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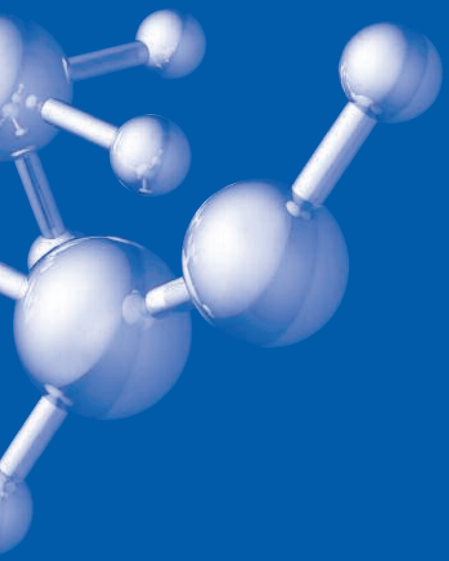


Zimmer® Polymer Technology

Polyamide 6 Process

PA 6 tire cord production plant

Introduction

More than 160 polyamide polymerization plants all over the world have been planned, erected and successfully commissioned with Zimmer® polyamide technology since 1953. During the past 50 years, Zimmer® technology has constantly been improved with respect to quality and economics, resulting in large-scale units of up to 300 t/day in one line of polymerization and caprolactam recovery.

Polyamide 6 polymerization

Polyamide 6 polymerization

Polyamide 6 is preferably produced in continuous operation. Batch operation is recommended only for small capacities and a more flexible production program. Previously, for medium-viscous polymer (textile-grade products), the polymerization of caprolactam, together with catalyst and stabilizer, was preferably carried out using one-stage technology in a VK-tube reactor.

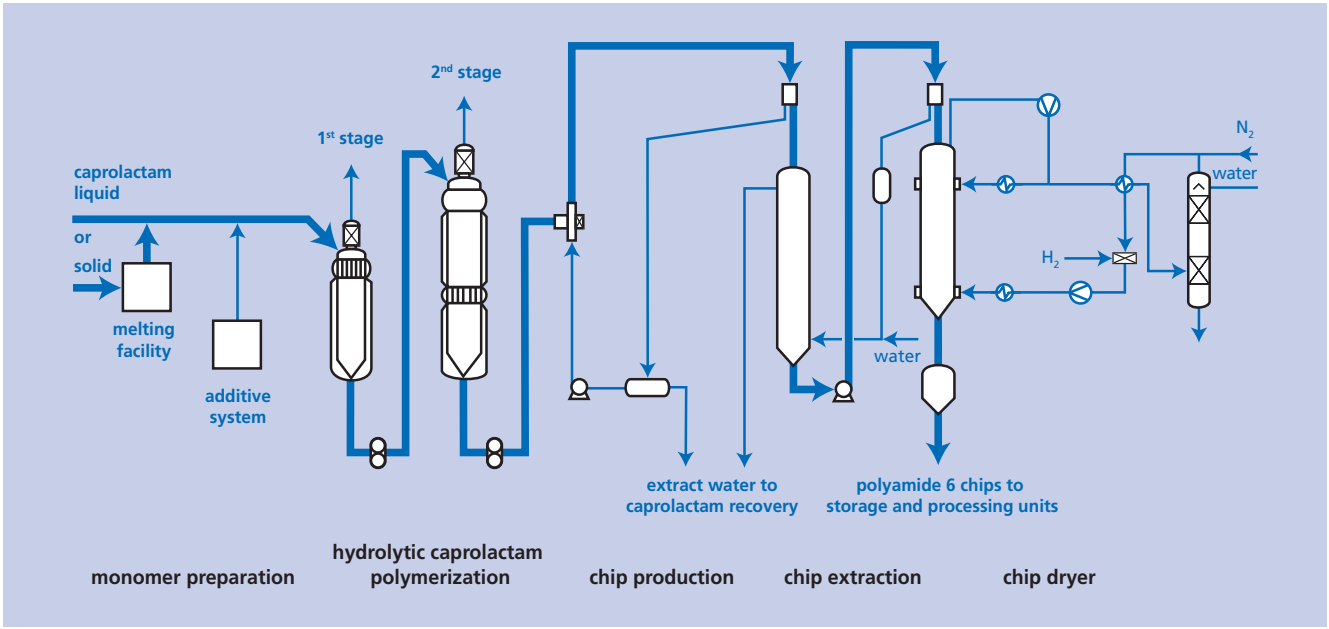
Today, for a flexible production of medium- to high-viscous polymer (e.g. tire cord grade products), the polymerization of caprolactam with catalyst is better carried out in a two-stage process. For details please refer to the adjacent flow sheet.

