Atypical Twin Screw Extrusion Compounding Systems for Polyolefins

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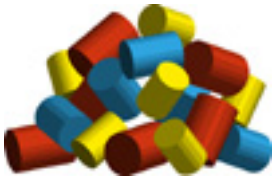
HSEI TSE Process Sequence

Pellets



Powders/Fillers

Liquids

Fibers

TSE
feed
melt
mix
devolatilize
pump

Size & cool
air
water
rolls
conveyors

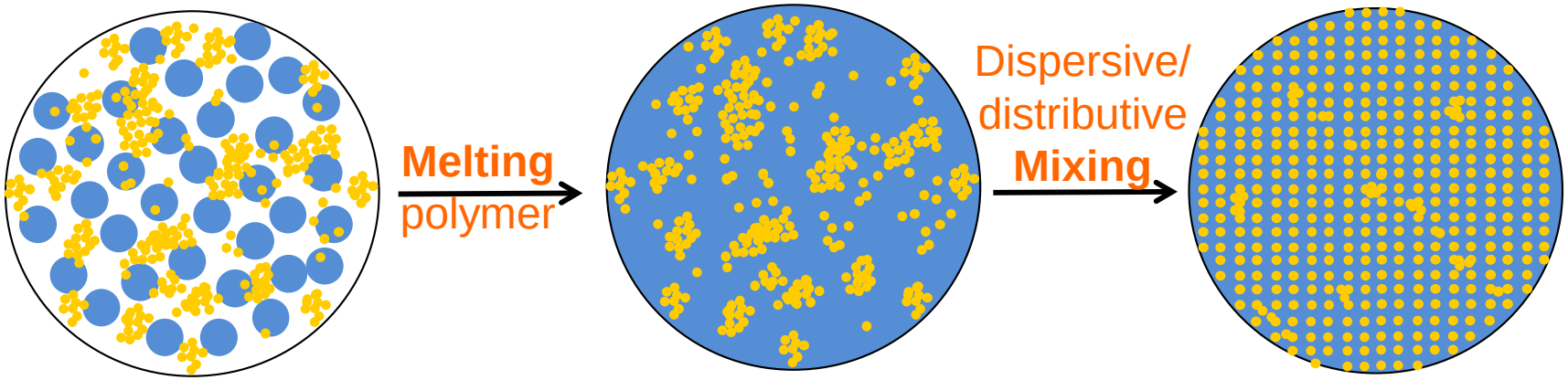
Finish
Pellets
- SSE
- Inj. mold

Direct extrusion

- *99% Comp'd, devol & or REX*
- *90%+ HSEI TSE's make pellets*

Physical Phenomena in Polymer Compounding

- Solid additives/particles
- Polymer granules/pellets



Polymer+ additives+ particles

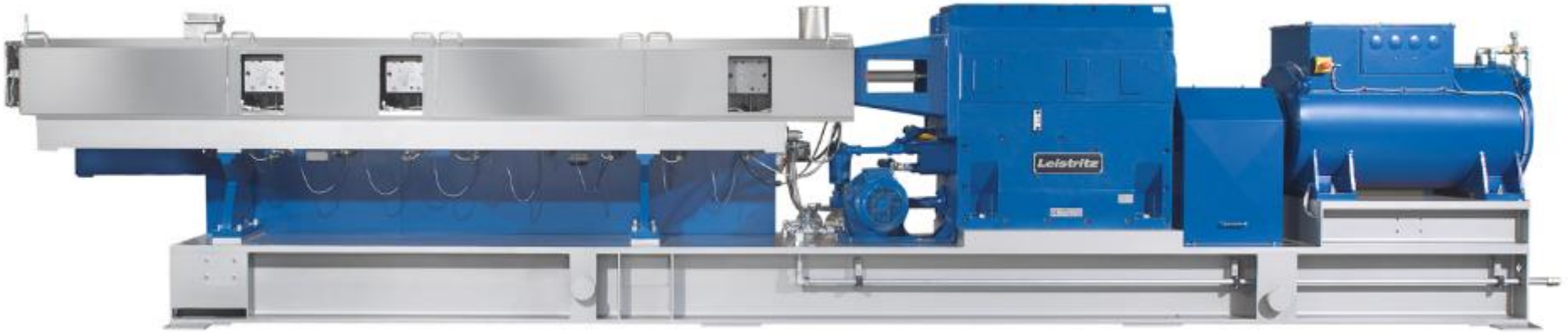
Suspended additives particles in polymer melt

Uniformly mixed particles with a few agglomerates

Gogos and Ioannidis

ZSE-110 MAXX HSEI TSE, 1500 HP

Twin screw extruders are high speed, energy input devices



Applications:

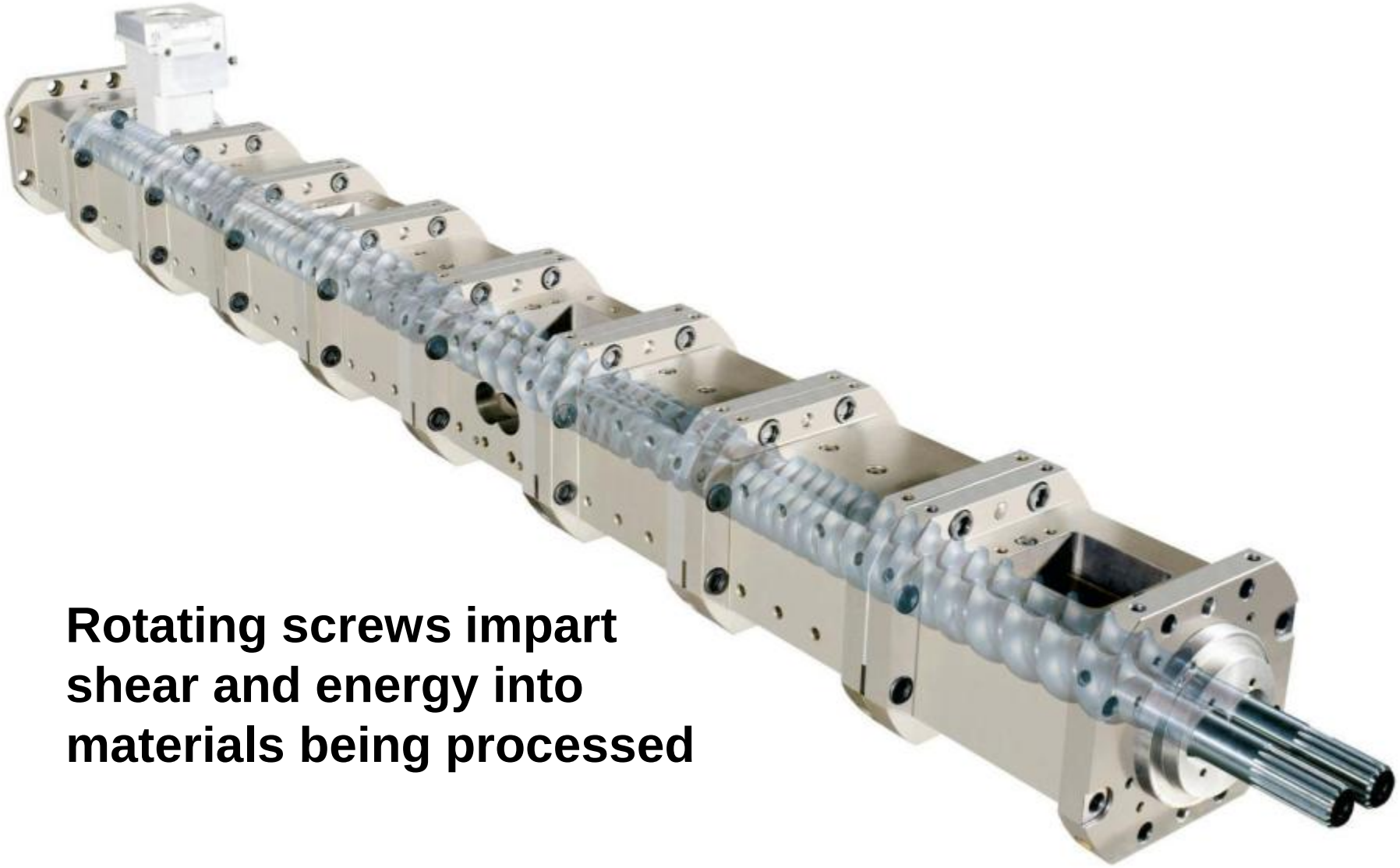
- **compounding,**
- **devolatilization**
- **reactive extrusion**

