućište alata



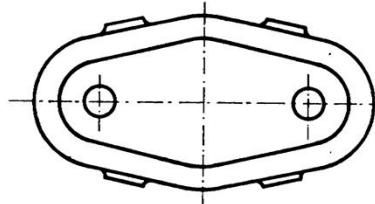
a)



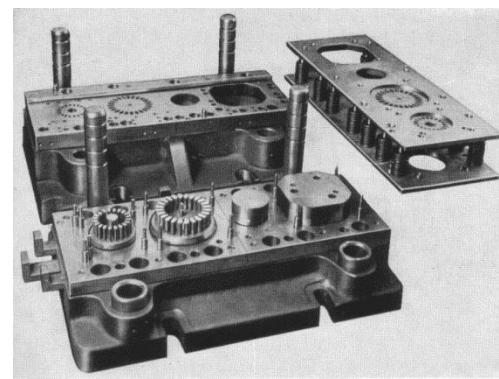
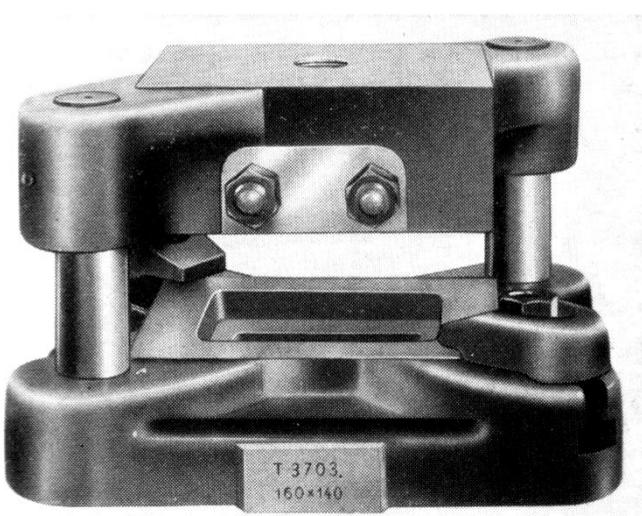
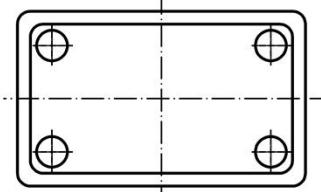
b)

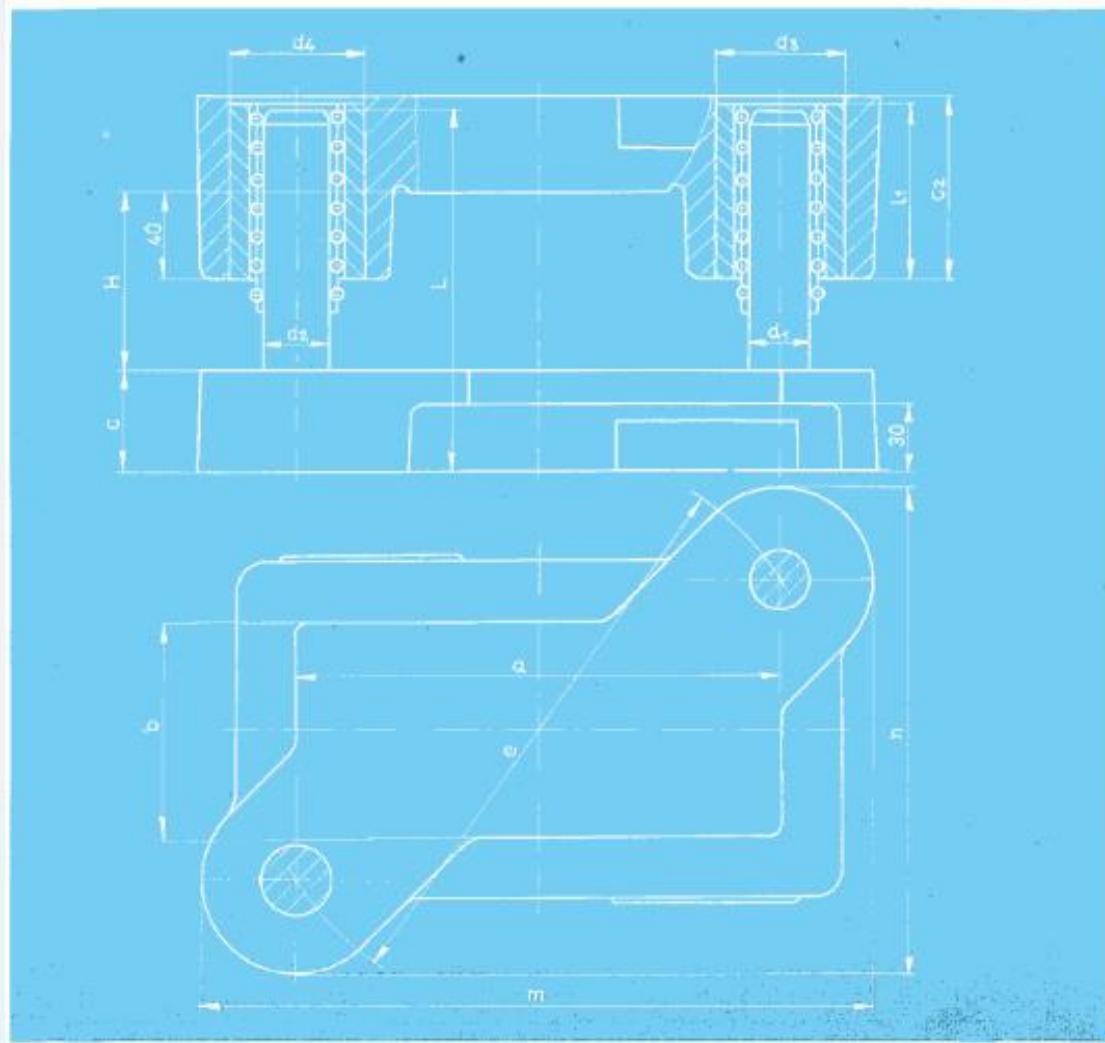


c)



d)





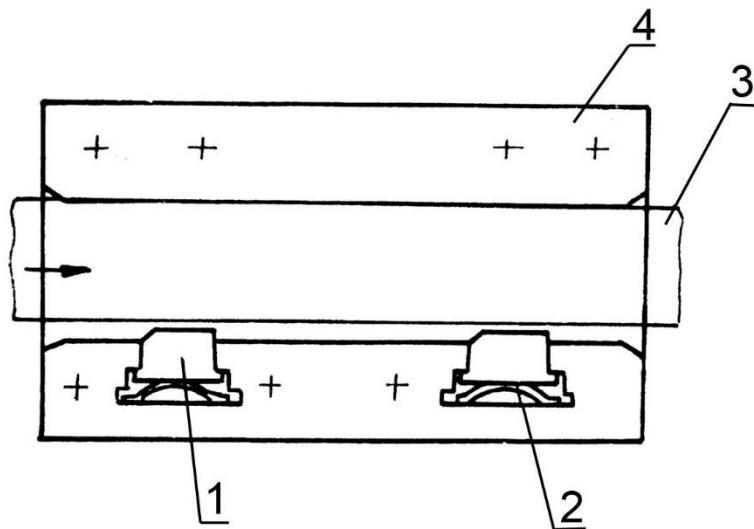
Nomenklatura oznaka	$a \times b$	m	n	c	c_1	e	H		V O D I L I C E					
							H_d	H_g	d_1	d_2	d_3	d_4	t_1	L
S 120 K, 80x63	80 x 63	130	158	50	70	134,4	85	130	18	19	30	32	70	160
S 120 K, 125x80	125 x 60	185	193	50	70	182,5	95	135	24	25	36	38	70	170
S 120 K, 160x100	160 x 100	220	213	50	80	221,4	85	135	24	25	36	38	80	170
S 120 K, 200x125	200 x 125	271	259	56	80	274,5	90	135	30	32	46	48	80	180
S 120 K, 250x160	250 x 160	321	294	56	90	335	105	155	30	32	46	48	88	206



