BEPEX is a world leader in designing, building and optimizing equipment and technology for polymer crystallizing, drying and reacting processes. Providing customers with proven total process solutions cost-effectively is a hallmark of BEPEX. For example, our acclaimed state-of-the-art PolyQuest Development Center empowers PET resin producers to optimize a specific process and generate market samples, before committing to full-scale plant modification and changeovers.

The continuous Solid State Polymerization (SSP) process for condensation polymers has been a specialty at BEPEX for over 40 years. The BEPEX technology for processing polymers evolved over the decades utilizing the most modern technologies in developing and commercializing new polymers. Our engineers and designers developed innovative solutions by thoroughly understanding the industry trends and the customers' needs. Our in-house knowledge and expertise in particle processing provides a strong platform for this purpose.

**Our commercialized technologies for processing polymers include:**

**Polyesters** — Process equipment and technology for heating, crystallizing, drying, reacting, cooling and dedusting are available. The range of aromatic polyesters processed includes:
- Poly(Ethylene Terephthalate (PET))
- Highly modified COPET
- Poly(Trimethylene Terephthalate)(PTT)
- Poly(Butylenes Terephthalate) (PBT)
- Poly(Ethylene Naphthalate) (PEN)

**Biodegradable Polymers** — Process equipment and technology for heating, crystallizing, drying, reacting, cooling and dedusting are available. Examples include:
- Poly(Lactic Acid) (PLA)
- Aliphatic Polyesters

**Recycled Plastics** — Process equipment and technology for upgrading recycled material by decontaminating it of volatile impurities and increasing its molecular weight. Examples are the recycling of PET and COPET bottle flakes.

**Retrofitting and Process Upgrades**
We help our customers stay competitive and profitable by providing continuous improvement and updating the technology of existing systems. Customers benefit from new BEPEX process technology and developments that can increase existing plant capacities by over 50%, or improve the profitability of older systems.

**Polyolefins** — Process equipment and technology for stripping the monomer and removing volatiles from freshly polymerized powders and pellets are available. Examples are polyethylene and polypropylene along with their comonomers.

**Other Polymers** — Process equipment and technology have been commercialized for proprietary processes such as:
- Poly(amides) (PA)
- Poly(ketones) (PEK)
- Poly(Vinyl Alcohol) (PVA)
- Poly(Carbonates) (PC)
- Poly(Tetrafluoroethylene) (PTFE)
- Modified cellulosics
- Poly(Phenylene Sulfide) (PPS)
- Poly(Phenylene Oxide) (PPO)
- Poly(Etherimide) (PEI)
- Poly(Urethanes) (PU)
Modification to any link of the PET resin processing chain requires a corresponding change in one or more of the upstream processes. The further upstream this change occurs, the larger the number of processes that need adjustment and optimization. Thus, the most efficient response to the packaging property modification can be met by adjustments in the injection molding and the blow molding operations. This is reflected in the relatively large number of development activities with the injection molding and blow molding machinery suppliers compared to those at the resin suppliers. In most instances such development activities are initiated by the changing requirements of the PET containers. This is represented by the feedback loop mechanism sketched below.

The development trial matrix may involve several tests to quantify the effect of changes in process variables and to optimize the new process. Such trials are not economically feasible in a commercial plant with extremely high production demands. In order to reduce the cycle time and the cost of commercializing these developments, bench scale experiments and pilot scale trials with a well planned statistical design of experiments is recommended. The use of appropriate pilot scale facilities for melt phase polymerization and solid state polymerization along with commercial scale injection molding and blow molding machines is therefore essential for successful developments. However, resin suppliers rarely have in-house pilot plant capabilities that cover the entire spectrum and rely on out-sourcing some or all of the testing needs. BEPEX has long recognized the need for such a pilot plant for continuous solid state polymerization of polymers, in particular PET resins, resulting in the installation of a state-of-the-art pilot plant facility in 1996 in Minneapolis, MN, USA. This facility named PolyQuest Development Center, offers technology enhancement to PET resin suppliers. The center provides a "mini-plant" operation of an exact scaled-down version of the commercial SSP plants.

Benefits to the user are as follows:
- POLYMER PRODUCT DEVELOPMENT
- PROCESS DEVELOPMENT
- EQUIPMENT DEVELOPMENT
- PERSONNEL DEVELOPMENT
- MARKET DEVELOPMENT
- VALIDATION OF NEW PROCESS DESIGNS
- VALIDATION OF COMPUTER SIMULATION PROGRAMS
**POLYESTER PROCESSING**

**BEPEX SSP Technology:** The BEPEX Solid State Polymerization (SSP) process has evolved over the past 40 years with hundreds of successful installations producing a wide variety of quality polyester products.

**Crystallization/Drying:** Low molecular weight polyester polymer is normally available as free flowing pellets in the amorphous state having an equilibrium level of free moisture. Heat treatment is required to induce crystallinity in the polymer and to remove the moisture prior to SSP. During this processing step, agitation is necessary in order to prevent the pellets from “caking” and forming lumps with poor material flow characteristics. The efficient heating and plug flow material handling performance of the BEPEX horizontal Solidaire® crystallizer is the key to successful crystallization and downstream processing. Further drying of the heated pellets is optional and depends on the polymer formulation and product specifications.

