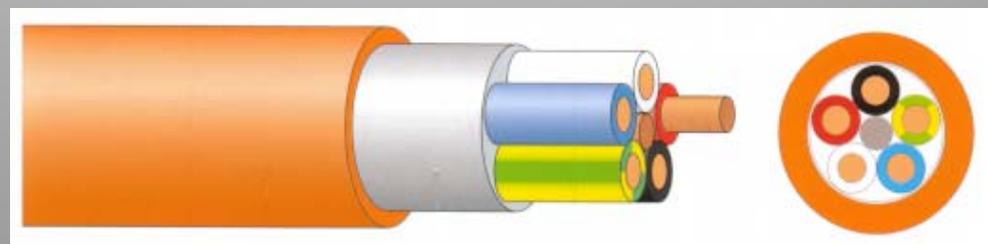
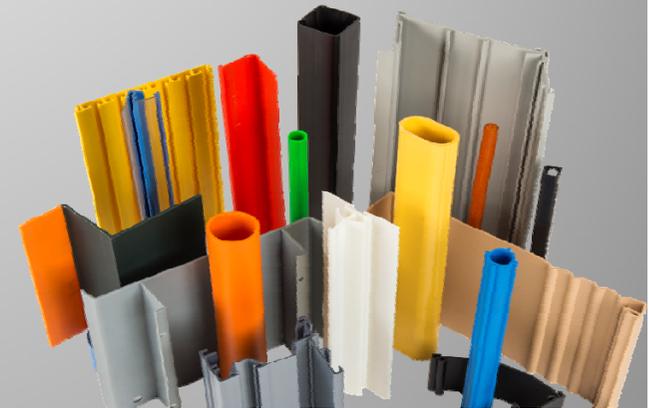
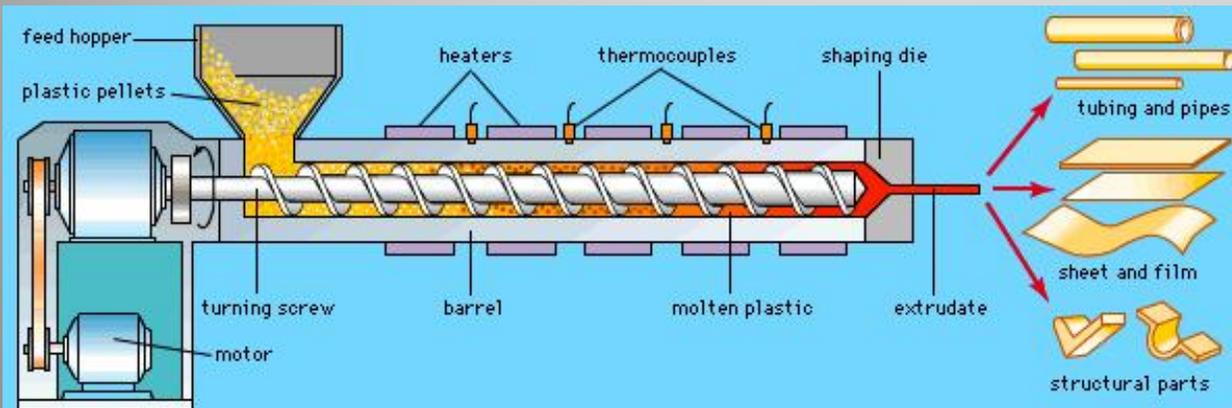
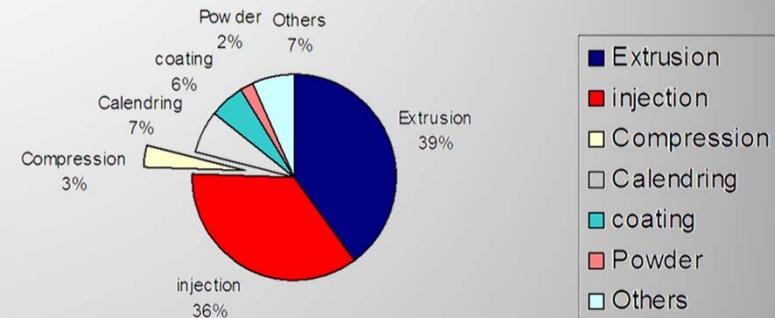


MAŠINE I UREĐAJI ZA PRERADU PLASTIKE

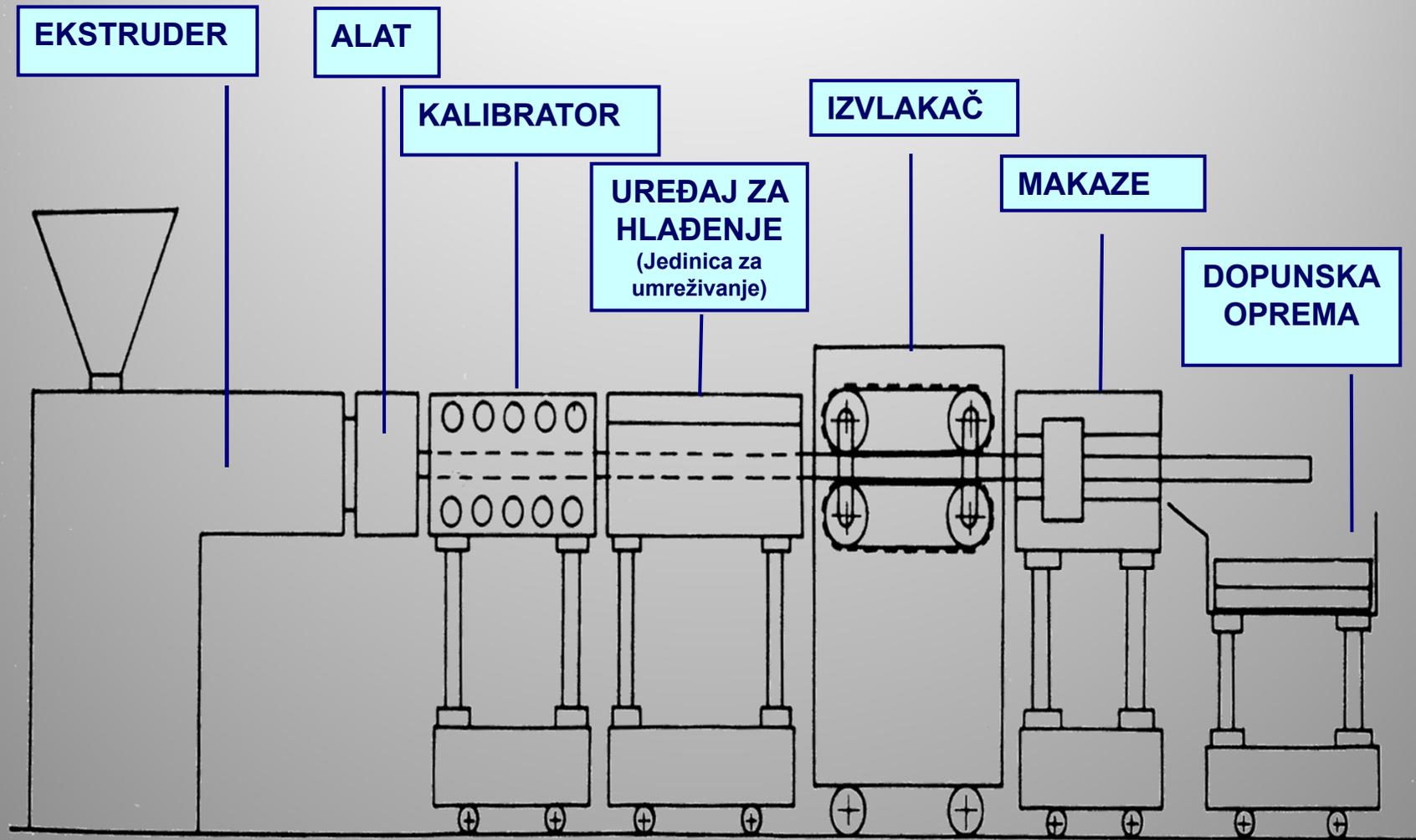
EKSTRUDIRANJE

- ❖ Ekstrudiranje je najrašireniji postupak prerade polimera!
- ❖ Kontinualni proces!
- ❖ U osnovi, ekstrudiranje se sastoji od kontinuiranog protiskivanja rastopljenog polimera kroz alat i njenog očvršćavanja u zadani oblik proizvoda (ekstrudata).
- ❖ Ekstrudiraju se gotovo svi materijali!

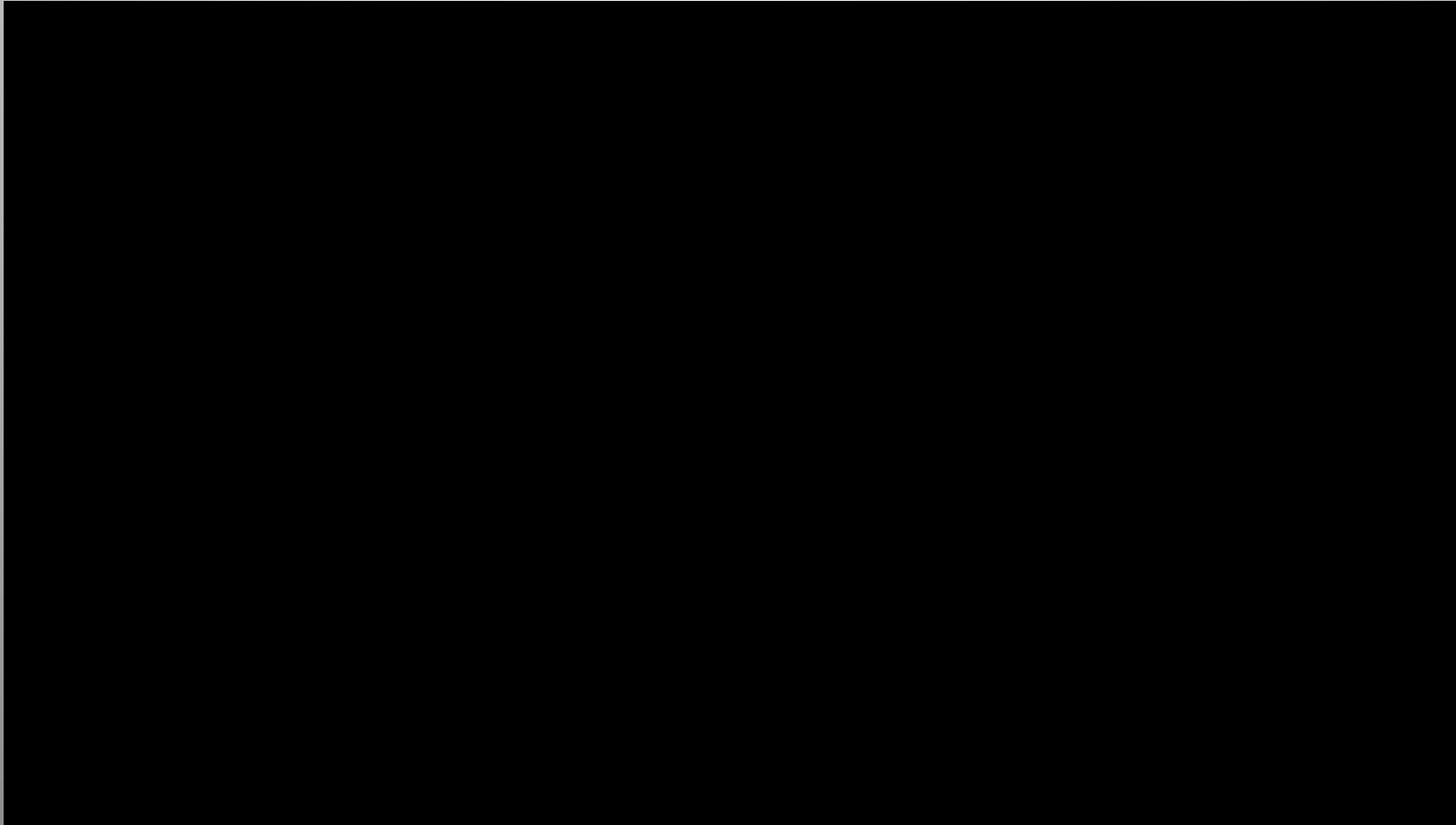


**Plastic Travel
through the Extruder**

Linija za ekstrudiranje (shematski)

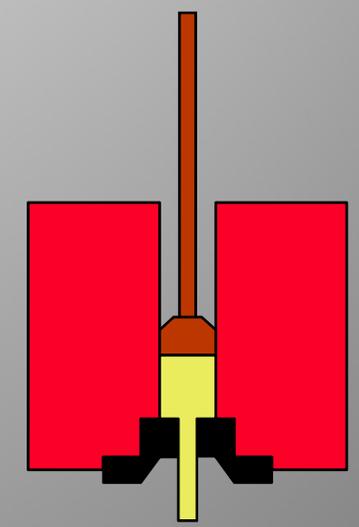
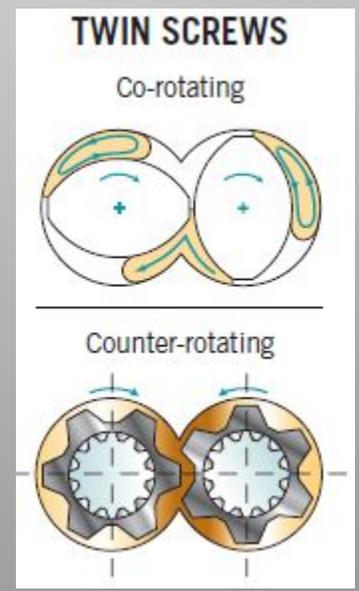
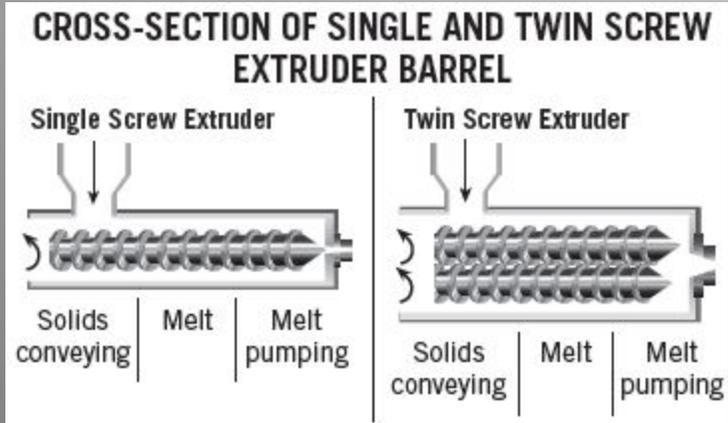
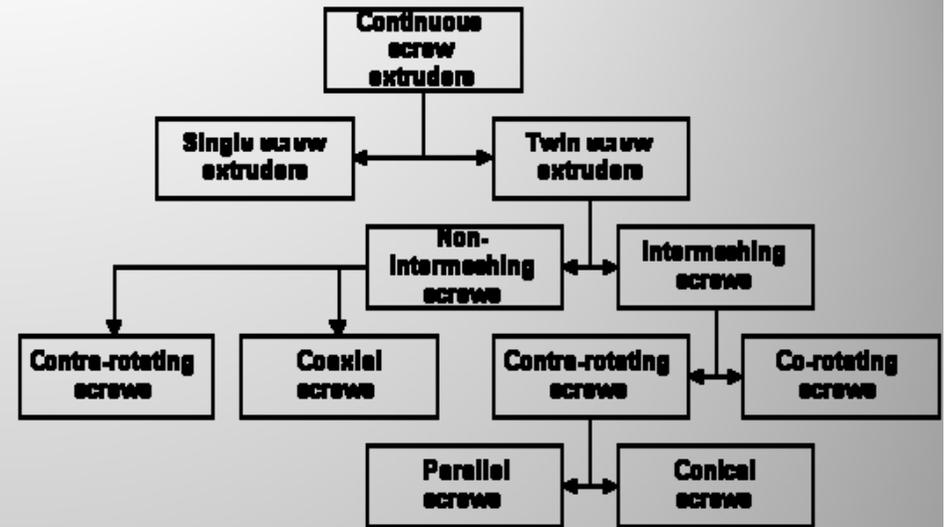