Chip production, extraction and drying are similar for both medium- and high-viscous products.

For chip production underwater granulators of different types are preferably used.

Extraction of the remaining caprolactam and oligomers is carried out in a single or multitube wash column where the chips are treated in a counterflow with hot water. The specific Zimmer® design allows a water/chip ratio that results in a high-extract content in the washing water, thus saving energy in the caprolactam recovery plant.

The drying system consists of separate gas distribution zones of sophisticated design and a closed loop for nitrogen recirculation, which includes a purification system and leads to a low consumption of fresh nitrogen.



Polyamide 6 continuous polymerization two-stage technology

If required, titanium dioxide, other additives and/or modifiers, in proportion to the caprolactam quantities, are fed as aqueous suspensions or solutions into the caprolactam stream before it proceeds to polymerization. All process reactors are designed for optimum residence profile by installing adequate flow rectifiers and/or distributors. Due to this design the plants can be operated under normal conditions for more than ten years without having to be shutdown and cleaned.

PA 6 polymerization facility

Solid state polycondensation (SSP)

Alternatively, the drying system can be designed for combined drying/solid state polycondensation (SSP) to increase the relative viscosity of the chips over a wide range. This technology can also be connected to existing plants or fed with polymer from other sources.

Caprolactam recovery process

Since the polyamide 6 polymerization reaction is limited to approx. 90 % conversion, the monomers and oligomers dissolved in water during extraction have to be recovered. An economical way of recovering caprolactam is to reprocess the extraction water together with the solid waste from the overall production system. Such a plant can consist of the following major process steps:

- multi-stage evaporation
- oligomer separation
- depolymerization
- chemical treatment
- distillation

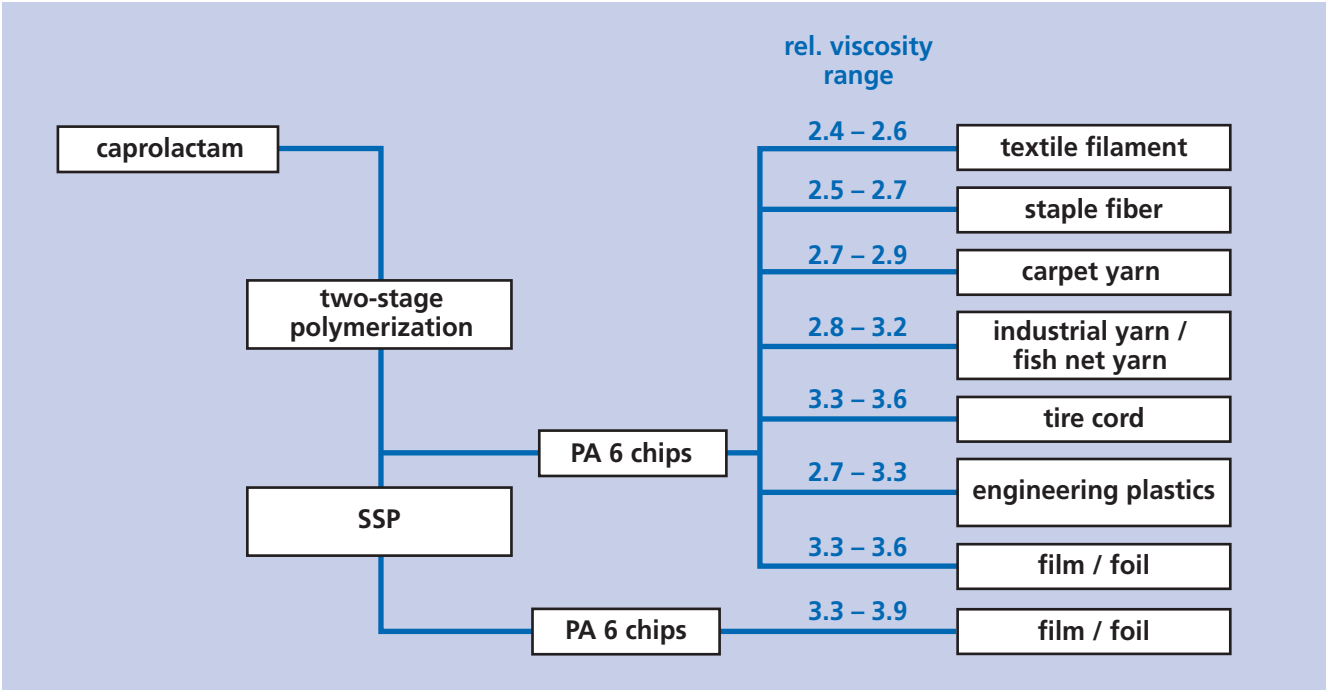
The extraction water is concentrated in the evaporation. The design can be multi-stage or single-stage with vapour compression. In the oligomer separation the oligomers, together with some caprolactam, are removed from the bottom of the reactor, while the caprolactam with residual water is taken away from the head for further processing. The oligomers and solid waste are treated in the depolymerization unit in the presence of steam and a catalyst. If required, the condensed caprolactam/water vapours are chemically treated and filtered, leaving behind a clean solution. Subsequent distillation is preferably carried out in continuous operation depending upon capacity. The recovered caprolactam will be immediately reused in molten form in the polymerization.

