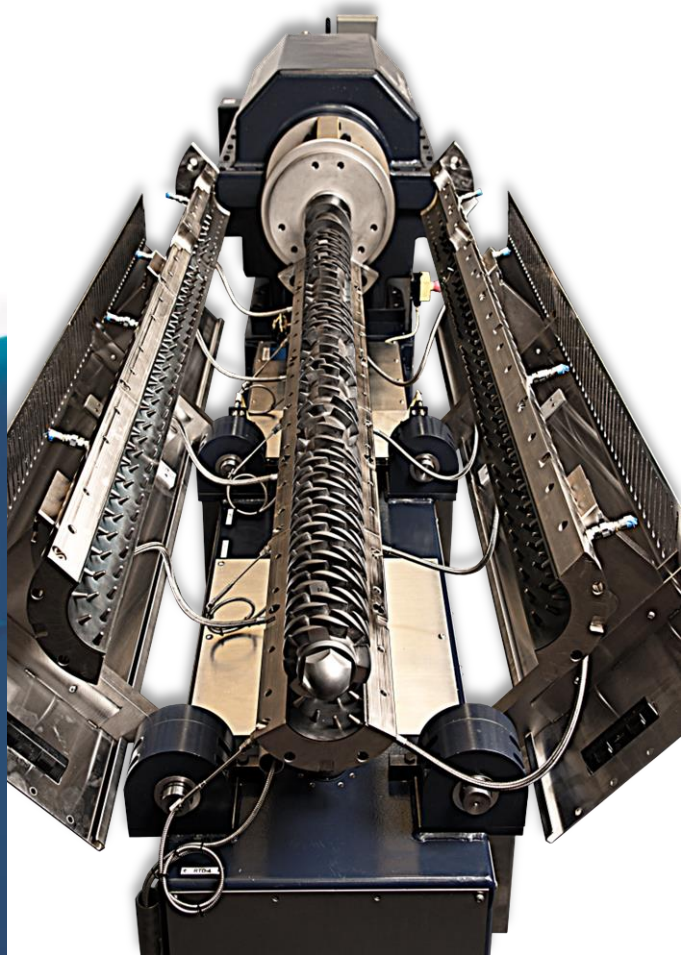
TriVolution® Compounder
2014 Product Guide

TRIVOLUTION®

NEXT GENERATION COMPOUNDING

B&P PROCESS EQUIPMENT

Strong Innovation • Strong Value • Strong Choice



TriVolution®

Next Generation Compounding

B&P has taken its more than 100 years of experience and traditional strengths in engineering high-precision, high-reliability processing systems and dedicated them to developing an innovative new compounding system that addresses many key issues facing processors today.

After three years of co-development through live test trials, addressing our clients specific process challenges and quantifying the benefits of this new technology, we are now supplying commercial production units to those customers and helping them to seize real-world opportunities. Through this empirical evaluation process, TriVolution® is proven to expand the range of capability while lowering both CAPEX and OPEX per kg of compound produced. Key associated benefits are:

- **Greater Energy Efficiency**
- **High Throughput at Slower Screw Speeds**
- **Broader Range of Applications**
- **High Capacity in a Smaller Footprint**
- **Improved Product Quality and Performance**
- **Increased Production Efficiency and Reduced Production Cost**

"The most recent major development in compounding," – Compounding World Magazine

Crammer Feeder (shown), Top Feeder or simple Feed Hopper for introducing raw materials into the process zone. Starve feeding, flood feeding and force feeding are all available options.

Atmospheric or vacuum vent stacks for ultra-efficient devol promoting stable processing and high quality melt.

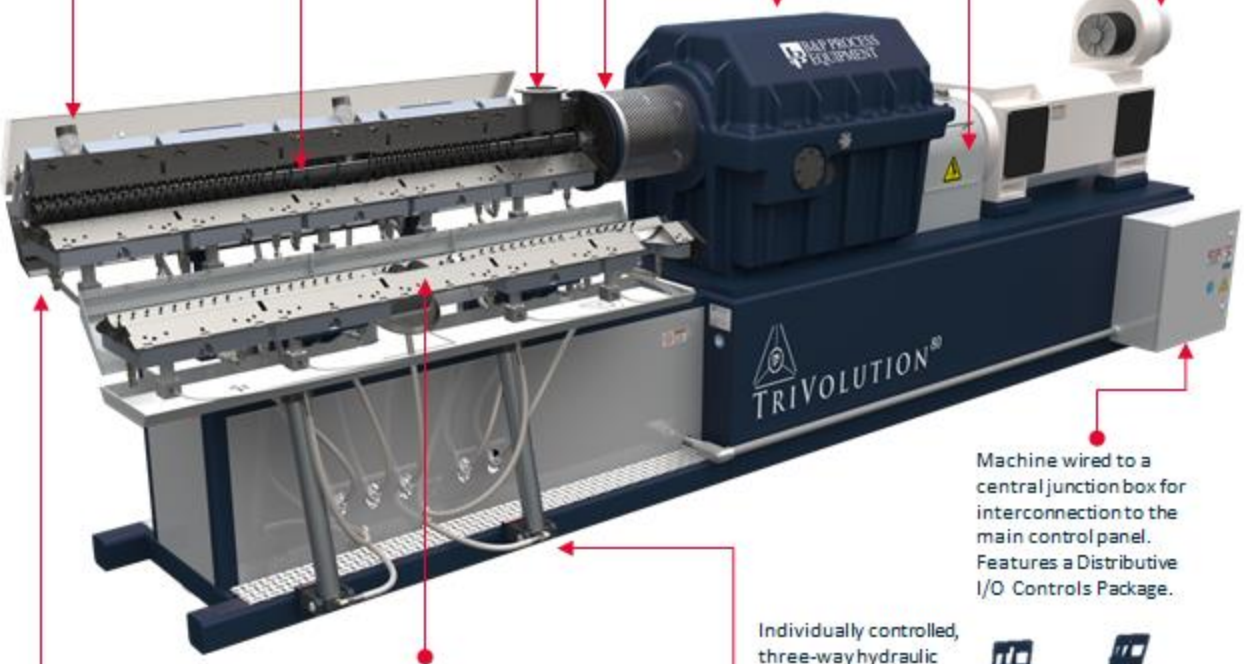
AC Motor and Variable Frequency Drive package provides the energy To power the TriVolution Tri-Kneader.