Feeders set rate: LIW feeders

Feeder #1: 80% polymer

Feeder #2: 20% pigment/additive+

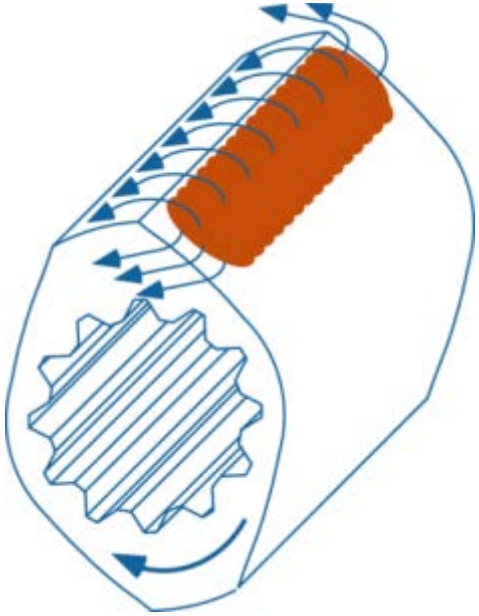
HSEI TSE Process Section



Rotating screws impart shear and energy into materials being processed

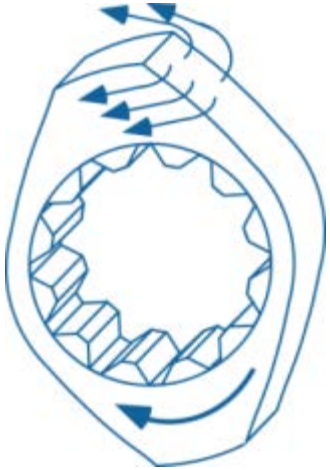
Example of Mixing Mechanism

BROAD



LOBAL POOL CAPTURE (DISPERSIVE)

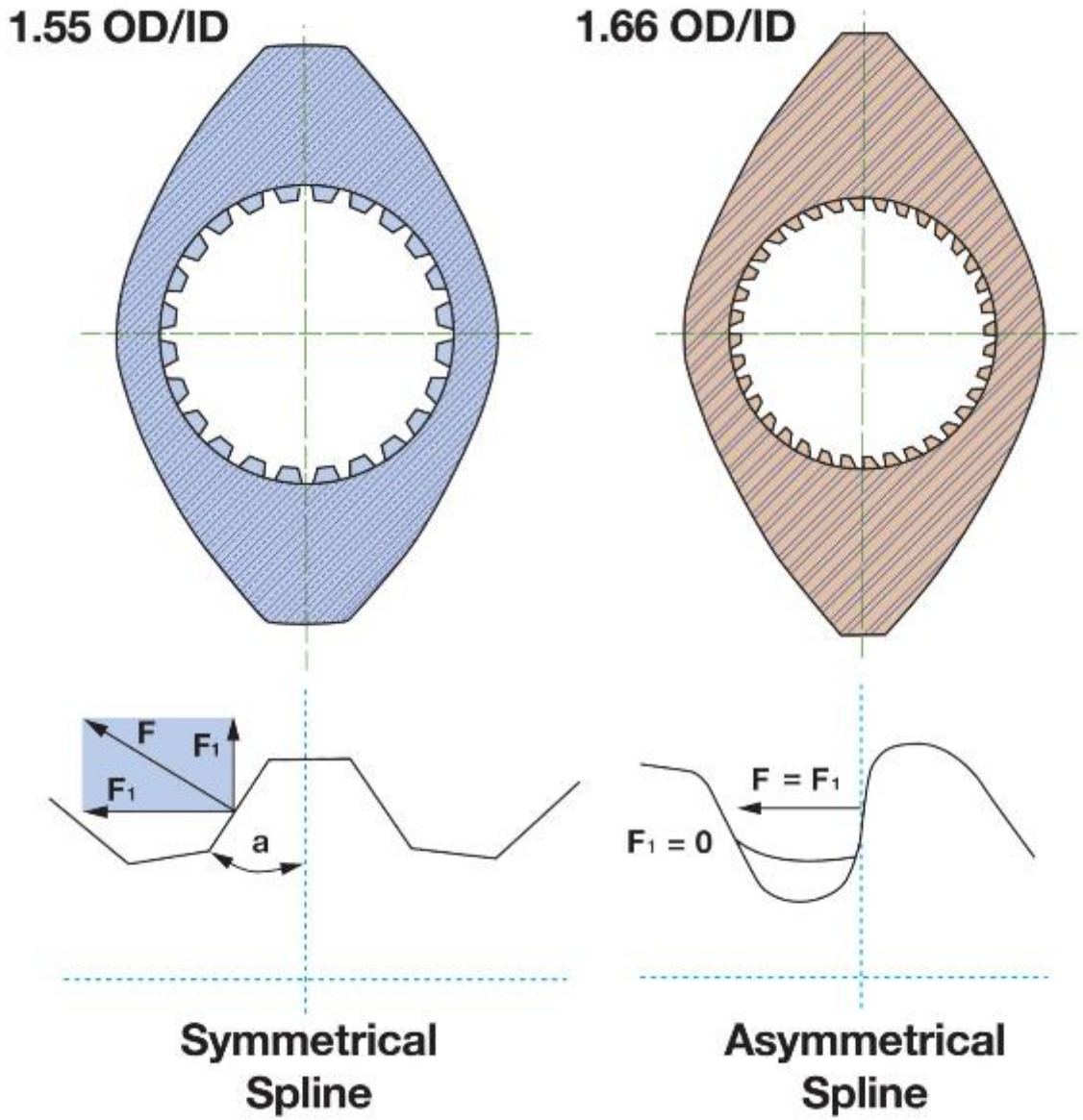
NARROW



MELT DIVISION (DISTRIBUTIVE)

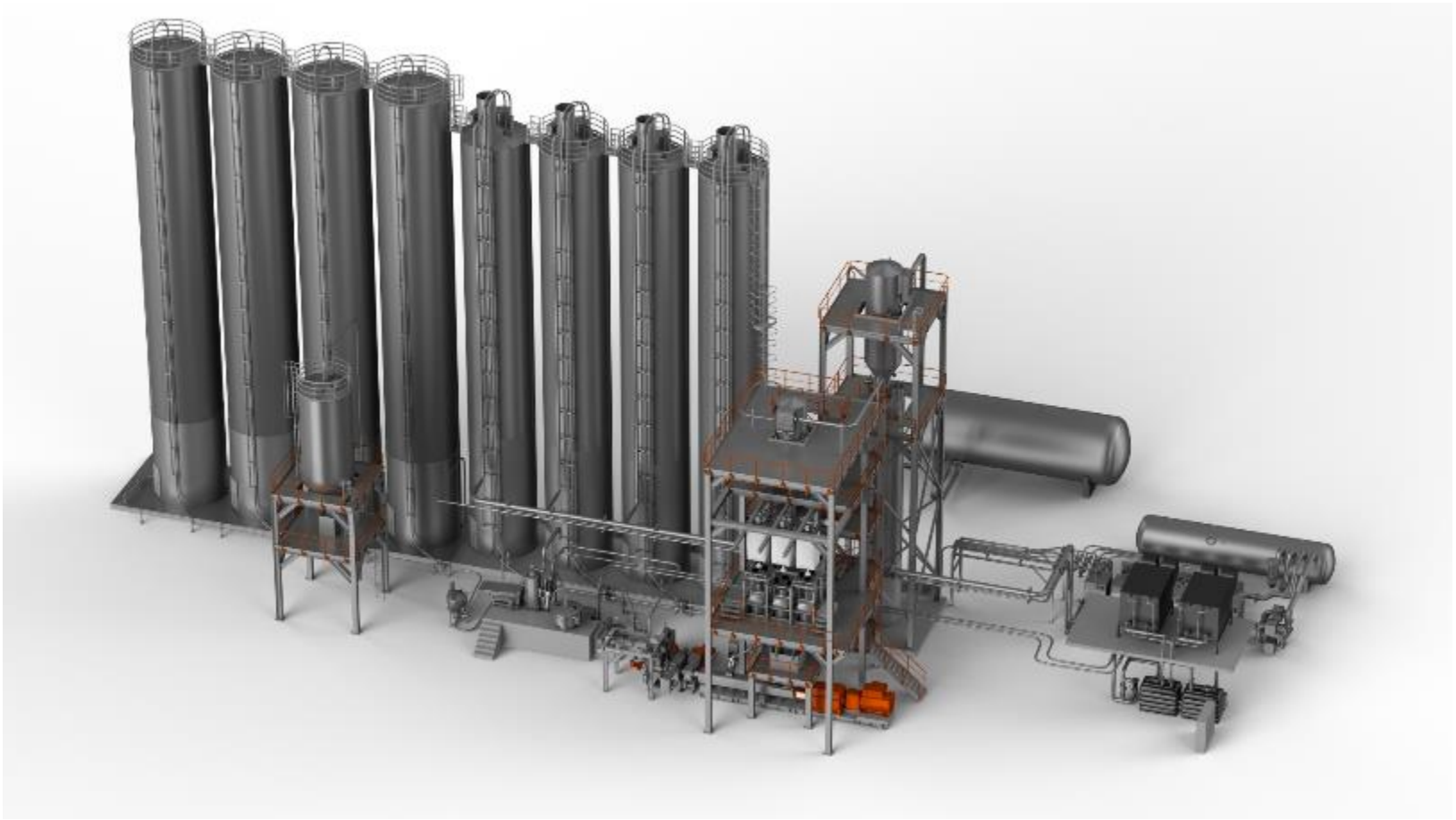
Wider disk = extensional shear/dispersive mixing

