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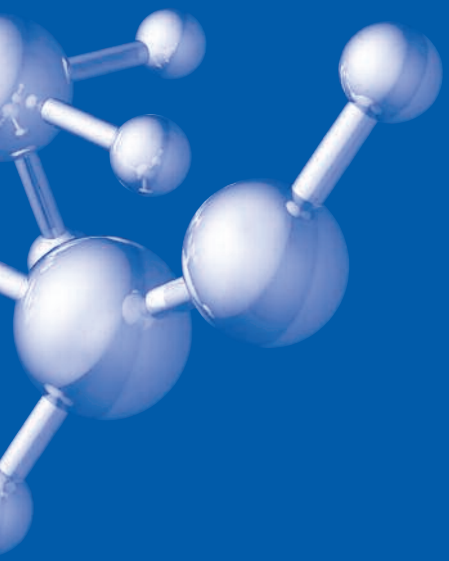


Zimmer® Polymer Technology

Polyester Continuous Process

Polyester polycondensation plant

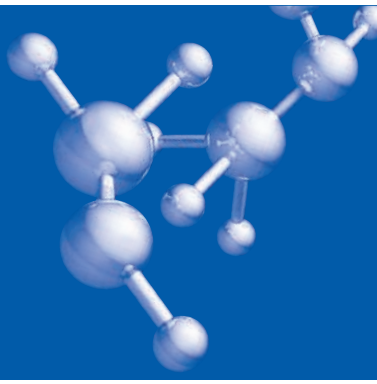
Introduction

Since 1962 continuous polycondensation plants for the production of polyethylene terephthalate (PET) has been build with Zimmer® proprietary technology; total built capacity is nearly nine million tons/year.

This success, which is currently increasing, results from a fast innovation cycle supported by

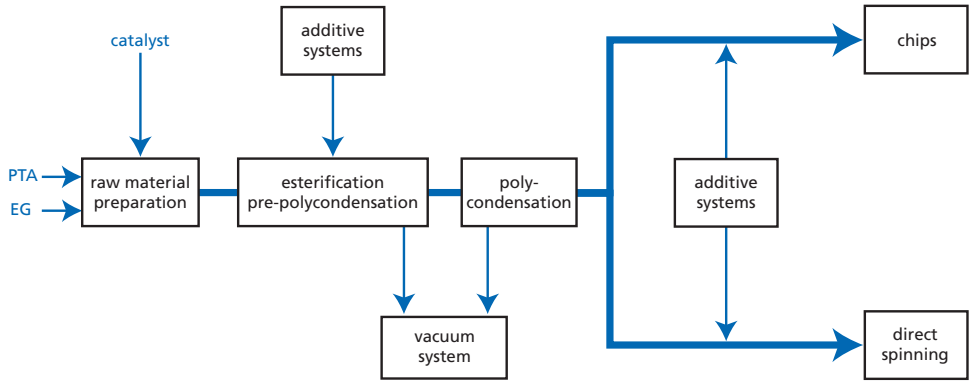
- Several plant start-ups per year incorporating improvements from ongoing R&D and operational experience
- Proprietary design for key equipment
- Close contacts to clients and markets.

Continuous technology is used for big plant capacities and technological reasons e.g. direct spinning of the polymer melt into fibers/filaments. The economic advantage increases with higher capacities.



Process principles

For continuous production PTA (pure terephthalic acid and slightly less purified terephthalic acid such as MTA, E-PTA etc.) can be used as raw materials together with EG (ethylene glycol).
The main process steps are the raw material preparation, the esterification/transesterification, the pre-polycondensation and the polycondensation. The PTA is mixed with EG and catalyst solution in a paste and fed into the esterification system. The esterification takes place under light overpressure by splitting off water. When DMT is used, the DMT melt and catalyst are pumped with EG into the transesterification system, where the reaction takes place under atmospheric pressure by splitting off methanol. The materials split off are rectified in a direct connected stand-alone column system for raw material recovery compatible with the environment.
In the final part of the vertical cascade compact reactor the pre-polycondensation reaction is performed under vacuum.
The vacuum generating system is operated with EG from the process. The pre-polycondensation product is discharged into the final polycondensation reactor.
The polycondensation takes place under increased temperature and increased vacuum. As part of a patented, glycol management and vacuum system, an EG driven jet is used to facilitate raw material recovery and contribute to environmental protection. The polyester melt obtained in the reactor is processed either directly into fibers/filaments or into chips.



Polyester continuous technology

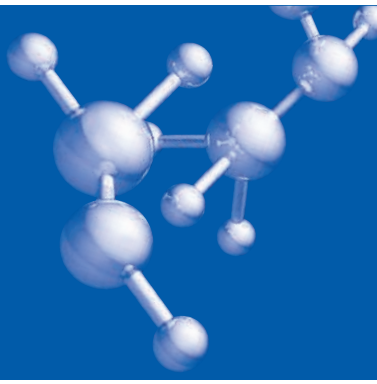
Key features of Zimmer® two-reactor technology

Two-reactor process

- Optimized residence times, facilitating capacities up to 1500 tons/day
- Low product temperature profile
- Low temperature difference between product and heat transfer medium
- Low catalyst contents
- Optimized process cascading resulting in more efficient conversion of raw materials and greater product homogeneity
- Low energy consumption
- Less space requirement

In addition:

- Low raw material consumption
- Low DEG formation
- Bright colour (L-value)
- Low yellowness (b-value)
- Low oligomer content
- Low acetaldehyde content
- Reduced reformation of acetaldehyde in further processing
- Very narrow residence time distribution
- Very uniform product with excellent rheological behavior
- Highest plant availability
- Excellent operating economics



Plant design

Esterification/Pre-polycondensation

- One vertical cascade reactor for smooth reaction progress up to 1500 t/d plant capacity

Final polycondensation reactor

- Specially designed and patented horizontal Disc Ring Reactor (DRR) with single shaft sealing operating as a multistage cascade system, guaranteeing narrow retention time spectrum and high uniformity of the product
- Low entrainment, high vacuum integrity and low maintenance requirements
- Low inlet temperature required; mild temperature increase occurs in the last third of the reactor
- Low jacket and wall temperature can be maintained by heat input from product shearing rather than by heat transfer
- Thermal stress to polymer is minimized
- For higher viscosities a special double drive disc ring reactor (DD-DRR) featuring the same advantages as the single drive reactor is used.