Elementi za vođenje trake

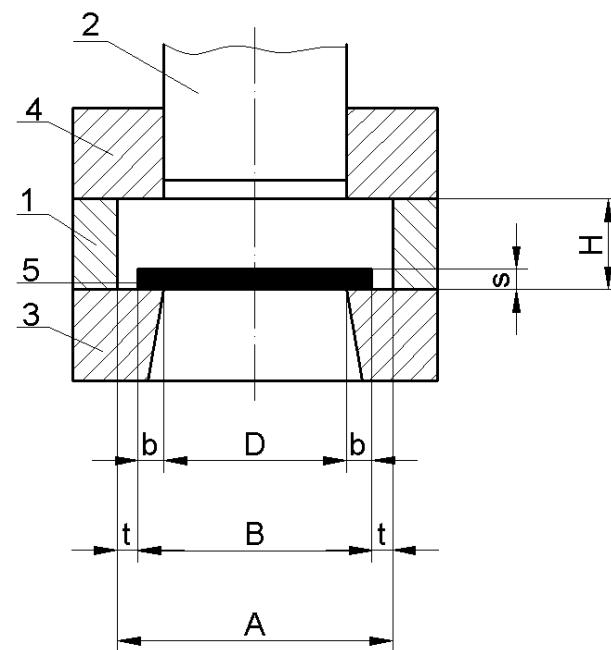
U slučaju razdvajanja iz trake potrebno je traku tačno pozicionirati u odnosu na oig i matricu

Vodenje trake pomoću vodeće letve



1 . potiskivač, 2 . opruga
3 - traka, 4 - fiksna letva

Fiksno vođenje trake



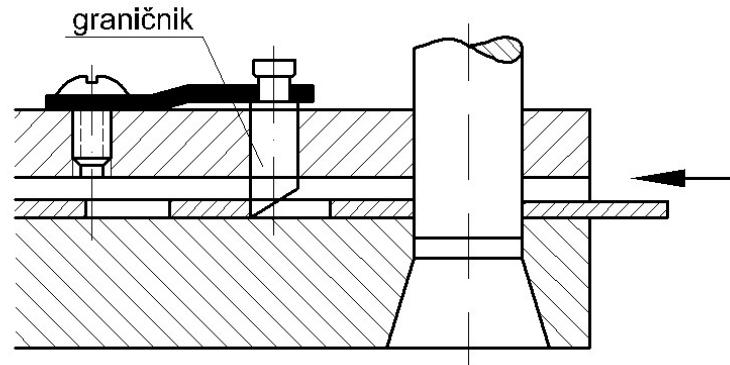
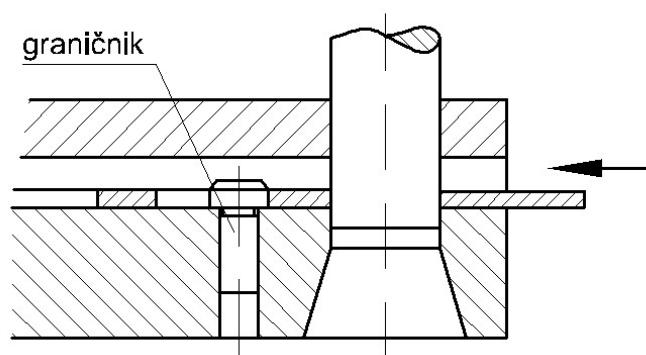
1 - fiksna letva, 2 . Oig, 3 - matrica,
4 - vodeća ploča, 5 . lim

Elementi za regulisanje pomaka trake

- ✓ Kod razdvajanja iz trake, posle svakog hoda prese potrebno je traku ru no ili automatski pomeriti za jedan korak unapred
- ✓ Ti koraci treba da su uvek isti
- ✓ U cilju ostvarivanja konstantnosti svakog koraka primenjuju se razli ita konstruktivna rezenja alata za razdvajanje

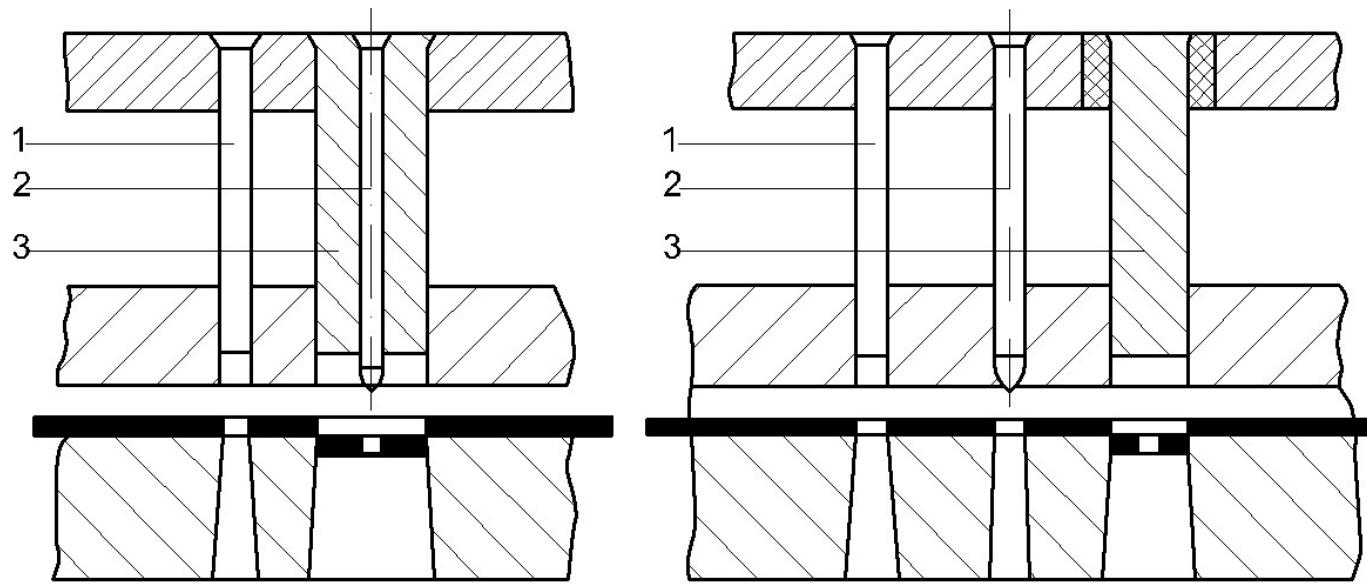
Graničnik predstavlja najjednostavnije konstruktivno rezenje za regulisanje pomaka trake

Graničnik je fiksiran u telo alata



Elementi za regulisanje pomaka trake

Lovac trake služi da se koriguju grezke u pomaku trake kod vizepozicionih alata, tj. da se traka neposredno pre delovanja 0iga postavi u pravilan položaj