Narrower disk = melt divisions/distributive mixing



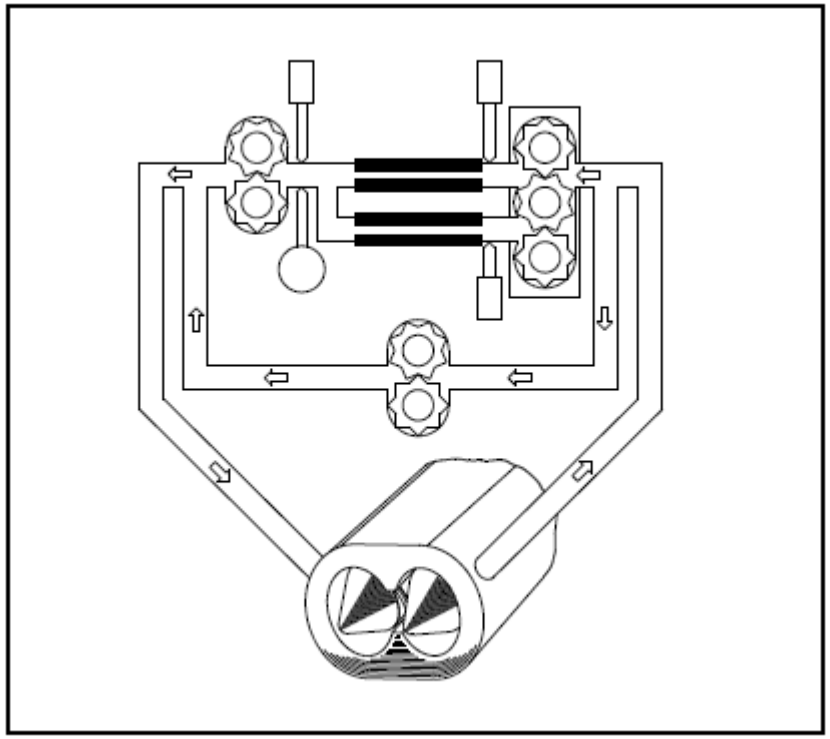
Higher OD/ID ratio =‘s more free volume and less torque

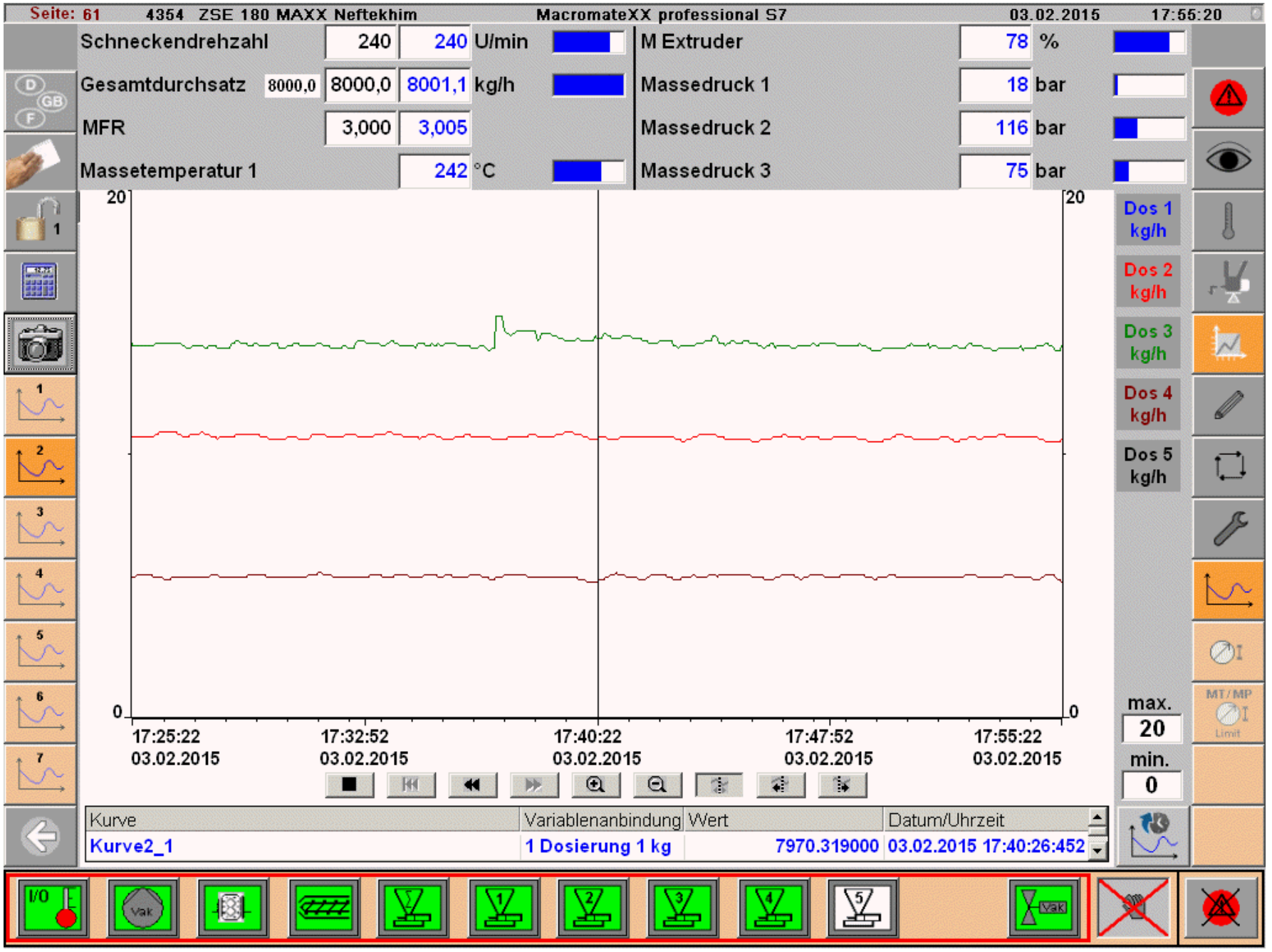
ZSE-180 MAXX w/ underwater pelletizing system



2400 KW motor – PP reactor @10 tons/hour

In-line rheometer

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4354 ZSE 180 MAXX Neftekhim
MacromateXX professional S7
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17:55:20
Schneckendrehzahl
240
240 U/min
Gesamtdurchsatz
8000,0
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8001,1 kg/h
MFR
3,000
3,005
Massetemperatur 1
242 °C
M Extruder
78 %
Massedruck 1
18 bar
Massedruck 2
116 bar
Massedruck 3
75 bar
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17:25:22
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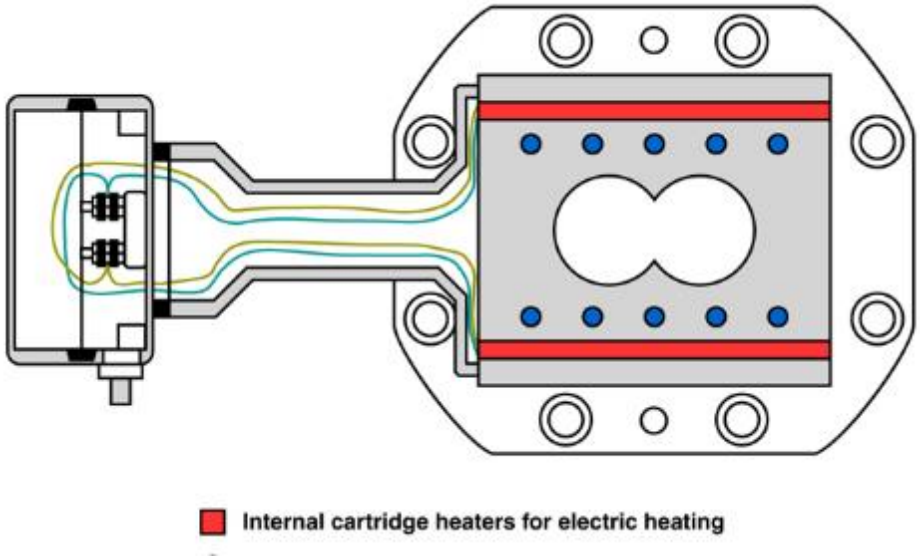
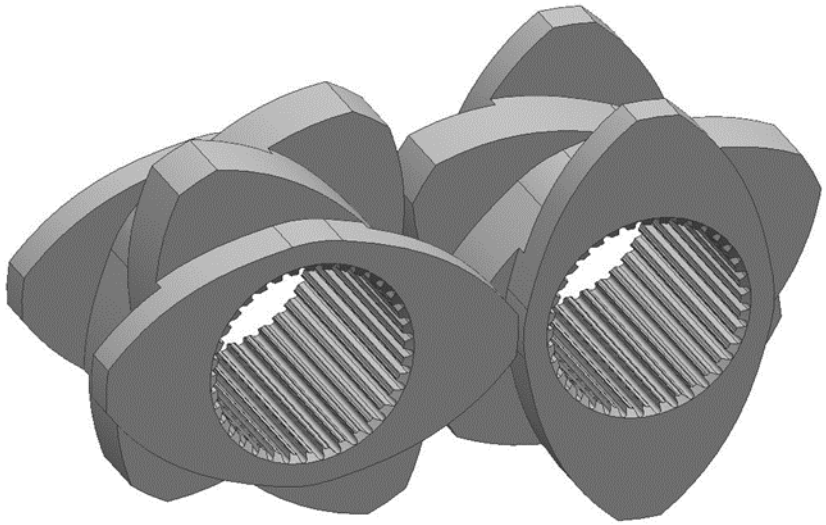
Purposeful degradation of HDPE*

Increase MFI by a factor of 3 to 6 times





Jack up the temps!!

