

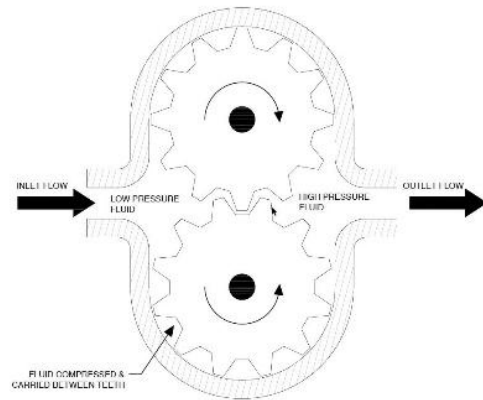
Injection systems integrated into the twin screw extrusion process

The co-rotating twin screw extruder (TSE) is a continuous mixing device where pellets, powders **and liquids** (the formulation) are metered into the TSE process section. A liquid (or melt) can be introduced at the main feed throat or into a downstream barrel section that is strategically positioned to inject prior to or into high division rate distributive mixers.



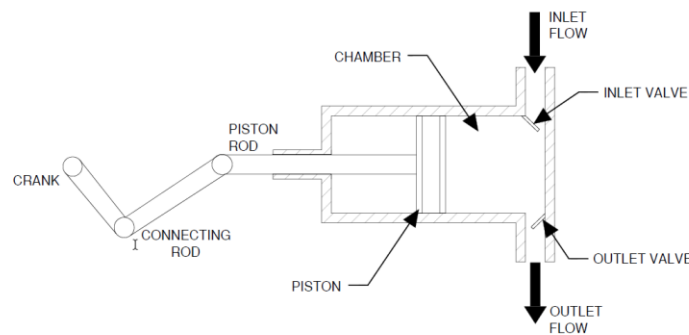
Example twin screw extruder with solids and liquid metering equipment

Gear pump: Processes to 1,000,000 cP at high pressures, provides a pulse-less delivery, and can be heated.



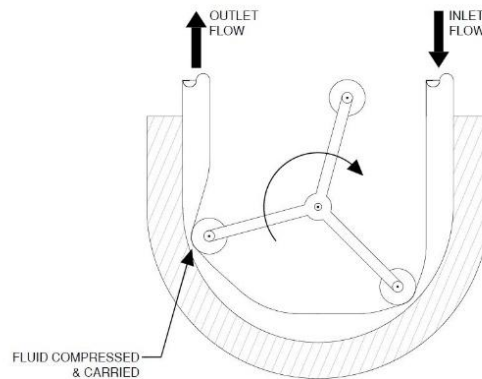
Gear pump

Piston pump: Processes up to 10,000 cP at high pressures with a pulsed delivery that can be minimized by high #strokes/min. or a pulsation dampener; can be heated and is easy to clean.



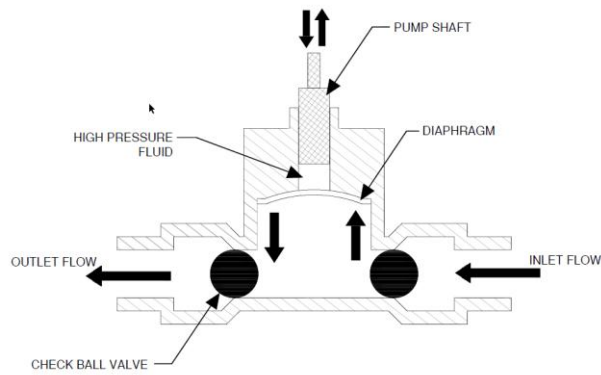
Piston pump

Peristaltic pump: Processes viscosities to 20,000 cP, but not at high pressures, with a pulse-less delivery; it can't be heated, is easy to clean and is available in a sanitary design.



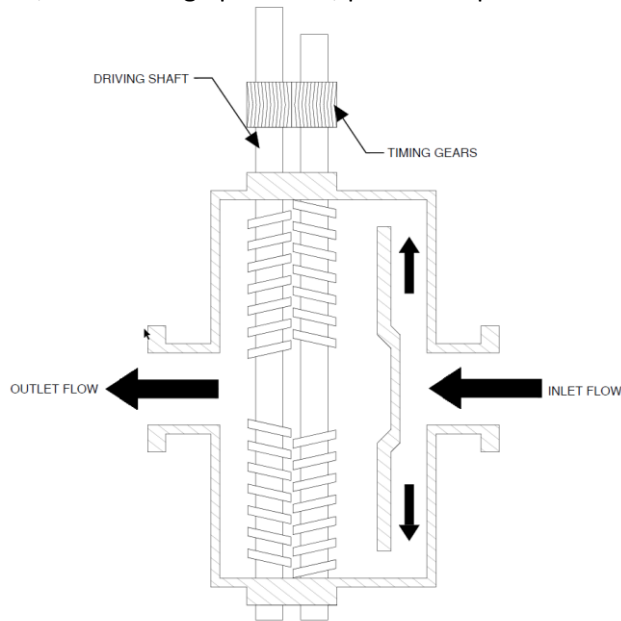
Peristaltic pump

Diaphragm pump: Processes at viscosities to 1500 cP with high pressures with a pulsed delivery that can be minimized by high #strokes/min. or a pulsation dampener, is easy to clean and available in a sanitary design.



