Industrial Solutions

MTR®

Melt-To-Resin

UIF Polycondensation Technologies
Cost-efficient, energy-saving
production of high-quality PET

thyssenkrupp

Polyester Technology

For all your packaging needs

Technical innovation

Our Team at UIF Polycondensation Technologies has demonstrated its drive for innovation throughout our history and will continue to do so, focusing on creating benefits for our customers. Our processes and our proprietary equipment are covered by worldwide patents. The innovation milestones of UIF Polycondensation Technologies in the PET business include:

- Continuous reduction of number of reactors and residence time by process intensification. The 2-reactor (2-R) technology is applied for capacities up to 1200 t/day,
- ESPREE reactor with integration of esterification and prepolycondensation stage, providing maximum energy yield
- DISCAGE reactor for extremely high viscosities of up to 1500 Pas with utmost product quality standards
- Integration of downstream process to ensure maximum efficiency
- MTR technology with all its features and benefits described on following pages

Melt-To-Resin MTR® production plant in Turkey (top) and Belgium

Production of bottle-grade chips using MTR® technology

The Melt-To-Resin (MTR®) process developed by UIF Polycondensation Technologies for the production of bottle-grade PET chips is a continuous polycondensation process that obviates the need for the solid-state polycondensation process step.

MTR® technology uses the established resin formulation to produce PET chips for all packaging applications. Since its appearance on the market in 2007, the MTR® technology has won the approval of producers and converters of PET resin, and this is reflected by the several million tonnes of MTR® resin produced annually.

UIF Polycondensation Technologies is recognized in the plastics industry as leading technology licensor and engineering company for polyester, polyamide and PLA plants. Our polyester technology portfolio comprises specialty polymers and advanced integration concepts as listed below.

- Polyesters and Co-Polyesters PET, PBT, PET-G, PBS, PBAT e.g. ecoflex® by BASF, PEN, PTT, etc.) for textile, bottle, film and engineering plastic grades. The commonly used plant set-up is our propriety 2-Reactor (2R) design
- MTR® as described in detail on the following pages
- High PIA co-monomer with up to 5 % PIA can be produced using our MTR® technology
- MTSF® Melt-to-Staple Fiber with the integration of PSF production Our latest MTSF® project has a nominal polycondensation capacity of more than 1000 t/day in a single line with full integration of 5 staple fiber production
- MTF® Melt-To-Film with the integration of BOPET production
- MTS Melt-To-Sheet with the integration of A-PET sheet production
- MTTY® Melt-To-Technical-Yarn with the integration of of high IV spinning

Melt-To-Resin MTR® production plant in Russia

MTR® Melt-To-Resin

Process Description

MTR® is a proven technology for producing PET resin from the feedstocks PTA (purified terephthalic acid) and EG (ethylene glycol), including conventional co-monomers and additives, in a melt-phase polymerisation process.
What is new here is that the technology produces a resin with a final high intrinsic viscosity in a one-step, ready-to-use process.

Conventional technologies initially produce a PET precursor, which, following intermediate storage, is then brought up to user viscosity in a long-term reheating/crystallizing/drying/solid-state tempering process (SSP) using the inert gas nitrogen which is expensive, and needs to be produced, cleaned and dried!

This conventional process is highly energy-consuming as well as investment and maintenance-intensive. Furthermore, it creates products sensitive to degradation and can easily develop fines of higher viscosity and agglomerates with an irregular molecular structure as well as high crystallinity.