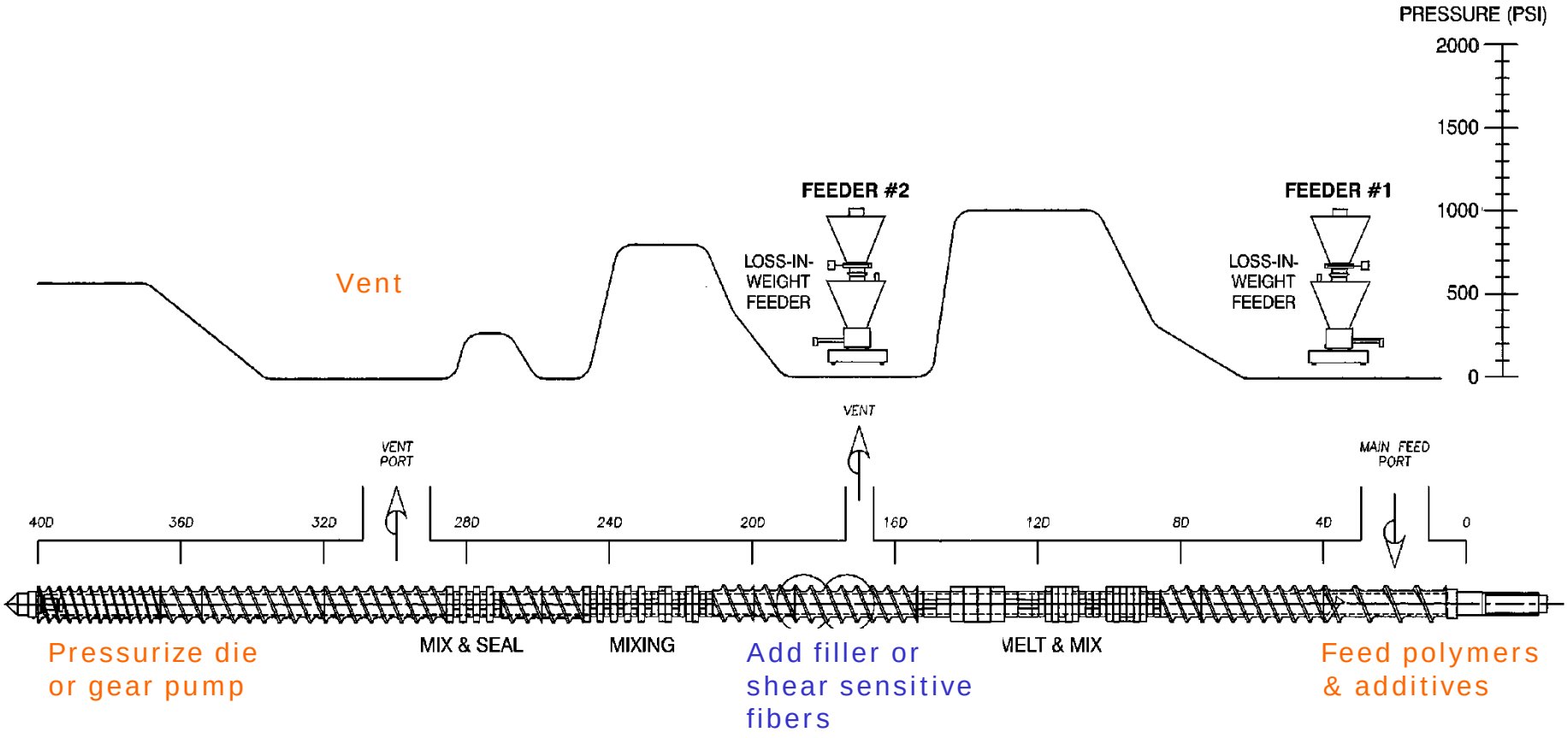
Beat up the polymer!!

* Atypical TSE system

Pressure profile in TSE

Facilitates downstream feeding and venting

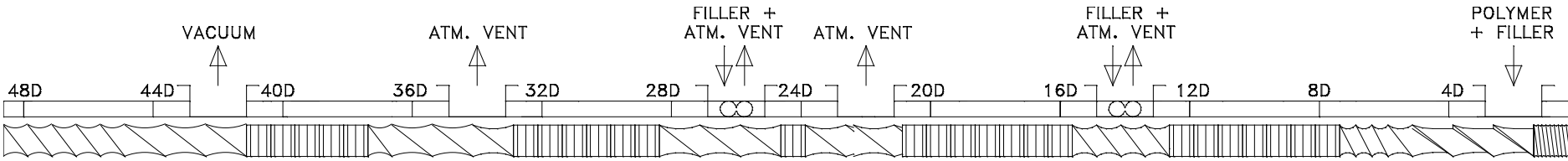
Feeders set rate & screws rpm optimizes comp'd



