PET Poly & SSP

Proven Way for successful Production Units

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PET Poly & SSP

Safeguarded way for
successful Clients

1. State of the Art Polycondensation Unit
2. Newest Solid State Polycondensation Technology
3. Total Plant Optimization
4. Benefits for our Client

PET Poly & SSP

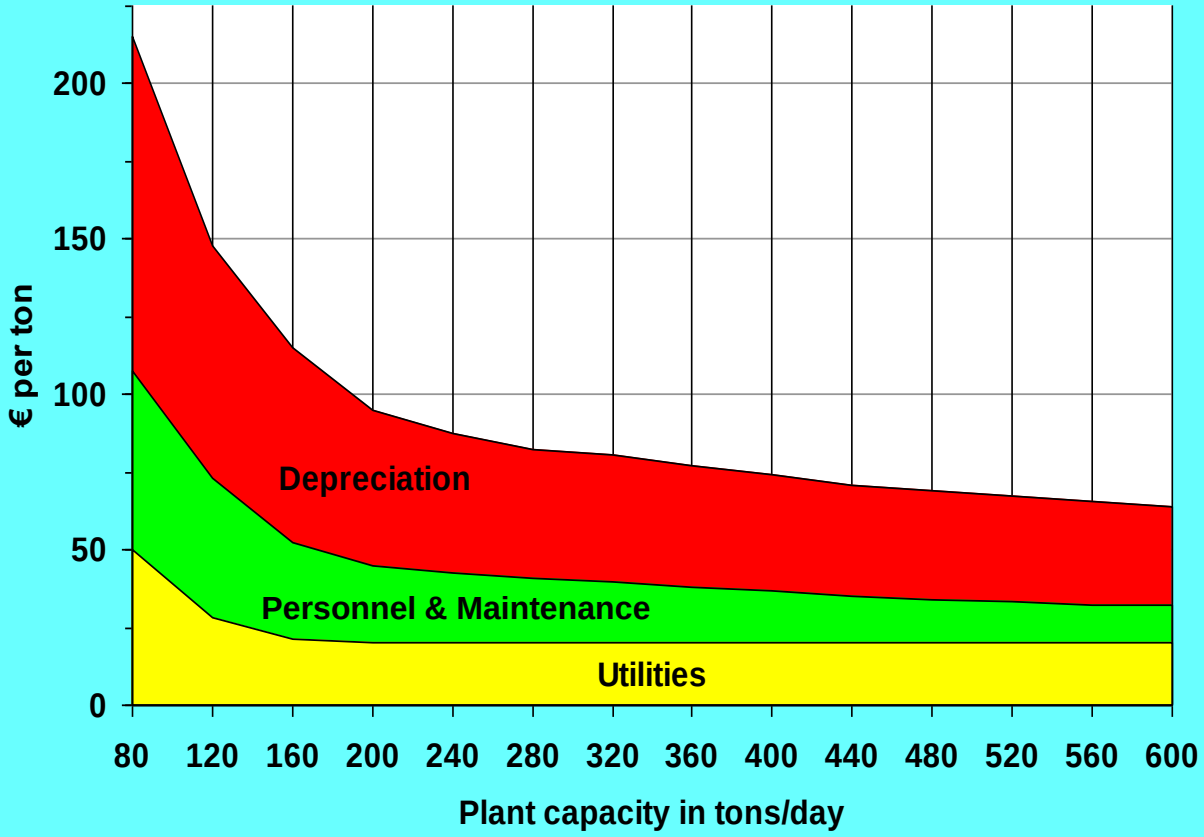
1. State of the Art Polycondensation Unit

Profitability of plants based on:

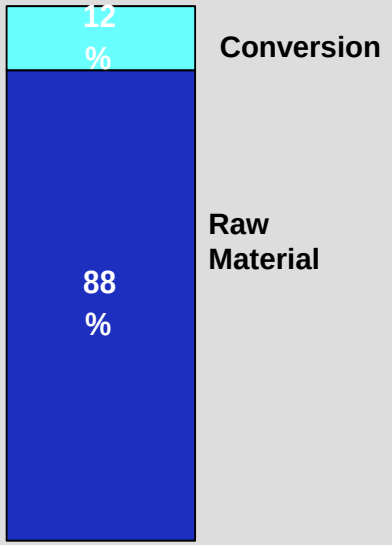
- **low conversion cost of product**
  - investment cost
  - personnel and maintenance costs
  - utilities cost
  - plant reliability
  - environmentally friendly process
- **excellent product quality**
  - controlled by the process (melt polycondensation and SSP)
  - controlled by co-monomers
  - controlled by additives

PET Poly, low conversion cost of product

By increasing plant capacity, melt/chip conversion cost drops



Production cost
(300 t/d)



Plant Reliability

There are Zimmer customers who operate their plants up to 6 years without shut down, e.g. JCT / India.

- Due to local legal regulations inspection of equipment is ordered
  - in Germany every 5 years inside inspection of reactors
  - in Taiwan every 2 years check of safety-valves
- Mechanical maintenance cycle
  - Zimmer's recommendation: every 3 years operation, plant shut down for regular general maintenance, continuous preventive maintenance granted
  - Zimmer's clients: mainly every 4 - 6 years operation, plant shut down for regular maintenance depending on:
    - local authorities
    - plant operation
    - preventive maintenance

PET Poly & SSP, low conversion cost of product

On stream factor of polycondensation plant & SSP

- Required time for shut down and maintenance
  - shut down and cooling down of equipment for inspection — 3 days
  - inspection of equipment, exchange of mechanical seals — 1 day
  - heating-up and leak check of plant — 2 days
  - restart of plant — 1 day
  - **Total — 7 days**

Based on a shut down period of 7 days every 3 years, the yearly operation time is calculated to 363 days.