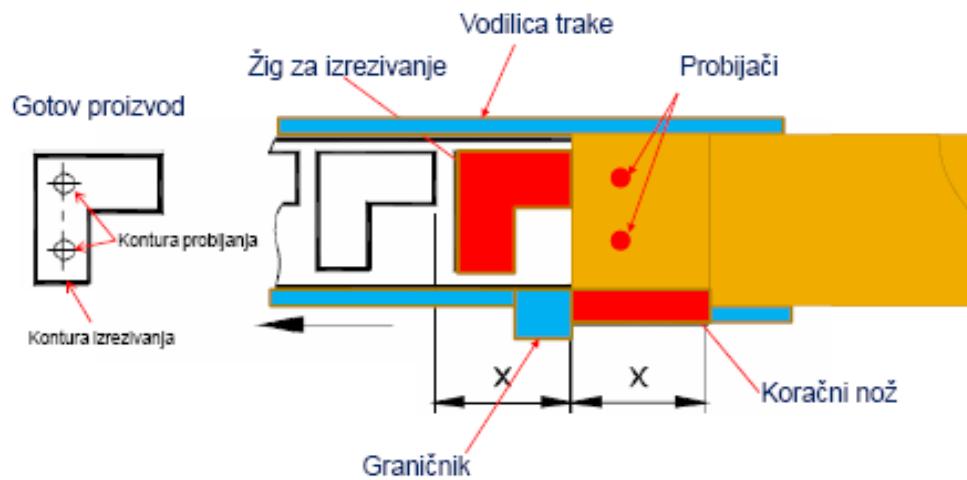
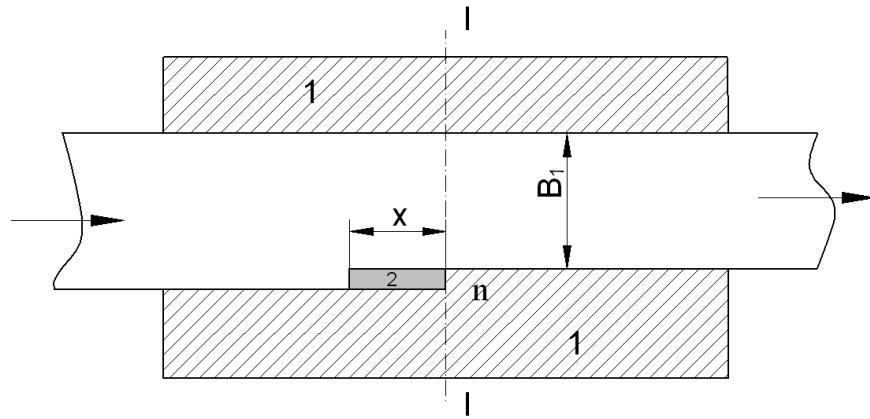
$$d > 4\text{mm}$$

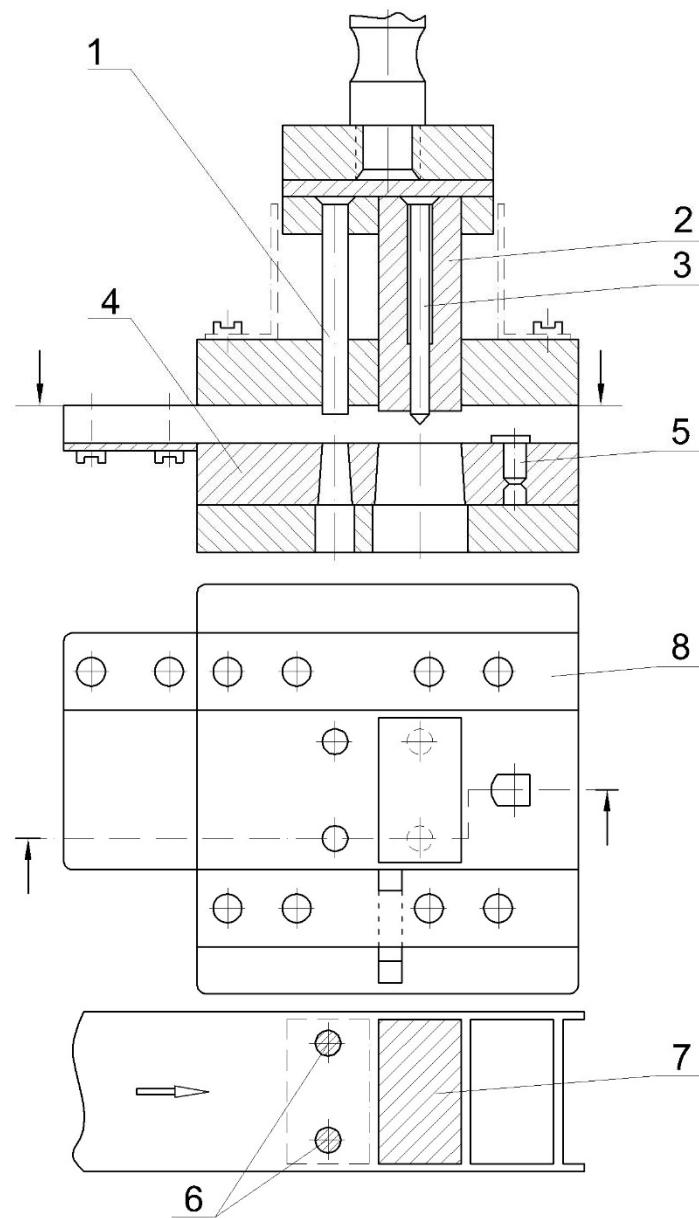
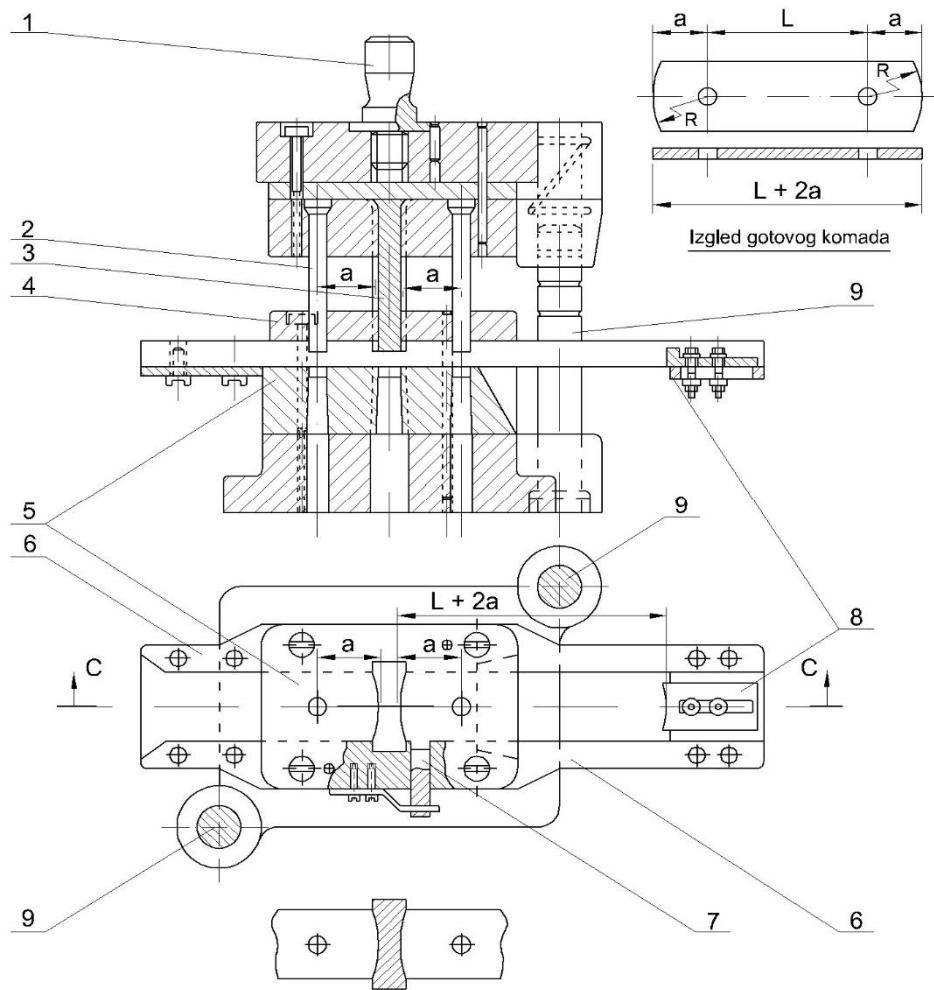
$$s \geq 0,25\text{mm}$$