Extraction water recovery

Alternatively, for specific applications the extraction water is concentrated in a multi-stage evaporation system and fed directly back to the polymerization stage, which is most economical.

Remelting solid waste recovery

Facilities can be offered either as stand-alone units producing engineering plastic grade chips or in conjunction with caprolactam recovery units.

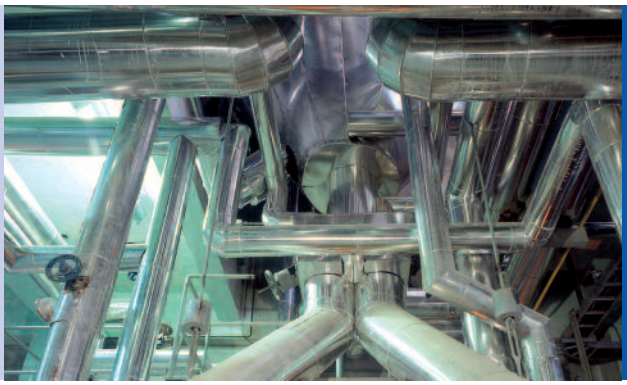


PA 6 viscosity ranges and applications

Plant capacities, products and applications

Polyamide 6 fully continuous polymerization plants with capacities of 65 to 260 t/d for both one- and two-stage technologies have been supplied. The design of a 300 t/d plant is available. The chart on the right outlines viscosity ranges for the various technologies.

	Capacities	Product
Caprolactam recovery	Size in proportion to the polymerization capacity	Purified caprolactam for high rate re-feed into polymerization
Extraction water recovery	Size in proportion to the polymerization capacity	Concentrated extract water for re-feed into polymerization
Solid waste recovery	Individual sizes designed to match the quantity of solid waste from the overall production	Chips for use as engineering plastics, melt to introduce in depolymerization



Piping

Highlights

- Own process development to support customers' competitiveness
- Extensive experience in fibre and plastic applications
- Economic plant configurations:
  - Attractive investment cost
  - Low raw material consumption
  - Low utility and personnel cost
  - Wide variety of products for textiles, technical yarns, film and engineering plastics
- Different products with one line
- Wide capacity range up to 300 tons/day guaranteed
- Well-proven two-stage polymerization technology for all applications
- Advanced Spinning Performance (ASP) modifier for improved textile yarn production
- Improved product quality due to shorter residence time
- Proven equipment, highly automated
- No agitators in polymerization
- Extremely long operation periods
- Highly uniform products
- SSP technology for higher viscosities
- Caprolactam and solid waste recovery technology

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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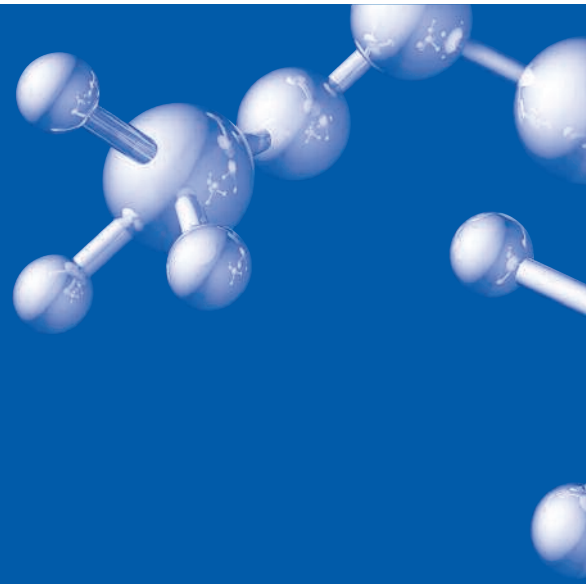

Lurgi GmbH
Lurgiallee 5 · 60439 Frankfurt am Main · Germany
Phone: +49 (0)69 5808-0 · Fax: +49 (0)69 5808-3888
E-mail: communication@lurgi.com · Internet: www.lurgi.com