363 days operation per year ➔ On stream factor: 99.45%

PET Poly, low conversion cost of product

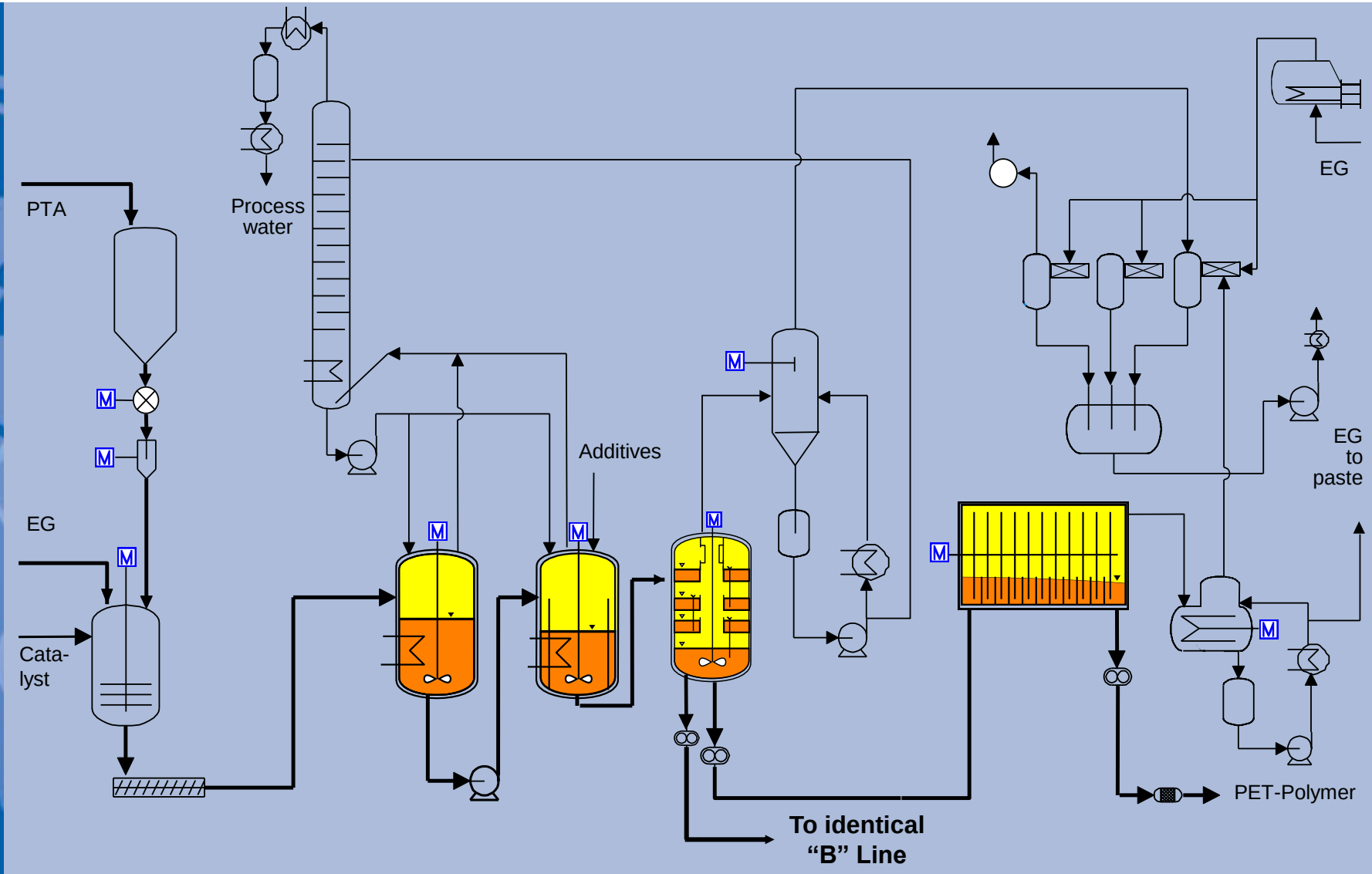
Environmentally friendly process

- **low energy consumption because of:**
  - low mol ratio
  - low temperature in esterification
  - EG-jet
- **less waste water**
  - no waste water from polycondensation (refer to vacuum system)
- **waste water is precleaned in stripper column**
- **emission**
  - off gas is thermally treated in HTM unit

  Result:
  - efficient and safe
  - values according to TA-Luft regulations

PET-Poly, Economic 4-Reactor Plant concept

Lowest conversion cost / plant concept



PET-Poly, Economic 4-Reactor Plant concept
Lowest conversion cost / plant concept

Zimmer

- **Process conditions at design capacity**

		Paste	E 1	E 2	PP	DRR	
MR		1.1 - 1.2	1.75				
Temperatur	°C		262	266	274	282	
Pressure	mbar		1 600	1100	15	1	
Residence time	min		225	90	75	120	∑ 510
Esterification degree	%		92	96.8	99.3	99.7	
Chainlength			4.5	6.6	22	86	
IV	dl/g		0.09	0.11	0.25	0.60	

PET Poly, low conversion cost of product

		SABIC 1200 Bottle grade Poly & SSP (USG Cutter; Air Condenser)						
		PTA Conveying	2x DRR Poly (AB+AH)	KB amorph	2x 600 t/d SSP	KB bottle grade	HTM	Total
Electric Power	[kWh/t]	3,17	58,20	0,05	80,00	0,17	15,92	157,50
Steam	[kg/t]		11,67					11,67
Soft Water	[m^3/t]		0,06				0,12	0,18
Demin. Water	[m^3/t]		0,05					0,05
Chilled water	[m^3/t]		1,00					1,00
Cooling Water	[m^3/t]	0,38	37,5		5,33		0,50	43,71
Compressed Air	[m_n^3/t]			70,00	1,92	35		106,92
Instrument Air	[m_n^3/t]	0,08	1,21	0,04	1,00	0,04	0,21	2,58
Nitrogen	[m_n^3/t]	1,67	0,92		8,00		0,08	10,67
Fuel Gas (37260 kJ/m^3)	[m_n^3/t]		62,50		8,50			71,00

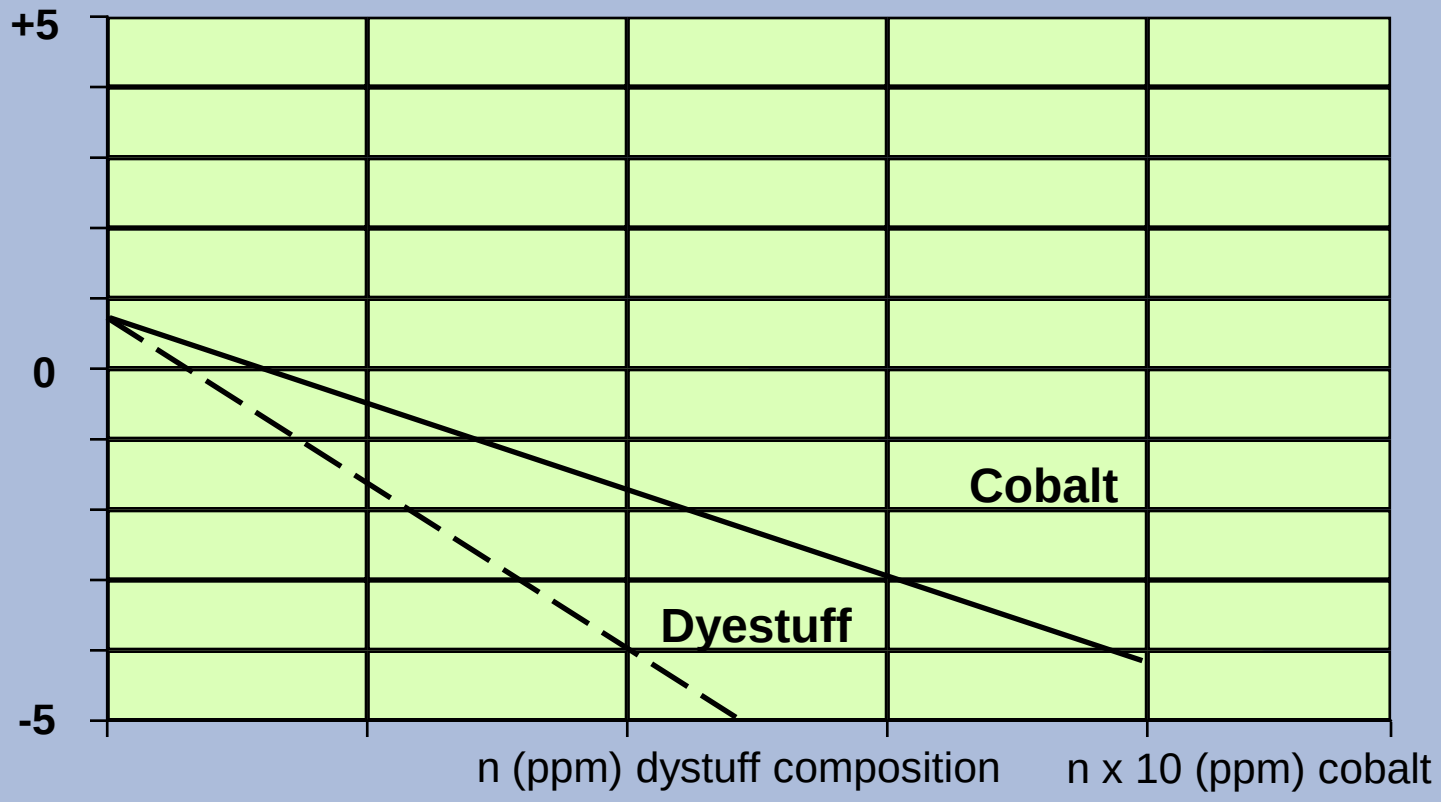
PET Poly, product quality

Bottle polymer

polymer properties	bottle quality / bottle production
1. *controlled by the process* - viscosity - AA-content - color - purity • ash content • products of thermal destruction - AA-reformation - dust content	 mechanical strength of the bottle influence of taste brilliance clarity and crystallization behavior AA-content in pre-form gels and fish eyes in bottles