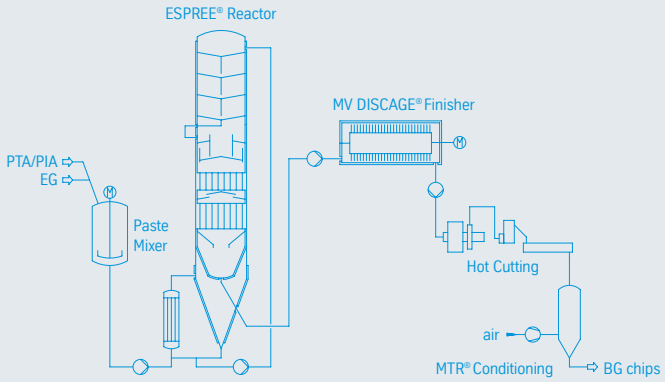
The 2-Reactor + MTR® technology offered by UIF Polycondensation Technologies has successfully overcome these disadvantages by offering an intelligent, low heat-stress system comprising a single-step esterification and prepolycondensation reactor, the ESPREE®, which features high-intensity reactions, and a proficient DISCAGE® high-intrinsic-viscosity reactor for producing a high-viscosity melt with an unusually low acetaldehyde (AA) content.

The direct contact spray apparatus for condensing the reaction vapours has no mechanical moving parts, which increases its reliability and reduces maintenance costs.

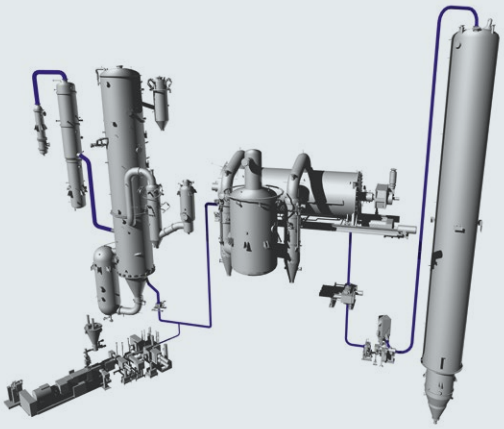
The spherical PET resin pellets are created by an underwater die-face system in which they are not amorphously frozen as in conventional methods, but are kept above their glass transition temperature for a period of several hours without any additional external heat input. This results in a significant energy saving! Furthermore, it avoids the sticky phase – for which PET is renowned – during transition from the amorphous to semi-crystalline structure and removes the aldehydes, water and other low boilers from the pellets in a minimised cold, dry air stream. With this treatment, the resin is subject to a low degree of crystallization.

The highly effective 2-Reactor (2R) polymerisation system in itself has proven beneficial when used for textile, technical (chips or direct spinning) and film-grade polyesters as well as polyester co-polymers.

MTR® technology features 2-reactor (2R) process for capacities up to 1200 tpd



Melt-To-Resin MTR® 3-D model with FTR® recycling concept



Benefits of MTR®

High-quality PET bottle resin in a single step

The advanced, commercially well-proven MTR® process with complete build-up of interinsic viscosity in the melt phase combined with the latest underwater cutting technologies for spherical chips and latent heat recovery eliminates the need for solid-state-post-condensation (SSP) process steps and delivers the following benefits for our customers.

Economic advantages due to lower conversion costs

Investment savings, optimized energy and utilities consumption, maximum utilization of feedstocks and effective plant operation reduce the total conversion cost by 20–30% compared to conventional technologies:

- Eliminating the SSP building and equipment leads to total project cost savings of 15–20% as shown in recognized studies comparing MTR® and SSP technologies.
- Utilizing the of latent heat of the pellets permits operation of the final de-aldehydization step of the MTR® process without the need to input of external energy.
- Spherical chips generated in the underwater cutting process as well as optimized downstream chip handling due to the avoidance of SSP process steps reduce dust and volatile formations and maximize feedstock utilization.
- Further reduction of conversion costs by avoiding nitrogen and its purification for the SSP technology.
- Amount of rotating equipment is drastically reduced compared to conventional technologies, resulting in less operation and maintenance costs.
- Optional integration with upstream PTA technologies permits relaxed feedstock requirements, energy recovery and cost-efficient common utilization of DCS, utilities and off-site facilities.
- Possible economy-of-scale benefits by upscaling single lines up to 3000 t/day using our PECASTEC® technology.