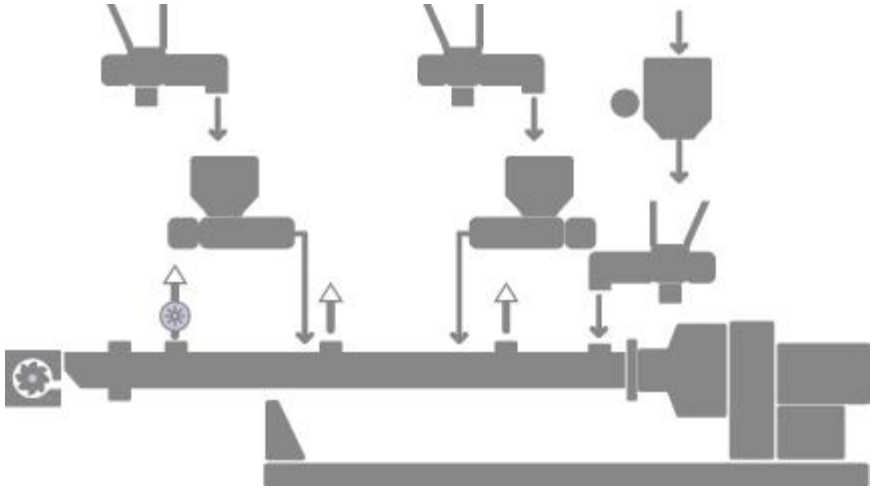
TSE System for highly filled compounds

ZSE-MAXX system: PE/PP + 80% CaCO3, TiO2, CB+

Screw Geometry

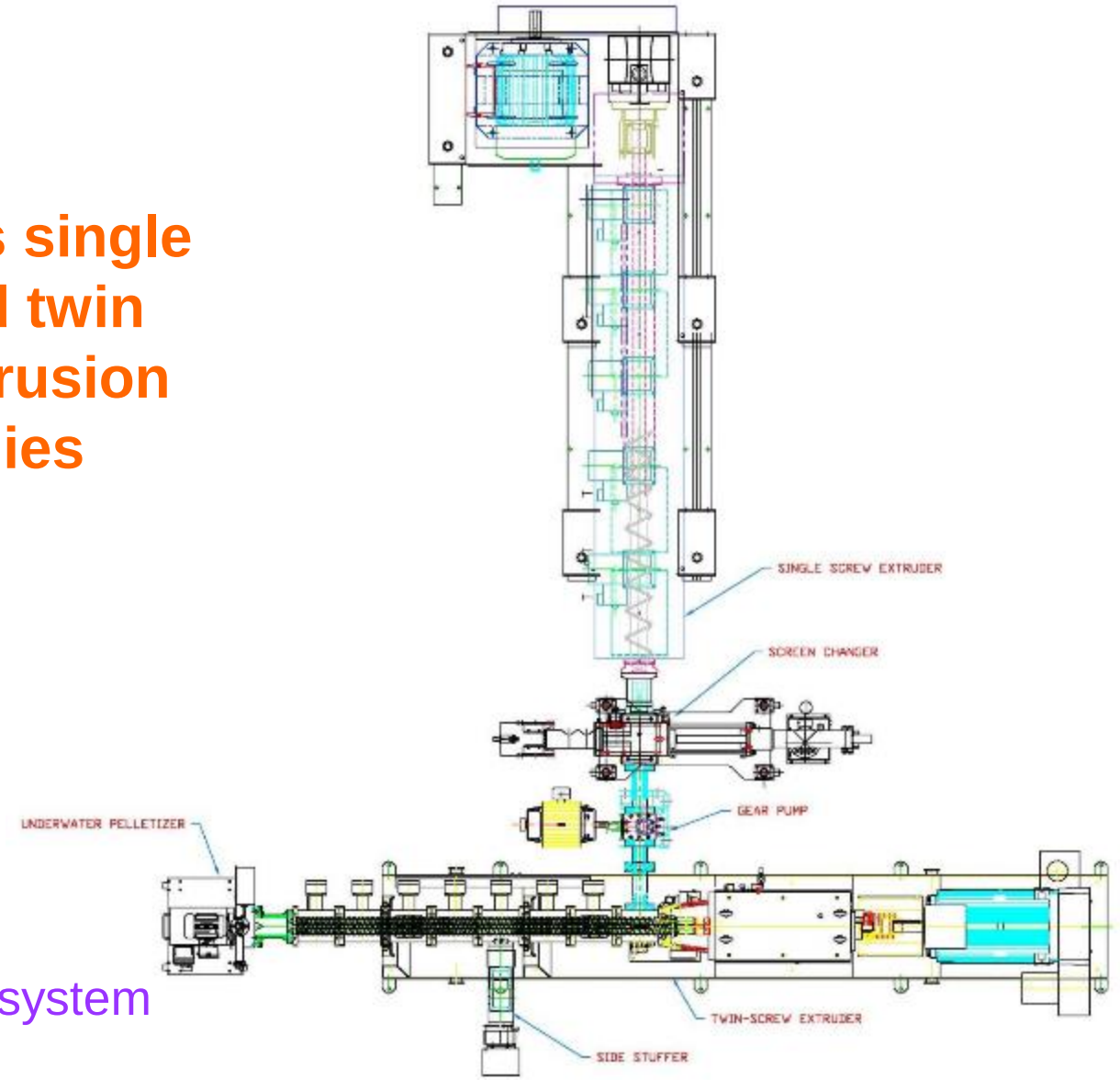


Line Setup



Reclaim/compounding system

Combines single screw and twin screw extrusion technologies



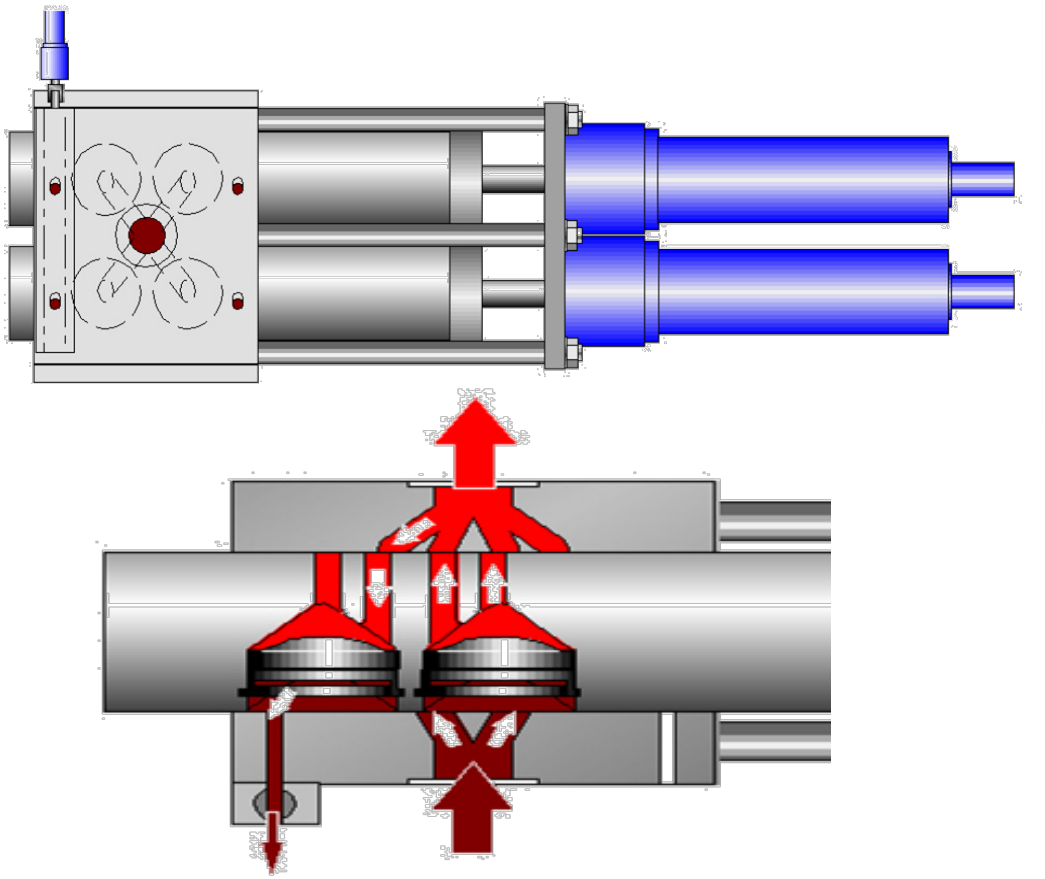
* Atypical TSE system

Continuous backflush screen changer

Backflush action cleans 1 screen at a time

Maintains 75% of total filtration area during back-flush

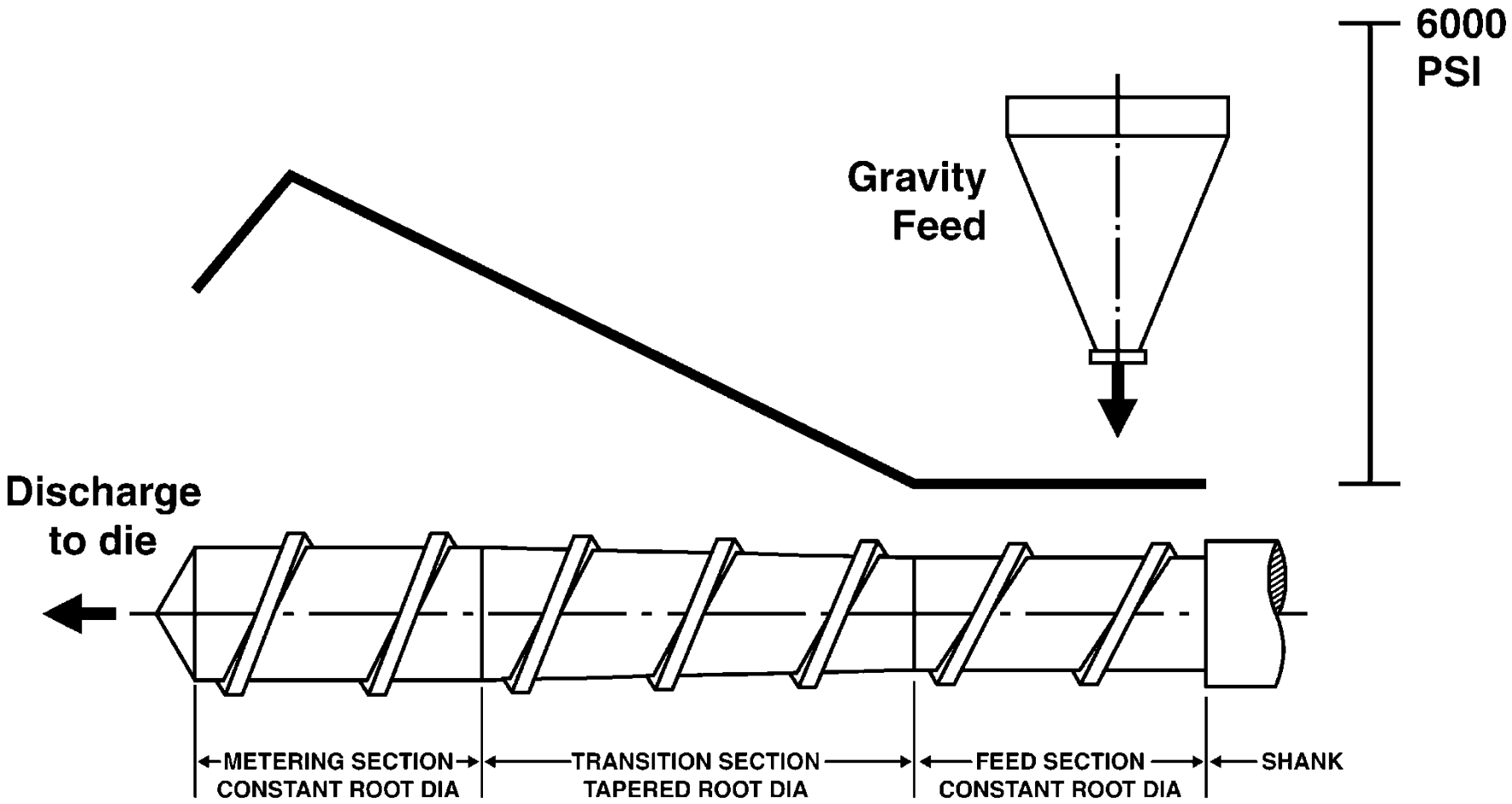
More efficient cleaning and better process stability