Compounders Toolbox offers widest array of elements for fine tuning of distributive and dispersive mixing as well as conveying, compression, renewable surface, free volume and degassing.

B&P's revolutionary gearbox provides both stroke and reduction while maintaining a high specific torque capability and a long operating life with relatively low maintenance.

Process zone sealed off from screw shaft coupling prevents contamination.

Torque limiter coupling prevents the System from torque overload by Disengaging the motor from the gearbox.

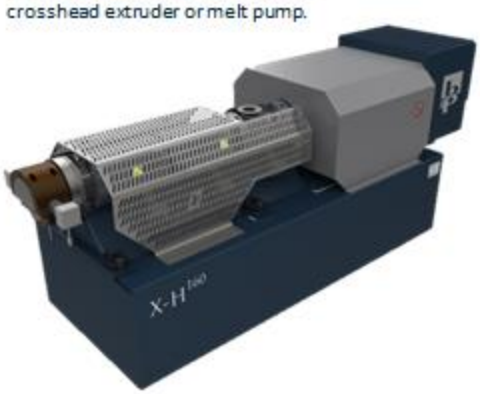


Machine wired to a central junction box for interconnection to the main control panel. Features a Distributive I/O Controls Package.

Individually controlled, three-way hydraulic barrel hinge system.

Multi-stage mixing profile can be accomplished with downstream feed ports such as a twin-screw side feeder.

Discharge pressurization through a crosshead extruder or melt pump.



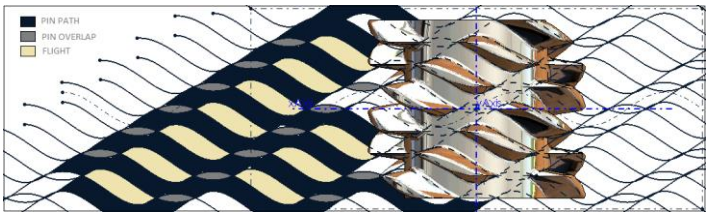
TriVolution® Operating Principle

TriVolution® is a unique compounding system based upon multiple axial oscillations per revolution of the screw shaft. The mixing interaction occurs between the discontinuous flights of the screw and stationary pins positioned along the interior barrel wall. The flights weave in a slalom pattern around the pins. A repeating cycle of product separation, folding, compression, shear, decompression and reorientation.

There are 12 pin-flight intermeshing zones in the cross section of the TriVolution®, versus 2 for a typical twin screw extruder or 3 for a typical Continuous Kneader. The key to improved plastics and manufacturing efficiency lies in these 12 zones, where elongational mixing occurs.

Legacy kneaders have a single stroke per revolution of the screw shaft. They have three or four rows of flights and pins. With the triple-stroke action of the TriVolution®, the unit operation is completed much more efficiently as a result of the high frequency and flow-stream reorientation. Furthermore, the barriers of the traditional kneaders are eliminated and material stagnation positions are now overlapped in self-wiping.

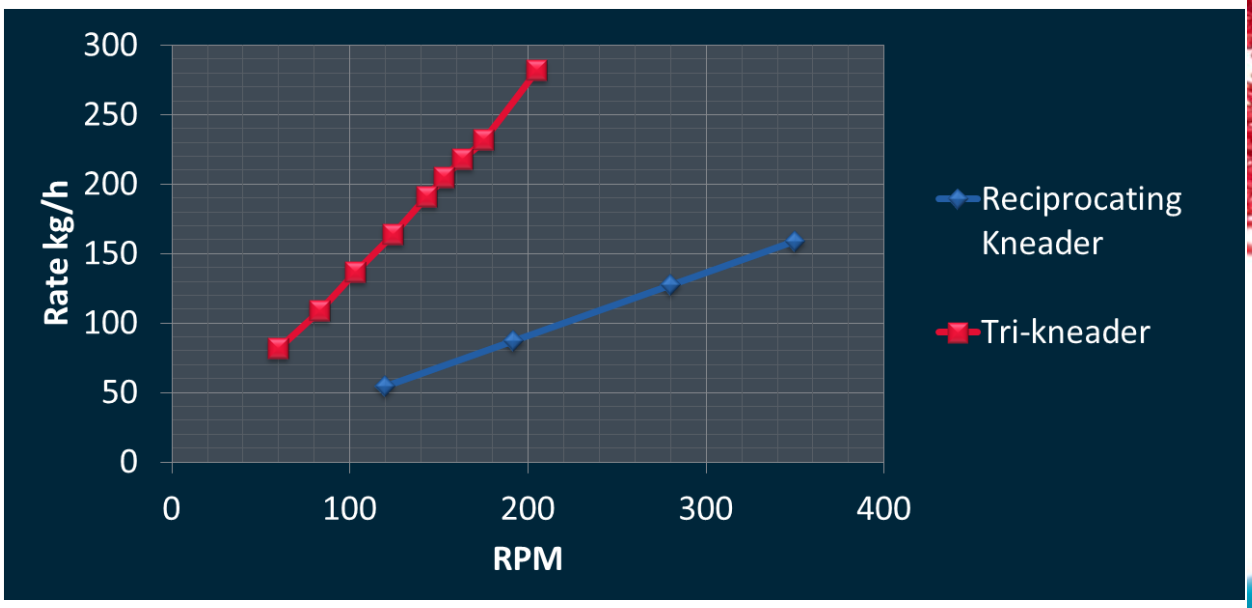
Efficiency, versatility, control and consistency are the key advantages of TriVolution®. This system is particularly beneficial if the melt viscosities and ranges of the various components vary widely and if high proportions of fibers or fillers must be incorporated.



TriVolution® leverages elongational mixing to stretch and disperse viscous materials, producing a consistently high-quality compound. Elongational mixing is highly effective in imparting a high degree of particle droplet deformation and breakup necessary to finely disperse additives, modifiers, and fillers without excessive shear or heat generation. Elongational mixing inside TriVolution® is advantageous, especially over mixing derived from planar shearing devices such as kneading blocks, blister rings, or other high-shear devices that consume more energy and cause higher viscous energy dissipation resulting in higher melt temperature.