- 1 . Oig za otvor za lovca
- 2 . lovac
- 3 . Oig za razdvajanje

Elementi za regulisanje pomaka trake

Bo ni (kora ni) no obezbe uje vrlo ta an hod (korak) trake





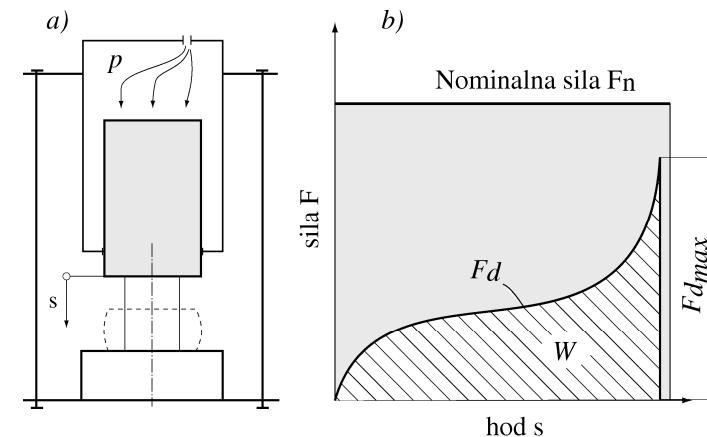
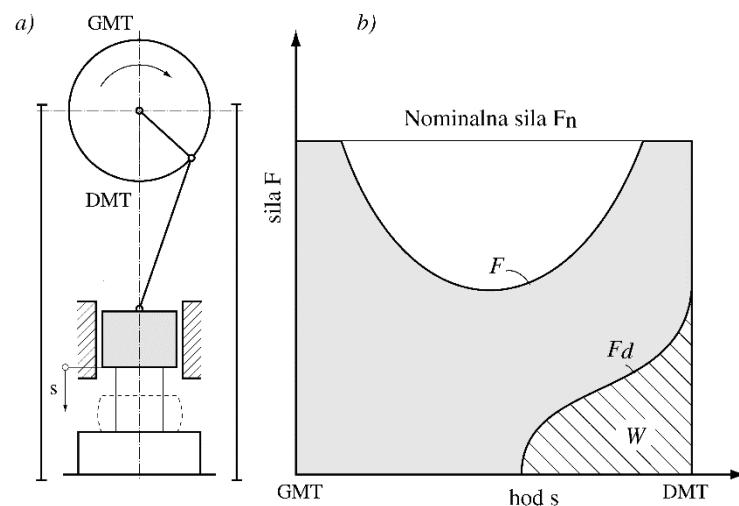
Mašine za prosecanje i probijanje

Mehaničke prese:

- jednostavne delove
- veće serije
- delove za koje nije potrebno permanentno prilago avanje parametara mazine procesu razdvajanja
- tanje limove

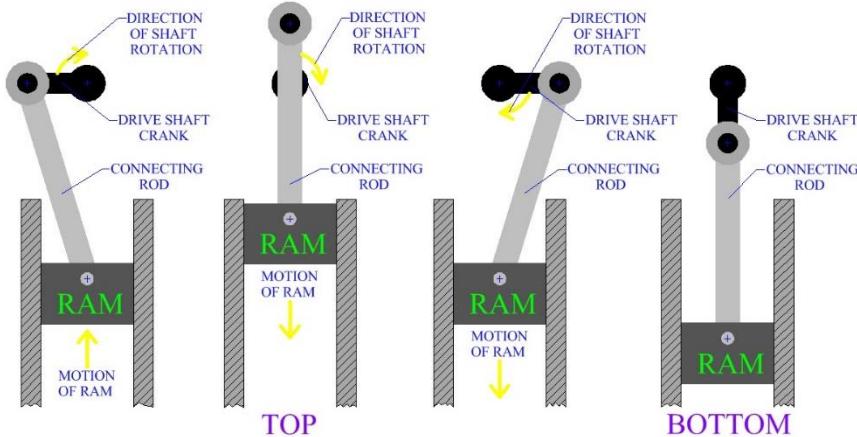
Hidraulične prese:

- komplikovanije delove koji zahtevaju prilago avanje (regulisanje) brzine u toku procesa
- delove s većim dubinama (prostorne delove, npr. kada za kupanje)
- manje serije sa estivim zamenama i podezavanjima alata
- deblje limove



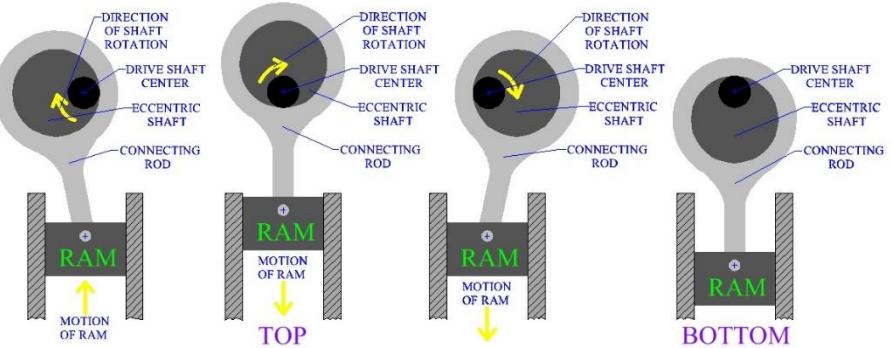
Krivajne prese

CRANK PRESS



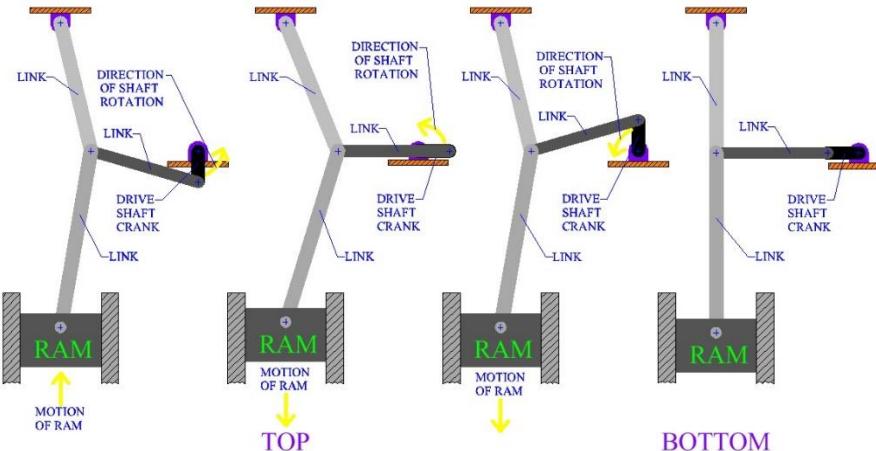
Ekscentar prese

ECCENTRIC PRESS



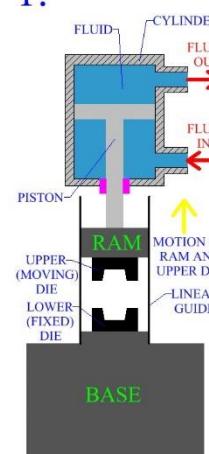
Kolenaste prese

KNUCKLE JOINT PRESS



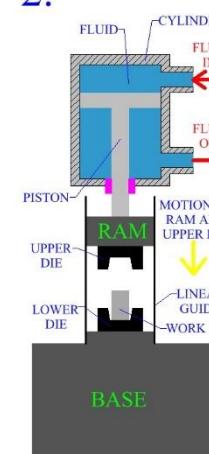
HYDRAULIC PRESS

1.



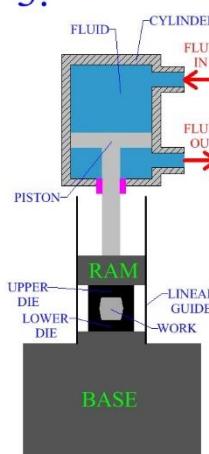
A HIGHER PRESSURE OF THE FLUID BELOW THE PISTON THAN THE FLUID ABOVE IT CAUSES THE PISTON TO RISE

2.