Single screw extruder (SSE) for reclaim

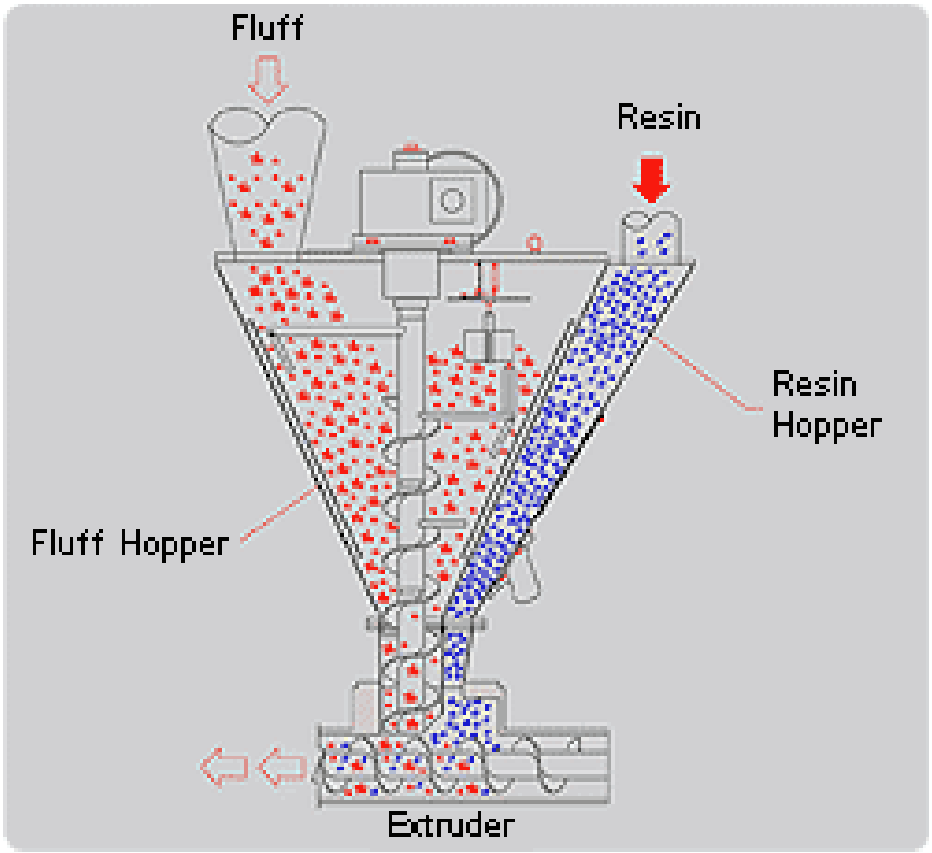
Reclaim systems are filtration intensive/limited

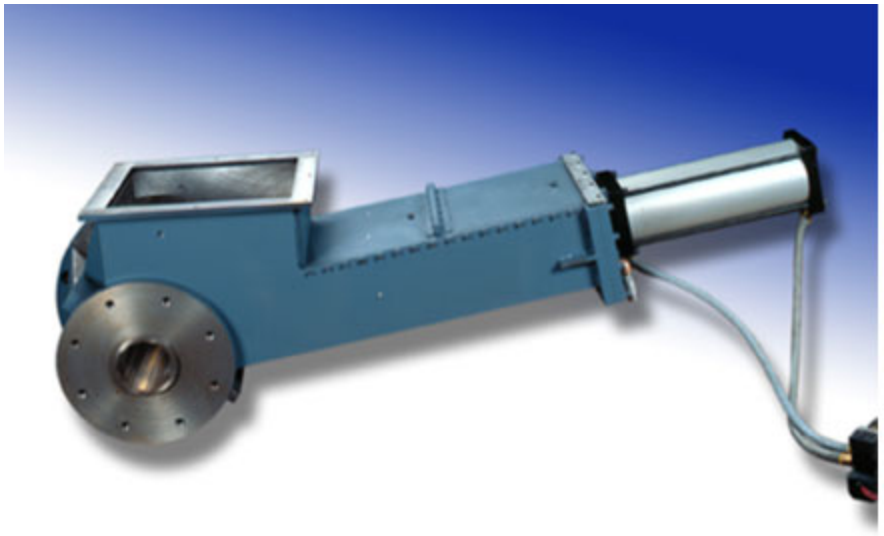
Pressure Gradient in SSE



SSE are high pressure machines used mainly for pumping

Feed mechanisms into SSE

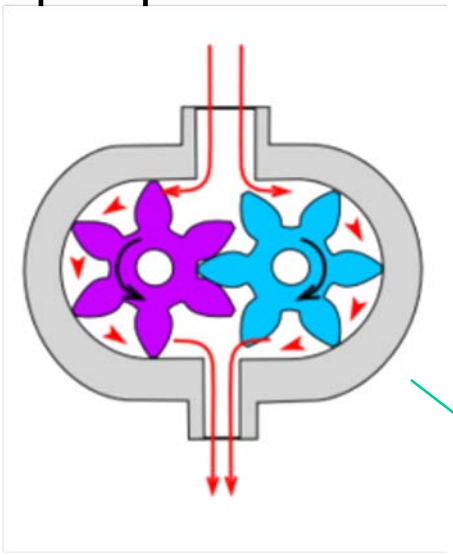




Reclaim/compounding system*

Gear pump as feeder to TSE

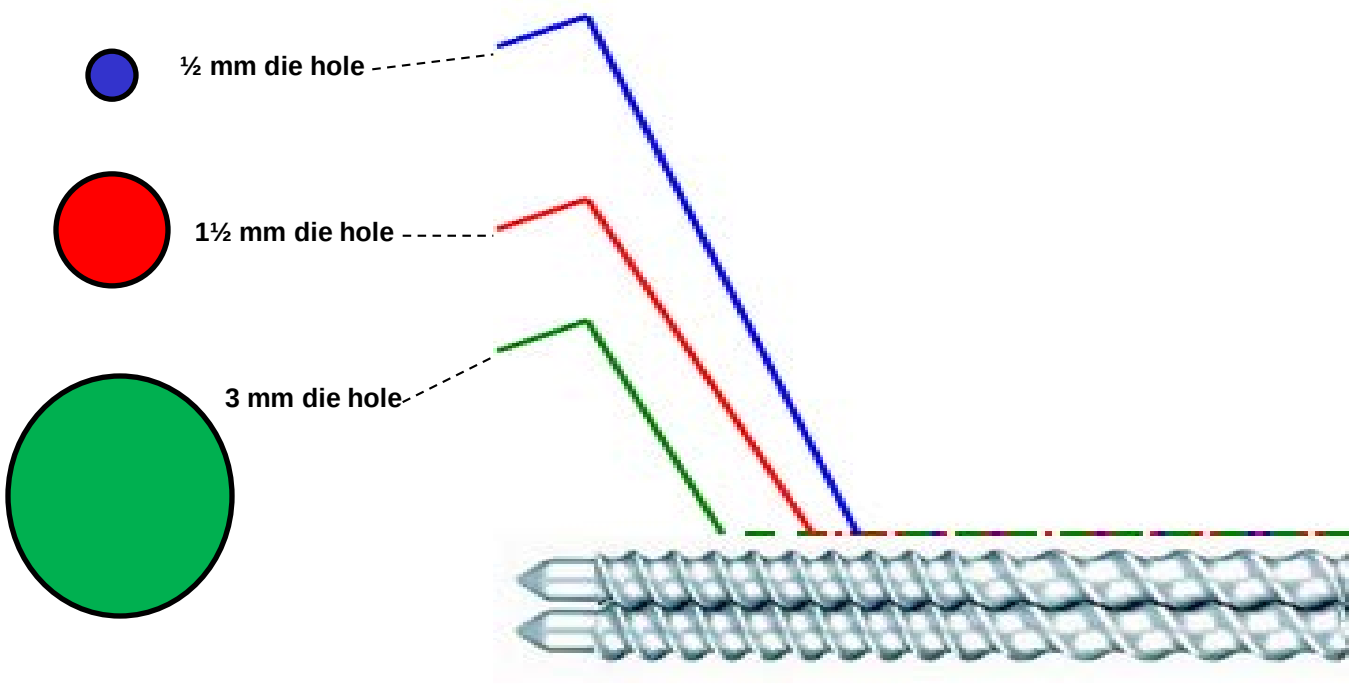
* Atypical TSE system



Temperature rise during pressure generation

$$\Delta T\ (°C) = \Delta P\ (bar) / 2\ (+/-\ 50\%)$$

- 40 Bar (580 PSI) Pressure results in a 20°C melt temperature rise (40/2)
- Restrictive front-end designs may adversely effect the product
- RPM, discharge screw elements & materials play a role in Tm