Diaphragm pump

Screw pump: Processes up to 35,000 cP at high pressures, provides a pulseless delivery, and can be heated.



Screw pump

Standard features:

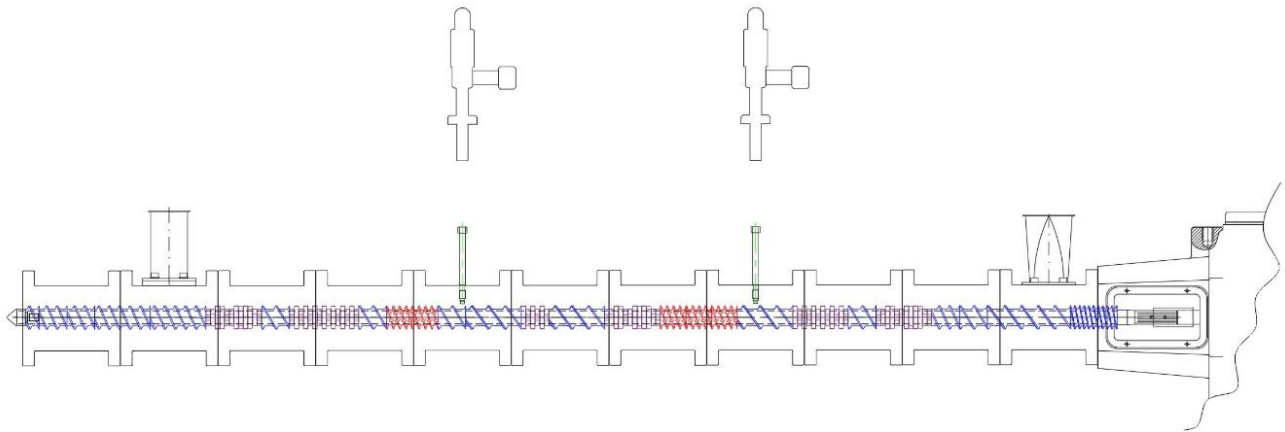
- Stainless steel reservoir with cover and drain valve
- Flexible hoses from pump to injector with pressure gauge and bleeder valve
- Stainless steel components with quick disconnects
- Components on common cart with casters and drip pan
- AC motor/drive

Options:

- Controls: volumetric, loss-in-weight and mass-flow meter
- Ambient or heated
- FDA and XP environments/classification

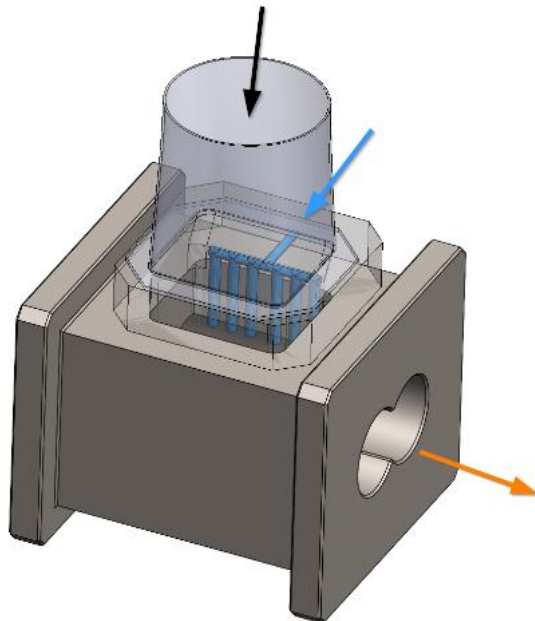
- Single or multiple pump configuration
- Tank agitation
- Manual or automatic refill
- Nitrogen purge or pressurized reservoir
- Interface to drum or pre-melt station
- Refrigerator chilling for supercritical fluids

Various injection scenarios are possible. For instance, the mixing of complex, high-liquid phase formulations (i.e. 70%+) requires sequentially staged injection points to prevent pooling in the screw channels. Once mixed, the formulation is devolatilized, cooled and pumped into a die or gear pump.