MOTION OF RAM AND UPPER DIE
LINEAR GUIDE WORK

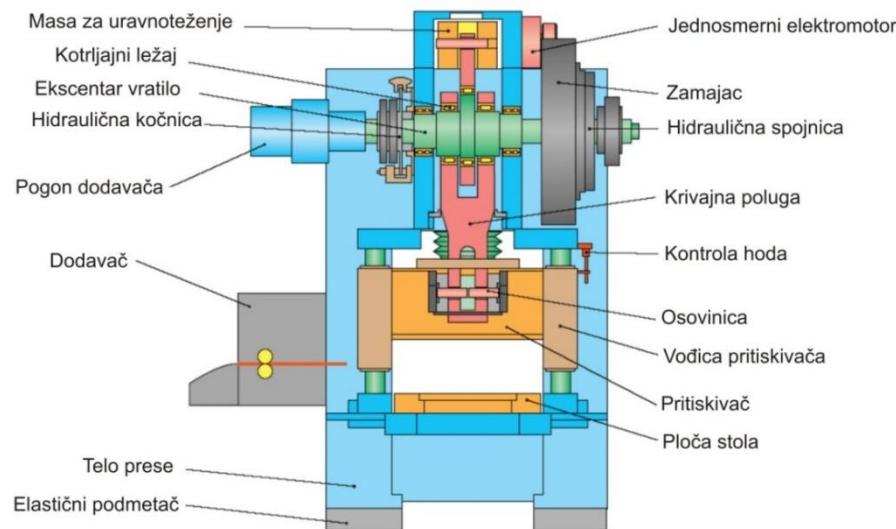
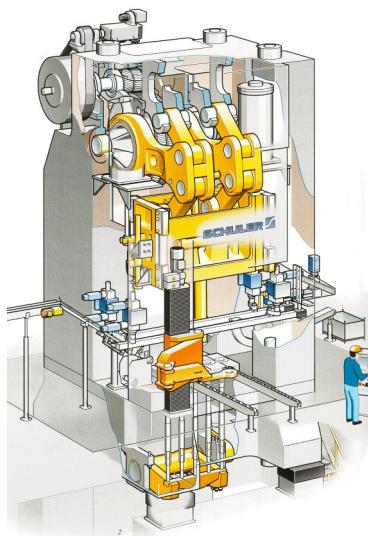
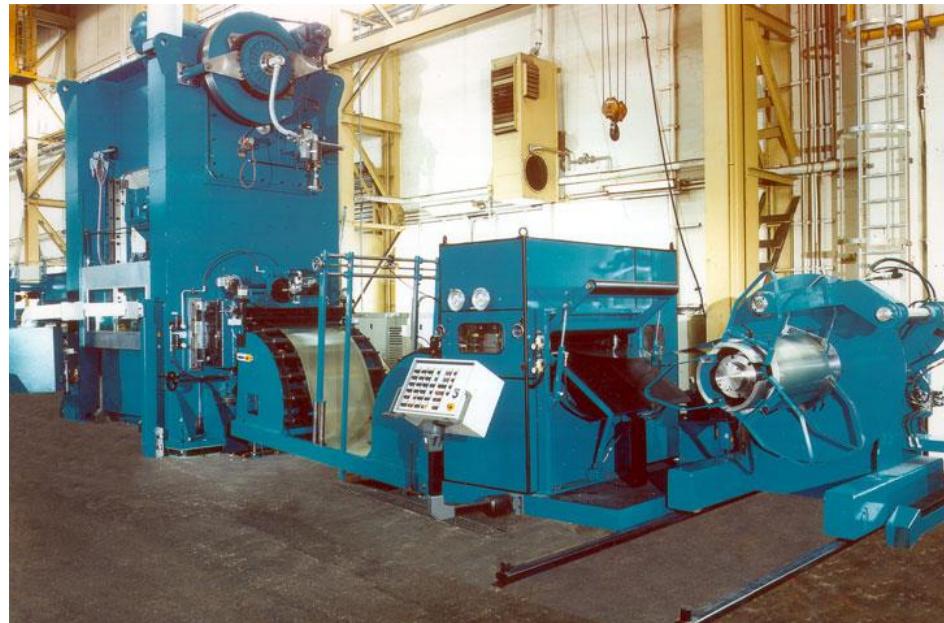
3.



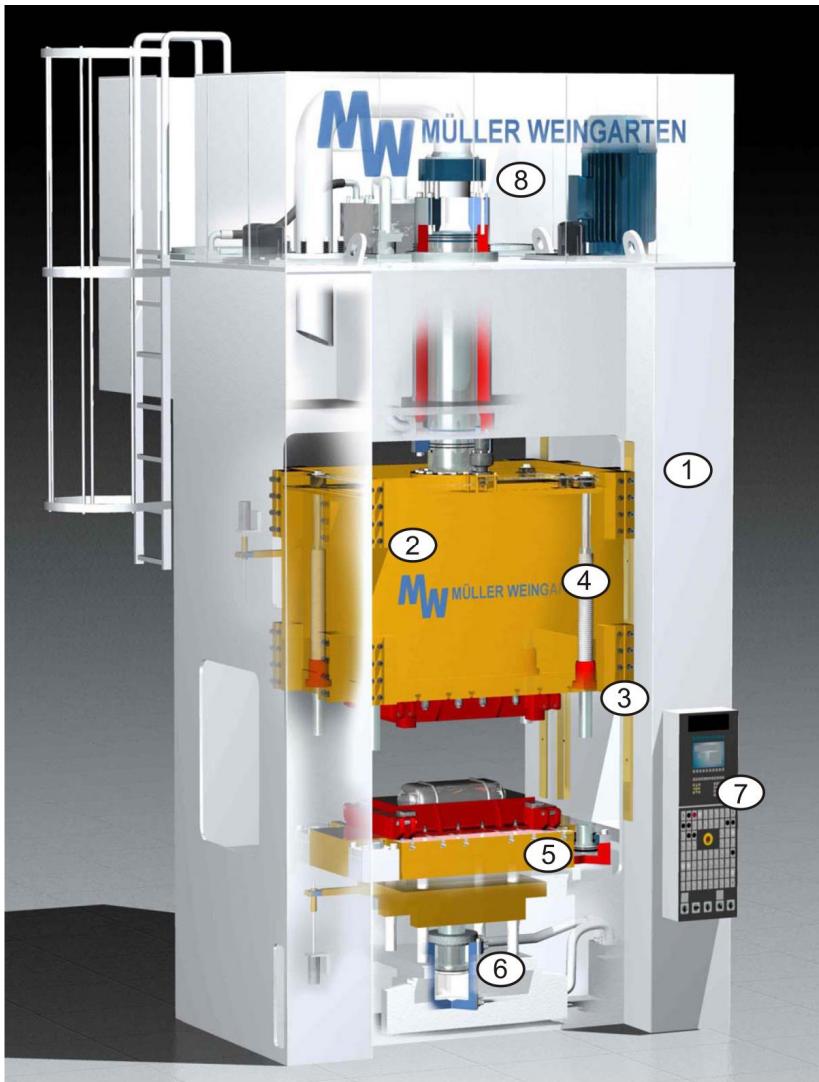
THE FLUID PRESSURE DELIVERED THROUGH THE APPARATUS CLOSES THE MOLD AND FORMS THE PART