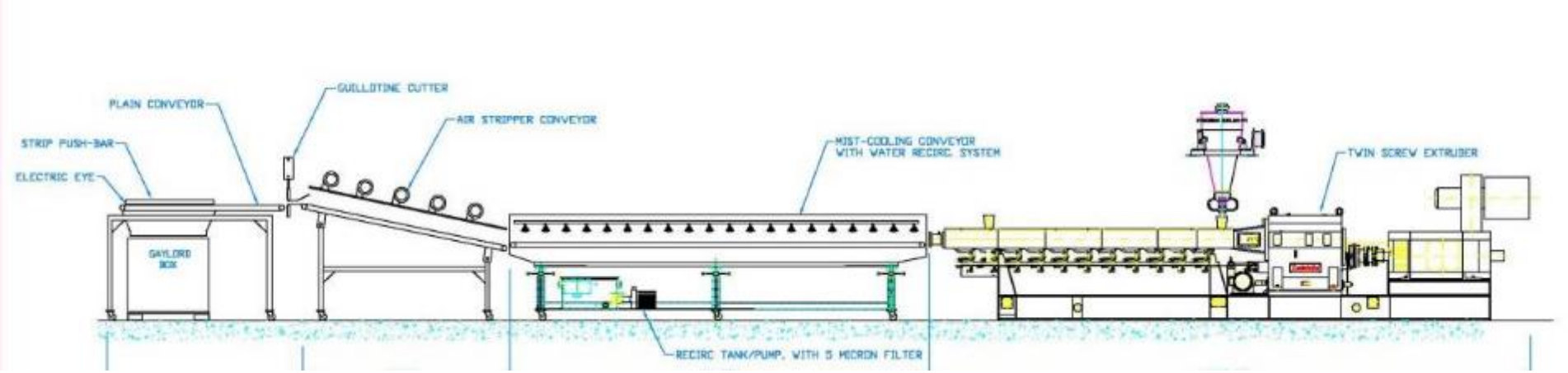


Thermo-mechanical devulcanization process with Supercritical CO_2

Process invented by Dr. C. Tsonganakis @ Univ. Waterloo

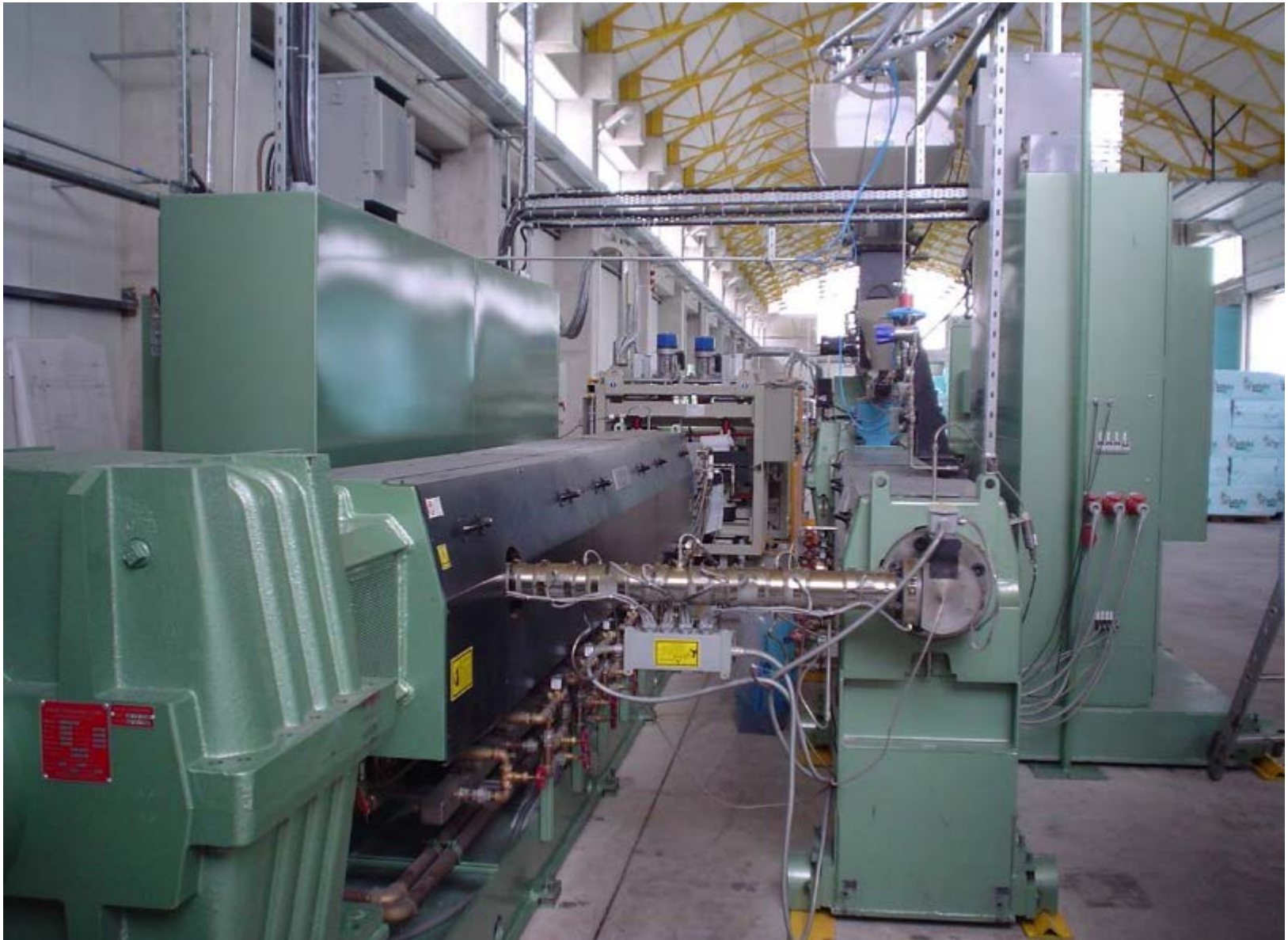
- A continuous devulcanization process which is carried out in a twin screw extruder
- No chemical agents
- $scCO_2$ acts as a plasticizer and with shear facilitates the process
- US patent 7,189,762

ZSE-90 MAXX Devulcanization System



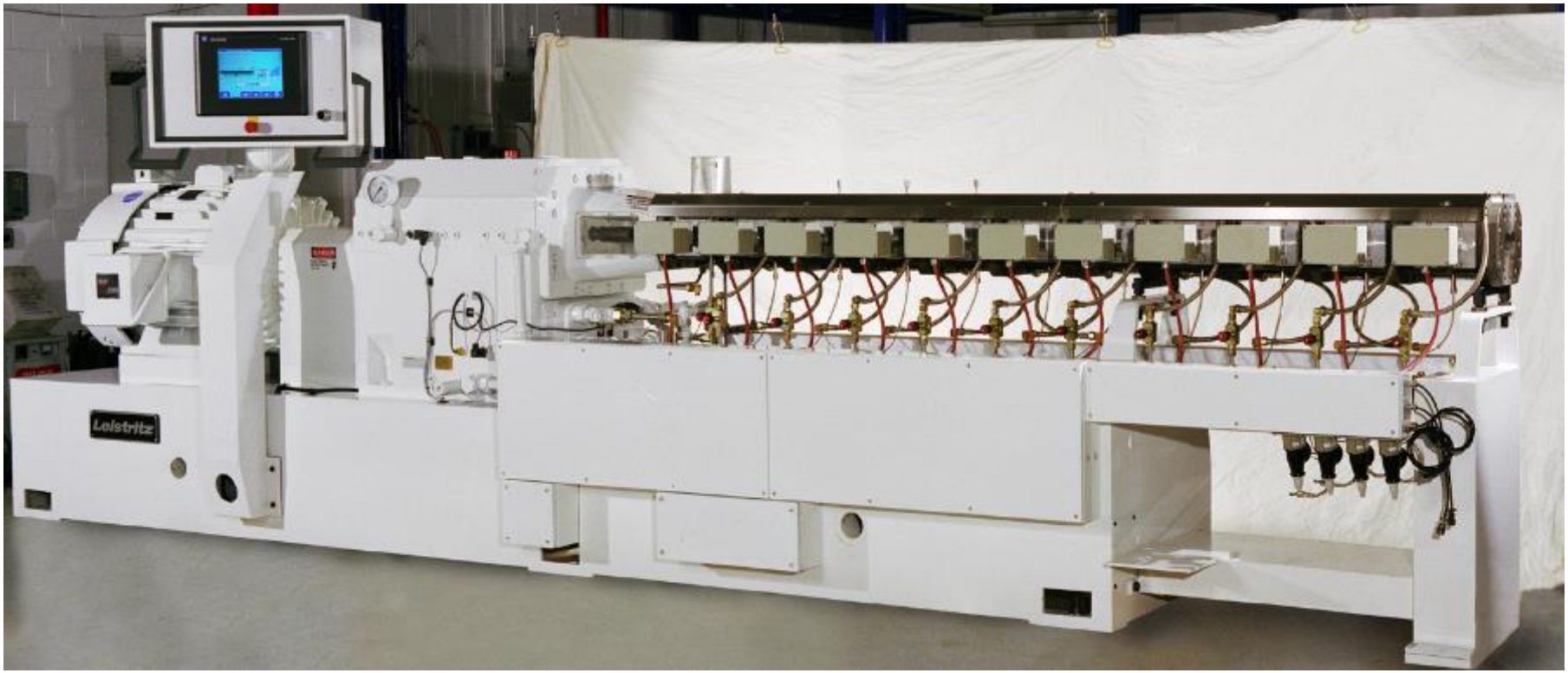
Licenses available from Tyromer, Inc.