Procesi prerade plastike - pregled



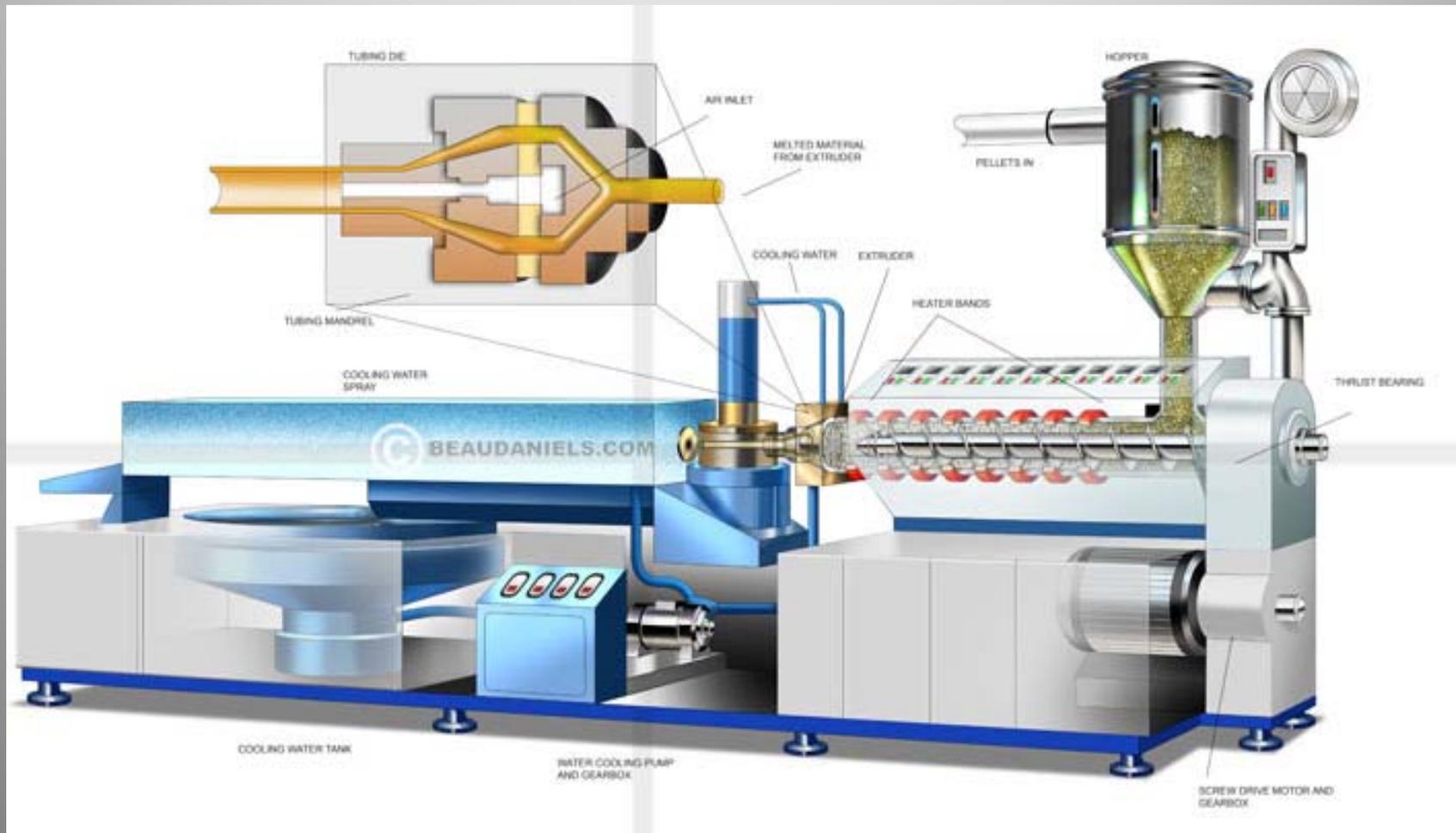
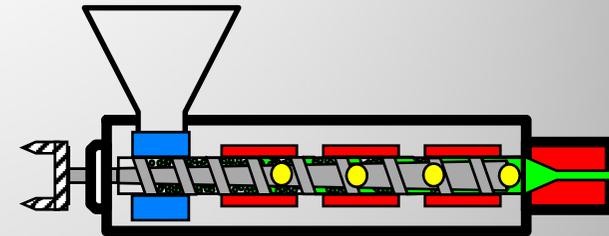
TIPOVI (podela) EKSTRUDERA

Screw extruders (continuous)	Single screw extruders	Melt fed Plasticating Single stage Multi stage Compounding
	Multi screw extruders	Twin screw extruders Gear pumps Planetary gear extruders Multi (>2) screw extruders
Disk or drum extruders (continuous)	Viscous drag extruders	Spiral disk extruder Drum extruder Diskpack extruder Stepped disk extruder
	Elastic melt extruders	Screwless extruder Screw or disk type melt extruder
Reciprocating extruders (discontinuous)	Ram extruders	Melt fed extruder Plasticating extruder Capillary rheometer
	Reciprocating single screw extruders	Plasticating unit in injection molding machines Compounding extruders such as the Kneader



Ekstruder sa jednim pužem – singl ekstruder

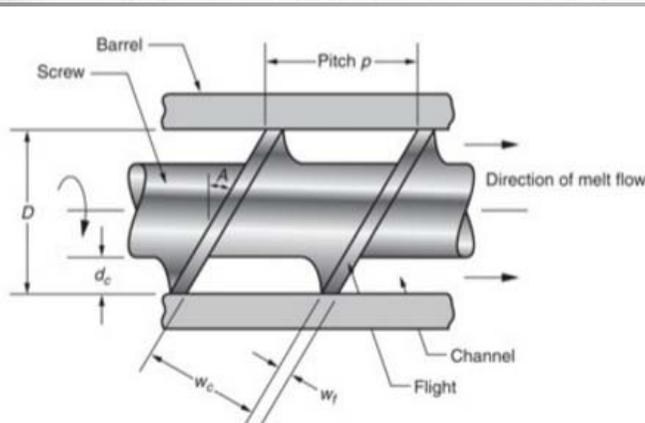
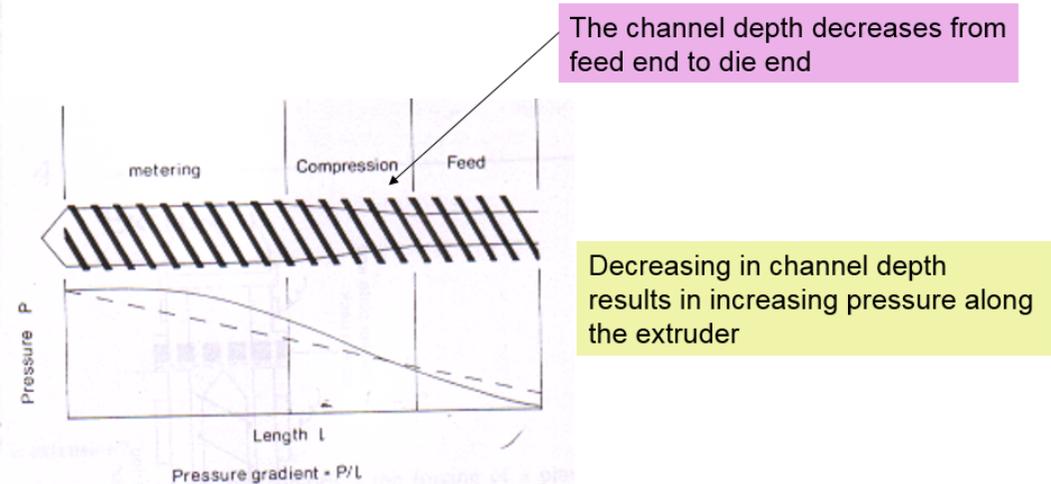
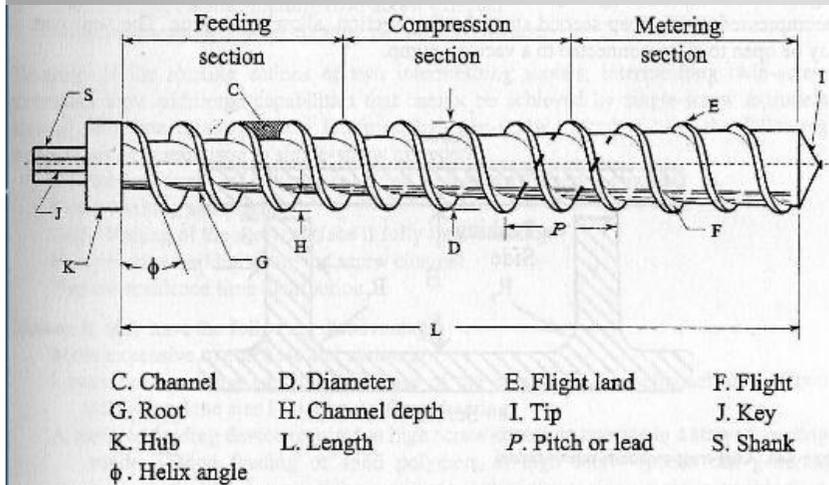
- niža cena,
- jendostavna, robusna i pouzdana konstrukcija,
- dobre tehničke performanse



Ekstruder sa jednim pužem – singl ekstruder

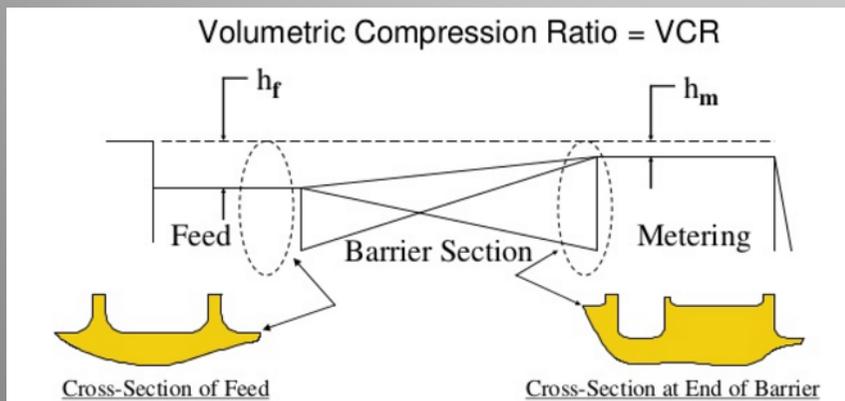
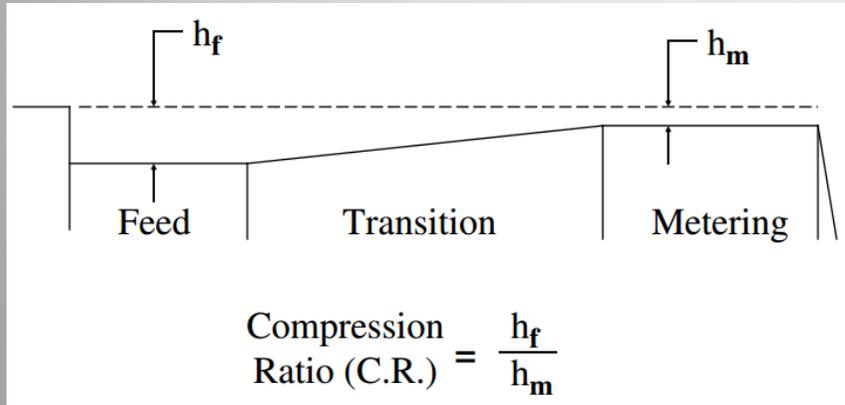
- funkcije puža -

- Transport rastopljenog polimera kroz ekstruder (cilindar)
- Mešanje
- Obezbedi pritisak neophodan za potiskivanje rastopa kroz matricu
- Da prenese mehaničku energiju kao deo procesa topljenja



- Stepen kompresije ekstrudera h_F / h_M
- Odnos dužine i prečnika puža $L/D - 20 \div 30$ (24)

Ekstruder sa jednim pužem – singl ekstruder - stepen kompresije -



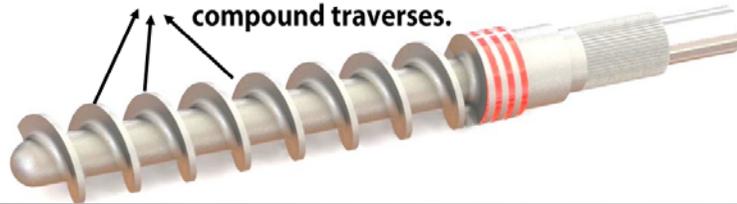
SCREW COMPRESSION RATIO

Material	Compression ratio
TPE - thermoplastic elastomers	3.5 : 1
PVC-P - polyvinyl chloride plasticised	2.5-3.5 : 1
PVC-U - polyvinyl chloride unplasticised	1.75-2.5 : 1
PS - polystyrene	3.0-3.5 : 1
PP - polypropylene	3.0-4.0 : 1
PMMA - polymethyl methacrylate	1.8-2.8 : 1
PE-LD - polyethylene low-density	3.5-4.0 : 1
PE-HD - polyethylene high-density	3.0-3.5 : 1
PC - polycarbonate	2.25 : 1
PA66 - Polyamide 66	3.0-4.0 : 1

Ekstruder sa jednim pužem – singl ekstruder - geometrija puža-

Increase Of No. of Flights → **Decrease In Output**

□ **FLIGHTS:** The built up part in between which the rubber compound traverses.



Increase Of Pitch → **Increase In Output**

□ **PITCH:** Distance between two consecutive flights



Increase Of Core Diameter → **Decrease In Output**

□ **CORE DIAMETER:** Diameter of the Core Shaft



Simple Calculation for Rate

$$Rate = 2.3 \times D^2 \times h_m \times MD \times N$$

Where:

D = Screw Diameter

h_m = Metering Depth

MD = Melt Density of the resin (gm/cc)

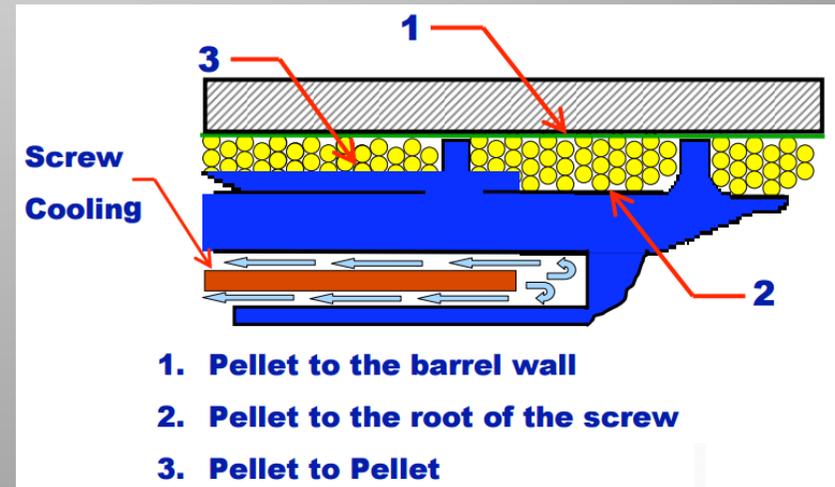
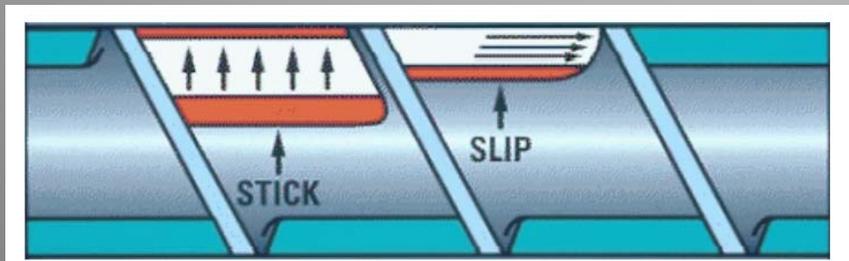
N = Screw Speed (rpm)

Ekstruder sa jednim pužem – singl ekstruder - geometrija puža-

Zona uvlačenja (Feed zone)

- Predgrevanje polimera i potiskivanje do naredne zone
- Uzvlačenje granula iz levka
- Dubina zavojnica puža konstantna
- Sekcija ima mali, konstantan prečnik korena puža – rezultat velika dubina zavojnice što omogućava prihvat velikih granula i drugih aditiva

- 5 to 6 turns - typical
- 8 to 10 turns for poor feeding materials
- 10 to 12 turns when the material requires heat to be absorbed before it can be melted.



Ekstruder sa jednim pužem – singl ekstruder - geometrija puža-

Kompresiona zona (Compression zone)

Druga zona - smanjuje se dubina kanala (zavojnice)

Naziva se kompresiona ili tranziciona zona (transition zone)

Komprimovanje materija – rezultat postepenog povećanja prečnika korena puža duž ove sekcije. Istovremeno dolazi do potiskivanja (unazad) vazdušnih džepova ili isparljivih materija.

Vazduh izlazi ili kroz ventilacione otvore ili zazor puž/cilindar

- Length should match melting rate of polymer of resin being processed
- This is where all of the work is done and more generally the most amount of screw and barrel wear is seen.
- Typically 5 to 10 turns long

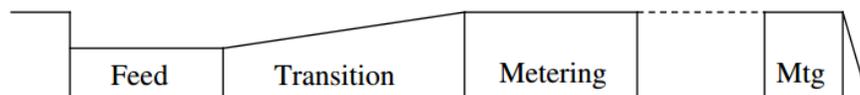


Ekstruder sa jednim pužem – singl ekstruder - geometrija puža-

Zona istiskivanja/doziranja (Metering zone)

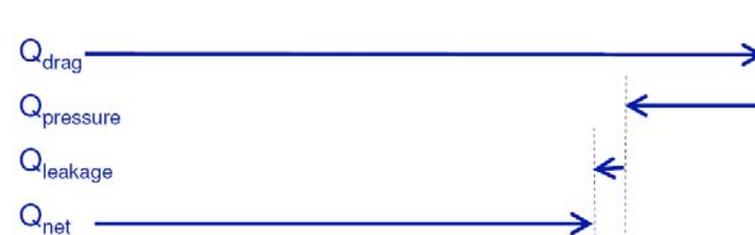
- Konstanta dubina navoja sa veoma plitkom zavojnicom
- Funkcija - homogenizuje rastopa, potiskivanje rastopa u alat i završno mešanje
- Mala dubina zavojnice obezbeđuje intenzivno trenje čime se osigurava topljenje i najtvrdih čestica
- Intenzivno trenje diže pritisak rastopa čime se omogućava potiskivanje rastopa kroz alat

- Minimum of 5 to 6 turns before mixer, even if a mixer is being used, to help insure stable output and pumping.
- 2 Turns after mixer for re-orienting the melt.
- Longer Metering Section typically for Non-barrier type screws.