The TriVolution® is an impressive machine in that it was able to process the high pigment loads we trialed without having to run at high RPM's,"

- Plastics Color Corp



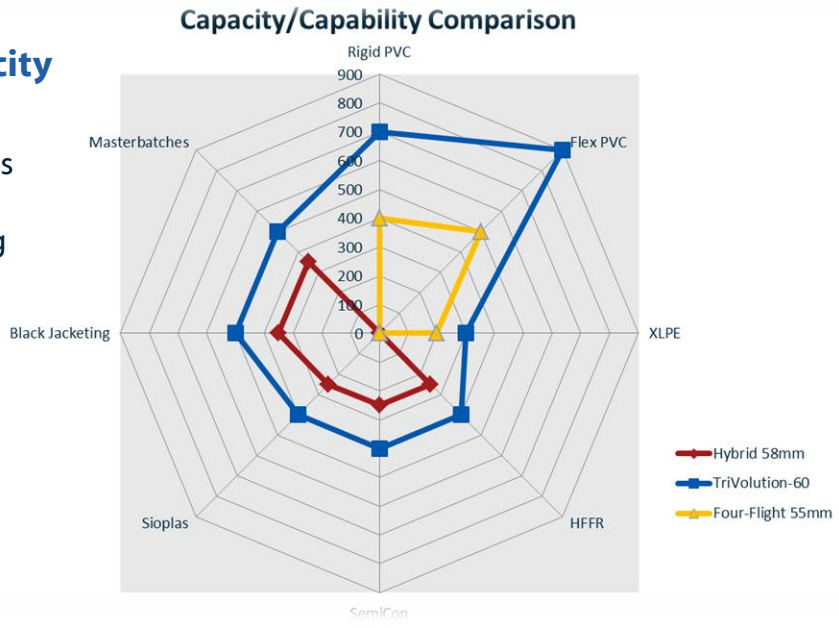
TriVolution® demonstrates high throughput at slow screw speeds and a reduced SME

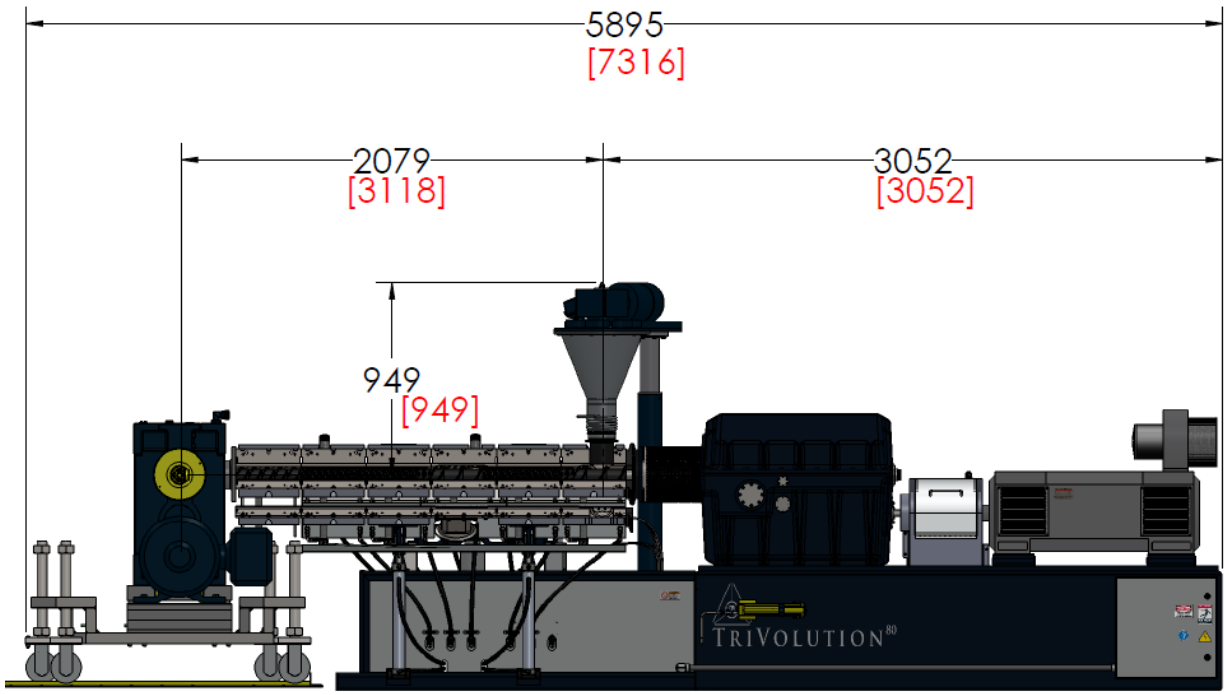
High Performance Devol, Crosslinking and Reactive Extrusion

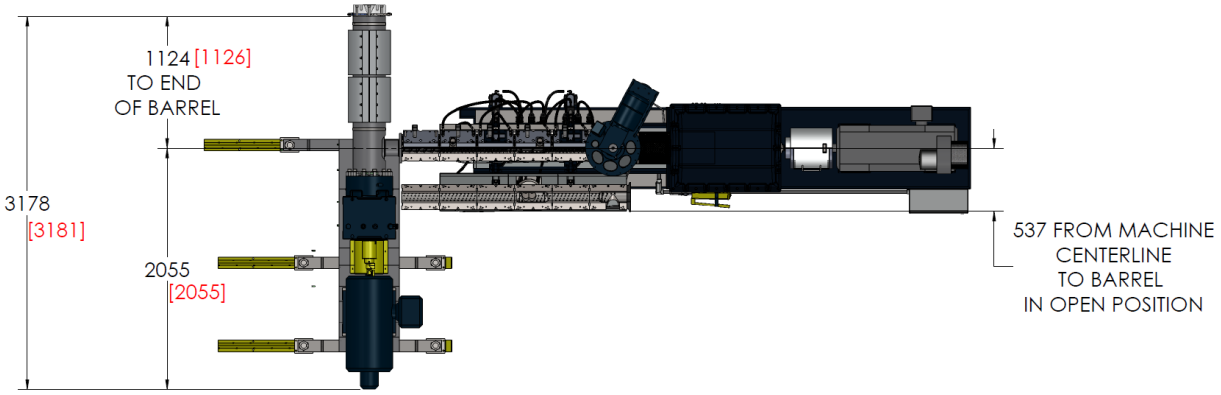
Several aspects of the TriVolution® design enable very efficient devolatilization and reactive extrusion. Smaller channels and quick multiplication of flow splitting for a given throughput result in thinner material thicknesses. This creates shorter diffusion paths for volatiles to escape from the melt. Larger free volume for a given screw diameter offers longer residence times. A narrow residence time distribution coupled with excellent surface area renewal promote efficient temperature control of the melt. Volatile byproducts can therefore be efficiently removed and ideal conditions for effective reactive processing. In grafting processes the flow-splitting and high renewable surface features create an increased number of grating sites presented. This makes TriVolution® an excellent performer in crosslinking applications.