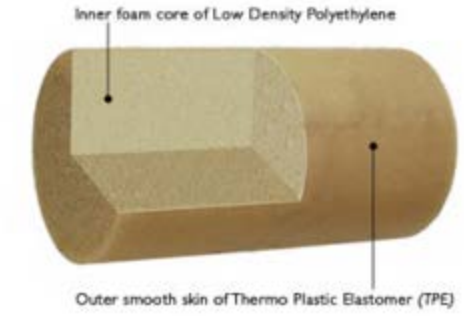
Davis-Standard Tandem Foam System



Inject/mix supercritical fluids > TSE

Most foam processes run @ 200 rpm or below



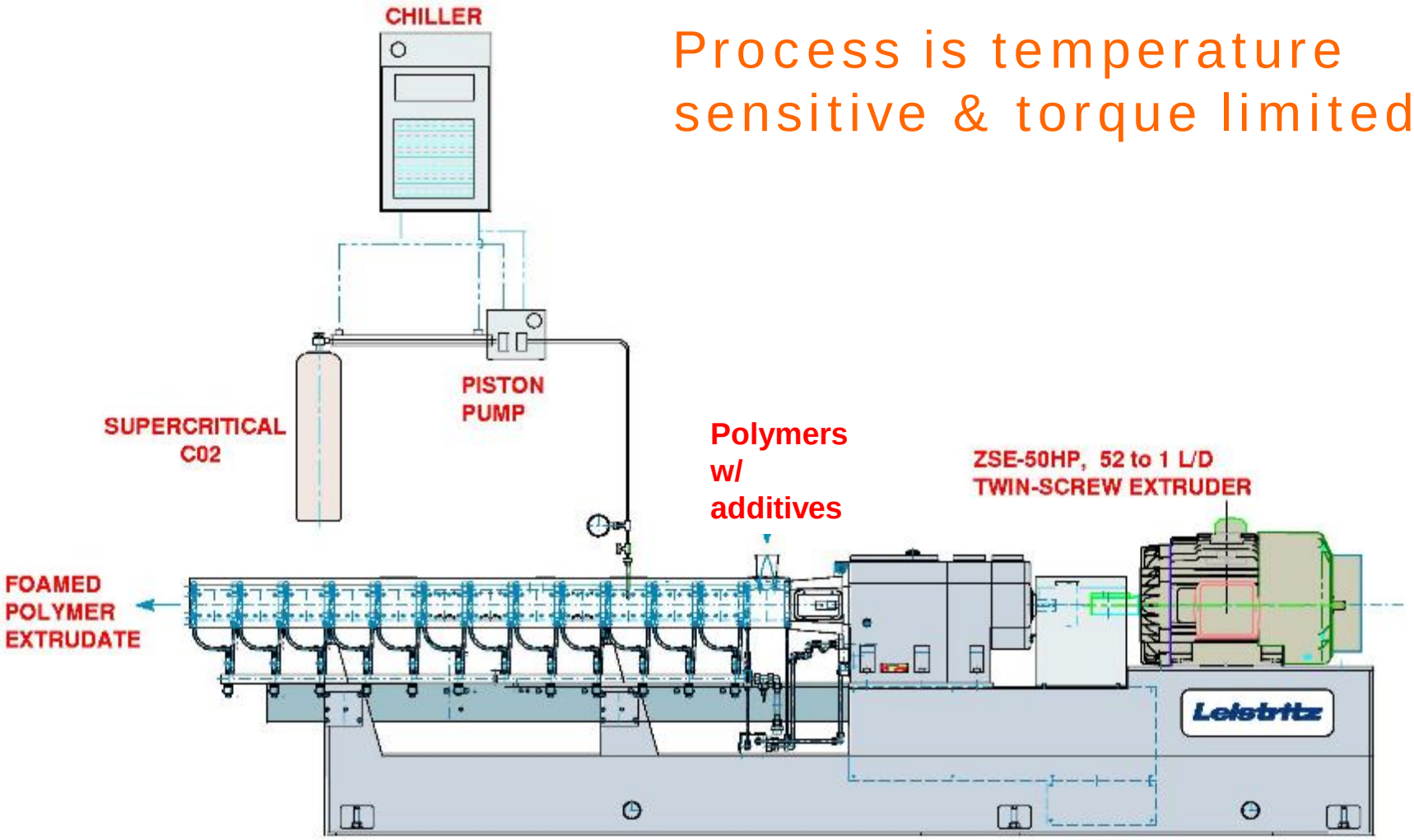


See YouTube
“How it’s made”

* Atypical TSE system

SCO2 injection into TSE

Process is temperature sensitive & torque limited



TSE screw design for SCO2 injection

- Dynamic seal is critical
- Screws run filled after injection
- Melt temperature must be kept low
- Process draws high torque

Supercritical CO2 liquid injection

Note dynamic seals and distributive mixing elements

Discharge element comparison

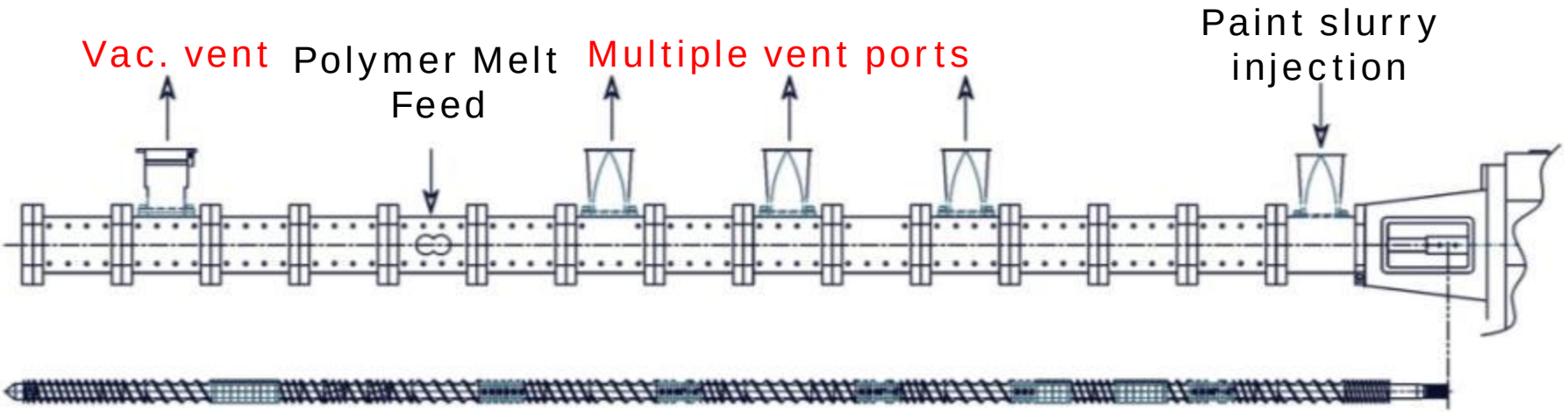
Open meshing elements = better heat transfer/cooling

Close meshing elements = more viscous heating

HSEI TSE process for paint reclamation

Paint/polymer blend on HSEI TSE*

Process developed @ Rutgers Univ.



Devolatilization efficiency depends on:

- **Residence time under vent(s)**
- **Surface area of melt pool**
- **Surface renewal of melt pool**
- **Vacuum efficiencies**

* Atypical TSE system

What's the TSE boundary condition?

- Volume limited- for high filler levels
- Torque limited- for foam and fractional melts
- Heat transfer- melt temperature must be managed
- Venting- a mass transfer limited unit operation
- Systems can be downstream limited

TSEs are often sub-systems of complex manufacturing operations