Mehaničke prese

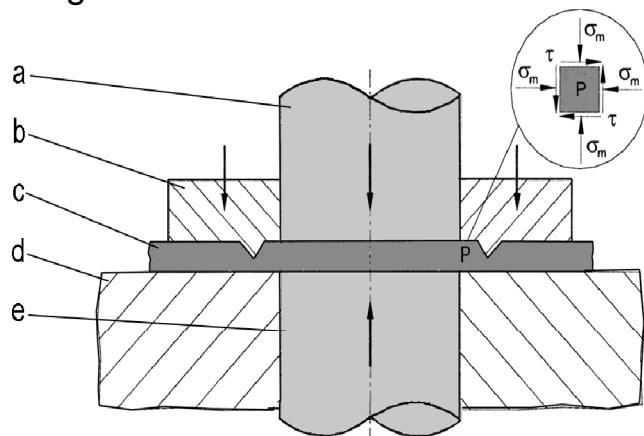


Hidraulične prese

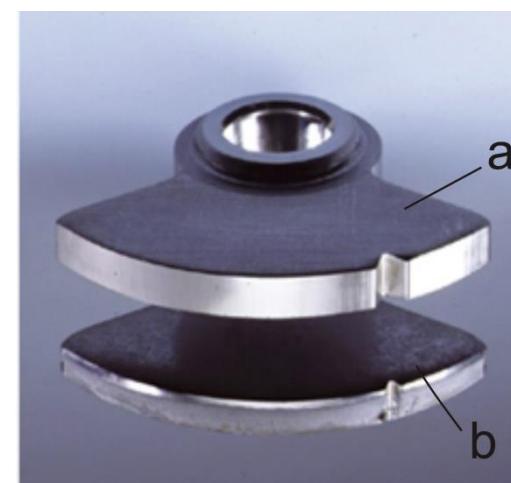
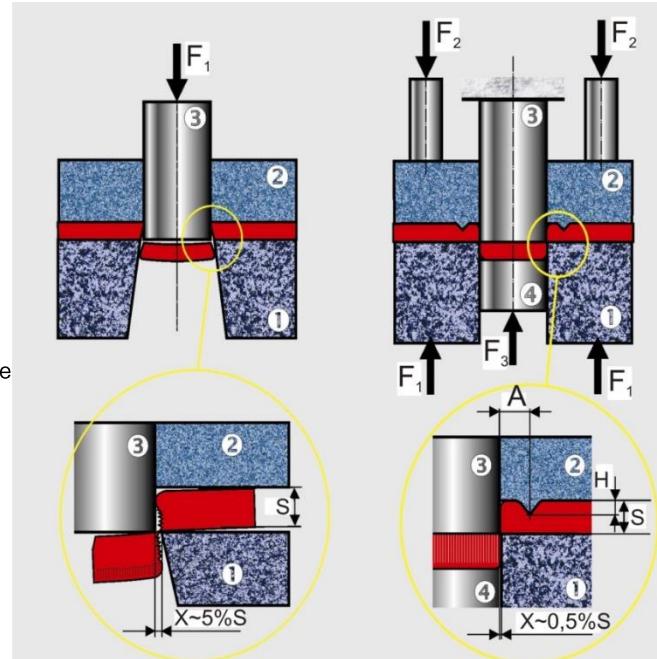
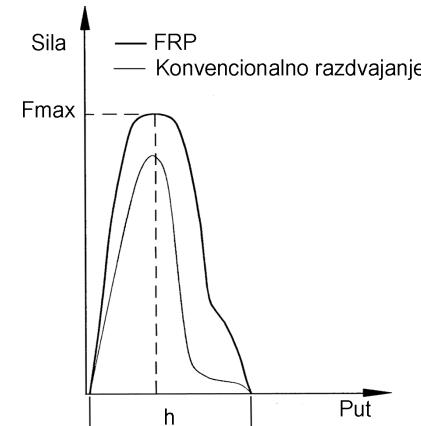
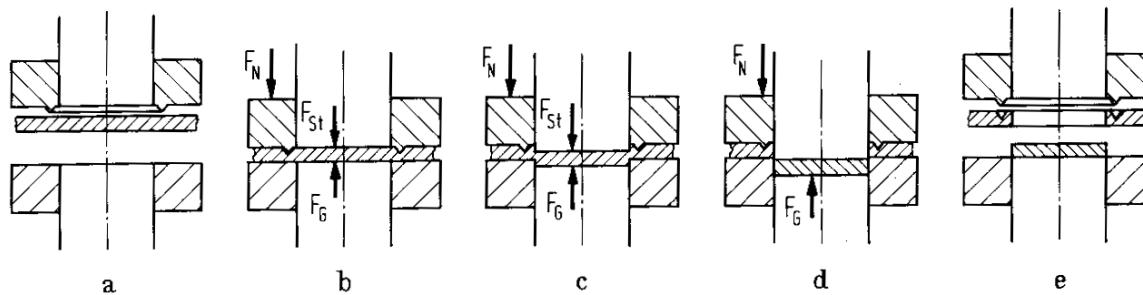


Fino razdvajanje presovanjem

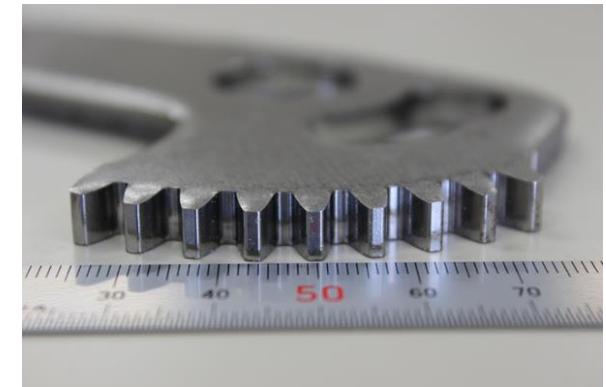
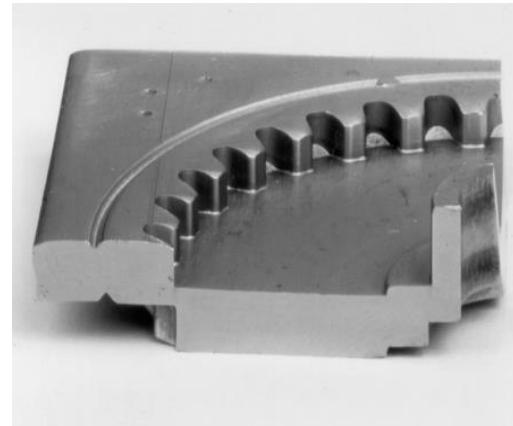
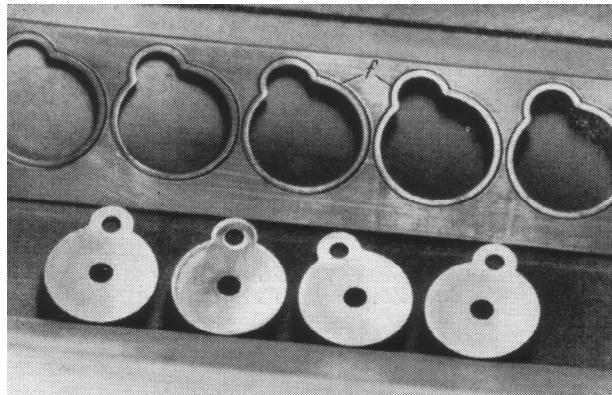
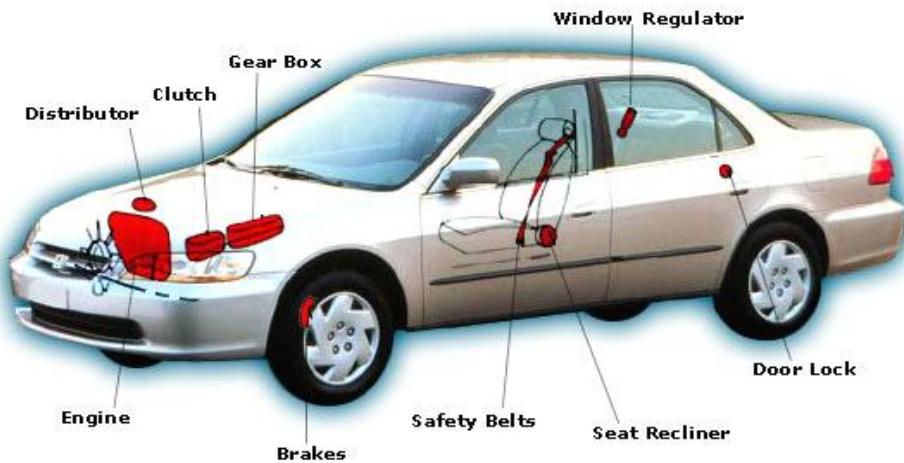
- “ Fino razdvajanje presovanjem je obrada lima razdvajanjem kojom se dobija visok kvalitet i tačnost prese ne površine delova
- “ Proces se izvodi na specijalnom alatu s konturnim zubom koji se utiskuje u lim neposredno pre delovanja Oiga



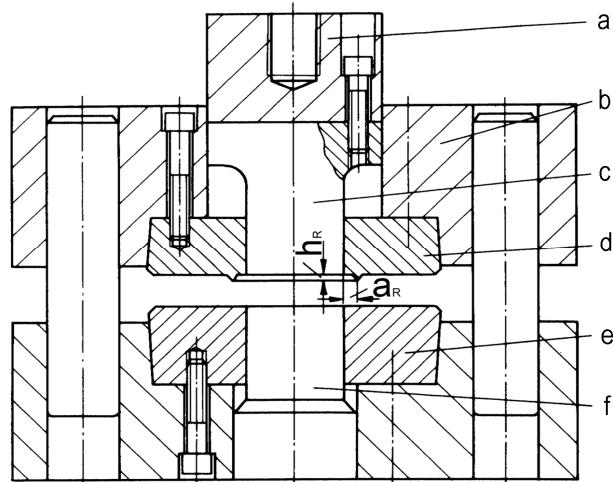
a . Oig, b . konturni zub, c . lim
d . matrica, e . protiv Oig