We would be happy to perform a detailed conversion cost analysis for your project needs and site conditions

Unique selling proposition by special product features

With its extremely gentle process conditions throughout the MTR® technology can boast following outstanding product features:

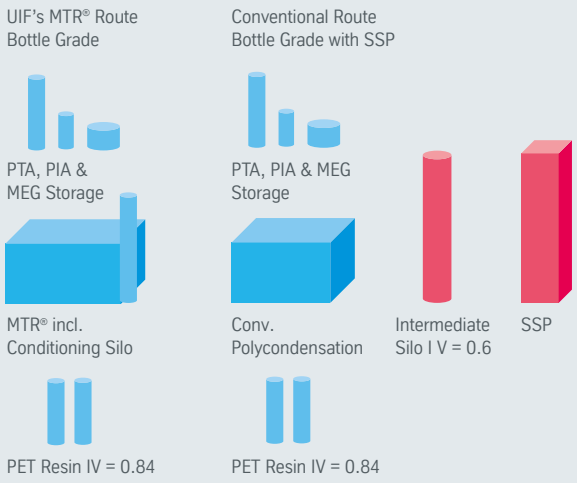
- MTR® granulate is suitable for all applications and is accepted by all major brand owners.
- Highly reliable plant performance and product availability through a minimized amount of rotating equipment. Furthermore, the reduced inventory product in the plant results in high flexibility for specification changes.
- Homogeneous product quality in the spherical MTR® chips and less dust formation leads to uniform, mild drying conditions as well as minimized preform defects.
- Reduced degree of crystallinity of MTR® product results in lower heat of fusion and consequently saves up to 10% energy for the drying and extrusion process.
- Reduced AA (acetaldehyde) regeneration through the gentle conditions in the preform production process obviates the use of scavengers to meet market requirements.

Outstanding public perception through sustainability

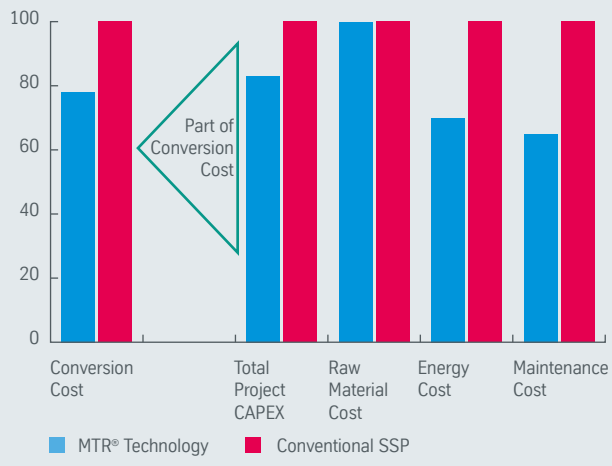
The modern, state-of-the-art MTR® process meets today's demand for sustainability for the following reasons:

- Carbon footprint in terms of fuel and electrical energy reduced by around 30% in comparison with SSP technology.
- Our optional fully integrated recycling process FTR® (Flakes-To-Resin)of post-consumer PET bottle flakes directly into the polymerization of virgin like rPET resin material allows the replacement of up to 50% of raw materials without affecting food approvals from FDA and EFSA for the final product.

Principal set-up of MTR® technology compared to conventional SSP technology



Conversion cost comparison for 750 tpd PET



ESPREE® & DISCAGE®

Highlights of the MTR® technology

ESPREE® reactor

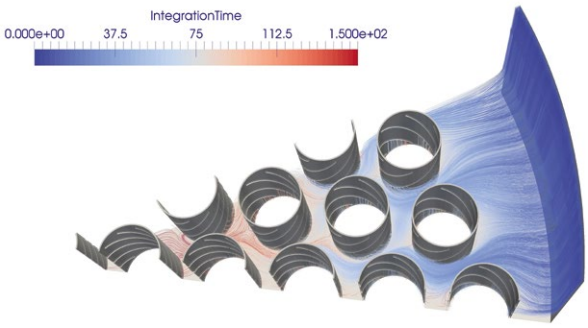
The innovative ESPREE® reactor is an energy-efficient and cost-efficient tower reactor that replaces the first three reactors of typical conventional polycondensation plants as it combines all relevant reaction sections within a single reactor. One of the technical highlights of the ESPREE® is the liquid film that flows down the inner surface of its vertical tubes to produce the pre-polymer. The falling-film section has been optimized using CFD analysis.