PET Poly, product quality

Controlled by Additives:
Cobalt and dyestuff composition on color “b” value



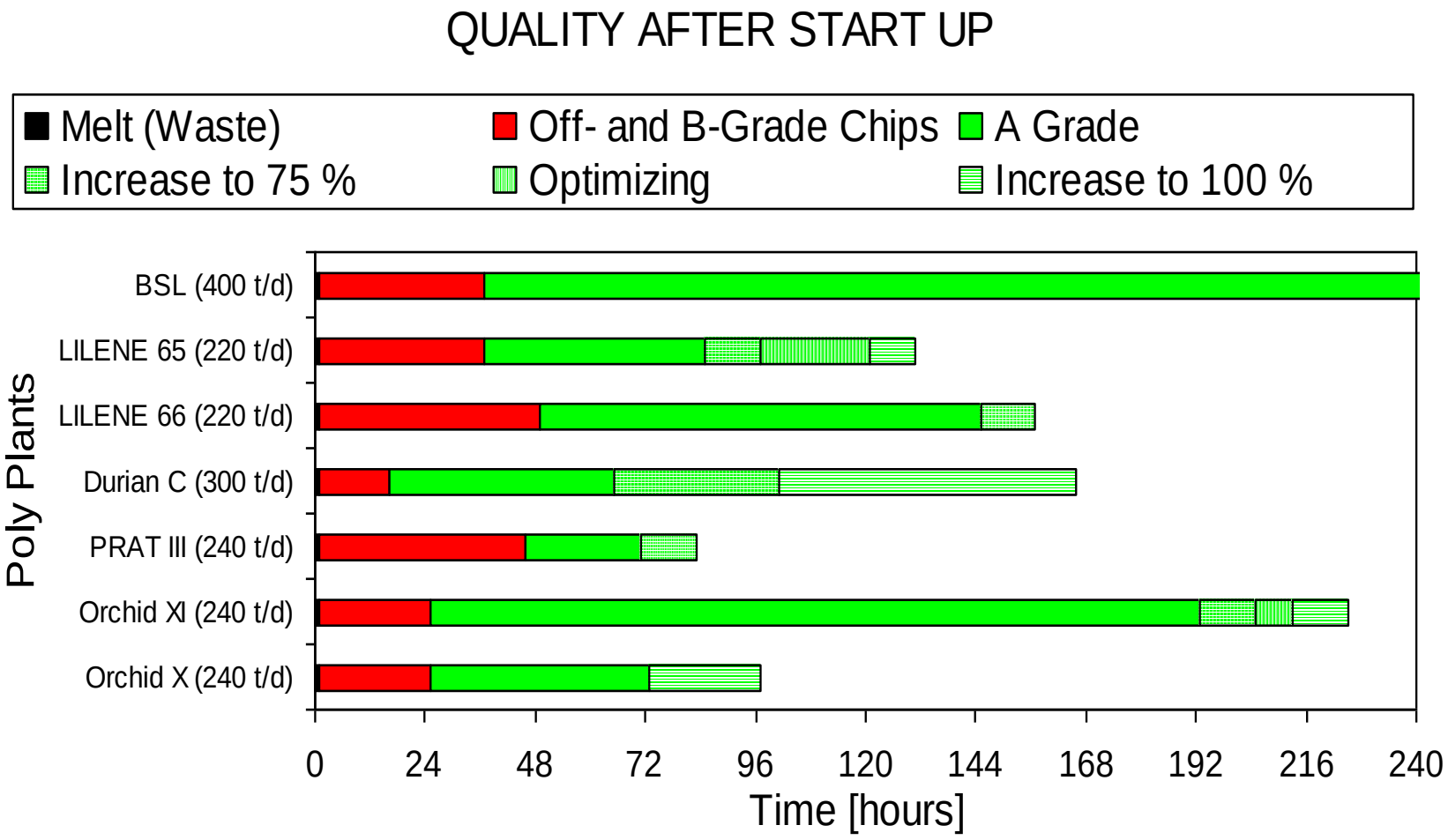
PET Poly, product quality

polymer properties	bottle quality / bottle production
2. controlled by co-monomers	
- Co-monomere content	optimized cycle time in preform-manufacturing
- melt temperature	AA-reformation during preform production
- crystallization behaviour	clarity, cycle time during production of pre-forms
- glass transition point	refill ability of the bottle

PET Poly, product quality

polymer properties	bottle quality / bottle production
3. controlled by additives	
- stabilizer	increased thermo-stability • lower AA-content • lower IV-drop • reduced discoloration
- IR-absorber	better performance during stretch-blow molding • reduced power consumption • increased capacity