Pumping in the Metering

$$Q_{\text{net}} = Q_{\text{drag}} - Q_{\text{Pressure}} - Q_{\text{leakage}}$$

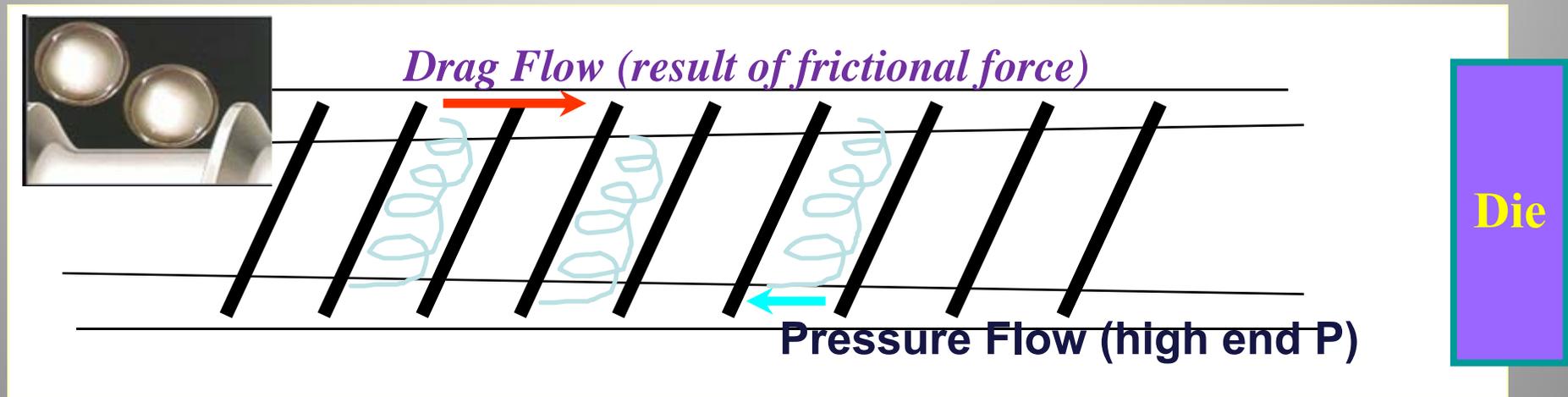


- Pressure Flow must never be greater than 33% of Drag Flow
- On a new screw Leakage Flow is typically less than 1%

$$Q_m = \frac{p\rho V_{bz} WHF_d}{2} - \frac{p\rho WH^3 F_p}{12\eta} \left[\frac{\partial P}{\partial z} \right]$$

Flow of Plastics Through Extruder barrel

1. **drag flow** : molten plastic is pushed forward (along screw edges)
2. **pressure flow** : reverse flow due to high end pressure
3. **leak flow** : reverse flow over screw edges

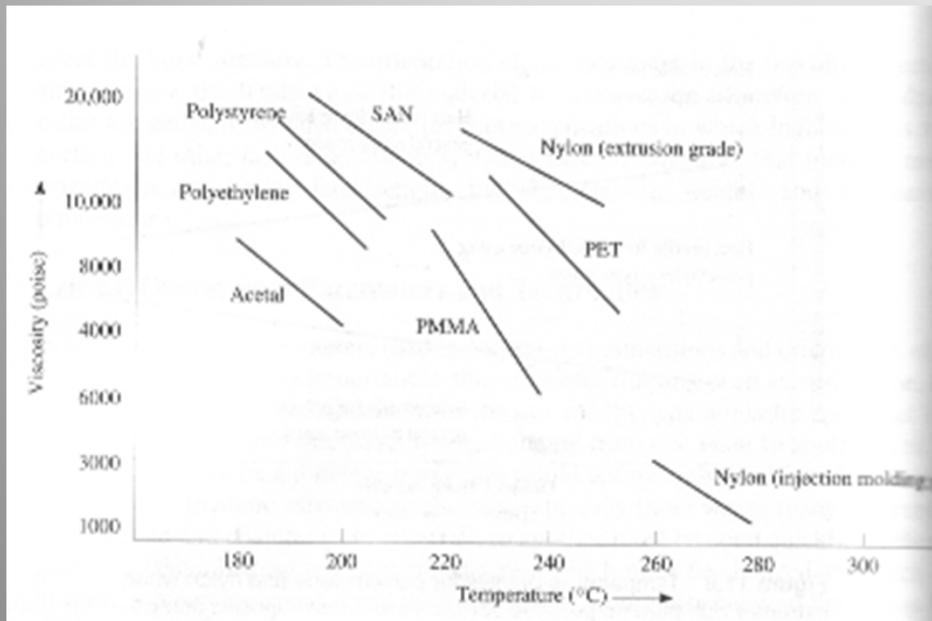


$$\text{Total flow} = \text{drag flow} - \text{pressure flow} - (\text{leak flow})$$

Output ↓ as pressure at the end of screw ↑
factors: screw geometry, screw speed, barrel Temp, flow of plastics

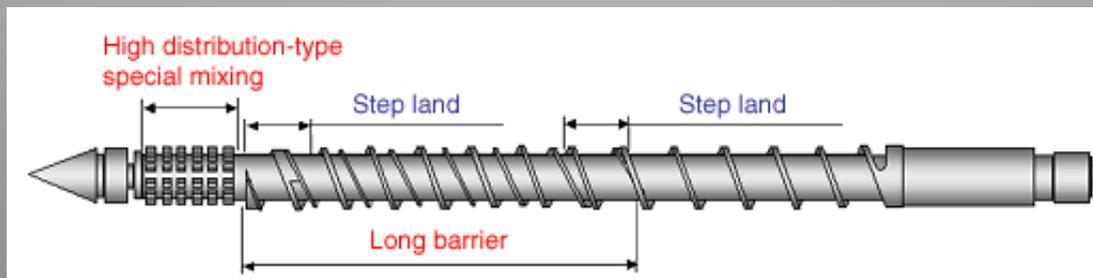
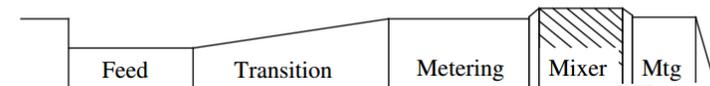
Ekstruder sa jednim pužem – singl ekstruder - geometrija puža, puž sa mikserom -

- Mešanje dva ili više materijala izuzetno zavisi od viskoznosti (materijali se mešaju efikasnije kada imaju sličnu viskoznost (npr. temperature mešanja PMMA i PE je na 218C)

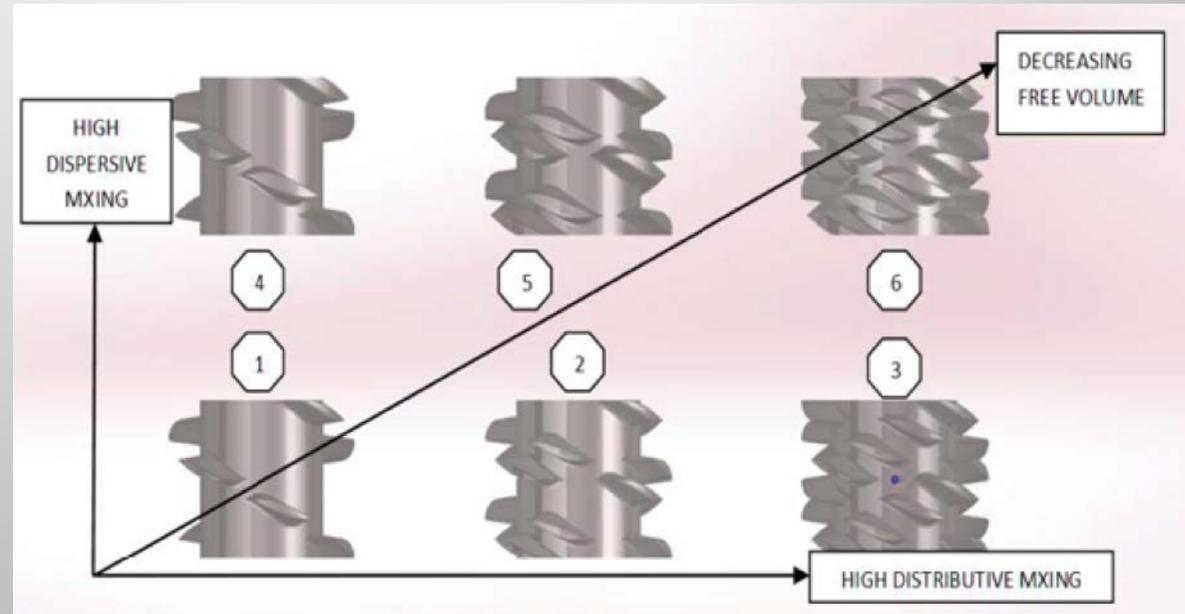
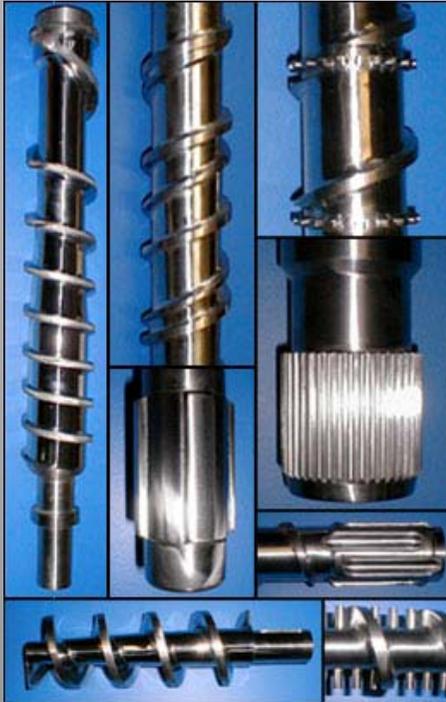


Section Lengths - Mixers

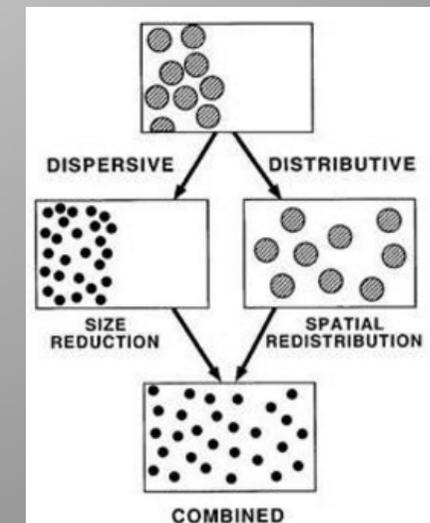
- Two types of Mixing - Distributive and Dispersionary Mixing
- Most mixers are 2 turns long
- Some of the more intense dispersionary mixers are 3+ turns long.
- Mixers should be located back from the tip of the screw approximately 2 turns to help in re-orienting the melt.



Ekstruder sa jednim pužem – singl ekstruder - geometrija puža, puž sa mikserom -



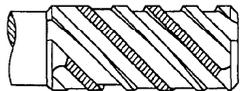
- Pri zadatoj brzini puža, najveći napon smicanja javlja se kada materijal ima najveći viskozitet što pospešuje disperzivno mešanje
- Mešanje materijala i poprečni tok pri niskom pritisku pospešuju distributivno mešanje
- Pravilnom konstrukcijom puža u smislu geometrije sekcija (zona), konfiguracije, i orijentacije omogućuje kako disperzivno tako i distributivno mešanje



Ekstruder sa jednim pužem – singl ekstruder - geometrija puža, puž sa mikserom -



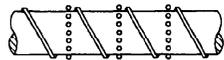
UC (MADDOCK) MIXING SECTION-1967



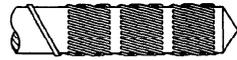
EGAN MIXING SECTION



BLISTER RING



PIN MIXING SECTION



DULMAGE MIXING SECTION



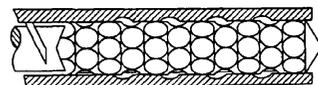
SAXON MIXING SECTION



PINEAPPLE MIXING SECTION

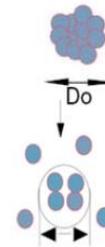


SLOTTED SCREW FLIGHT



CAVITY TRANSFER MIXING SECTION

Dispersive
Mixing
=
Break up of
agglomerates and
aggregates

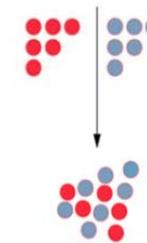


Screw elements for dispersive mixing

Kneading blocs and kneading discs

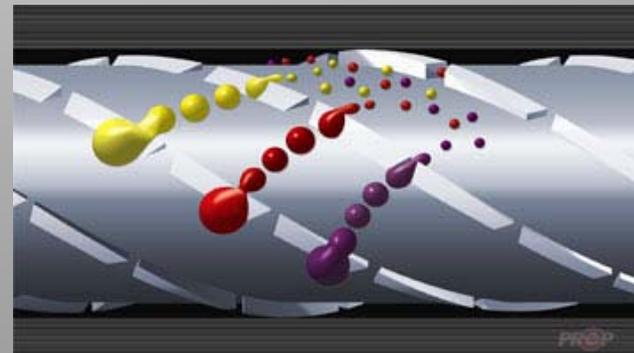


Distributive
Mixing
=
Distribution of
primary particles



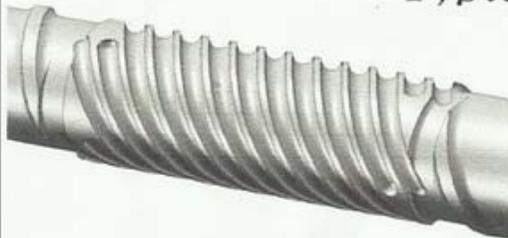
Screw elements for distributive mixing

Mixing elements for the incorporation of fibers,
fillers or for blending polymers



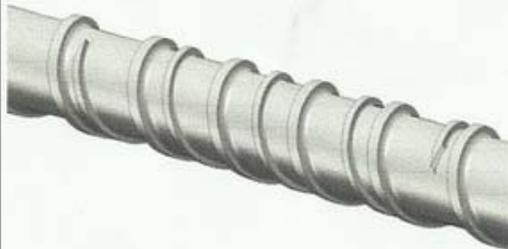
Ekstruder sa jednim pužem – singl ekstruder - geometrija puža, puž sa mikserom -

Typical **CONCOR** Mixer Options



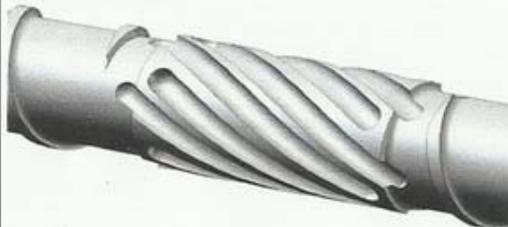
Dulmage Mixer

This is a high shear dispersive mixer used primarily for creating a good homogenous melt and color dispersion when processing unfilled nylon.



Concor Barrier

Provides improved melt quality and increases throughput rates an average of 10% - 20% for a wide range of materials.



Spiral Maddock Mixer

Dispersive type mixer for good homogenous melt for any non-shear sensitive materials such as Olefins.

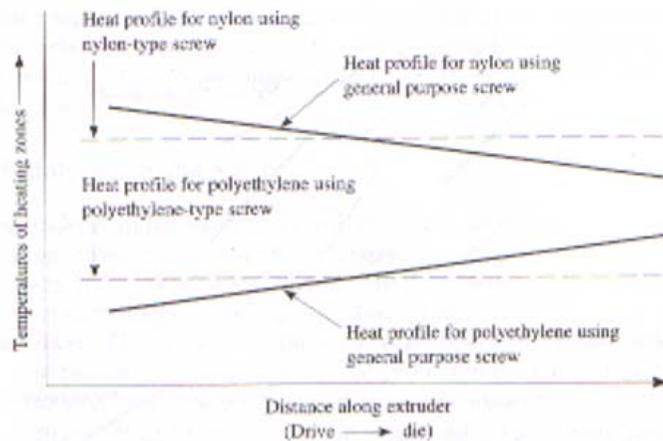


Saxton Mixer

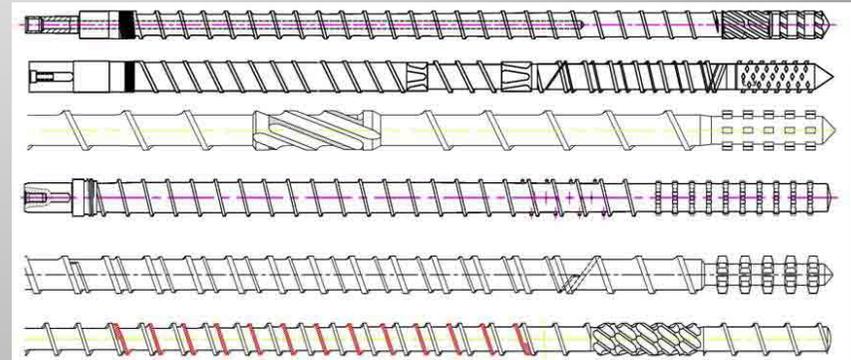
General purpose distribution mixer provides good melt quality and color mix for most materials.