**Preheating/Annealing:** For a successful control of the entire SSP process, crystallinity levels of around 50% are required. This is achieved by heating the crystallized pellets to the final reaction temperature and holding it at this temperature for the required time. Here again, agitation is necessary in order to prevent the pellets from “caking” and forming lumps with poor material flow characteristics. Depending on the polymer formulation and product specifications, the optimal time temperature history in this step requires special consideration. The BEPEX Solidaire® Torusdisc® Purge Screw and Annulator provide exceptional performance in this step.

**Solid State Polymerization:** To produce today’s high throughput requirements with a molecular weight increase ($\Delta$Mn) of 12,000 to 17,000 ($\Delta$IV of 0.2 to 0.35), a reactor design is required which provides reliable operation with an extremely tight plug flow characteristic. The BEPEX Purge Hopper and the Mechanical Discharge not only provide excellent plug flow characteristics but can break up “cakes” and lumps that pass through the SSP reactor.

**Gas Purification:** For an economical SSP process, the inert nitrogen gas used in the preheating and polymerization process is purified of the reaction by-products and recycled back to the process. Proper purification of the gas is essential for the control of product quality. BEPEX offers alternative methods based on gas scrubbing, adsorption or catalytic oxidation principles depending on the available utilities and client preferences.

**Cooling/Dedusting:** The high molecular weight crystallized product leaving the SSP reactor needs to be cooled to facilitate storage and packaging. At the same time, the dust content of the pellets is normally reduced to below 100 ppm in this step. The BEPEX fluid Bed has proven to perform well for this application. The Solidaire® Torusdisc® or the ThermaScrew® have proven to be cost effective alternatives when dedusting is not required.
BEPEX is a single source for continuous Solid State Polymerization (SSP) PET plants. An in-depth understanding of the fundamental mechanism of various processes created the breakthrough in computer modeling of the SSP process. Today’s PET resin producers are facing more competitive pressure than ever before to expand capacity while profit margins are shrinking. BEPEX can help you capitalize on new PET resin opportunities by getting to market faster and at less cost.
Recycling PET benefits the environment by reducing the amount of waste in landfills and benefits the processor by cost savings in raw material. Furthermore, the energy required in reclaiming post consumer PET is lower than that of producing virgin PET from petroleum.

The primary sources for recycled PET are textile waste and soft drink bottle scrap. The sorted, cleaned and ground wastes are of a low bulk density with poor material handling characteristics. Versatility of our mechanically agitated lines as well as the diversity of what we are capable of supplying has helped us find technically and economically feasible solutions for the needs of the recycler.
**BIODEGRADABLE POLYMERS**

*Biodegradable polymers of commercial interest* are a class of aliphatic polyesters derived from either biomass or crude oil. It is not surprising that BEPEX particle process technology for aromatic saturated polyesters has found applications in emerging biodegradable polymer technologies. The new polymers tend to be slow to crystallize and easily agglomerate when the amorphous pellets are heated. Versatility of our lines as well as the diversity of what we are capable of supplying has helped us find technically and economically feasible solutions to the needs of the biodegradable polymer producer. We constantly work to improve existing equipment designs while developing new ones altogether in order to meet our customer’s unique requirements. The applications of particular interest to the biodegradable polymer producer are BEPEX crystallizing, drying and solid state polymerizing process equipment and technologies.

**RETROFITTING**

*Retrofitting existing plants* can be a very quick and cost effective way to boost the profitability of a manufacturing operation. This is especially important in today’s business climate of high interest rates and low budget outlay for capital equipment. BEPEX with its wide range of innovative particle processing equipment designs and broad-based knowledge of process technology is particularly well positioned to serve the retrofitting market.

**BEPEX has proven capabilities** in this area and continues to provide this valuable service to existing and new clients in the polymer processing industry. Examples include boosting production capacities by up to 50% in drying polyolefins and terephthalic acid powders; and modifying older, low-capacity PET SSP Systems to operate efficiently on higher valued polyesters. A specific example is illustrated in the sketches above and at left.
Other Bepex Services:

PROCESS DEVELOPMENT
Using our state-of-the-art pilot plants, we can work with you to develop the necessary process steps to deliver a product that meets your final specifications. We start with bench-scale analysis and move to small processing systems.

CUSTOM PROCESSING
We will work with you to deliver the necessary quantities of materials to allow you to conduct market studies or to meet your customers' requirements.

ENGINEERING SERVICES
We can take the data generated from our pilot plant and determine the optimum process to meet your final goals. Our engineers will work with you to establish process flows, equipment specifications and system layouts.

PROCESS OPTIMIZATION
Skilled process engineers will visit your facility and make an in-depth study of your solids processing system. In conjunction with our application and processing engineers, we will make recommendations for achieving maximum performance from your system.

MECHANICAL FIELD SERVICE
Our field service engineers will work with your personnel to bring your equipment up to original factory specifications.