Vacuum systems

The two-reactor process is combined with a vacuum system using the vapors from the first stage as motive vapor. The vapors from the finisher are partially condensed in a scraper system and extracted using a glycol vapor jet system. A second jet system is directly driven by vapors from the pre-poly-stage. The vapors are condensed and sent to the process column. This ensures total recovery of EG and other valuable materials and results in significantly reduced water consumption and waste water treatment as well as elimination of gaseous emissions when compared to steam-jet systems.

Avoidance of oxygen intrusion

Nitrogen blanketing of the process prevents oxidation degradation of the product.
The integrity of the nitrogen blanketing is achieved by proven design features (ex: reduced number of flanges and seals), resulting in higher quality product and greater plant availability.

Supplementary technology availability

Product formulas

Proven formulas and additive packages designed to meet specific polymer characteristics for textiles, bi-oriented films, packaging, bottles and engineering plastics are available.

a) Delustering and additive systems

- Suspension and post-polycondensation masterbatch delustering systems
- In-line and masterbatch additive systems for film grades and special additives as liquid or solid

b) Solid state polycondensation for specialities
In order increase viscosity to high values and removing volatiles a solid state polycondensation is available at capacities up to 1000 tons/day.

c) Dealdehydisation (DAH)
DAH technology removes volatiles as acetaldehydes of feed material with high IV. Capacities up to 1000 tons/day in one line are available.

Plant capacities		Tons/day	Applications
Medium viscosities 0.50 – 0.66 IV	Vertical cascade reactor and disc ring reactor	90 – 1500	Textile filaments, staple fibers, BCF carpet yarns, feed materials for solid state polycondensation for specialities
High viscosities 0.66 – 0.96 IV	Vertical cascade reactor and double drive disc ring reactor	≤1000	Industrial yarns, engineering plastics
	DAH tower	≤1000	Packaging & bottles
Very high viscosities 0.90 – 1.00 IV	Vertical cascade reactor and disc ring reactor and self cleaning reactor	≤100	Tire cord, rigid engineering plastics
Products	Polymer melt or chips		

Polyester disc ring reactor

Summary

Polyester markets ask for several requirements to select an appropriate technology and engineering package. Those requirements include:

- Minimum investment and operating costs per unit of capacity (economies of scale)
- High capacities with optimum operational flexibility
- Consistent and market-leading polyester product quality
- Environmental compatibility
- Optimum engineering execution with fastest time-to-market
- High reliability, up-times >3 years

Therefore, the Zimmer® polyester production processes combine a sophisticated and proven process philosophy with innovative technologies and strong capabilities in plant engineering.

In particular, the advantage of continuous PET polycondensation process is mainly given by very smooth and moderate operational conditions, providing easy handling of the plant and stable operation. The reliability and high technical standard of the operating equipment has been proven in many plants and the process with its key units, the Zimmer® reactors and the total internal recycling, is recognized by important PET producers as being the best polycondensation technology yet available.

Lurgi is a leading technology company operating worldwide in the fields of process engineering and plant contracting. Based on syngas, hydrogen production and clean conversion technologies for fuels or chemicals Lurgi offers innovative solutions that allow the operation of environmentally compatible plants with clean and energy-efficient production processes.
Its technological leadership is based on proprietary and exclusively licensed technologies which aim to convert all carbon energy resources (oil, coal, natural gas, biomass, etc.) in clean products.

Lurgi is a member of the Air Liquide Group

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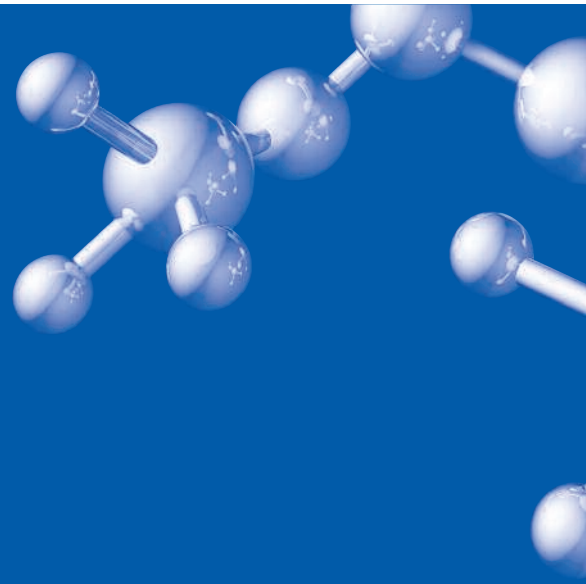

Lurgi GmbH
Lurgiallee 5 · 60439 Frankfurt am Main · Germany
Phone: +49 (0)69 5808-0 · Fax: +49 (0)69 5808-3888
E-mail: communication@lurgi.com · Internet: www.lurgi.com