Ekstruder sa jednim pužem – singl ekstruder - specijalni puževi -

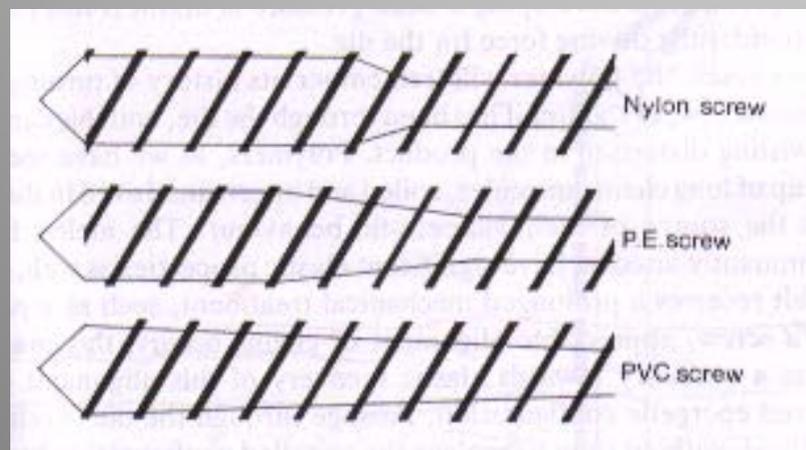
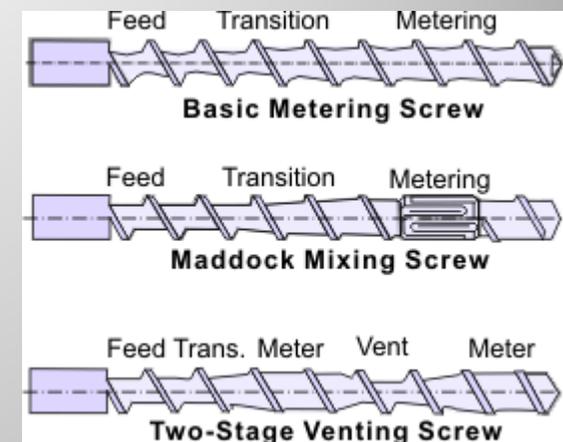
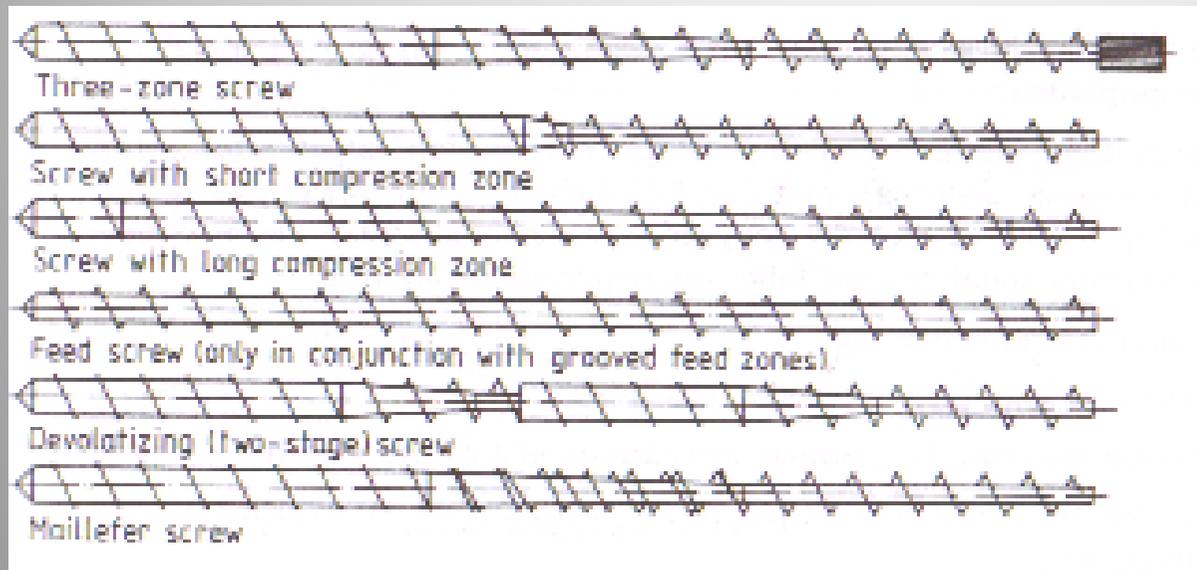
- Modifikacija osnovnog dizajna puža je potrebna da bi se dobila dobra distribucija rastopa.
- Međutim promena dizajna puža je težak zadatak, tako da se generalno najviše koriste puževi opšte namene.
- Performanse puževa opšte namene mogu biti modifikovane promenama parametara procesa kao što su temperatura, brzina puža, itd



Temperature profiles for PE and nylon when extruded with general- purpose screws versus resin-specific screws



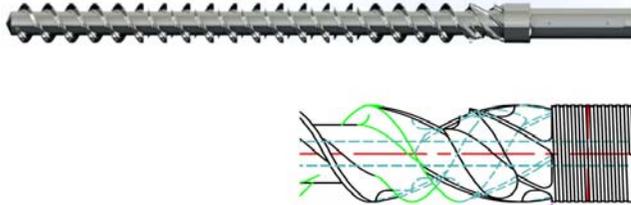
Ekstruder sa jednim pužem – singl ekstruder - specijalni puževi -



- PE tj. LDPE se topi postepeno – koristiti puž sa ukupnom dužinom jednako podeljenom između tri zone (PE puž)
- Ako se polimer naglo topi – potrebna je vrlo kratka kompresiona zona (puž za najlon)
- PVC – veoma sporo se topi (teško ga je ekstrudirati) – koristi se puž sa jednom dugom kompresionom zonom čitavom dužinom

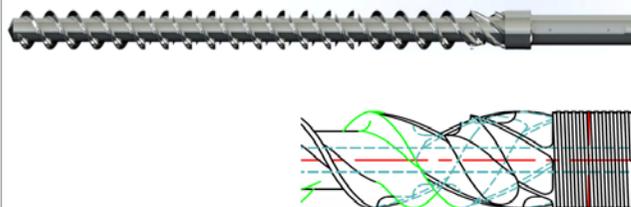
STANDARD SCREW

- 6 Flight Inlet Section
- Constant Pitch
- Constant Core Diameter



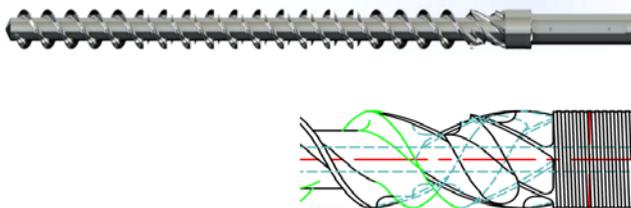
HIGH PERFORMANCE HOMOGENIZATION SCREW

- 6 Flight Inlet Section
- Constant Pitch (larger than standard screw)
- Constant Core Diameter



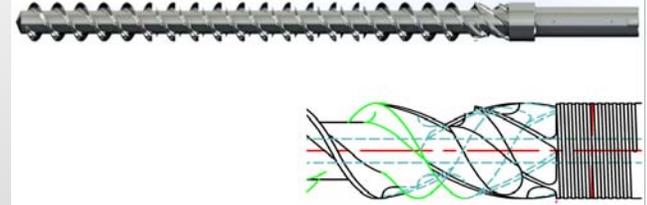
SCREW WITH THICKENED CORE

- 6 Flight Inlet Section
- Constant Pitch
- Constant Core Diameter (larger than standard screw)



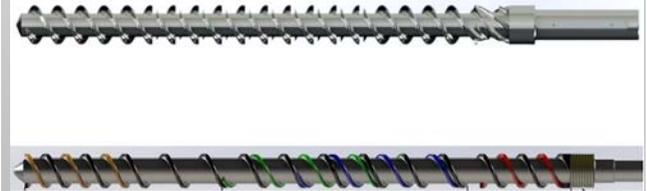
COMPRESSION SCREW WITH HIGHER HOMOGENIZATION

- 6 Flight Inlet Section
- Variable Pitch
- Increasing Core Diameter from Inlet To Tip



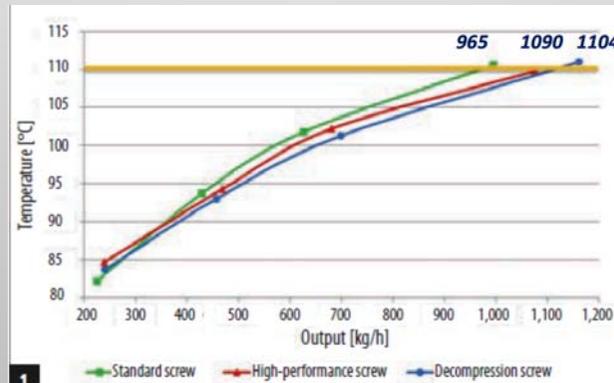
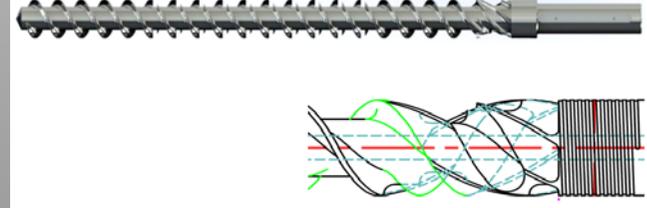
COMPRESSION SCREW

- 2 Flight Inlet Section
- Variable Pitch
- Increasing Core Diameter from Inlet To Tip



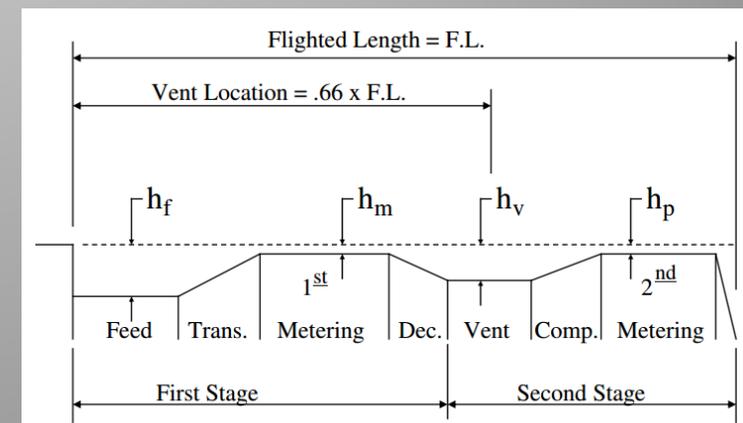
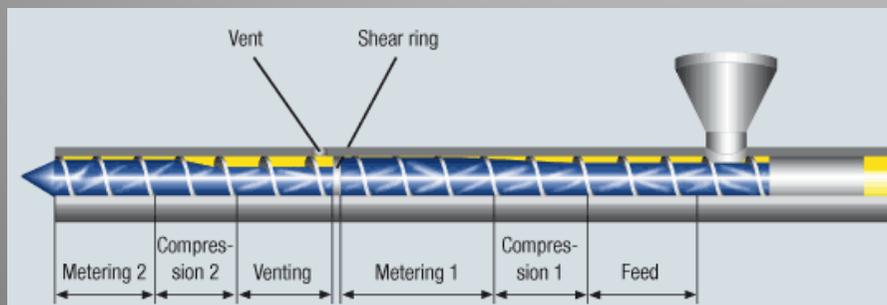
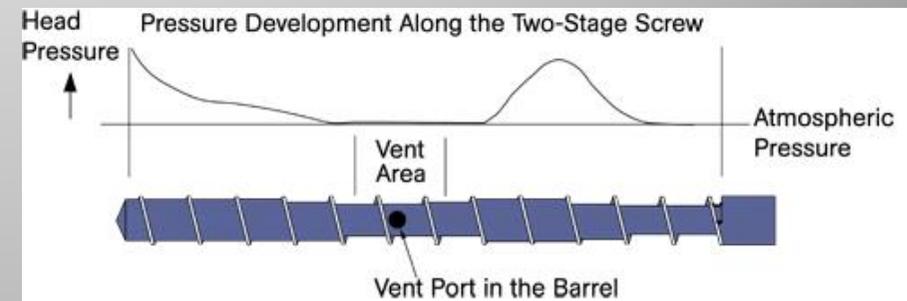
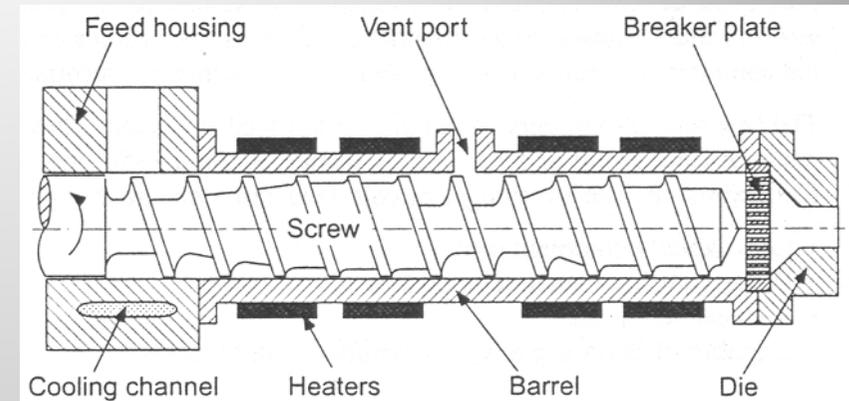
DECOMPRESSION SCREW

- 6 Flight Inlet Section
- Constant Pitch
- Decreasing Core Diameter from Inlet To Tip

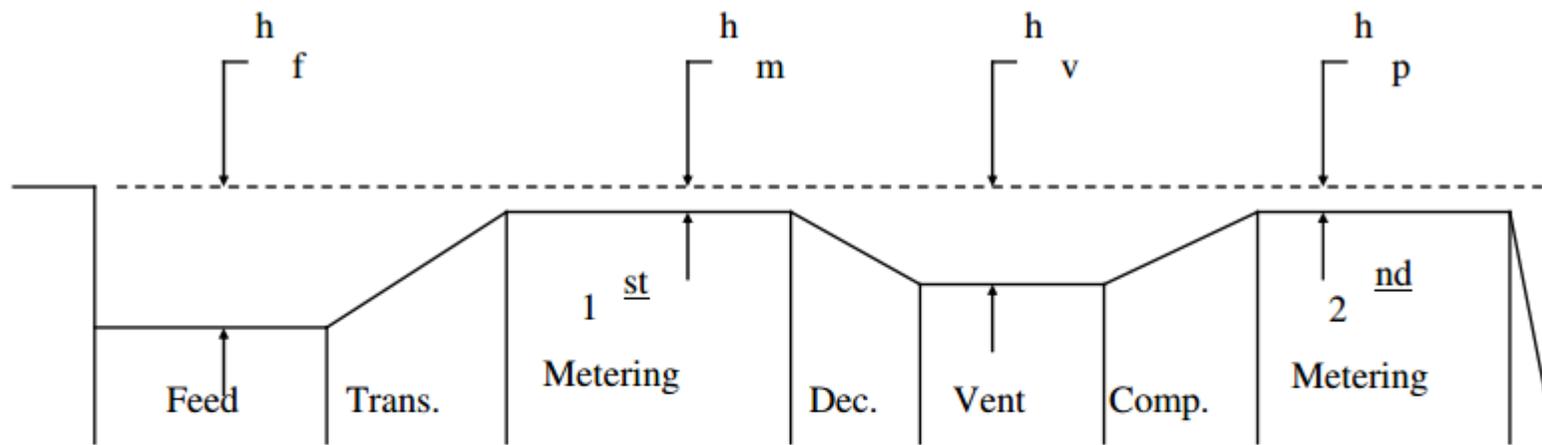


Ekstruder sa jednim pužem – singl ekstruder - ventilirajući ekstruderi-

- Postoje posebno dizajnirani otvori kroz koje se vrši odstranjivanje isparenja iz radnog cilindra koja su nastala oslobađanjem iz zagrejanog polimera.
 - Ponekad se ovi otvori mogu koristiti za drugu svrhu, npr. za dodavanje aditiva, boja, ispuna
 - Problem kod ovog ekstrudera je ometanje toka materijala na mestima ventilacionih otvora
 - Dvostepeni puž za odzračivanje
 - Tipičan vrednosti odnosa L / D kod dvostepenih puževa su 32: 1 do 36: 1.
 - U ekstremnim varijandama odnos L/D se kreće u rasponu od 24: 1 do 40: 1 i više.
- Kapacitet dvostepenog puža obično iznosi 2/3 od kapaciteta ekvivalentnog puža (iste dužine) normalne konstrukcije.