ESPREE® reactor features

- Minimized hold-up and reaction time
- Autogenous stirring / no mechanical agitators
- Pre-polycondensation: high film surface vs. volume ratio
- Co-current flow of vapor & liquid
- Liquid flow from top to bottom
- Compact design

ESPREE® reactor advantages

- Low energy and maintenance costs
- High raw material yield
- Excellent color values
- Short reaction time at low temperature
- Fast, optimized esterification and polycondensation
- Hold-up time of only three hours from raw material to polymer
- Low side-product generation due to large heat exchanger surfaces and low wall temperatures
- Minimal oligomer formation and losses
- Vacuum generated by steam from reaction
- Total recycling of EG



CFD simulation of a detail at the ESPREE® reactor for PET

DISCAGE® reactor

The DISCAGE® reactor is the finishing reactor for the continuous polyester processes and is suitable for the production of PET, co-PET, PET-G, PBT, PBS, PEN and other polymers. The reactor generates the surface needed for de-volatilization and polymer chain build-up, while at the same time creating a perfectly homogeneous polymer with minimal polydispersity.

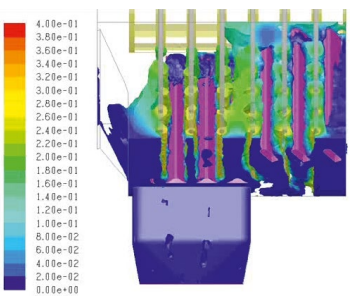
The DISCAGE® reactor has a shaftless design, thus avoiding the disadvantages associated with melt adhering to a central shaft. With this unique design, the agitation elements that generate the surface (uniquely shaped punched discs and spoked rings) are designed as a mechanically stable, rigid cage which is constantly moved and dipped through the melt. The position and shape of the spoke wheels – assisted by stripping elements – propel the polymer from inlet to outlet.

DISCAGE® reactor features

- Largest possible surface renewal of the polymer during residence
- Continuous viscosity build-up and optimum molecular distribution
- No “dead spots” and comparatively short residence time
- Optimum heating, low temperature difference between polymer and reactor wall
- Avoidance of polymer oxidation, all-welded closures

DISCAGE® reactor advantages

- Bending of the cage stirrer < 2 mm at a length of 10 m, for example minimum gap to the reactor wall guarantees maximum efficiency
- Low bending moments on the outer bearings and seals as no central shaft is used
- Long-life bearings and seal tightness, easily accessible, no bellows
- Stiffness of the construction increases with reactor diameters



CFD simulation of a detail at the DISCAGE® for PBT

FTR® Flakes-To-Resin

Fully integrated high-quality PET recycling process

FTR® Flakes-To-Resin – PET Recycling

Volatile prices for PTA and EG as well as widespread PET collection and sorting systems make PET recycling a very attractive option. Furthermore, consumer attention is becoming increasingly focused on “green” products, which is making PET products with recycled content increasingly popular.

UIF Polycondensation Technologies offers a cost-effective process for the recycling of post-consumer (PCR) PET bottle flakes into rPET resin.
The FTR® recycling technology is based on post-consumer flakes, which are filtered and adapted in their intrinsic viscosity before being introduced as a melt side-stream back into the prepolymer of the continuous polymerization process. The blend is finished in the DISCAGE® reactor like a virgin melt and passes through the further MTR® process without any additional treatment.