PET Poly, product quality



- **start-up waste : approx. 10 t**

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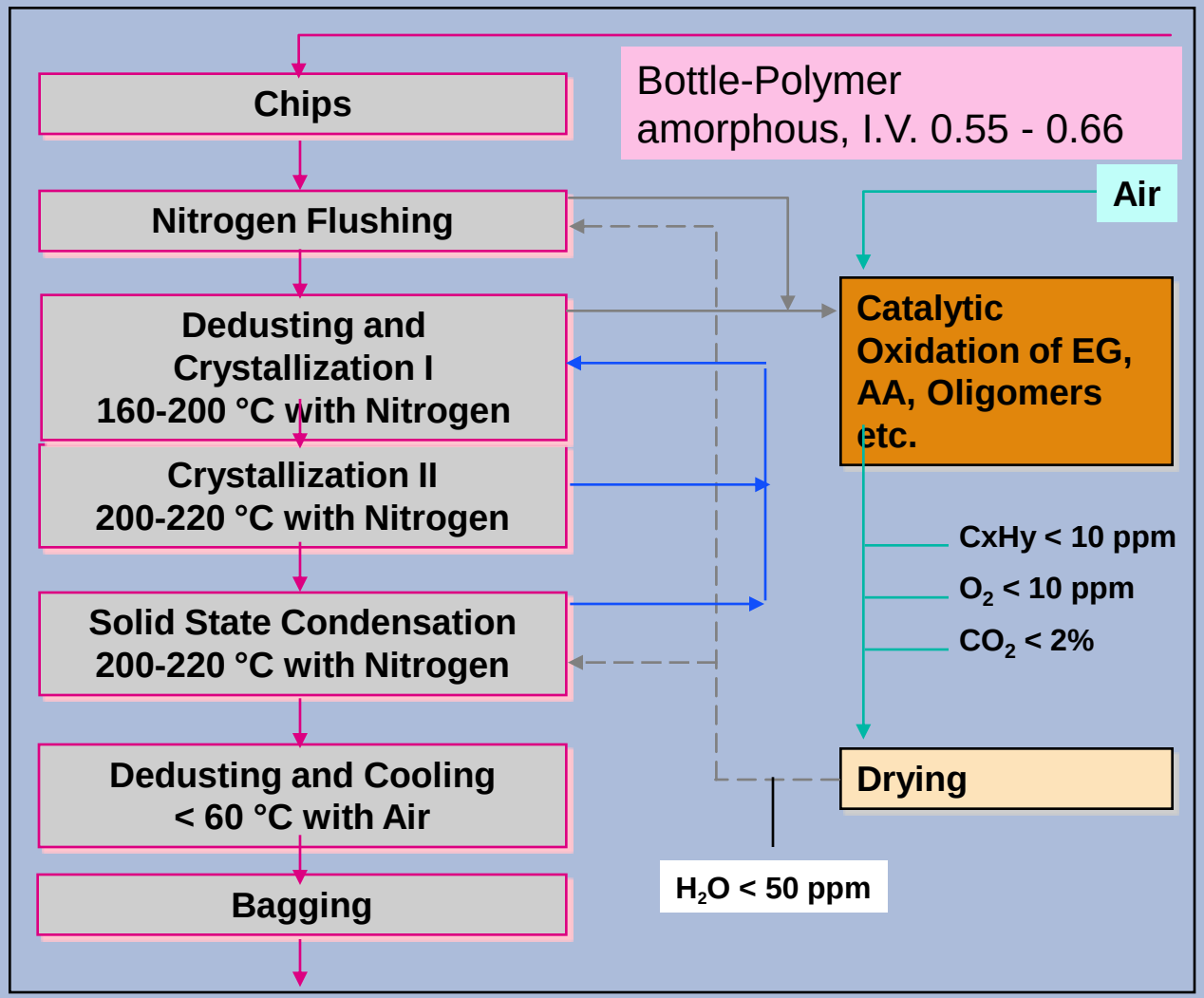
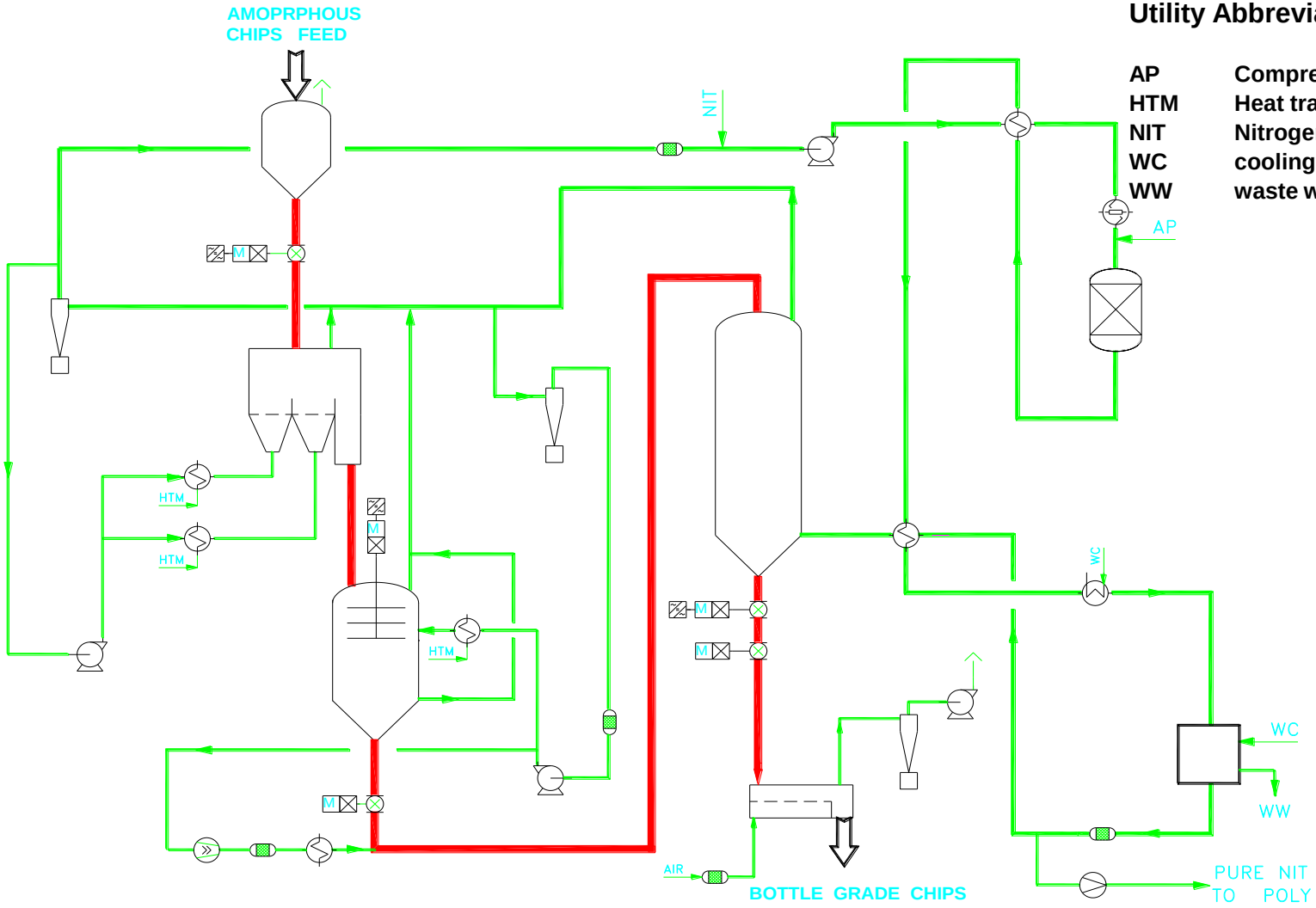
SSP Plant Technology (1)