Flexibility and Capacity

One TriVolution® has crossover capability that is not available on competitive reciprocating kneaders. Further, it has a significantly greater throughput range than even the latest competitive models.







Preliminary Dimensions TriVolution® in Crosshead Arrangement

TriVolution-80
[TriVolution-120]

The versatility inherent to TriVolution®, a TriVolution-30 self-contained lab system, and the "compounders toolkit" of flex elements presents key opportunities for development of applications across the enterprise.

A Wide Open Process Window

TriVolution® offers a wide range of process capability in traditional thermoplastics and thermoset applications but also has been tested in some other areas such as food, anode paste, bio-compounds, reactive and other various processes. The chart below offers a glimpse at some expected rates in thermoplastics compounding. For a precise calculation specific to your materials, take a test spin on the TriVolution-60 in the B&P Technology Demonstration and Development Center.

kg/h	30	45	60	80	120	160
FPVC	5-50	200-375	500-900	1100-2000	2400-5500	7000-13000
RPVC	5-50	175-300	400-700	700-1500	3500-5000	6000-9000
HFFR	5-30	75-175	225-400	400-1000	1500-2500	3000-4500
XLPE	5-25	75-125	175-300	400-1000	1400-2000	2500-4000
Sioplas	5-30	75-175	225-400	500-900	1500-2500	3000-4500
Semicon	5-30	75-175	225-400	600-1000	1500-2500	3000-4250
Masterbatch	5-35	125-200	300-500	600-1100	1800-3300	4500-6500
TPO/TPE	5-35	125-200	300-500	600-1100	1800-3300	4500-6500

The above figures are an estimate of performance subject to formulation variables and conditions which are typical of the given process. These are calculated based upon estimated scale-up conversions from our lab testing.

Testing, Proving and Demonstration

The B&P Customer Development and Demonstration Center is one of the most complete laboratory of this type in the United States. The 16,000 square foot building contains eight fully equipped pilot plant bays, an analytical laboratory, comfortable conference rooms and is staffed with experienced engineers and technicians. Here, customers' products and processes are evaluated on a pilot plant scale. B&P Process Engineers and Laboratory Technicians handle dozens of such confidential evaluations each year. Complete process data are generated for the B&P Marketing and Design Engineering departments to finalize the formal proposal for the buyer. Successful extrapolations of these data to production equipment have been well documented over the years!

Dead Stop Analysis:

TriVolution® has a three-piece hinged barrel that allows each third to be opened independently. During lab testing, this is useful for "dead-stop" analysis. During operation, the barrel full of material, is halted mid-stream and opened. Evaluation of the unit operations effectiveness allows for optimization.

Direct, empirical analysis can be performed on these available compounding systems in the B&P Technology Center:

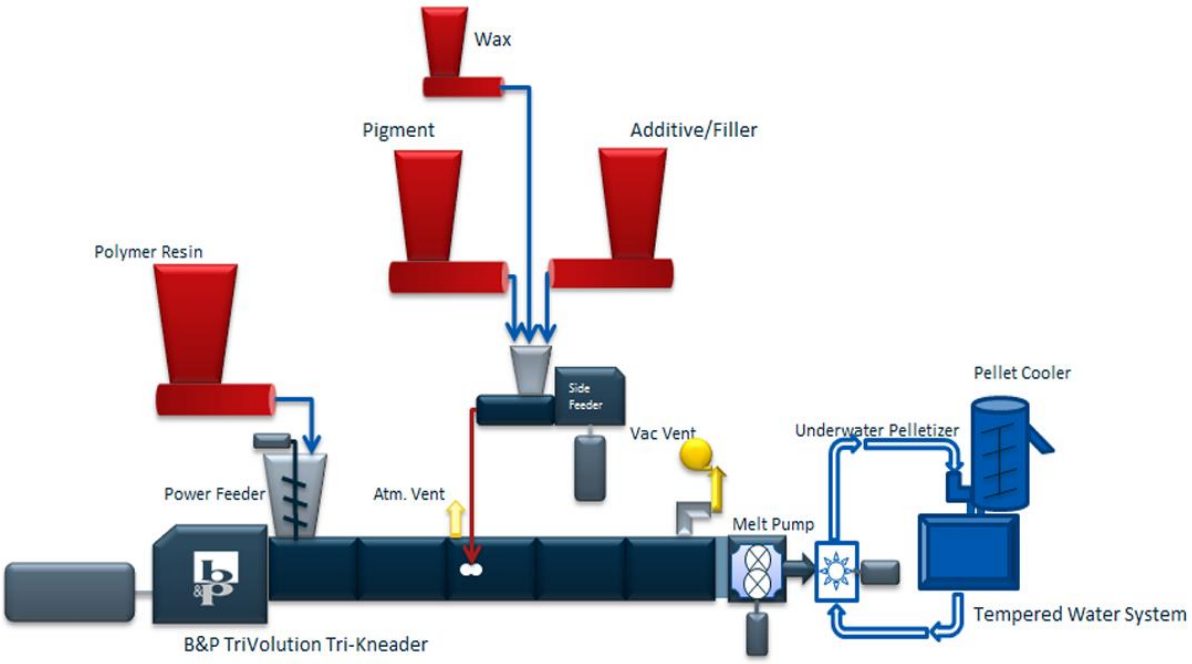
- 50mm BP Series Twin-Screw Extruder
- 40mm CT Series Twin Screw Extruder
- 60mm CK Series Ko-Kneader
- 60mm TriVolution® Series Tri-Kneader