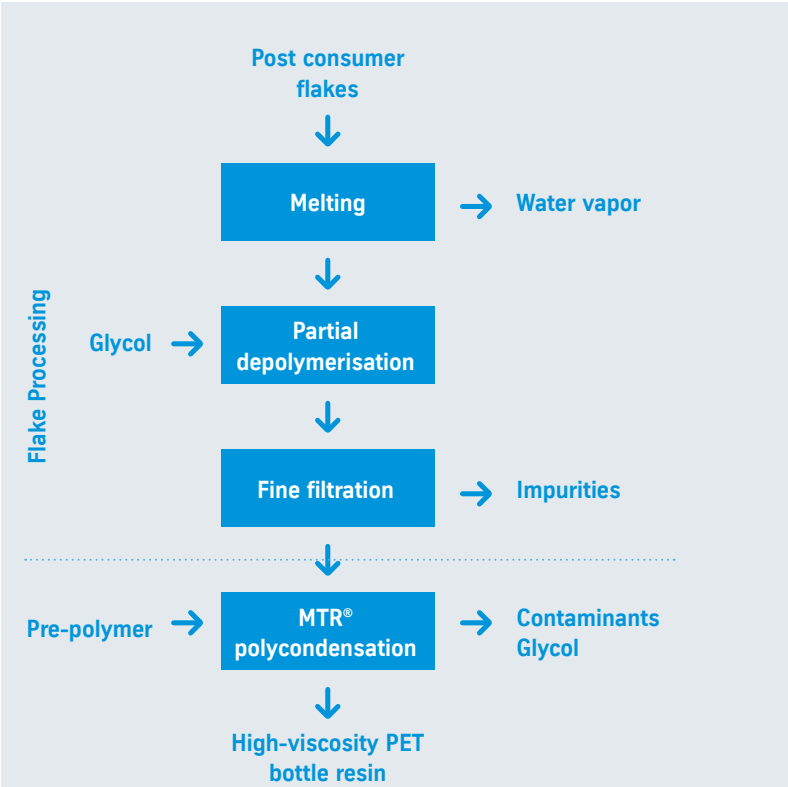
Any contamination which may have been entrained with the flakes from misuse of the bottles is eliminated during the melt- phase reaction in a high vacuum.

The FTR® technology has passed a “challenge test” with excellent results and has received the approval of the FDA for PCR contents of up to 50%. It has also been approved by European Food Safety Authority (EFSA).

The final product is a top-quality raw material for either bottle-to-bottle or packaging applications. There is no “down-grading” of the valuable polymer.

Advantages

- Recycling technology for food-grade PET packaging
  - Cleaning efficiency has been tested successfully in a challenge test
  - FTR® is approved by the US Food and Drug Administration (FDA) and by the European EFSA for food-contact applications
  - All contaminants are removed from the product at the latest in the DISCAGE® reactor, which can be regarded as the most efficient degassing device
  - No contaminant is accumulated in the system because it is transferred into the wastewater stream from the water steam driven vacuum system of the DISCAGE® reactor
- FTR® can be integrated into PET production plants
  - Up to 50% recycling material without an adverse effect on product quality
- Two-step process
  - Elimination of impurities & rebuild to virgin-like PET bottle
  - Filtration of material at a low viscosity level, which makes it much easier to remove any impurities