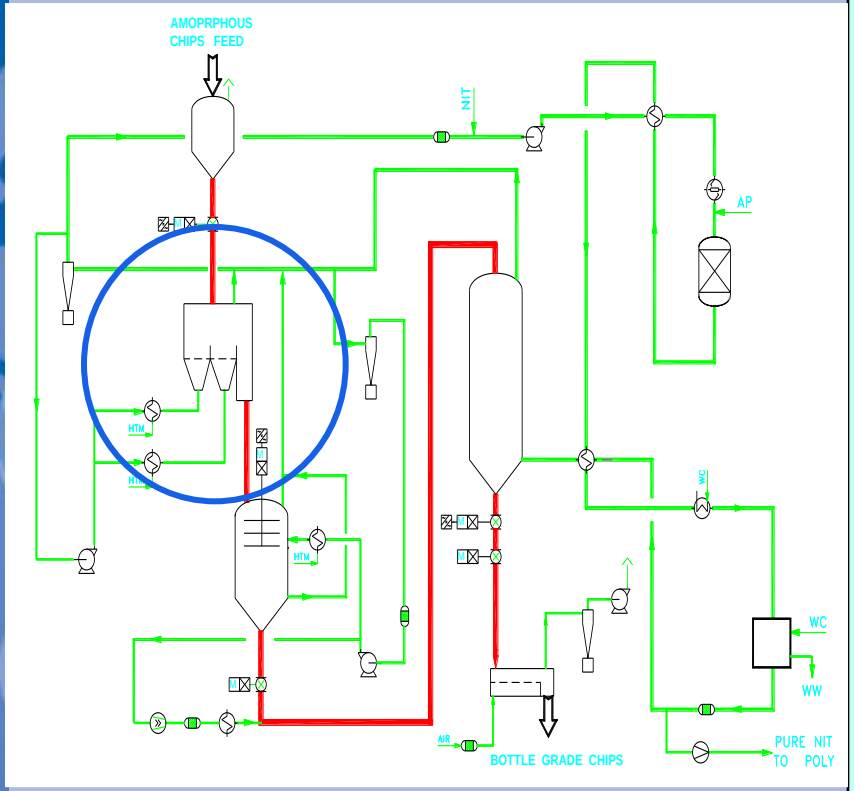


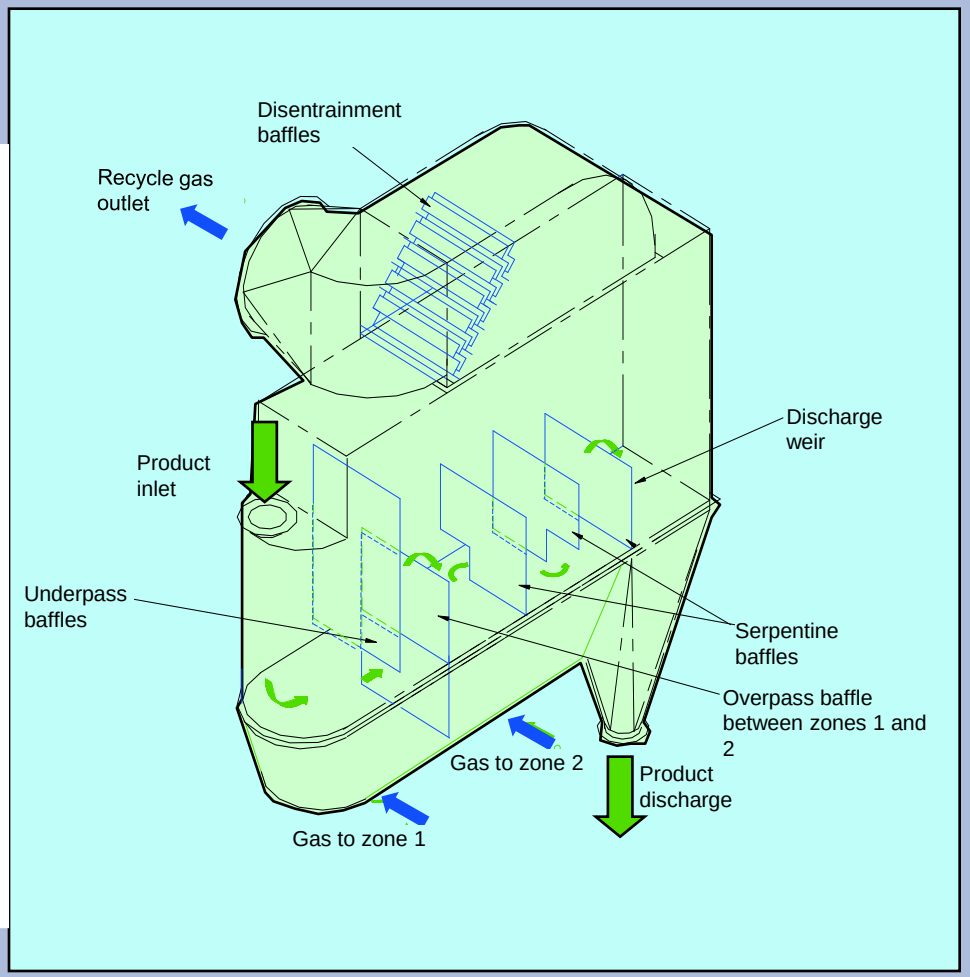
SSP Plant Technology

for Plant-capacities up to 660 t/d



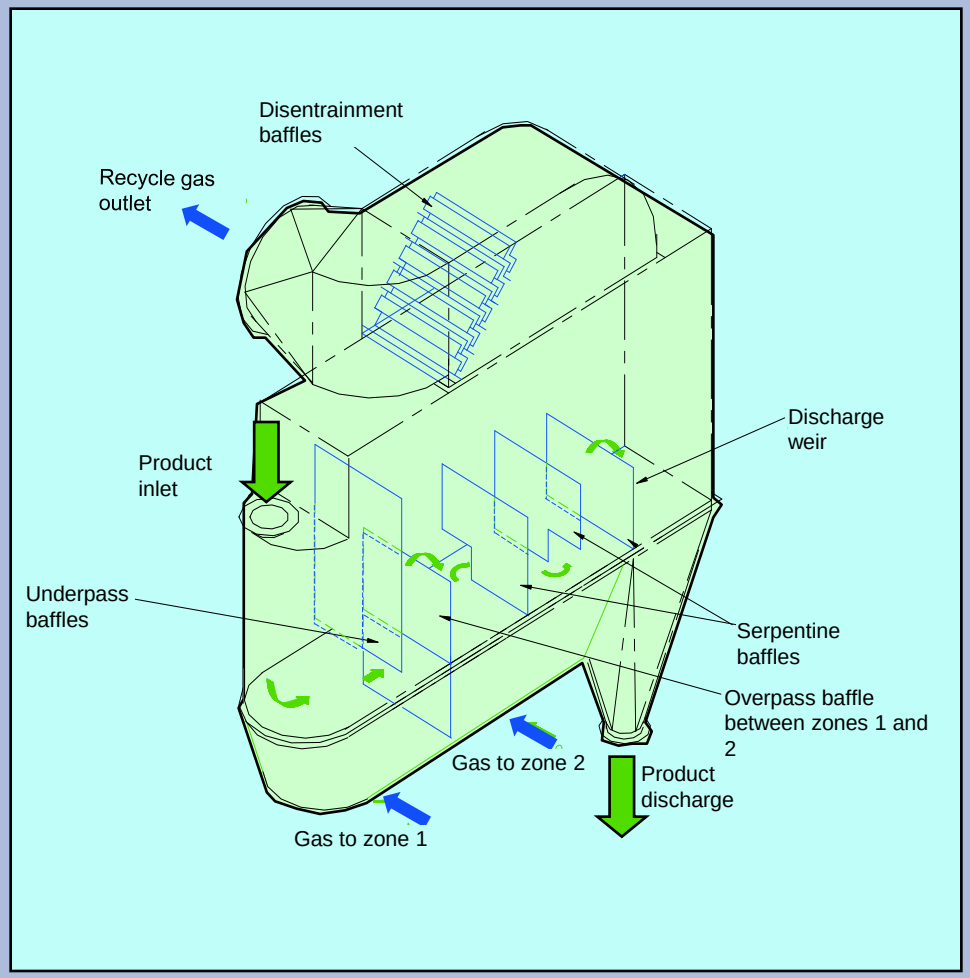
PET – Pre-crystallizer



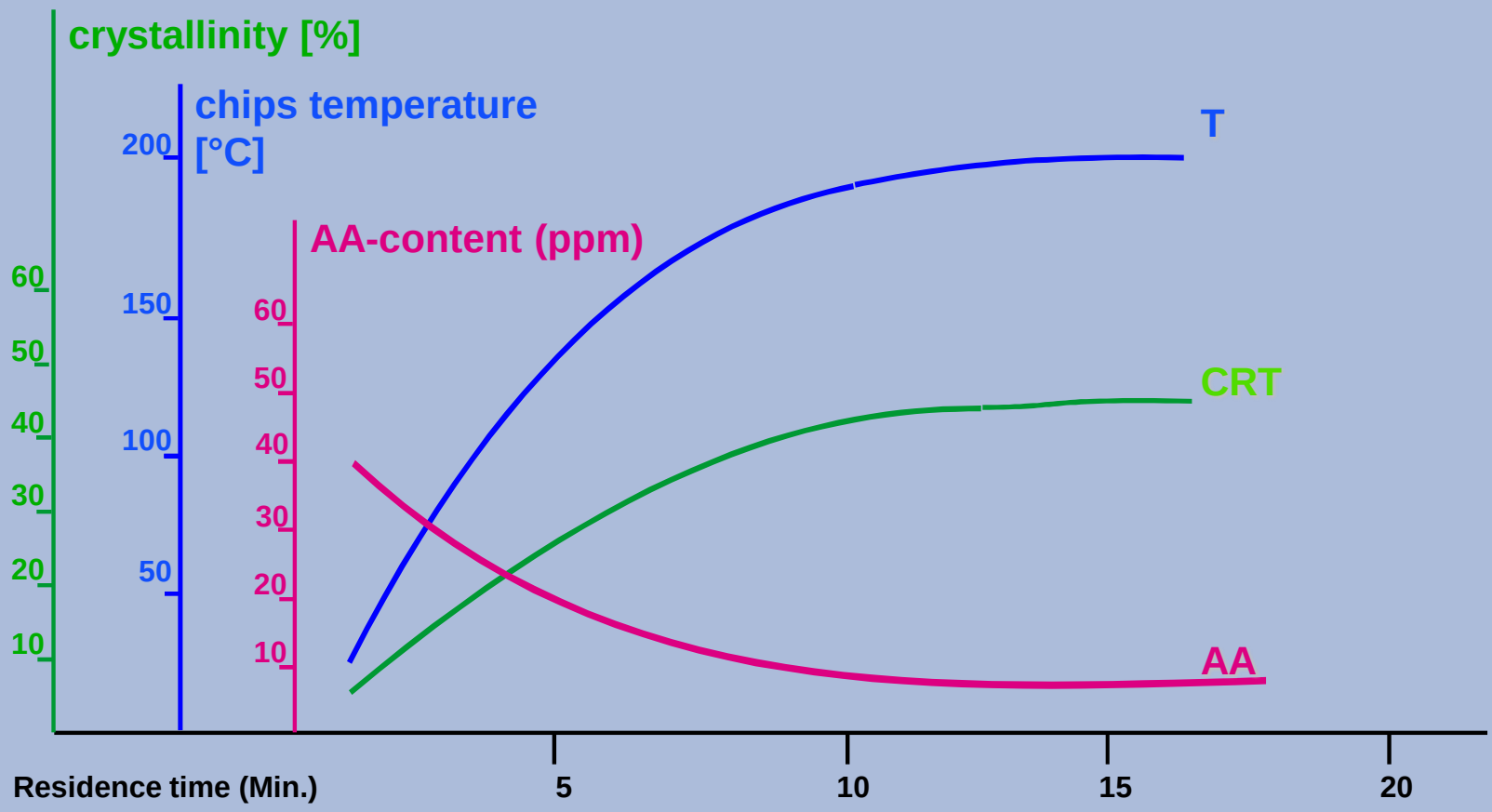


PET – Pre-crystallizer

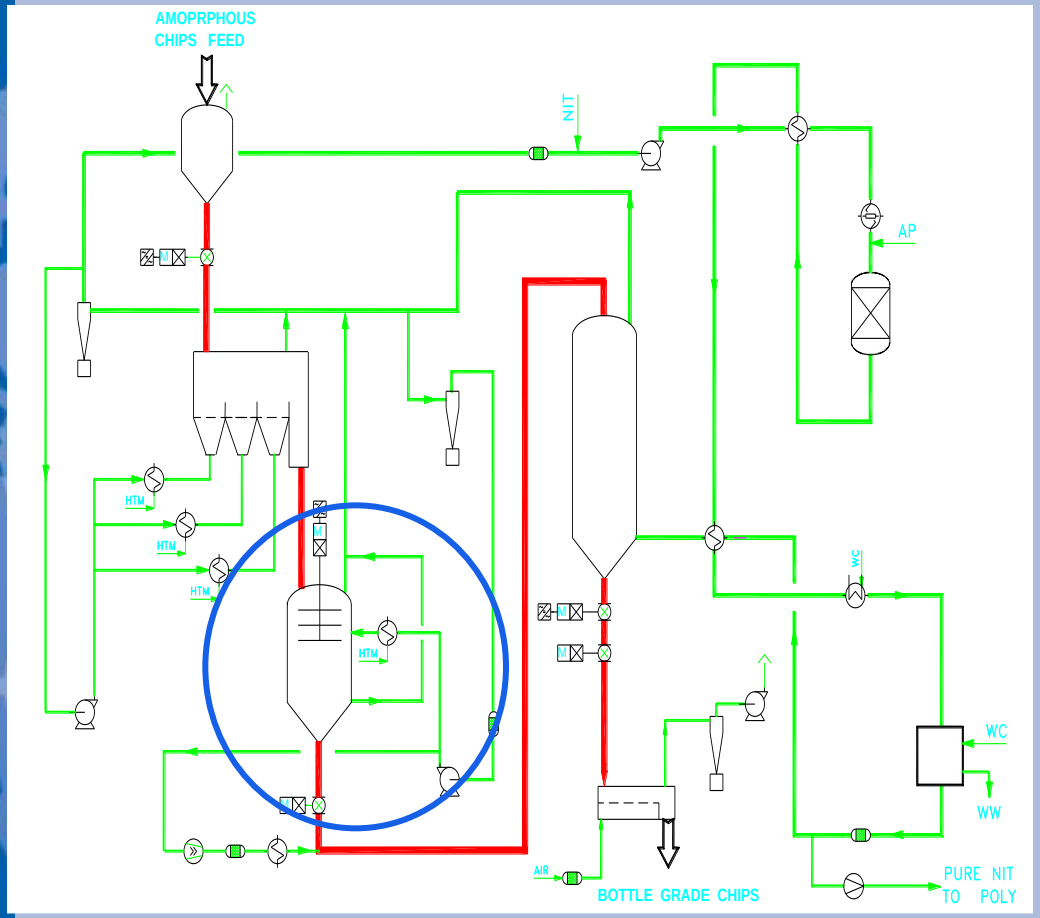
- crystallisation under nitrogen
  - oxygen free atmosphere prevents polymer degradation
  - crystallizer can be operated at a higher temperature level
  - low and constant moisture content in the nitrogen circulation system
- high nitrogen velocity through the chips bed
  - optimum de-dusting
  - high heat transfer coefficient