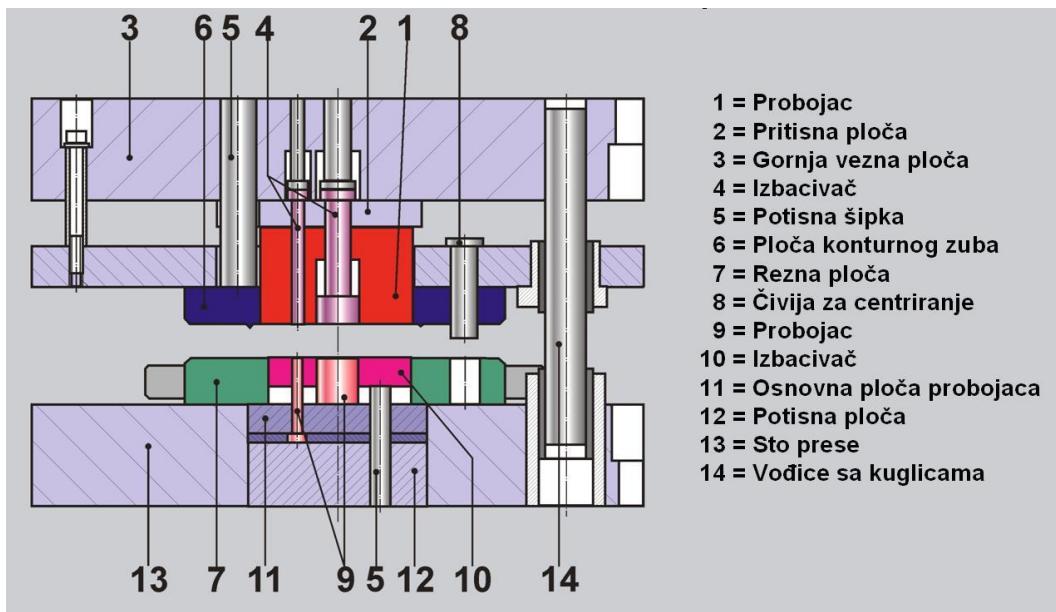
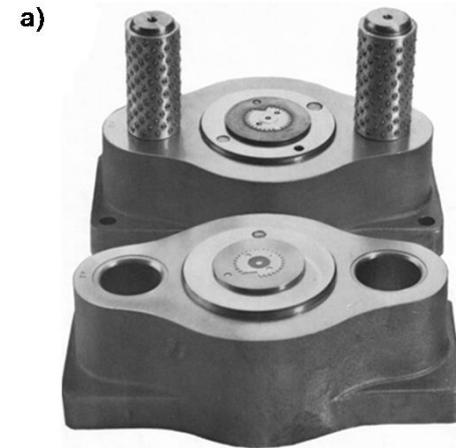
Fino razdvajanje presovanjem



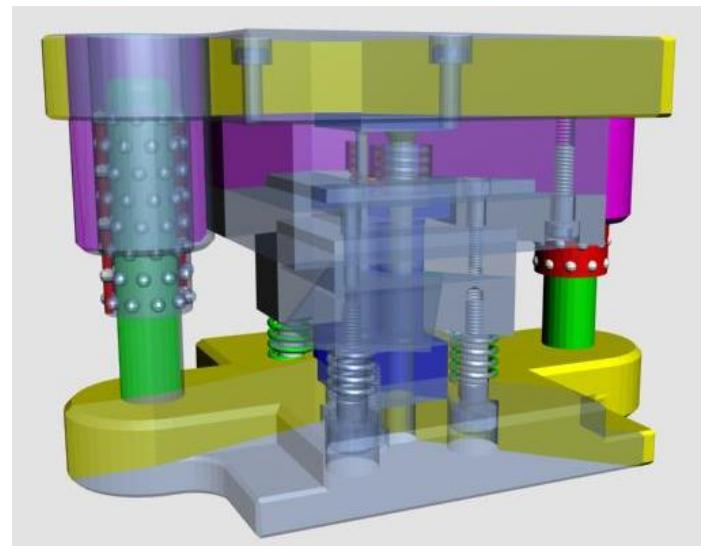
Alati za fino razdvajanje presovanjem



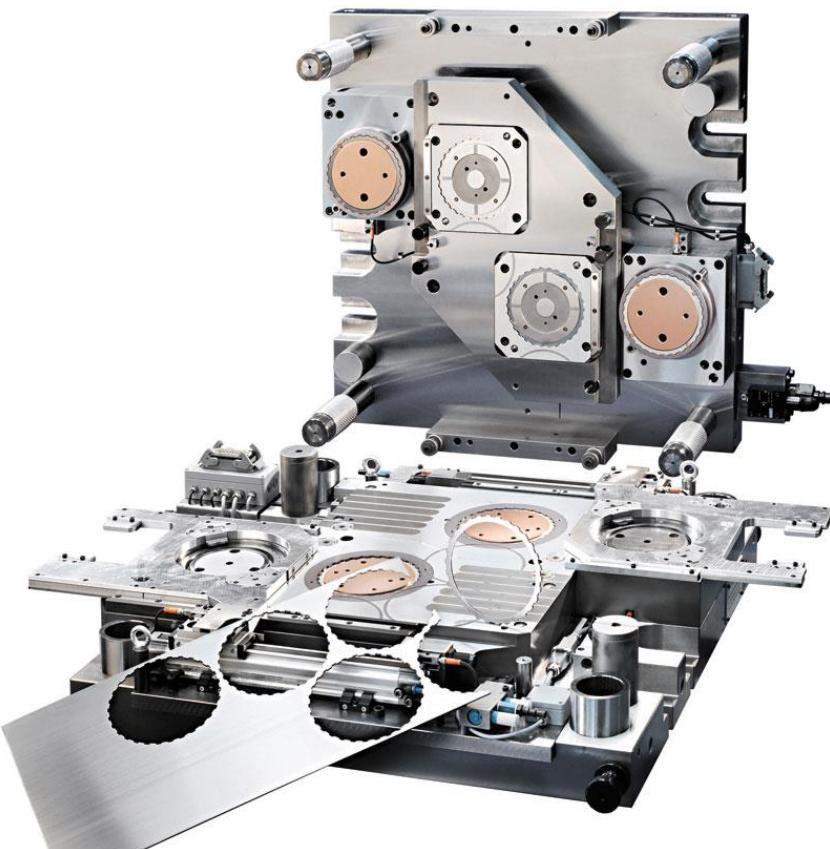
- a) glava Oiga
- b) telo alata
- c) žig
- d) ploča konturnog zuba
- e) Matrica
- f) protiv Oig.