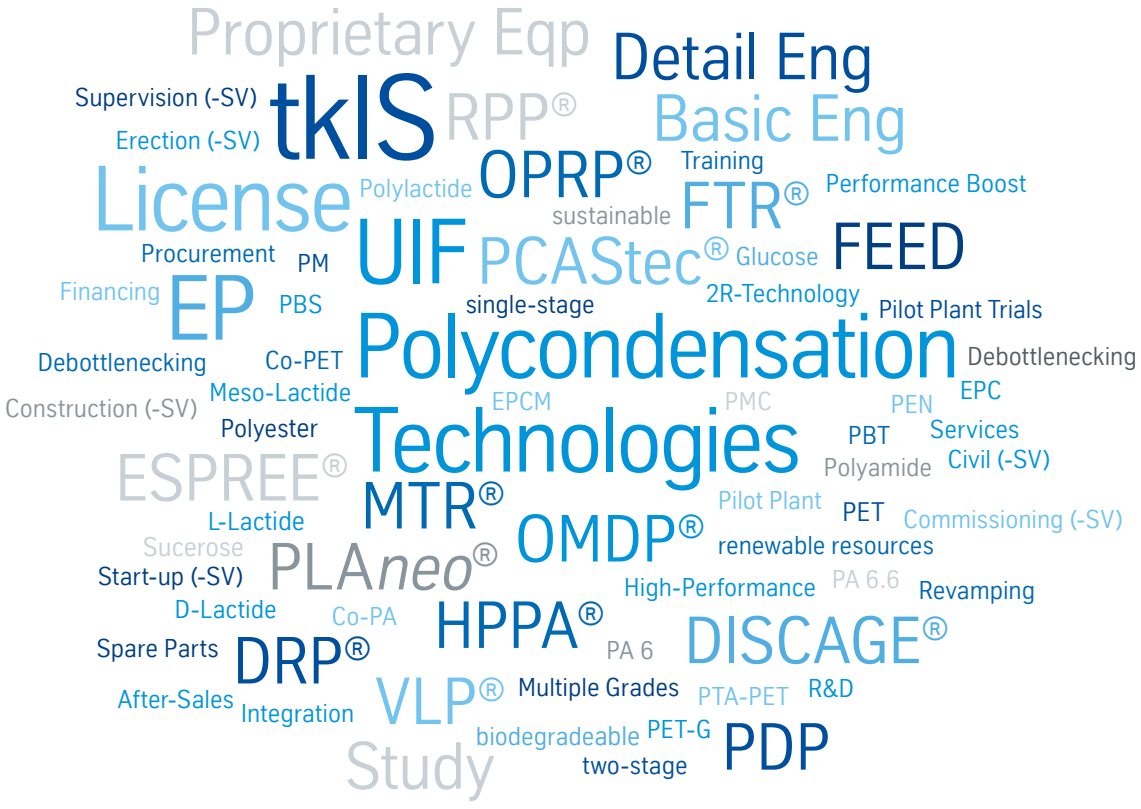
The Power Of True Efficiency

Optimal solutions for specific requirements

thyssenkrupp Industrial Solutions is one of the world's leading engineering companies for licensing, planning and constructing high-tech chemical plants. Around 19,000 specialists at over 70 locations around the globe ensure the highest degree of productivity as well as cost-effective, innovative and custom-made solutions to meet the technological and economic challenges of our customers. We offer a comprehensive array of services covering the entire life cycle of a plant.

UIF Polycondensation Technologies offer our proprietary, cutting-edge polycondensation technologies for producing various grades of polyesters, polyamides and sustainable biopolymers, such as polylactic acids, with customizable viscosity levels ranging from high to medium to low. These technologies are based on Uhde Inventa-Fischer's know-how, the engineering experience gained in the construction of more than 450 polymer plants worldwide since 1924 and through intensive research and development work in close cooperation with prominent scientific and industrial partners. UIF Polycondensation Technologies has successful established a large variety of self-developed, patented technologies and processes in the global market. Our customers can take advantage of these technologies to gain an edge over their competitors.

UIF Polycondensation Technologies, as part of thyssenkrupp Industrial Solution's polymer division, are located in Berlin, Germany and Domat/Ems, Switzerland. Around 150 polymerization specialists and engineers cover the entire field of professional project execution, from plant engineering with the delivery of proprietary and key equipment only up to procurement and construction services for turnkey EPC projects, working in close cooperation with local organizations of thyssenkrupp Industrial Solutions.



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