Ekstruder sa jednim pužem – singl ekstruder - ventilirajući ekstruderi-



$$\text{First Stage C/R} = \frac{h_f}{h_m}$$

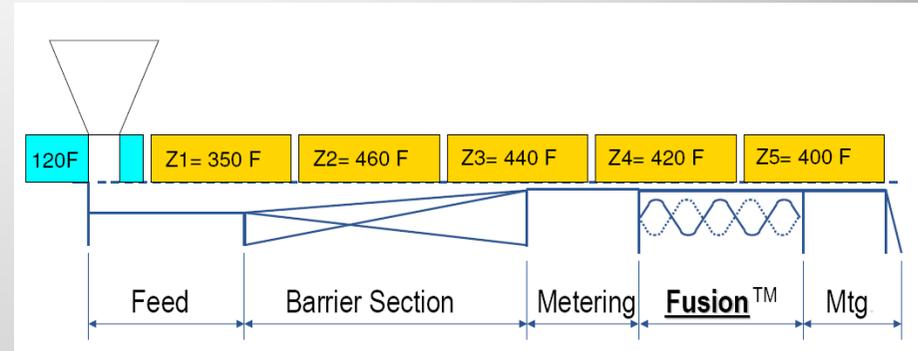
$$\text{Second Stage C/R} = \frac{h_v}{h_p}$$

NOTE:

Typically the Second Stage Compression Ratio is between 2:1 and 2.5:1

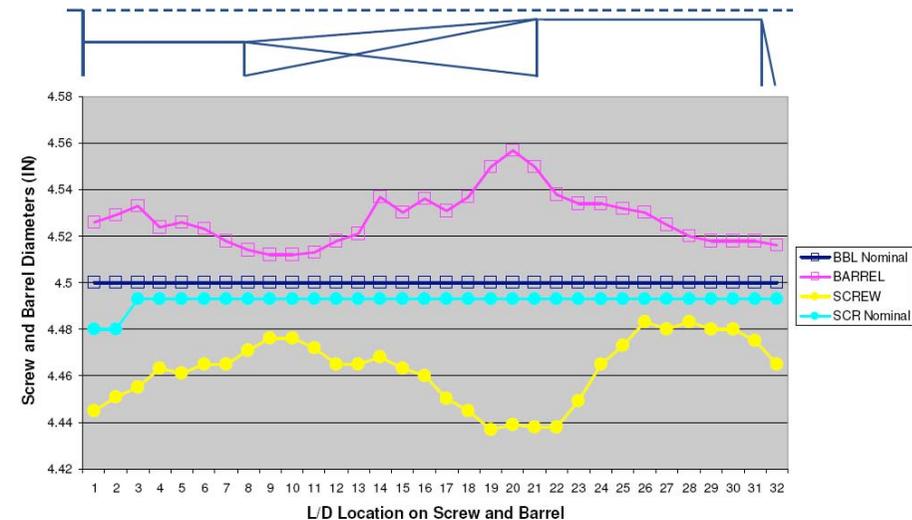
Ekstruder sa jednim pužem – singl ekstruder - barijerni puž-

- Advantages
 - Achieves more stable extrusion than simple conveying
 - No chance of unmelted material being beyond barrier section
 - Certain amount of dispersive mixing occurs as plastic flows over barrier into melt channel.
- Disadvantages
 - No better performers than screws with mixing sections
 - More expensive than non-barrier screws
 - More susceptible to plugging due to solid material restricted to the solids channel.
 - Melting can not keep up with reduction in the size of the channel in compression section of the screw, resulting in the solid material getting stuck in the screw channel.
 - Creates a momentary obstruction to flow and leads to surging or variation in extruder output



4.5" x 32:1 L/D Screw & Barrel Wear

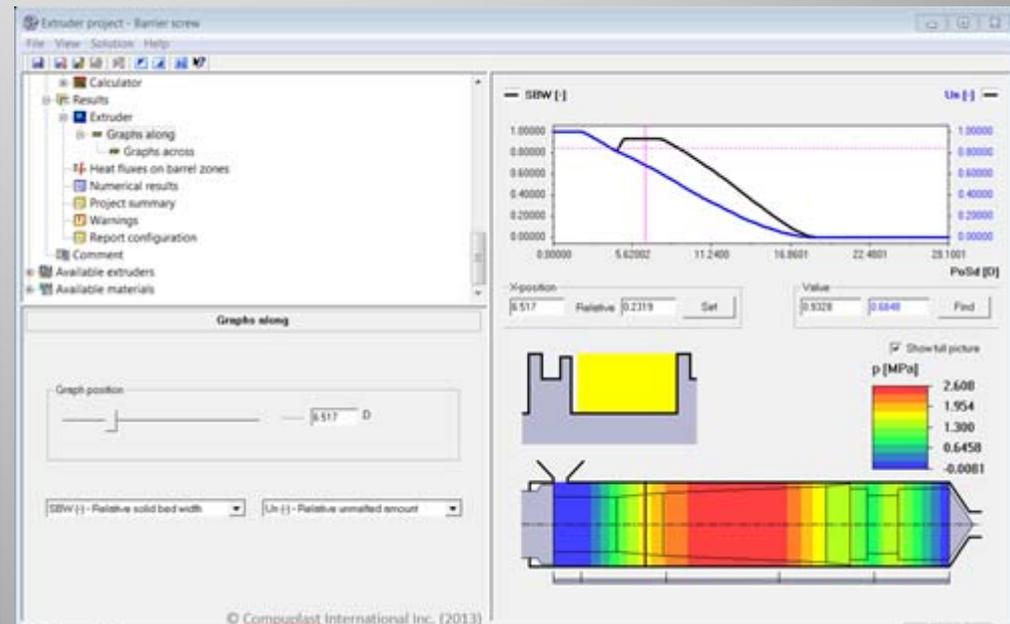
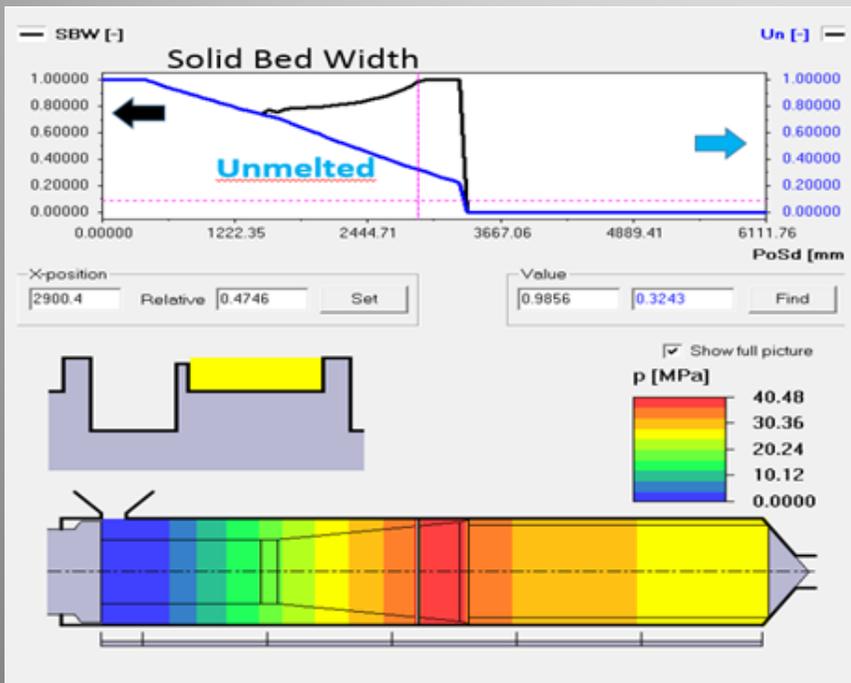
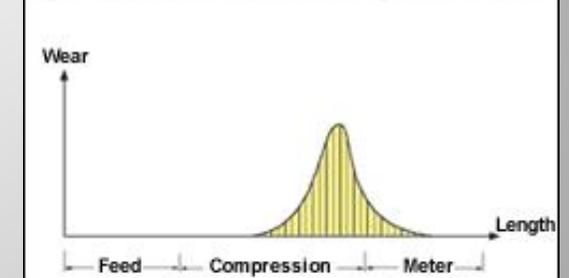
(Due to improper barrel temperature profile)



Ekstruder sa jednim pužem – singl ekstruder - Barijerni puž-



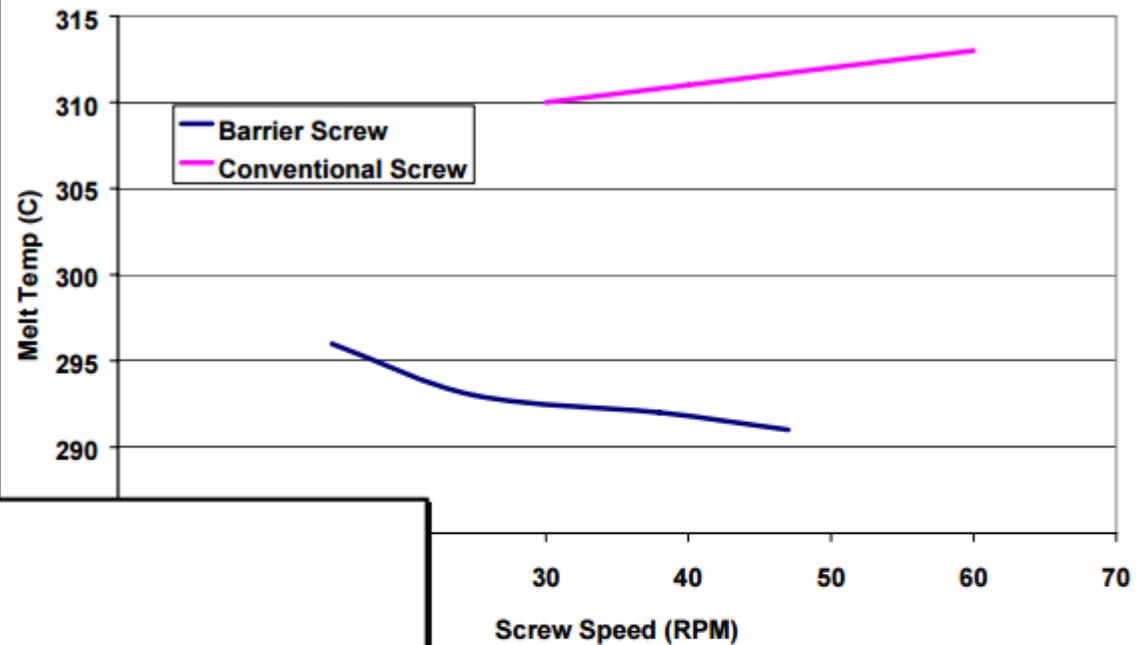
Fig. 1— Typical Wear Pattern in a Single-Screw Extruder



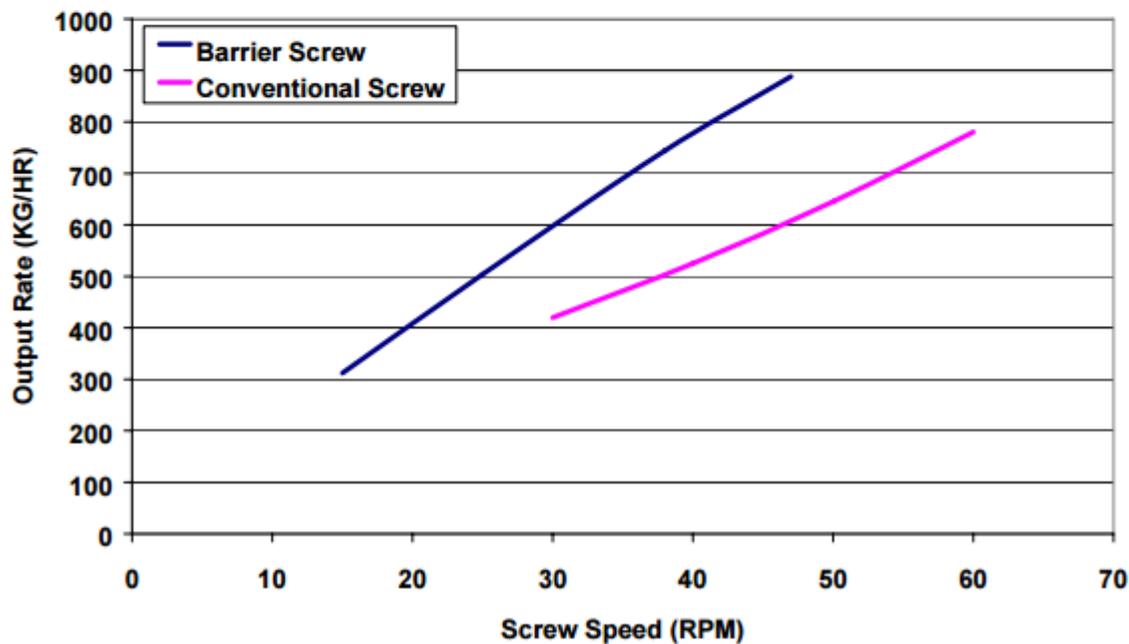
Performance Comparison

8", 30L/D Extruder
Resin: LLDPE Dowlex 3310
Conventional vs. Barrier

8", 30L/D Performance
LLDPE Dowlex 3310

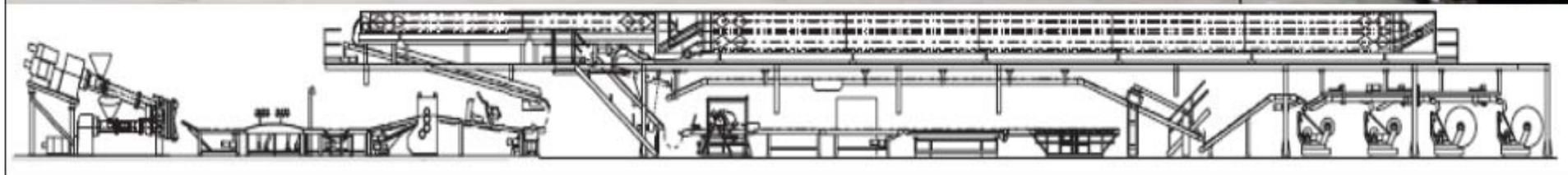


8", 30L/D Performance
LLDPE Dowlex 3310



Barrier screw provides higher rate and lower melt temperatures

Ekstruder sa jednim pužem – ekstruderi za gumu



Ekstruder sa jednim pužem – ekstruderi za gumu

U početku ekstruderi su građeni tako da je punjenje vršeno sa zagrejanim materijalom iz miksera. Od 1950. punjenje ekstrudera vrši se hladnim materijalom.

Prednosti hladnog ekstrudiranja:

- niži investicioni troškovi,
- bolja kontrola temperature magacina,
- redukcija laboratorijskih troškova,
- lakše rukovanje sa potrebnim materijalom.

Razlike u odnosu na ekstrudere za termoplaste

➤ redukovana dužina,

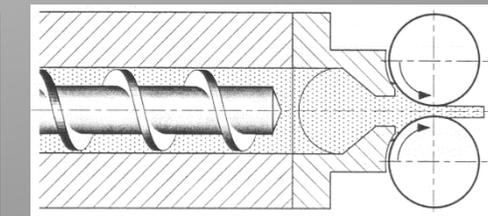
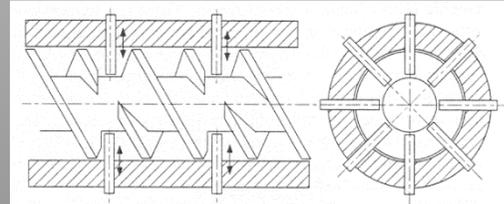
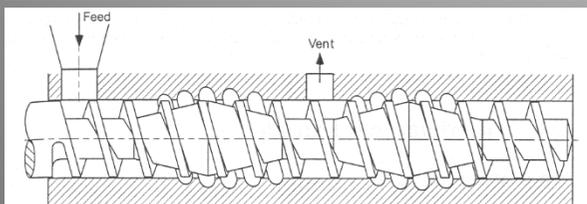
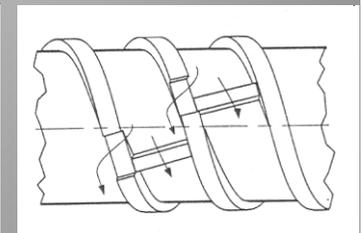
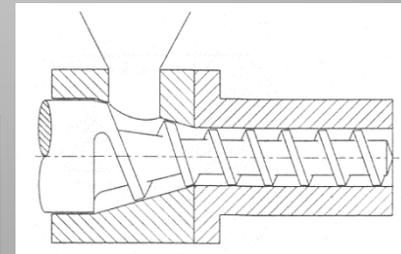
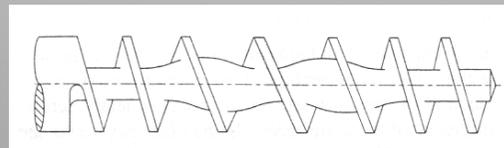
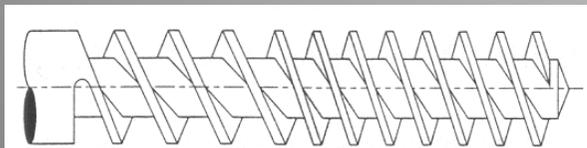
(kod toplo punjenog ekstrudera dužina puža je $L=5D$, a kod hladnog ekstrudera $L=15 \div 20 D$).

➤ grejanje i hlađenje,

(grejanje ekstrudera za gumu kod nižih temperatura vrši se parom, a kod viših električnim grejačima ili cirkulacijom zagrejanog ulja. Hlađenje ekstrudera izvodi se cirkulacijom vode.)