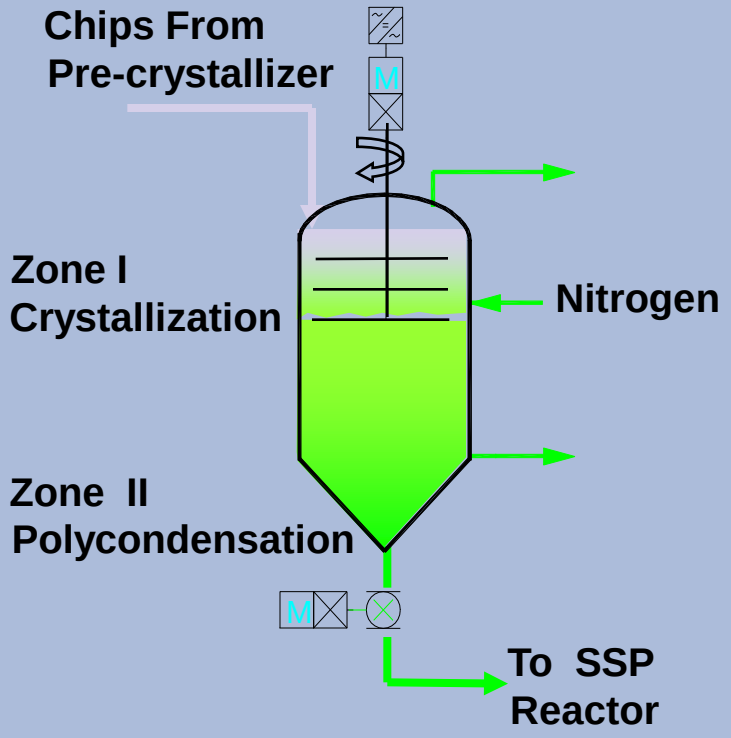


PET – Pre-crystallizer



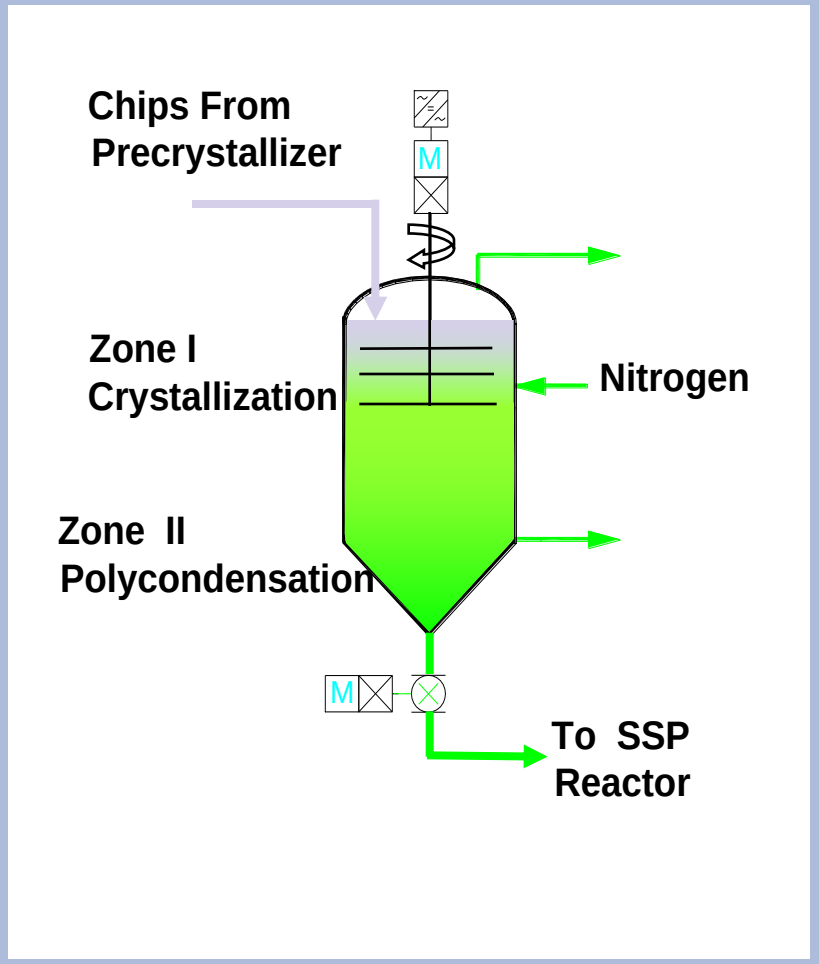
Crystallizer



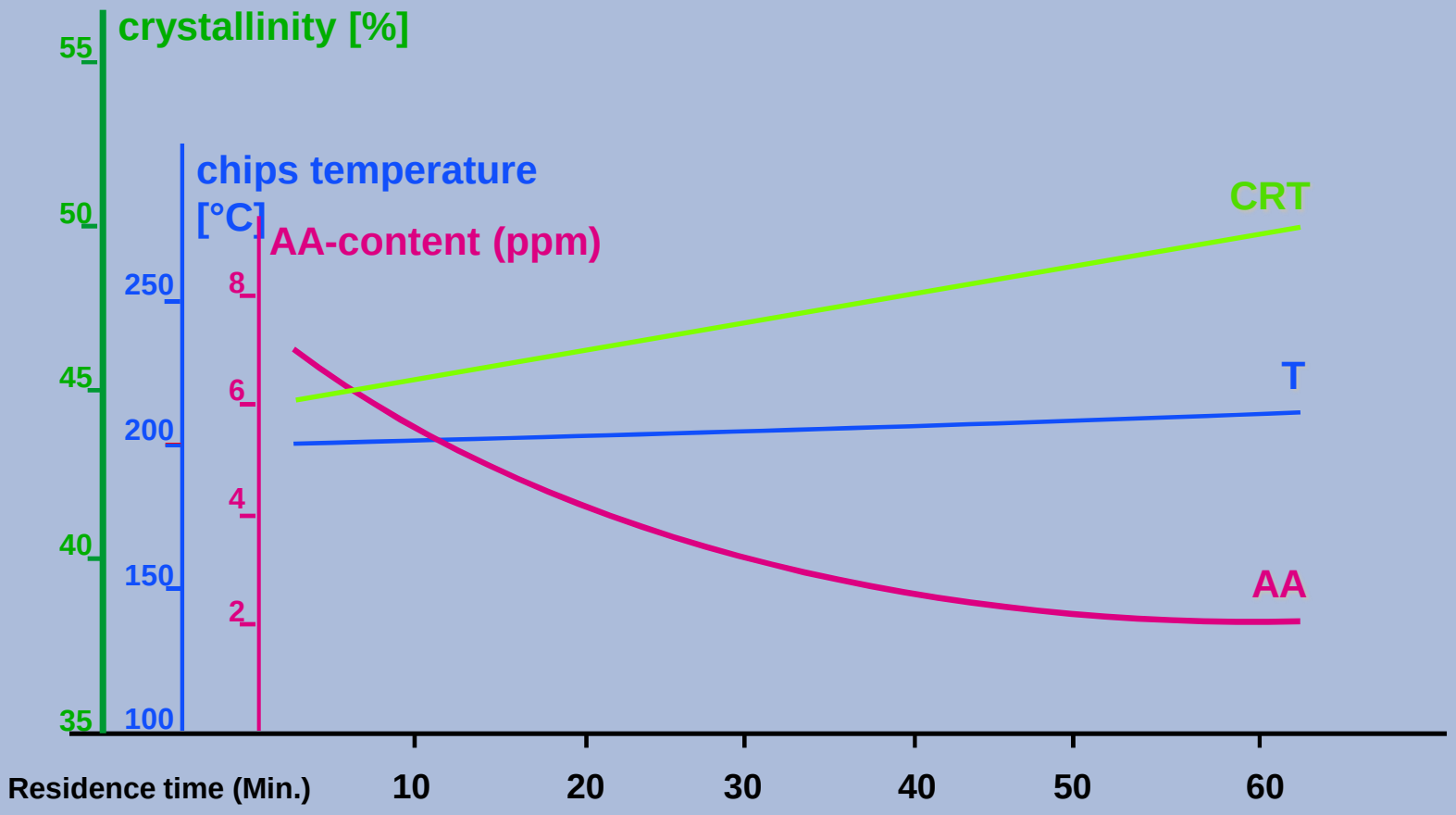


Crystallizer

- uniform crystallization by tube crystallizer
- uniform residence time
- minimum mechanical stress
- no dead spots
- effective transport of the impurities
- limited dust generation

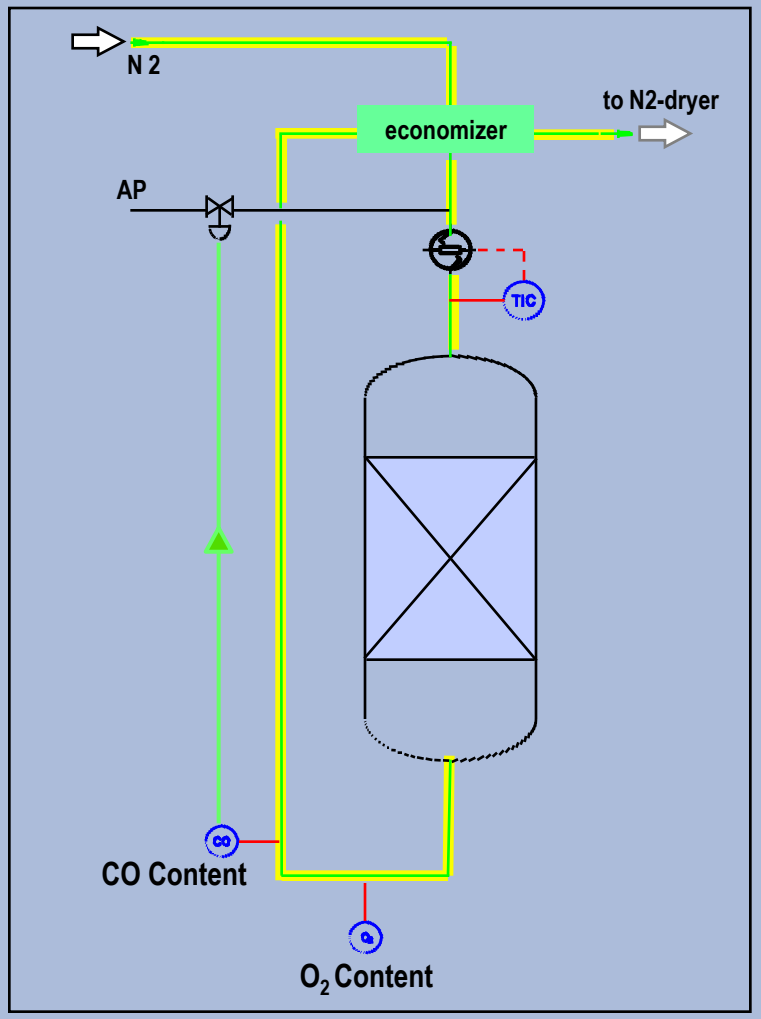


Crystallizer



SSP Plant Technology Single Stage Nitrogen Purification Unit

- **oxygen content < 5ppm after purification**
- **total organic content (TOC)**
  - < 10 ppm after purification
- **water content**
  - < 50 ppm after N_2 - dryer
- **water and carbon dioxide as only effluents**
- **hydrogen not required**
- **only technical Nitrogen required (< 2% O_2)**
- **CO-content used for control**
  - no surplus of O_2 or TOC
- **Generation of pure nitrogen**
  - usage for other plants/consumers