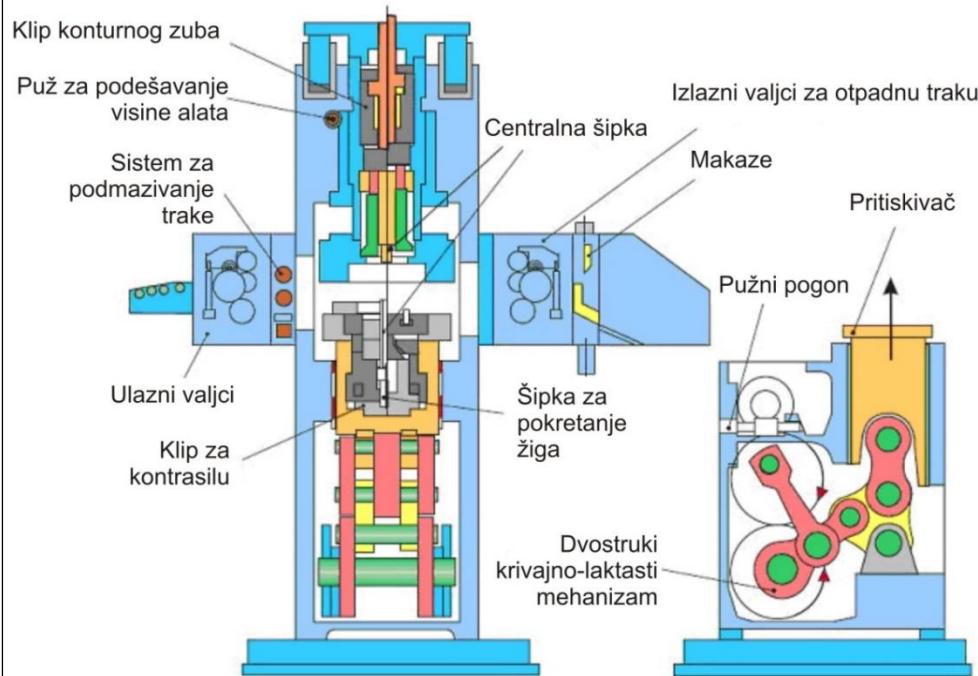
- 1 = Probojac
- 2 = Pritisna ploča
- 3 = Gornja vezna ploča
- 4 = Izbacivač
- 5 = Potisna šipka
- 6 = Ploča konturnog zuba
- 7 = Rezna ploča
- 8 = Čivija za centriranje
- 9 = Probojac
- 10 = Izbacivač
- 11 = Osnovna ploča probojaca
- 12 = Potisna ploča
- 13 = Sto prese
- 14 = Vođice sa kuglicama



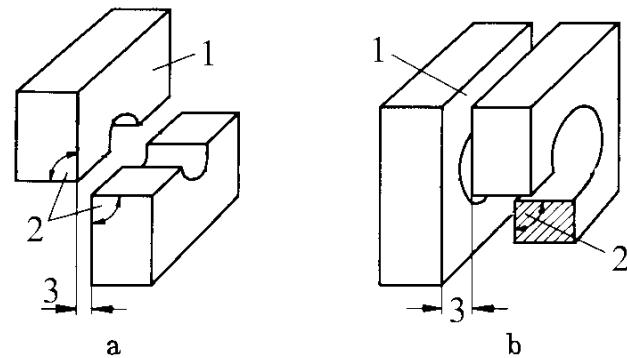
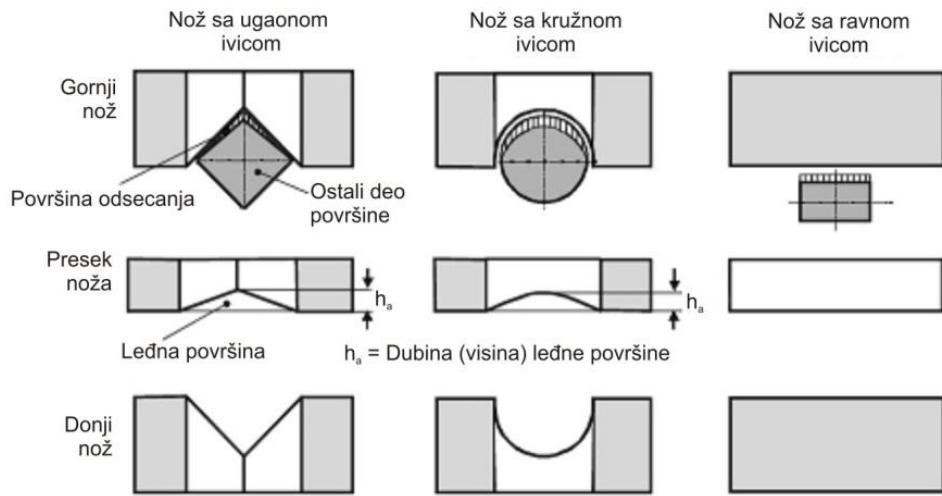
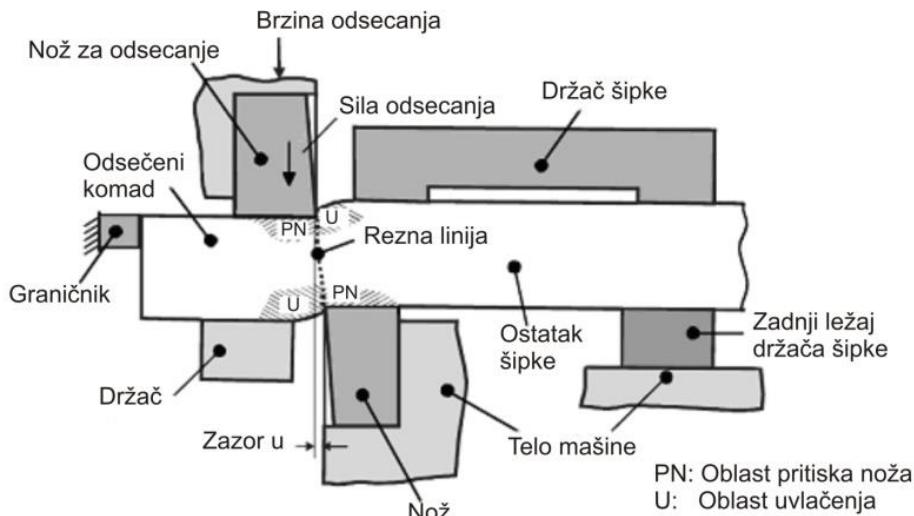
Alati za fino razdvajanje presovanjem



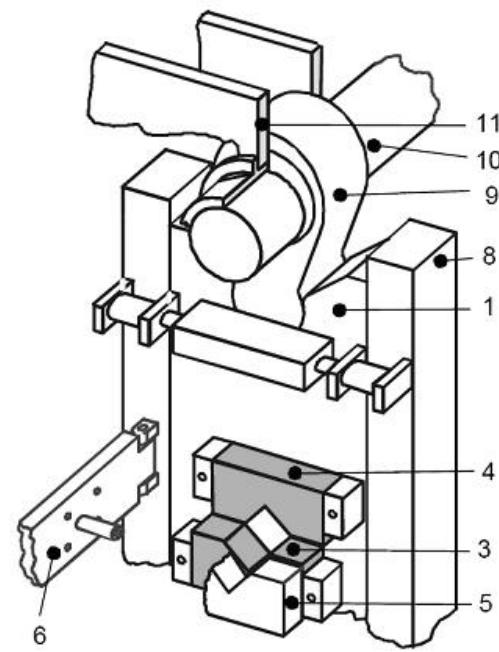
Masine za fino razdvajanje presovanjem

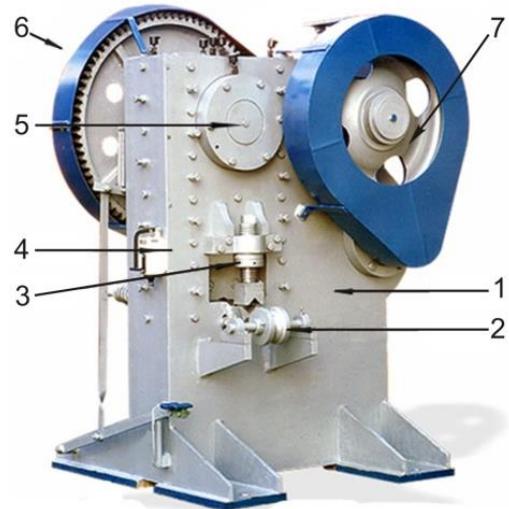


Razdvajanje lomljenjem

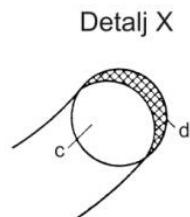
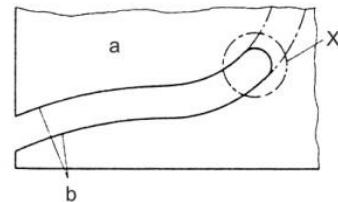


$$F = A \cdot K_s$$





Prese za parcijalno razdvajanje – seckalice



a – lim, b – rezna linija, c – alat, d – odsečeni deo lima