➤ sekcija za dodavanje,

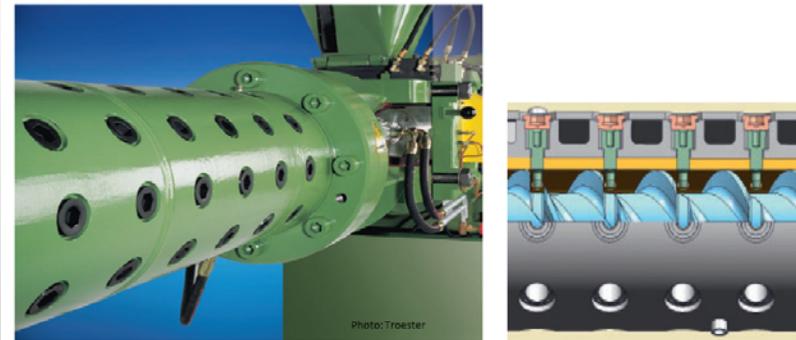
➤ konstrukcija puža.



Ekstruder sa jednim pužem – ekstruderi za gumu

COLD FEED EXTRUDERS

- Replacing conventional Hot Feed Extruders
- L/D >14
- Eliminates Warm-up Mill
 - Economic sense
 - Reduces heat cycle of rubber compound
- Improves geometric stability of extrudate
- Final die-pressure achievable ~30% higher
- TCU for controlling barrel temperature
- Higher output for the same size of feed



Plain Barrel Type

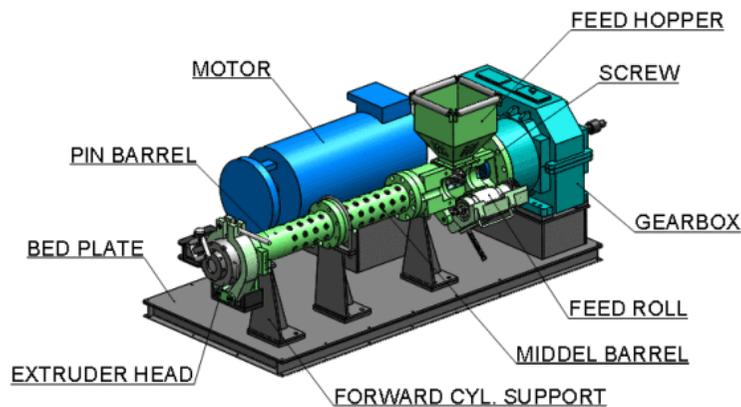
Manufacturing of hoses, blanks, fluorocarbon rubber, butyle rubber, etc

Pin Barrel Type

Universal for most of the rubber compound formulations

Vent Type

Production of non-porous profiles and hoses



Ekstruder sa dva puža – twin ekstruder

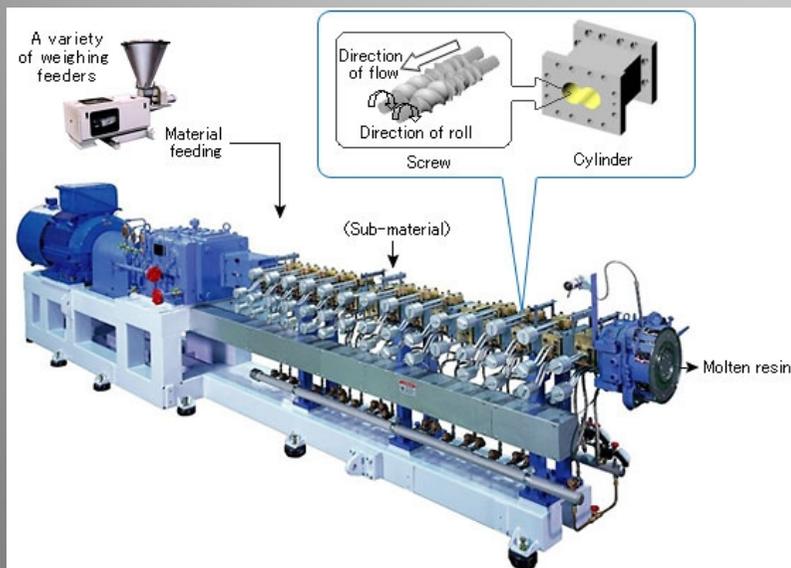
Single Screw Extruder

Twin Screw Extruder

- **90% of PVC pipes** are produced on twin screw extruders
- Twin screw extrusion is used extensively for **mixing, compounding, or reacting** polymeric materials
- Flexibility of screws operation
 - *Co-rotating or counter-rotating*
 - *Intermeshing or non-intermeshing*
- Flexibility of screw configurations
 - *forward conveying elements*
 - *reverse conveying elements,*
 - *kneading blocks*

PREDNOSTI:

- **LESS THERMAL HISTORY PROVIDES LARGE MARGIN AGAINST THERMAL DEGRADATION.**
- Better mixing, larger heat transfer area => good control of temperature.
- Good heat transfer, good devolatilization capacity, Large melting capacity
- L / D ratio is **12 to 16** in twin screw extruder against **24 to 32** in single screw extruders.
- Better feeding and more positive conveying characteristic => can process hard-to-feed materials i.e. powder, slippery materials, etc.
- More viscous & consistent melt and more uniform pumping action gives surge free melt discharge with **CONSISTENT PRODUCT** in case of twin screw extruder.
- Venting operation **at ease.**
- Self cleaning action.
- Relatively lower R. P. M. IN T.S.E. (15 – 30) as against (40 - 60) R. P. M. IN S. S. E.



Nedostaci:

- Twin-screw extruder is a relatively expensive machine;
- Difficult to accommodate bearings (dimensions limited)
- Complicated gear boxes
- Two screws

Twin Screw Design

- **How much and what type of mixing**
- **Pumping capability of extruder**
- **Amount of shear energy going into plastic**
- **Length of time the melt is in the extruder**

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Co-rotating vs counter-rotating twin screw extruders

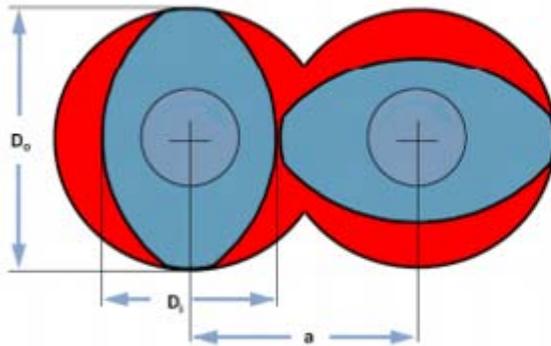
Co-rotating extruders:

- Relatively uniform shear rate distribution in the regular screw sections
- High screw speeds possible with corresponding high throughput rates
- Fair conveying efficiency

Counter-rotating extruders:

- High shear in the intermeshing region, which result in effective dispersive mixing
- Lower screw speeds than co-rotating extruders
- More positive conveying characteristics than co-rotating extruders because of the better sealing between the two screws

Design Principal



D_o / D_i = Diameter ratio
determines shear, degassing and powder intake

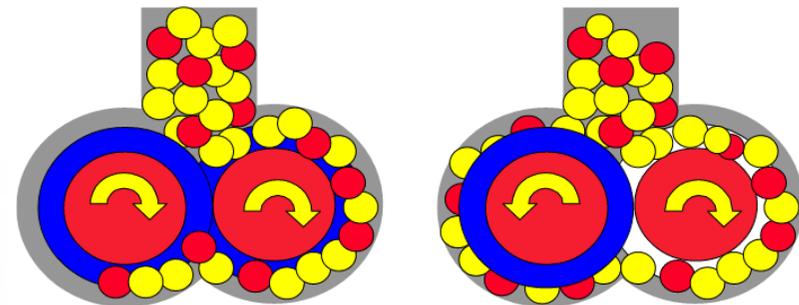
Md / a^3 = Specific torque
determines power density and filling degree

n = Screw speed
determines shear and mixing

D_o = Outer diameter

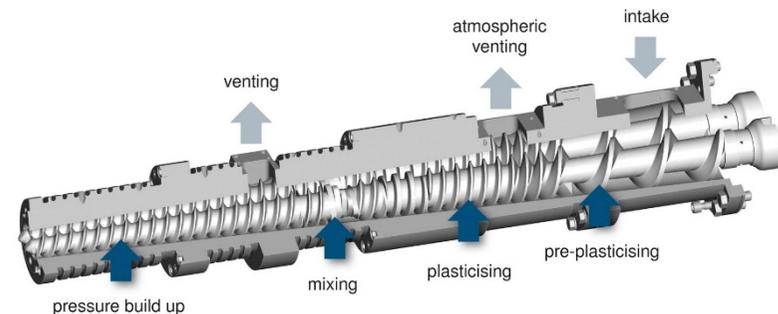
D_i = Inner diameter

a = Centerline distance



Co-rotating

Counter-rotating

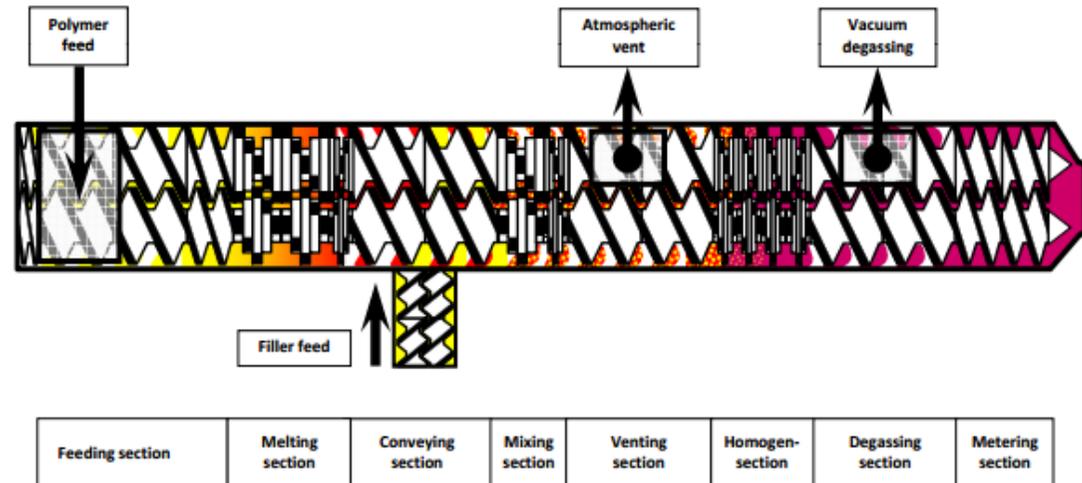


Functions of a Good Twin-Screw Design

1. To take in a maximum amount of powder per screw revolution
2. To transport, melt, and meter material into the die without hang-up
3. To mix the material without creating too much friction by too small or too large a gap between the outer diameter of one screw and core of the other
4. To homogenize and melt material by shearing it between flights
5. To vent material when it is agglomerate, not when it is still powder or already melt
6. To compress material before venting so that flights are full and so that a vacuum cannot act toward the hopper
7. To create frictional heat to plasticize efficiently by heating and cooling of screws and barrel

Processing section of the extruder

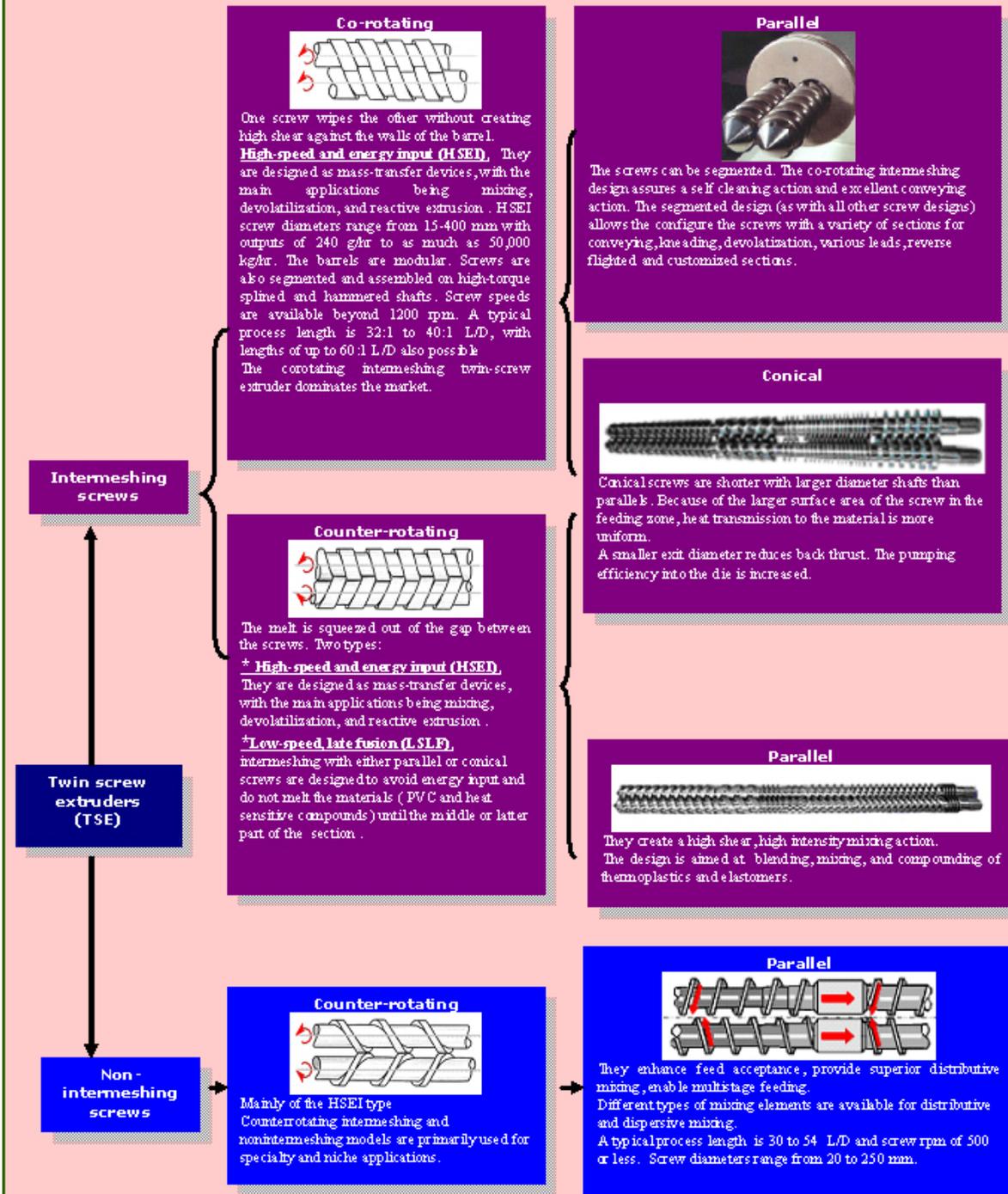
Typical extruder layout



Extruder sections with different flights and thread designs

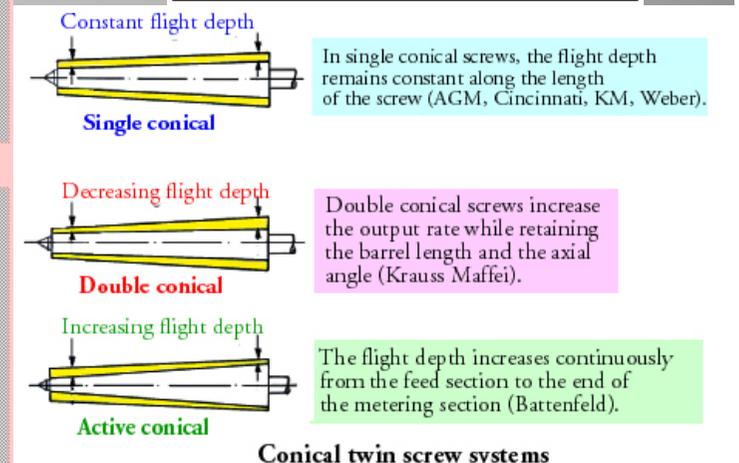
1. **The feeding section:** has open flights to ensure maximum material intake
2. **The melting section:** has large surface area. Multiple-thread design to ensure good heat convection
3. **The mixing section:** should mix materials and create no overheating
4. **Degassing section:** should has to be a decompression zone with open flights to prevent material form getting into the venting holes and should ensure effective degassing
5. **The metering zone:** should have an appropriate pressure buildup and balanced energy to ensure good homogenization without overheating to make high out put possible

2-Twin screw extruders-a classification



Intermeshing extruders	Co-rotating extruders	Low speed extruders for profile extrusion High speed extruders for compounding
	Counter-rotating extruders	Conical extruders for profile extrusion Parallel extruders for profile extrusion High speed extruders for compounding
Non-intermeshing extruders	Counter-rotating extruders	Equal screw length Unequal screw length
	Co-rotating extruders	Not used in practice
	Co-axial extruders	Inner melt transport forward Inner melt transport rearward Inner solids transport rearward Inner plasticating with rearward transport