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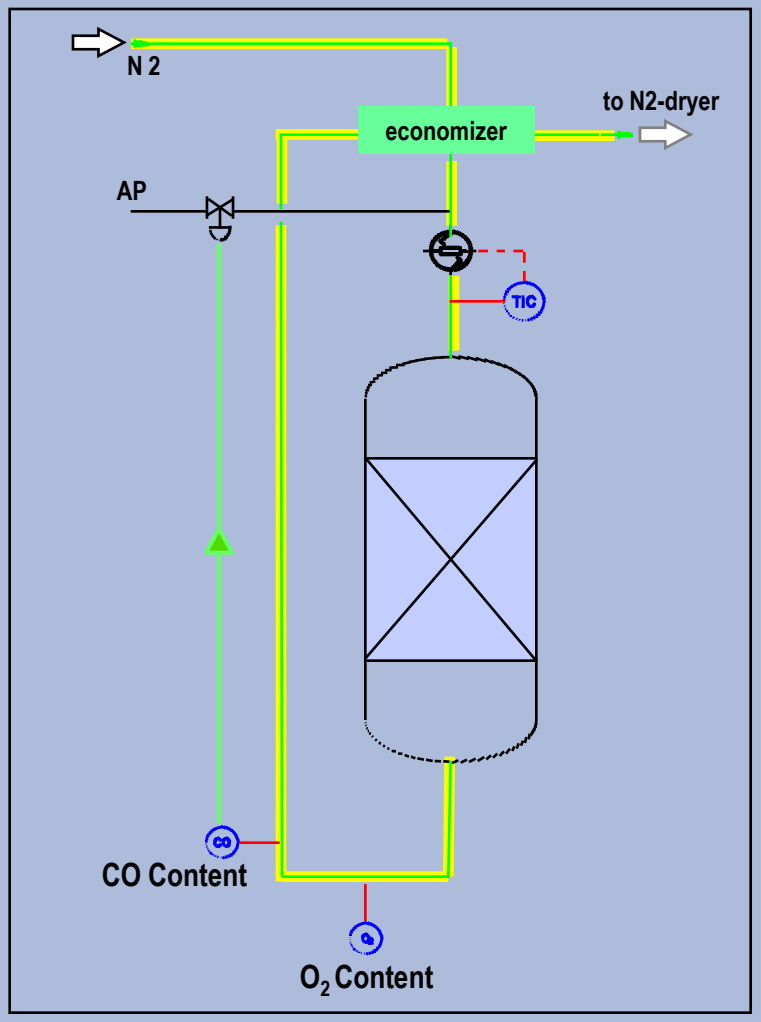
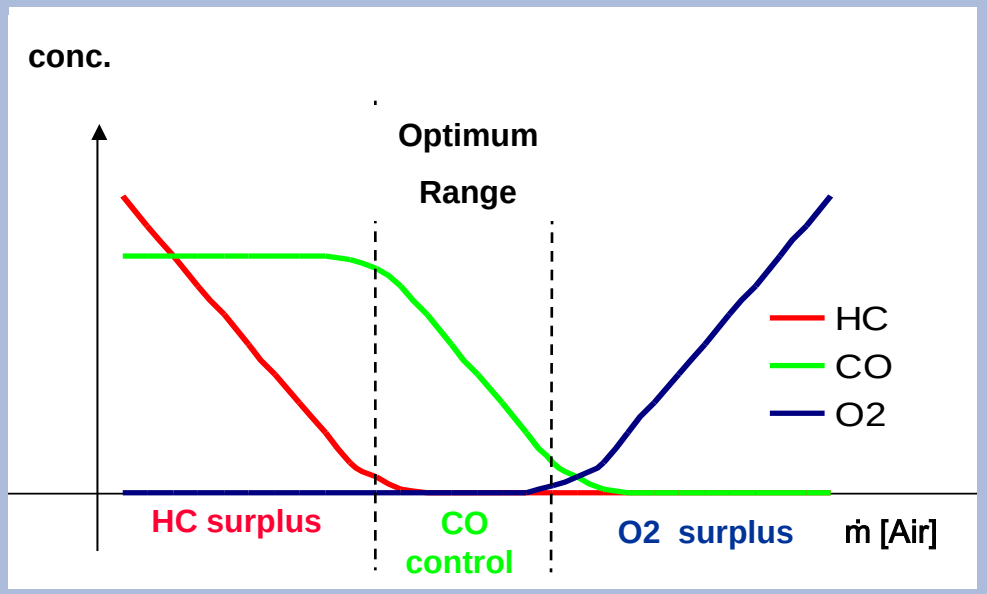
SSP Plant Technology

Single Stage Nitrogen Purification Unit





Patented by Zimmer AG:
DE 10043277
DE 10314991

Zimmer

Quality demands on final bottle polymer (after SSP)

- **AA-reformation during pre-forming depends on:**
  - melt temperature
  - residence time in injection molding system
  - prior formation of vinylester-endgroups in polycondensation and SSP

- **AA-reformation rate [ppm/s]**

temperature	270 °C	280 °C	290 °C	
Caripack (Shell)	0.0141	0.0249	0.0533	Zimmer process
comparison product	0.0236	0.0389	0.0780	(US-market)

- **AA-content in preforms**

projected requirement of the market depending on different application

water packaging:	1-3 ppm
CSD packaging:	2-5 ppm
general purpose:	4-8 ppm

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Bottle - PET resin processing

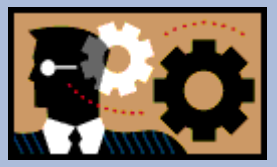
Effect of Co-monomers DEG and IPA on the cycle time

Pre-form: 51 g (bottle: 1,5 l)

Cycle time (sec)	IPA (wt %)	DEG (wt %)
18,0	2,5	1,3
20,0	2,0	1,3
21,5	1,5	1,3

PET Poly & SSP, Total Plant Optimization

- **Optimization by Process Technology, Reactor Design**
  - Usage of different catalysts, Sb-based and Ecocat, possible
    - Impact on Polycondensation Reactors
    - Impact on SSP Reactor



- **Optimization by Process Technology, Utilities**
  - Purified Nitrogen will be generated inside SSP for Continuous Polycondensation
  - Nitrogen with organic load from Continuous Polycondensation will be cleaned in SSP
    - Reducing technical nitrogen consumption
    - Reducing propane gas consumption
    - Eliminating purified nitrogen consumption (generation)

- **Optimization by Process Technology, Transfer Point**
  - Final product adjustment by COOH-level, IV-level, residence times
    - reduce catalyst consumption
    - reduce additive consumptions

PET Poly & SSP, Total Plant Optimization

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The 7-S of Project Management (*)

Strategy	**Requirements of the project and the means to achieve them.**
Structure	**Organizational arrangement that will be used to carry out the project.**
Systems	**Methods for work to be designed, monitored and controlled.**
Staff	**Selection, recruitment, management & leadership of those working on the project.**
Skills	**Managerial & technical tools available to the project manager and the staff.**
Style/culture	**The underlying way of working and inter-relating within the work team or organization**
Stakeholders	**Individuals and groups who have an interest in the project process or outcome**

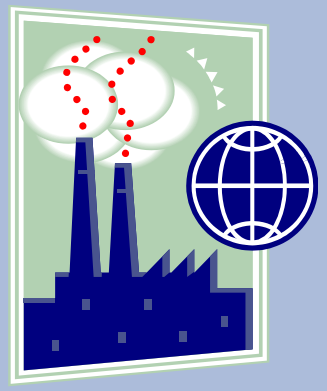
(*) 7-S framework by McKinsey & Co., management consultants

PET Poly & SSP, Benefits for our Client (1)

- **Process Advantages:**
  - Change downstream information into activities either in Polycondensation or in SSP independently
    - Changing / Adjusting parameter settings in both sections coordinated
    - Changing / Adjusting polymer composition (recipe)
  - Process optimization for CPU and SSP together
- **Technological Advantages:**
  - Interplay of forces from both, normally independent, production units
    - Off-streams used as feed-streams in the conjunctive facility
    - Common technological design philosophy is reducing number of sub-suppliers and by this costs for spare-parts
- **Economical Advantages:**
  - Combined optimization reduces catalyst consumption and/or additive consumptions
  - Optimized split of work-load (IV-lift) offers additional capacity

PET Poly & SSP, Benefits for our Client (2)

- **Management Advantages:**
  - Reduced work-load for clients Project Manager
    - One supplier = One's responsibility
    - Reducing amounts of cooperation meetings
  - Client's problems are Supplier's tasks
  - Support to achieve FDA approval



Result: Minimizing the risks by achieving the project success factors!

- **High-Quality**

  Meet the outcomes of the project, both, functional and performance features.
- **Within Budget**
- **On-time**