TriVolution® Application Areas

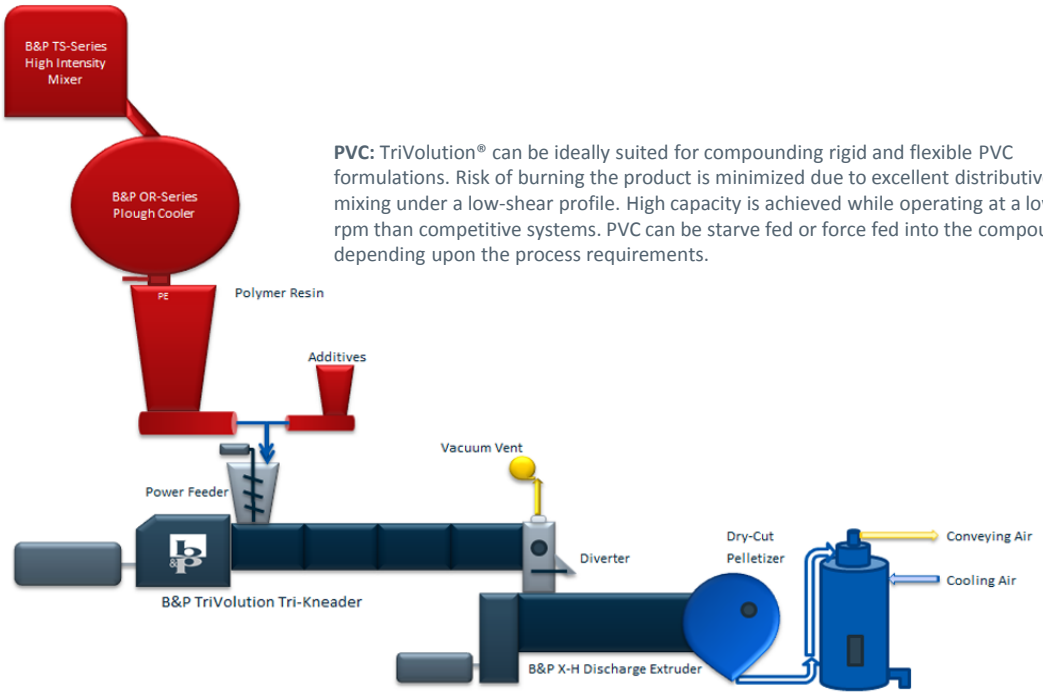
Ranging from the very aggressive, high-energy, high-shear dispersive nature to a rather finesse, low-shear, distributive nature, TriVolution® is a premium compounder across a very broad spectrum of application areas.

A significant percentage of tests performed at B&P were on formulations that processors were not able to compound by conventional means.

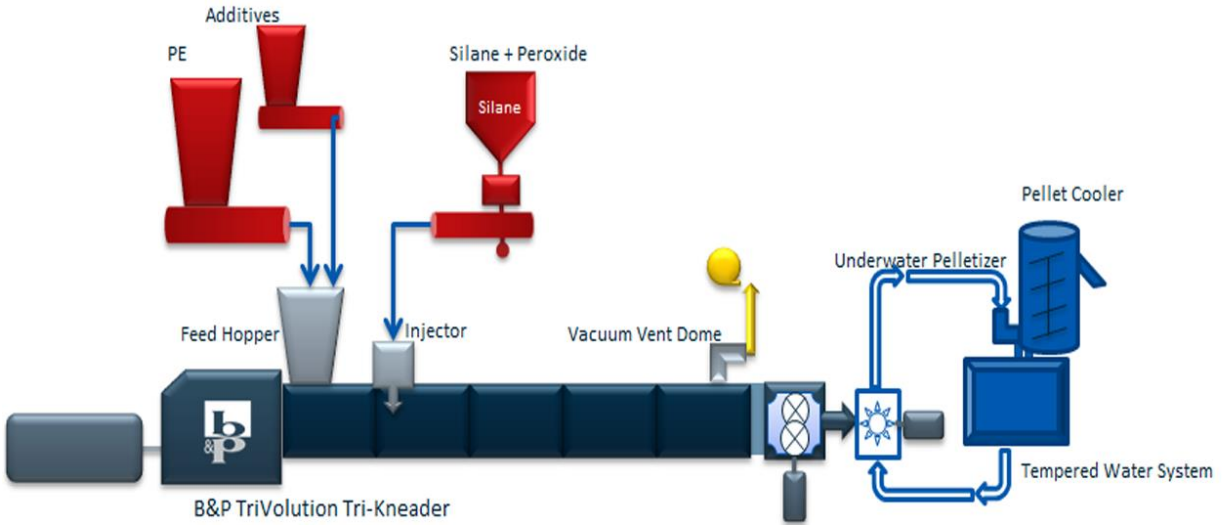
A cross-section of application areas relevant to target markets are represented here. Layouts, parameters and performance are dynamic according to material and formulation specifics.



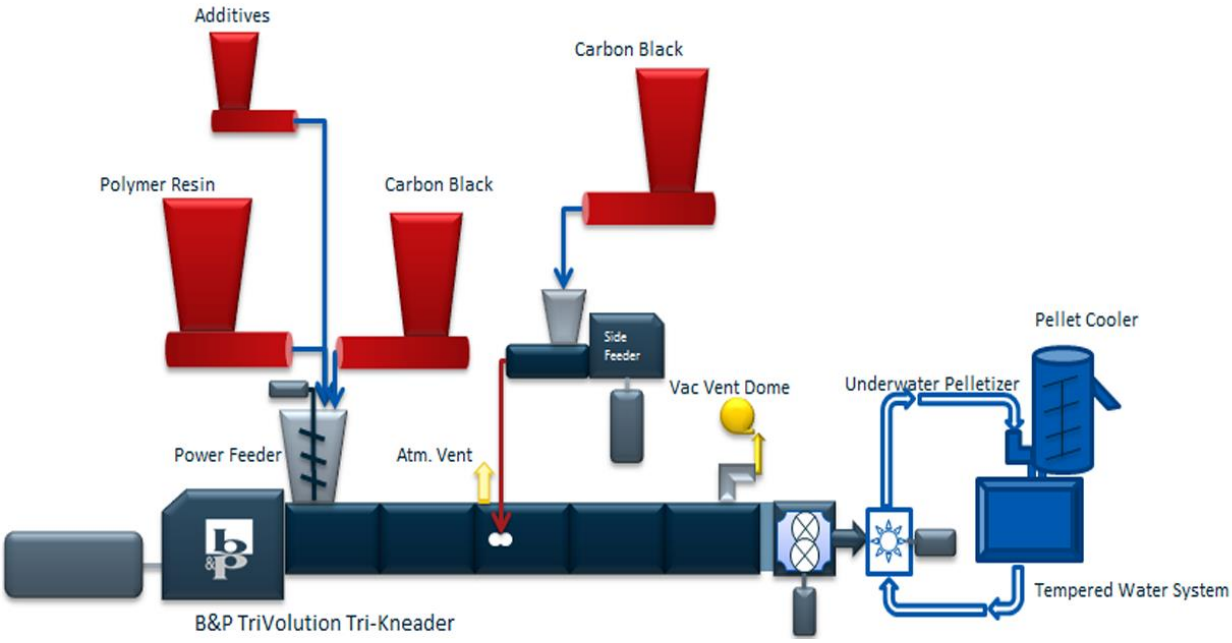
MASTERBATCH: Generally speaking, a reciprocating kneader is not an ideal solution for masterbatch compounding. The lack of heavy dispersion is a liability for most kneaders. The TriVolution®, however, breaks that rule. By incorporating a series of the SureFlite-24-TC elements from the compounders toolbox, TriVolution® becomes a high dispersion, high-torque machine which efficiently processes color, white, black and additive Masterbatches with a lower SME profile than traditional systems.