Screw design: feed, melt, mix, multi-stage injection, devol and pump

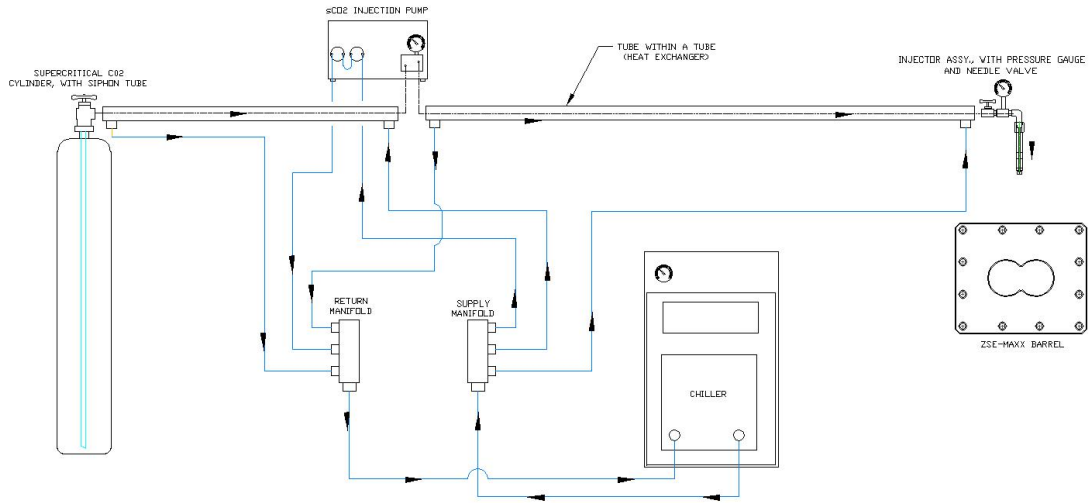
A liquid (i.e. plasticizer) can also be injected into an insert at the feed throat that sprays a plasticizer stream into a free-falling feedstock (i.e. FPVC pre-mix) to increase the attainable % in the formulation.



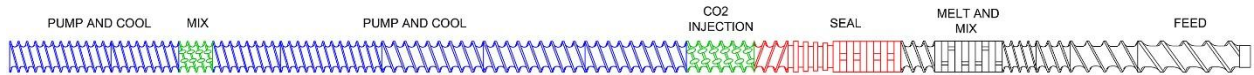
Feed insert for plasticizer injection at feed throat

Supercritical injection systems operate at high pressure, interface piping is refrigerated with intricate instrumentation that must be integrated with the ZSE-MAXX controls. The screw design is always

matched to intended process. For the injection of supercritical fluids a dynamic seal is integrated into the in the screw design to facilitate high-pressure injection.

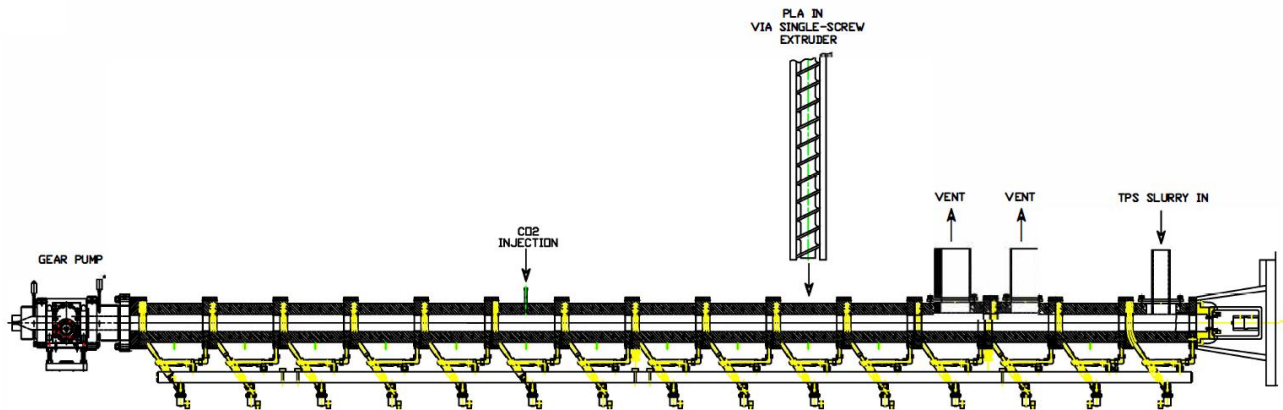


Injection system schematic for supercritical fluids



Screw design: melt, mix, sCO2 injection, cool and pump

It may be beneficial to use a single (or twin) screw extruder to melt and pump a polymer into a ZSE-MAXX barrel section. For instance, a Thermoplastics Starch (TPS) heated slurry can be metered into the ZSE-MAXX feed throat followed by early vents to devolatilize the water content. A PLA (or another polymer) melt can then be pumped into a downstream barrel (by a 2nd extruder) and mixed with the TPS. An additional sCO2 feed stream could then be injected to facilitate foaming, with a gear pump front-end attachment to help manage discharge pressures. This process is depicted as follows:



Twin screw extruder with single screw melt feed and sCO2 injection

Editor's note: The Leistritz Extrusion USA process includes the injection technologies for testing as part of twin screw extrusion systems.