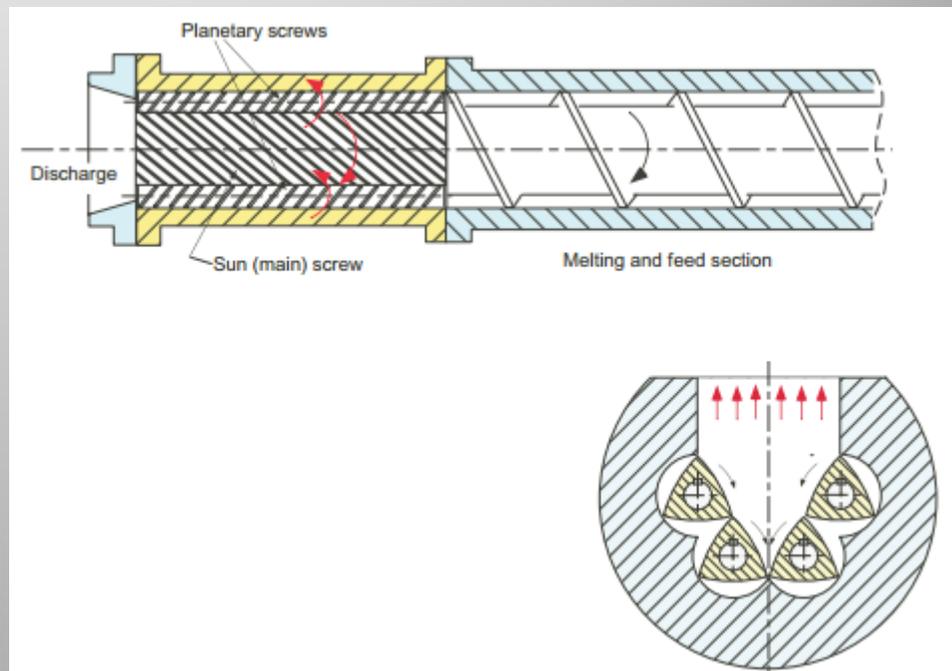
	Screw Distance	Material Flow	Counterrotating	Corotating
Fully Intermeshing	Closed to Length and Cross			Impossible
	Open to Length Closed to Cross		Impossible	
	Open to Length and Cross		Possible, Not Practical	Kneading Blocks and Gear Mixers
Partially Intermeshing	Open to Length Closed to Cross			Impossible
	Open to Length and Cross			
Nonintermeshing	Open to Length and Cross			



Ekstruder sa više puževa – planetary gear extruders



- tanki slojevi materijala
- efikasnu degazaciju materijala
- efektivno zagrevanje
- dobra kontrol temperature



Ekstruder sa više puževa – zupčasti pumpni ekstruder (gear pump extruders)

- ✓ Zupčasto pumpni ekstruder predstavlja dvopužni ekstruder kod kojeg se puževi okreću u kontra-smeru. Koriste se za povećanje pritiska, a kao samostalne jedinice nemaju primenu.
- ✓ Pritisak kod ovog ekstrudera zavisi od zazora puževa sa kućištem, zatim od viskoznosti i temperature sirovine.
- ✓ Kapacitet mešanja ovog ekstrudera je ograničen

Prednosti:

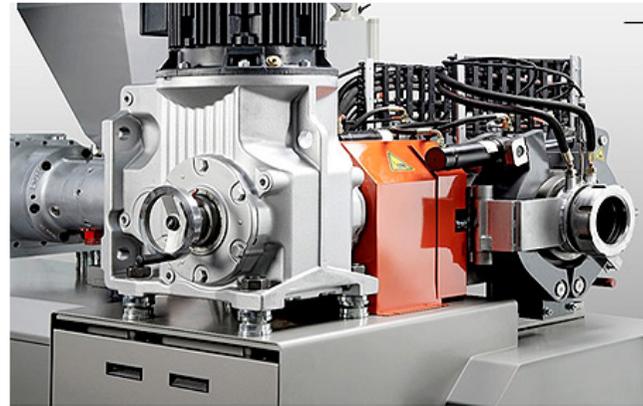
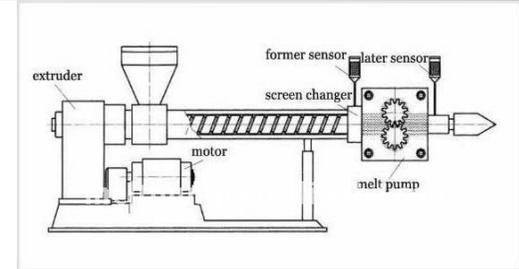
- stabilnost izlaznih dimenzija (npr. kod medicinskih cevi, oplaštanja žice, fibera, itd.,)
- prednost u odnosu na višepužne i dvopužne ekstrudere u pogledu obezbeđivanja stabilnosti pritiska.

Nedostatci:

- abrazivno delovanje sirovine utiče na promenu početnog zazora zbog habanja,
- kod polimera sklonih degradaciji nije moguće samočišćenje ekstrudera.

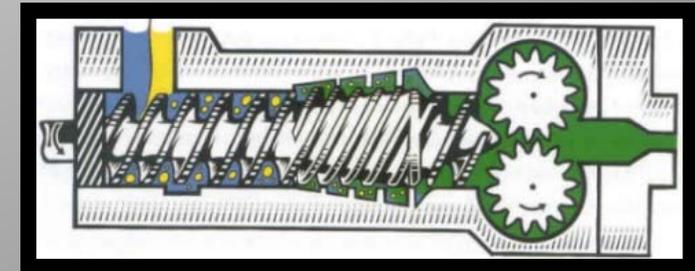
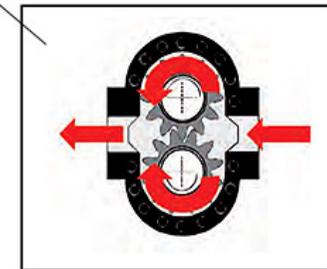
Benefits of Gear pump extruder:

- Pulsation free output through volumetric displacement
- Low thermal impact of the compound
- Less material treatment
- Increase of the system's output
- Increase of accuracy for profiles with very fine contours



Gear pump and profile head with clamping ring and swiveling mechanism

Functioning: Filling of the tooth gaps, transport in the tooth gaps, discharging of tooth gaps

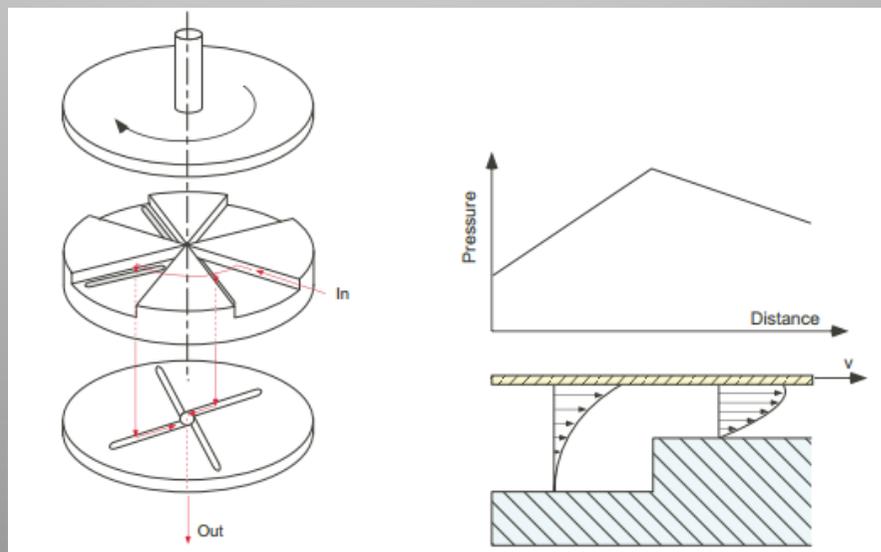
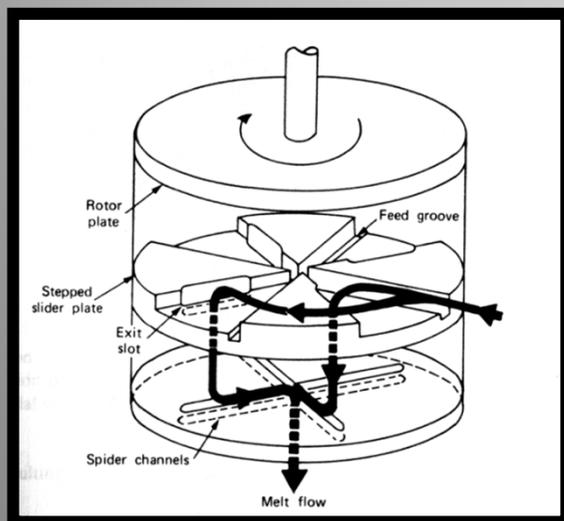


Disk ekstruderi

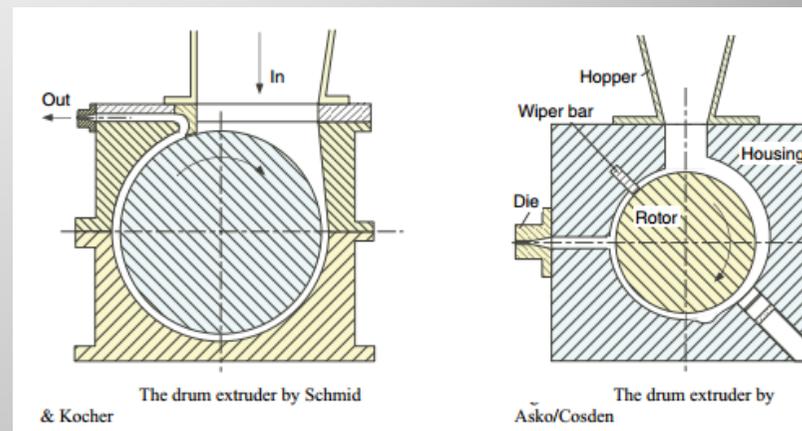
Visoko povlačni disk ekstruder (Viscous Drag Disc Extruders)

Stepenasti disk ekstruder

- Konstrukcija stepenastog diska se prilagođava potrebama zavisno od materijala i pritiska.
- Nedostatak ovih ekstrudera je nemogućnost čišćenja stepenastih ploča



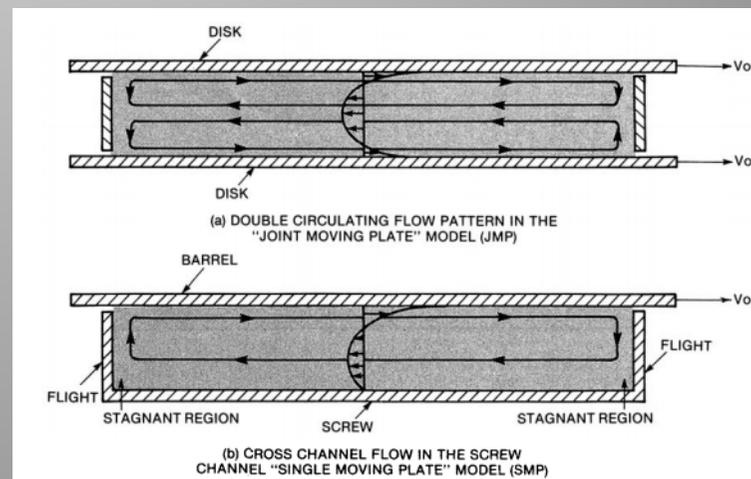
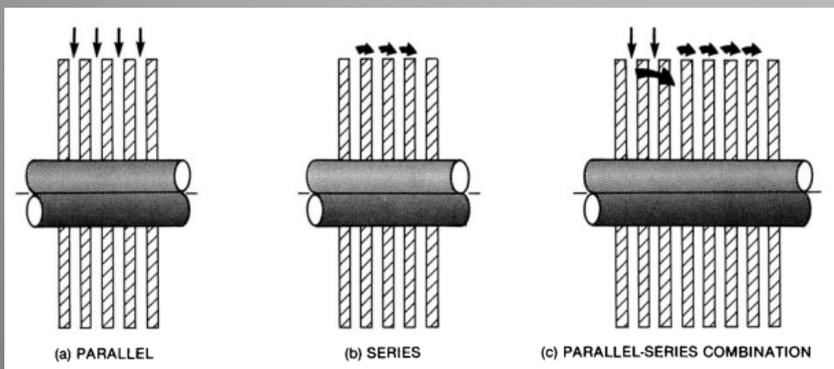
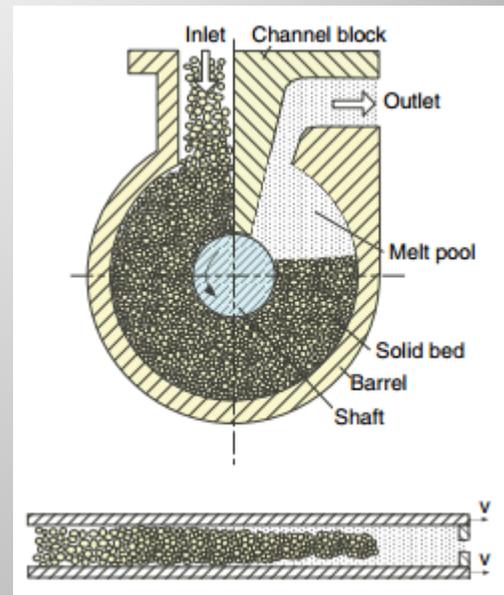
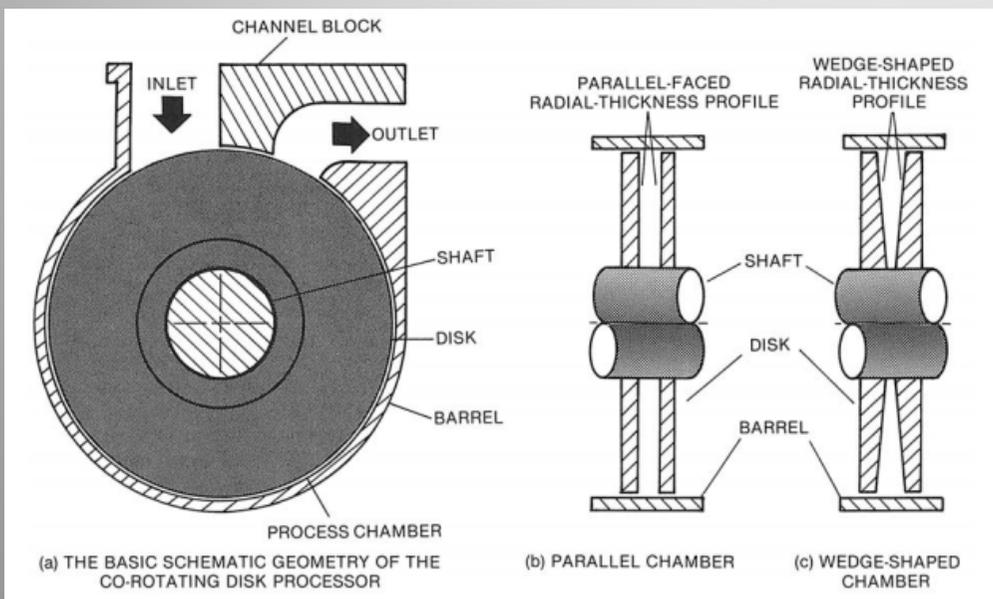
Ekstruder sa bubnjom



Disk ekstruderi

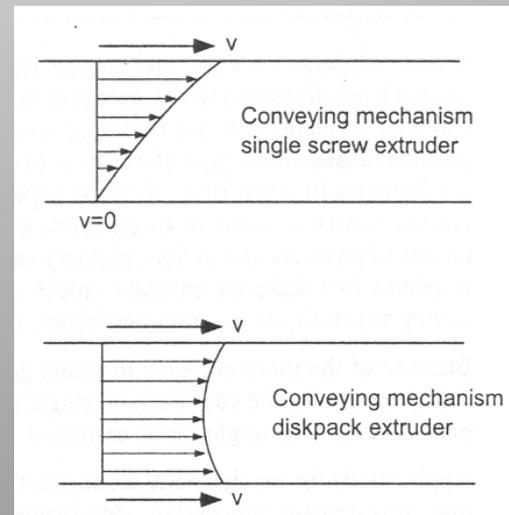
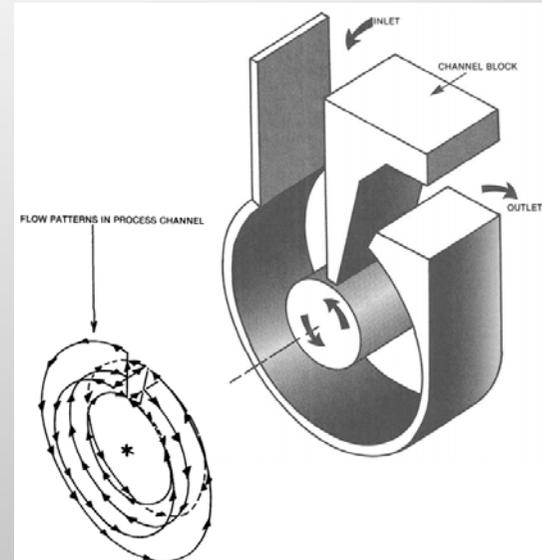
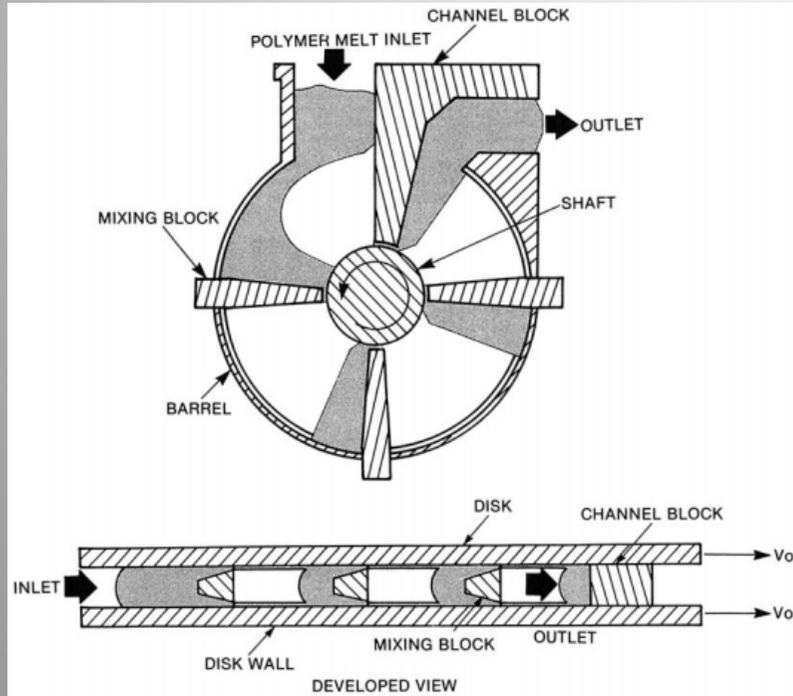
Pločasti ekstruder (ekstruder sa paketom ploča)

Geometrija diskova se optimira zavisno od funkcije; transport čvrste materije, topljenje, odvođenje gasova i para, transport rastopa, mešanje itd.