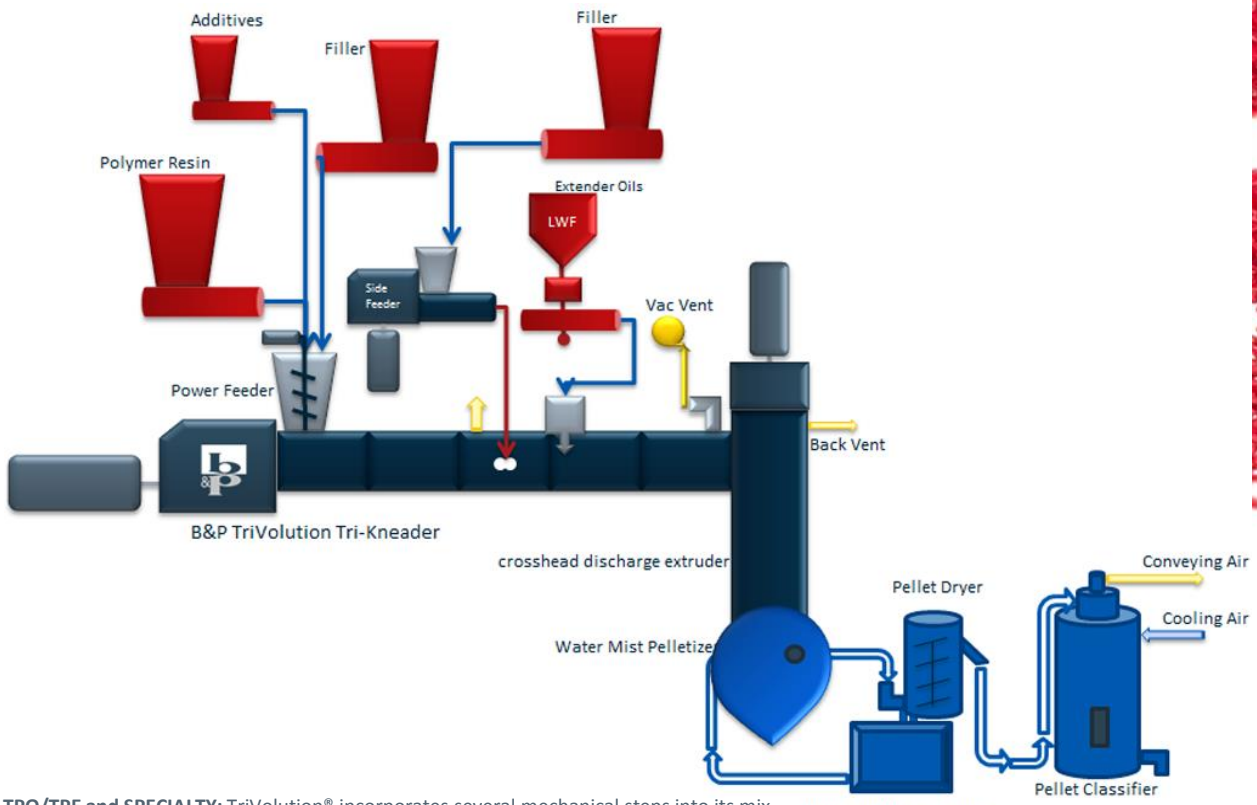
PVC: TriVolution® can be ideally suited for compounding rigid and flexible PVC formulations. Risk of burning the product is minimized due to excellent distributive mixing under a low-shear profile. High capacity is achieved while operating at a lower rpm than competitive systems. PVC can be starve fed or force fed into the compounder depending upon the process requirements.



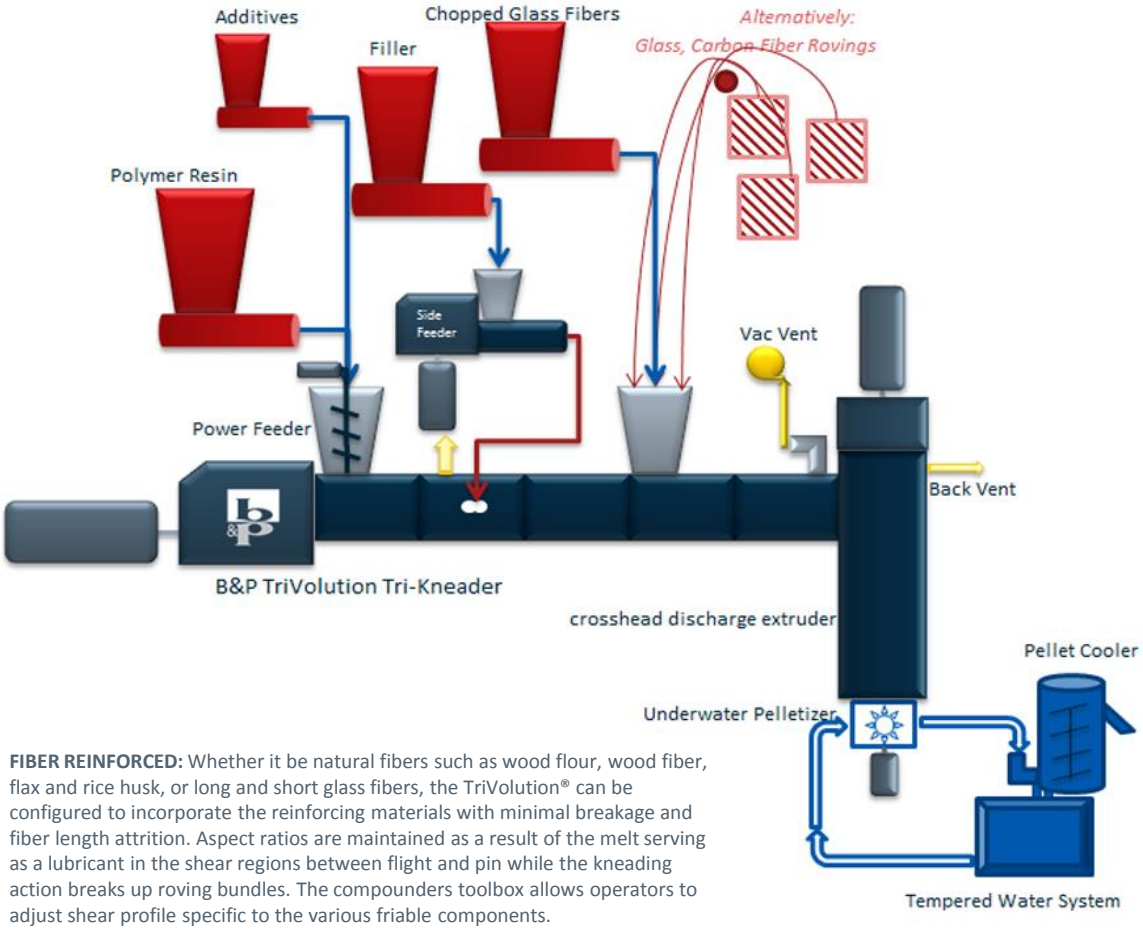
SIOPLAS: An excellent combination of adjustable residence time distribution and distributive mixing profile support the performance of TriVolution® in XLPE and Sioplas applications. TriVolution® is proven to achieve a high level of grafting to the polymer matrix. A well-controlled low temperature profile prevents the flashing off of liquid component. High dispersion SureFlite-24 elements from the compounders toolbox allow the polymer to be quickly melted prior to the introduction of liquid silane/peroxide mixture.



SEMICONDUCTIVE: Split-feeding special conductive carbon-black under a high-dispersion profile results in a consistent and homogenous semiconductive compound. TriVolution® is capable of achieving a high-loading of carbon black for this application while using averting shear-breakdown which results in a loss of conductivity. A combination of SureFlite-8, 16 and 24 elements from the compounders toolbox, with standard shear profiles results in compounding with zero imperfections.



TPO/TPE and SPECIALTY: TriVolution® incorporates several mechanical steps into its mix cycle and it repeats this cycle several times throughout the rotation and reciprocation of the screw shaft. Conveying, folding, orientation, compression, shearing, decompression and reorientation take place and, unlike traditional systems, the intensity of each cycle is adjustable. Control and consistency are primary advantages of TriVolution® and a very uniform dwell time and heat history can be presented resulting in high quality compounding of a wide range of materials.



FIBER REINFORCED: Whether it be natural fibers such as wood flour, wood fiber, flax and rice husk, or long and short glass fibers, the TriVolution® can be configured to incorporate the reinforcing materials with minimal breakage and fiber length attrition. Aspect ratios are maintained as a result of the melt serving as a lubricant in the shear regions between flight and pin while the kneading action breaks up roving bundles. The compounders toolbox allows operators to adjust shear profile specific to the various friable components.

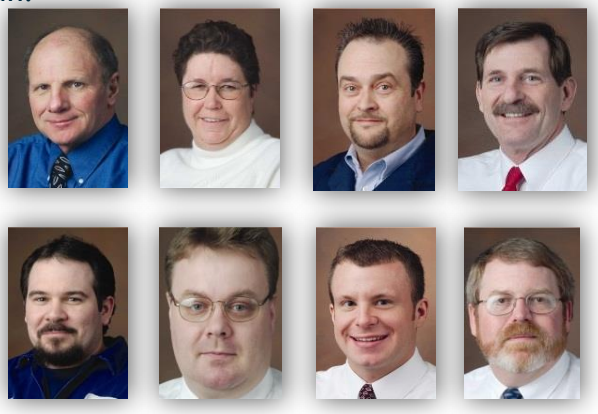
Choosing TriVolution®

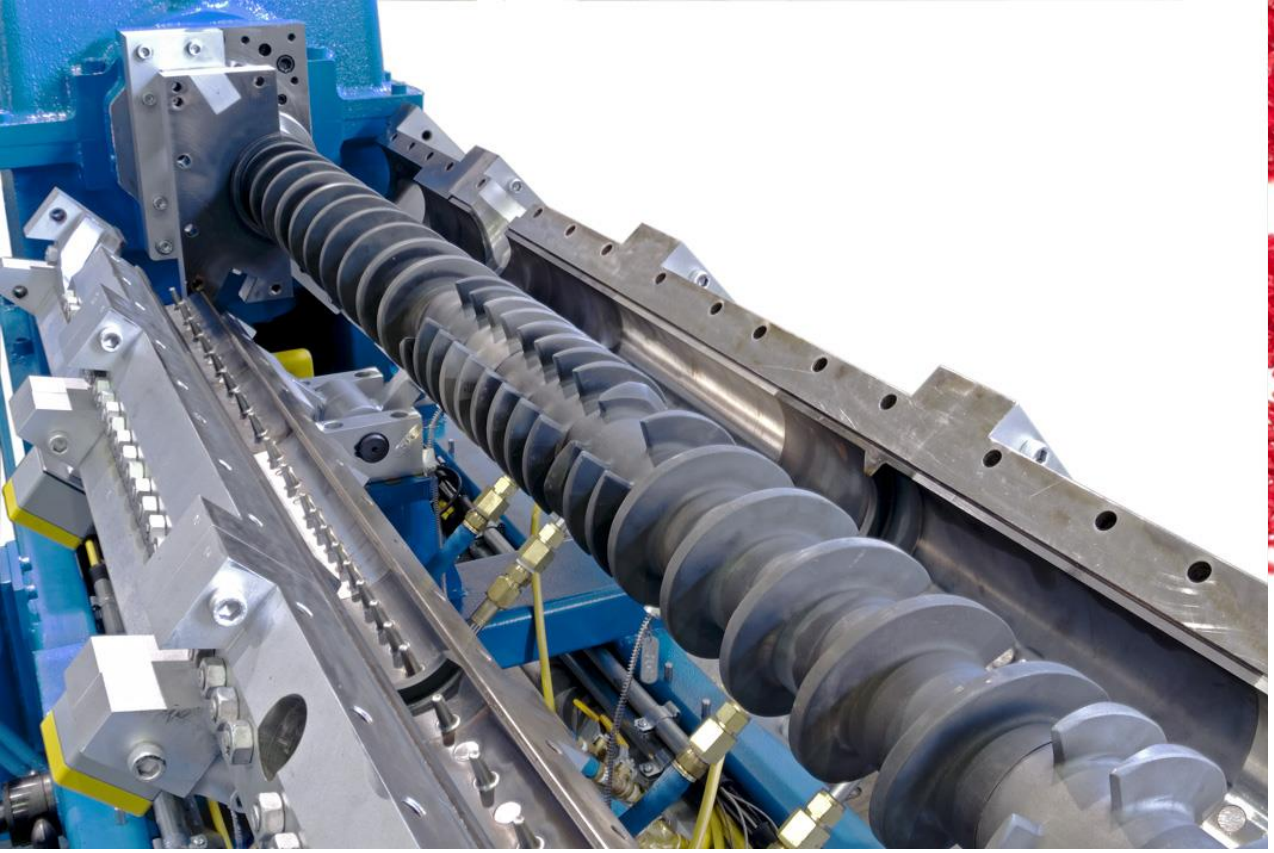
	Twin-Screw	Reciprocating Kneader	Tri-Kneader
Residence Time Distribution	Variable (wide)	Variable (narrow)	Variable (narrow-wide)
Dispersion	Excellent	Fair	Excellent
Heat Transfer	Excellent	Good	Excellent
Venting	Good	Poor	Excellent
Pumping	Excellent	Poor	Good
Self-Wiping	Excellent	Excellent	Excellent
Zoning	Excellent	Excellent	Excellent
Output Rate	Good	Fair	Excellent
Distributive Mixing	Good	Excellent	Excellent
Shear Intensity	Mod-High	Low	Low – Mod – High
L/D Ratio	15-55	8-20	8-28
Free Volume	Poor (Fixed)	Good (Fixed)	Good (Variable)