Disk ekstruderi

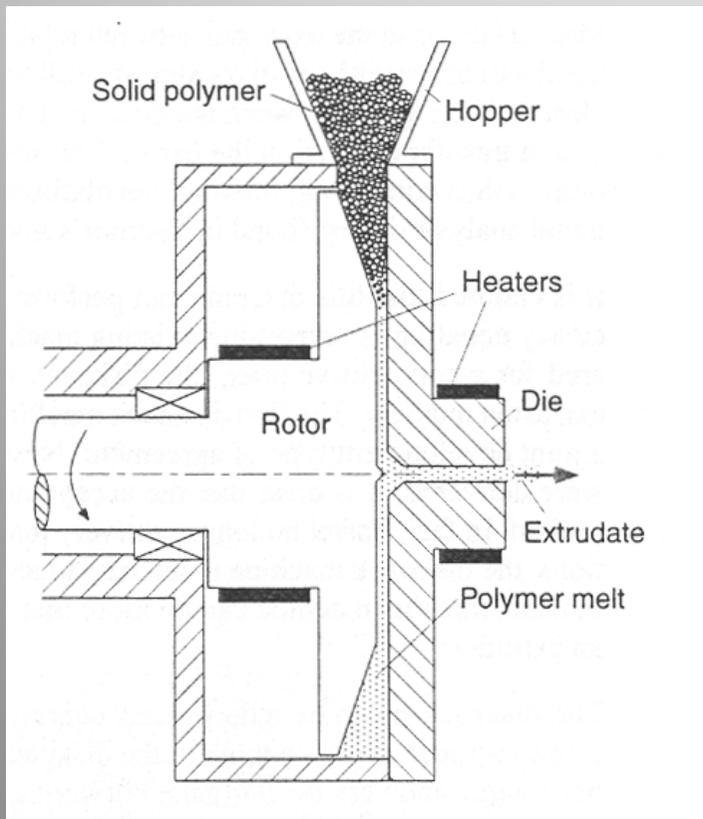
Pločasti ekstruder (ekstruder sa paketom ploča)



Disk ekstruderi

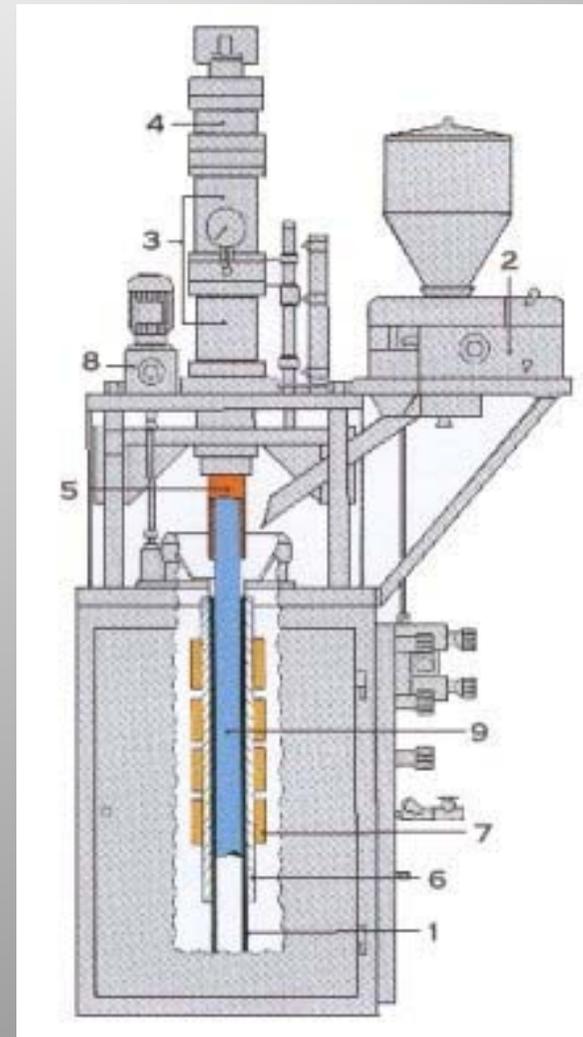
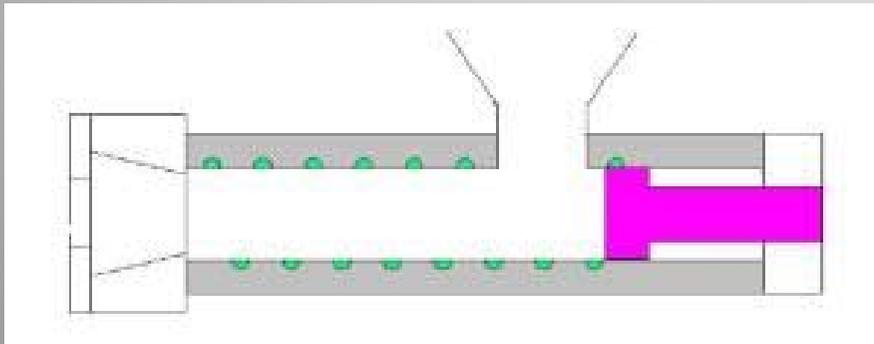
Ekstruder sa elastičnim topljenjem (The elastic melt extruder)

- Razvijen je 1950. godine
- Baziran je na visko-elastičnom ponašanju polimera
- Normalno-naponski ekstruder (kada je polimer izložen smicanju u njemu se pojavljuju i normalni naponi koji nisu isti u svim pravcima, upravo suprotno čisto viskoznom fluidu)



Klipni ekstruderi

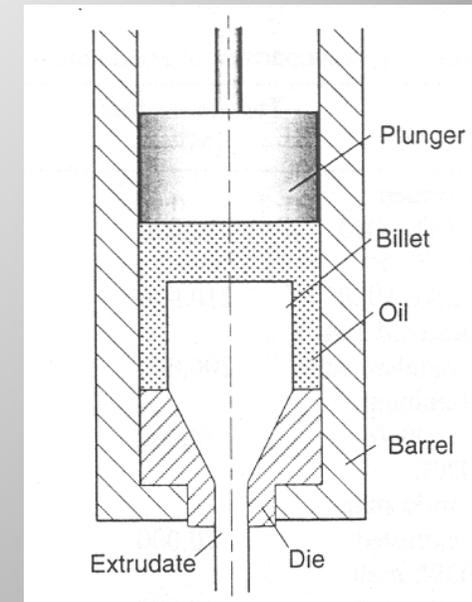
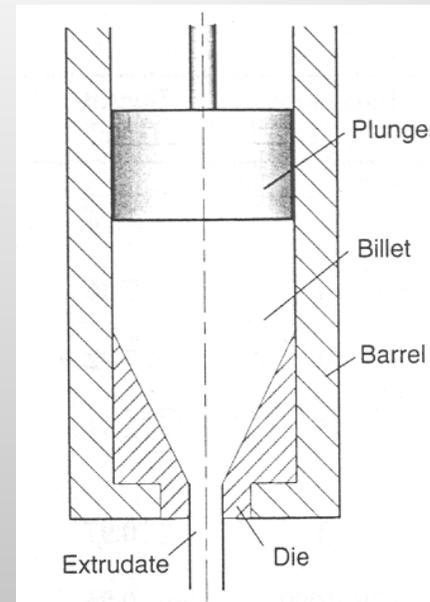
- Robusne konstrukcije, diskontinualnog dejstva.
 - Generišu visoke pritiske.
 - Zbog cikličnog dejstva primenjuju se kod injekcionog presovanja i duvanja polimera.
-
- ograničen kapacitet plastifikacije (topljenja),
 - skromna (niska) uniformnost temperature u materijalu



Klipni ekstruderi

Istiskivanje u čvrstom stanju

- U primeni od 1940
- a. klasično – istosmerno
- b. Hidrostatičko
- Koristi se pri koekstruziji različitih polimera
- Bolje mehaničke osobine i dimenziona stabilnost



Material	Tensile modulus [MPa]	Tensile strength [MPa]	Elongation [%]	Density [g/cc]
Annealed SAE 1020	210,000	410	35	7.86
W-200 °F SAE 1020	210,000	720	6	7.86
Annealed 304 stainless steel	200,000	590	50	7.92
Aluminum 1100-0	70,000	90	45	2.71
HDPE solid state extruded	70,000	480	3	0.97
HDPE melt extruded	10,000	30	20-1000	0.96

Klipni ekstruderi

Višeklipni ekstruderi

Glavni nedostatak klipnih ekstrudera je periodično izvođenje ciklusa ekstruzije



Triplex



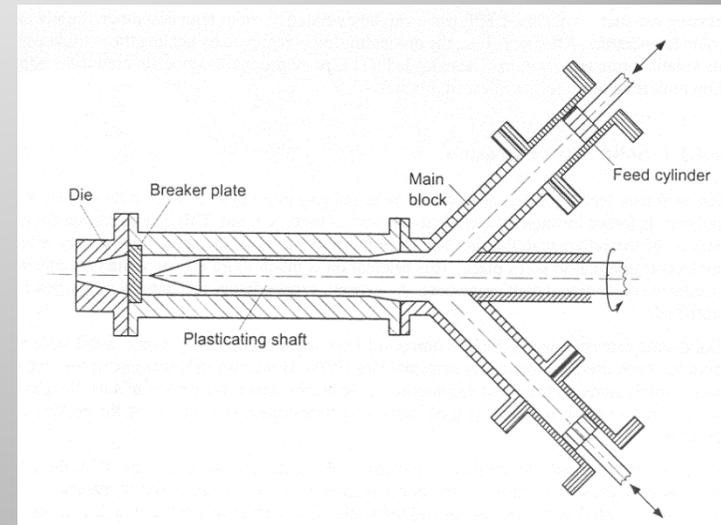
Quintuplex



Opposed Type Triplex



Opposed Type Quadruplex



Habanje ekstrudera

Extruder wear

Abrasive Wear:

- Erosion of metal surfaces due to harder materials(i.e. TiO_2) rubbing against softer materials
- Melting and mixing sections are regions where abrasive materials are present



Adhesive Wear :

- Rubbing of metal surfaces against each other
- It has be seen where mechanical stresses exist:
 - Inadequate screw support/centering
 - Shaft deflection
 - Incorrect screw assembly

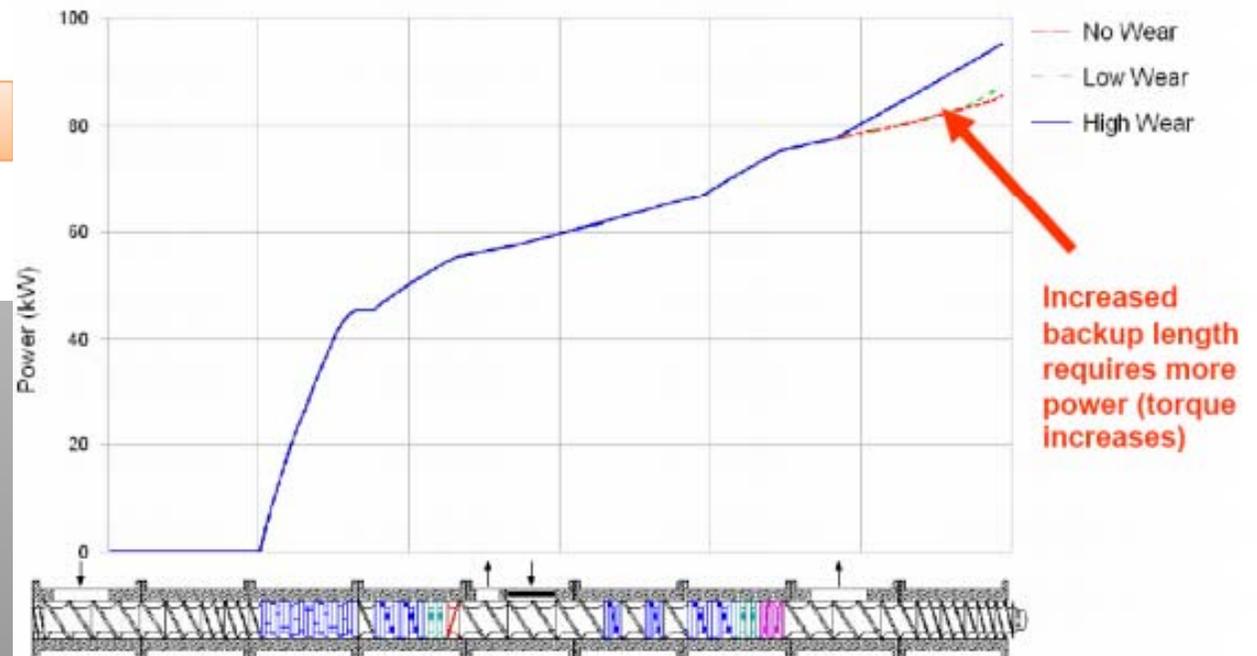


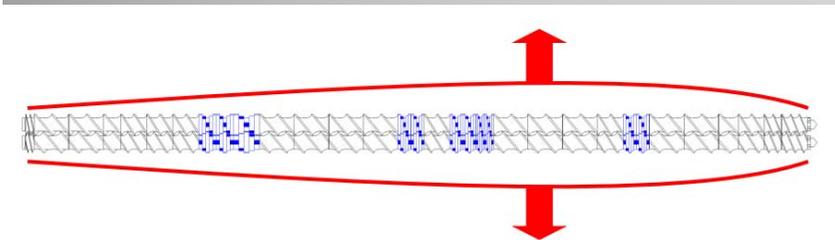
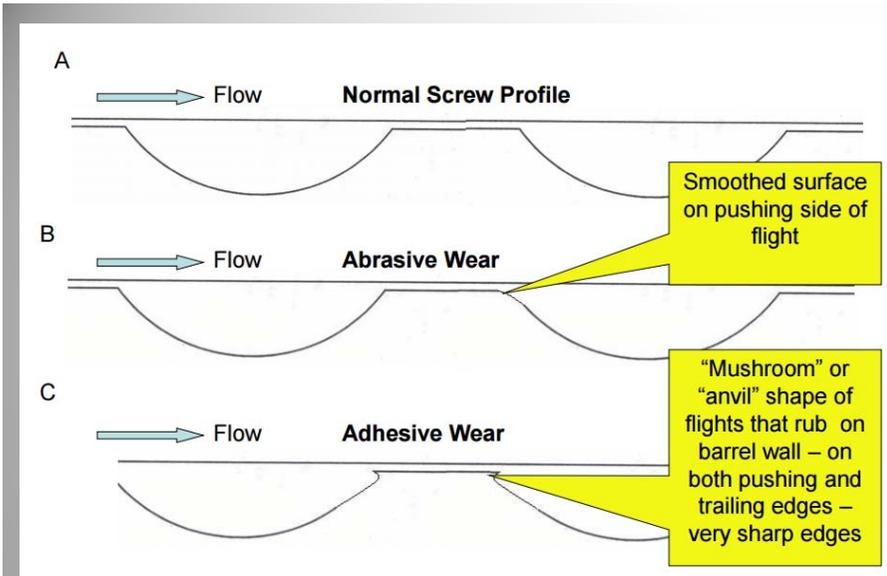
Corrosive Wear:

- Erosion of metal surfaces due to chemical attack

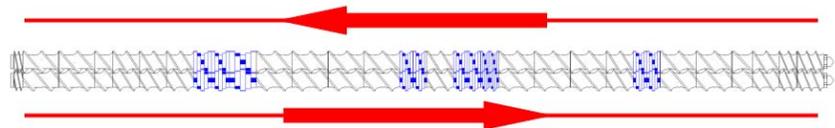


Mechanical Power Input





Without adequate centering of the screw shafts, high discharge pressure can cause deflection (bowing) of the screw shafts – this condition produces adhesive wear on the outer screw flights over an extended L/D



When inserting assembled screws into barrel, material within the barrel (polymer residue, pellets, etc.) can be pushed back behind the feed opening and prevent shafts from seating properly into the couplings.

Incorrect assembly of split rings in coupling assembly also creates a condition where one shaft can move axially



Glava ekstrudera