100% Guaranteed Performance!

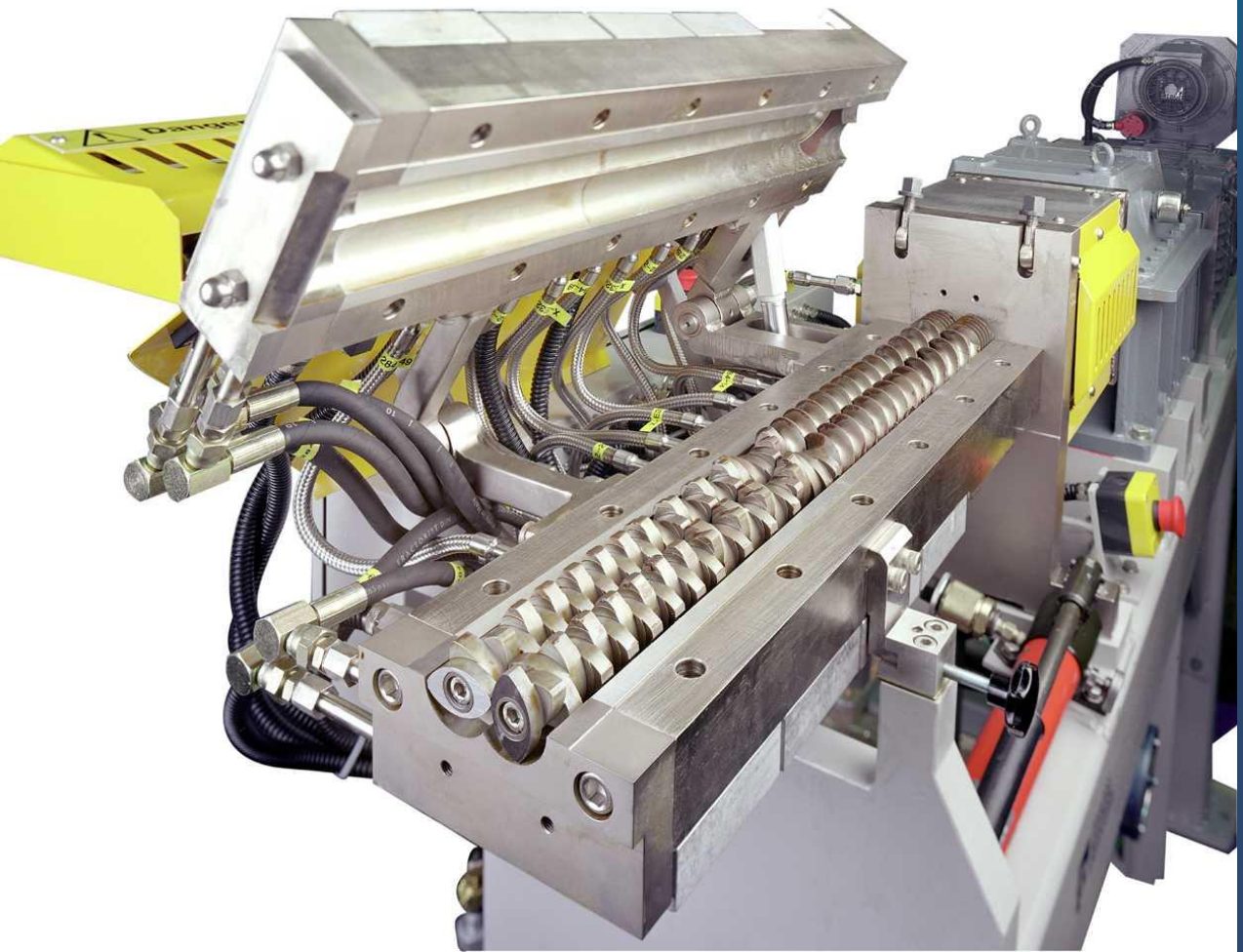
Not only will B&P put to work our more than 120 years of experience in building process machinery but we will also employ our high level of dedication to customer service and satisfaction. We realize that choosing a new technology presents a difficult decision. Thus, we designed TriVolution® from the common base of continuous compounding and dramatically improved the process performance. Further, we are backing it with our commitment to performance and our experienced, knowledgeable service and support staff.

Each customer is provided a dedicated team of experts proficient in the design and operation of our equipment. Our Field Advisory Services team will install and commission your machinery and ensure your total satisfaction with B&P Process Equipment!





B&P also offers both the ko-kneader (above) and twin-screw extruder (below). Our clamshell-barrel BP-Series Twin Screw is renowned for performance in thermoset compounding applications. Should you be committed to this technology in your plant, B&P will continue to present an option.



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