

Bottle-to-bottle PET Recycling of Post Consumer Waste



Asia Pacific Conference on 'Recycling of Plastics'

February, 2007 – Mumbai & Delhi
Elfriede Hell, Product Manager Recycling

[REDACTED]

[REDACTED]

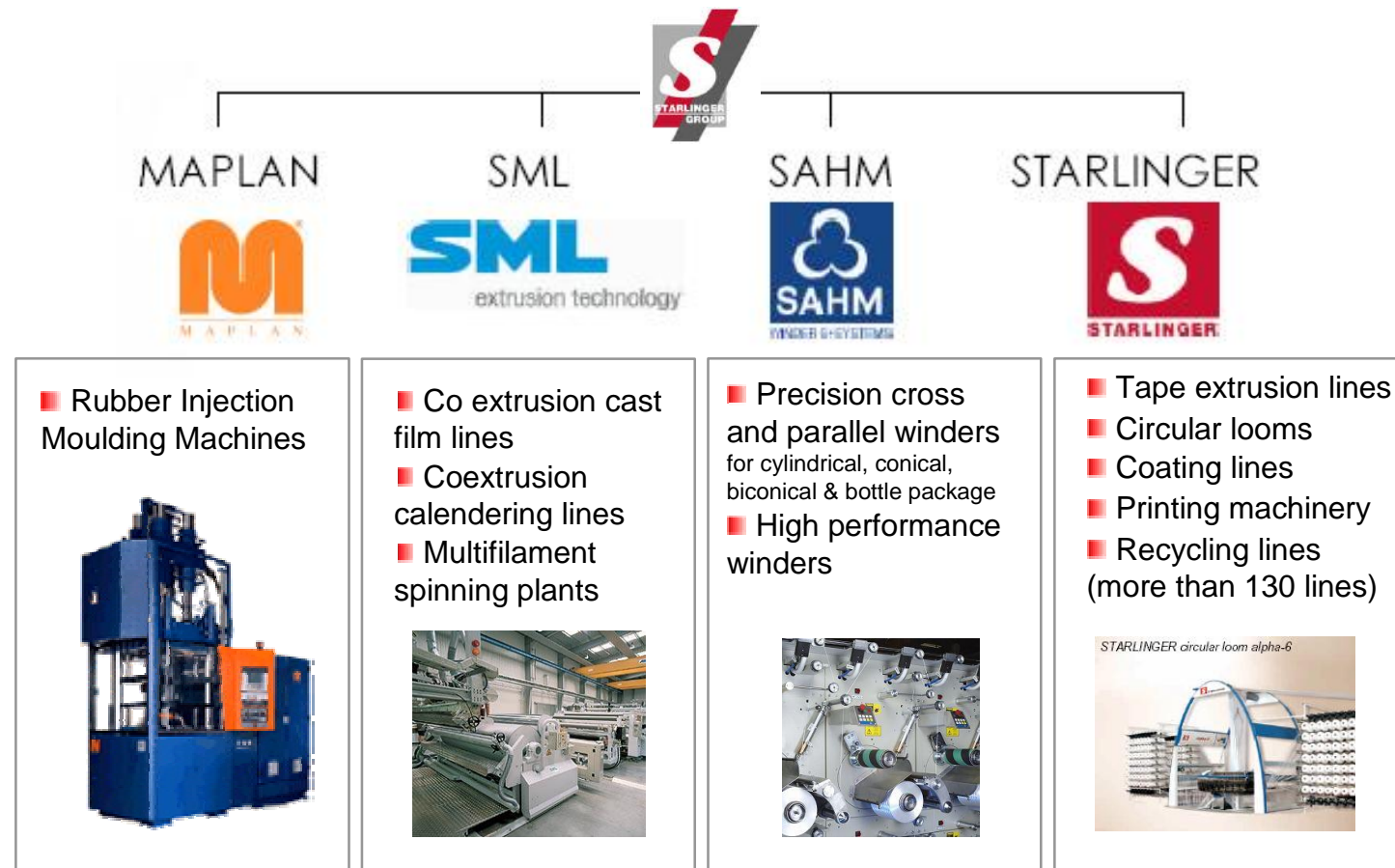
[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

Appendix 1: Starlinger Group



- Machinery in more than **130 countries worldwide**
- Privately owned company

Variety of approaches for BtB

Starlinger Recycling Technology

Situation food contact approvals

Summary and Conclusion

Q & A

- Tougher competition within the industry and from other industries
 - Pre-form is a commodity
 - Competition from other industries (e.g. PP, PLA)
- Increasing importance of R-PET as an economic alternative to resin
 - Fluctuating resin prices
 - Cheap resin imports from Far East
 - Competition – see point 1!
- Increased emergence of waste
 - Higher volume for classical applications and new applications
 - Acceptance of PET bottles as glass replacement
 - Origin: production (preforms), post-industrial (preform, sometimes bottles), post-consumer (bottles)
- Legal frameworks
 - Quota for amount of R-PET to be used
 - Ever-changing national collection rules

- One of many definitions:

Process consisting into turning collected post consumer PET bottles into new bottles through mechanical recycling or depolymerisation.

(Source: website of M/S PETcore / BE)

- Usually means direct food contact with R-PET (not multi-layer)
- Distinguish national situation of food contact approvals
 - Some countries allow / disallow / do not regulate use of R-PET
- Variety of challenges originating in the material PET

- Characteristics of PET
 - Types of degradation: hygroscopic, hydrolytic, oxidative
 - Required IV level: thinner walls – higher IV
- Get enough PCR-PET
 - Quality: type of contamination, origin, barrier technologies
 - Quantity: many consumed bottles go into other applications
- Economic gain
 - Price of collected material (fluctuates with resin price)
 - Transformation costs (including washing, pelletising, IV increase and decontamination)
 - Compared to price of virgin material (R-PET approx. 80 %)
- Cleansing efficiency and IV increase
 - à Here Starlinger Recycling kicks in!!!

- Physical properties
 - for the pre-forming / bottle blowing process: IV
 - Up to 100 % R-PET usable
- Decontamination
 - for food contact application: cleansing efficiency
 - Up to 100 % R-PET usable (see approvals)
- Quality of end product
 - for the marketing people and the end user: AA and limonene level (taste), transparency / yellowing (appearance), ...
 - Usually limits the use of R-PET between 30 – 50 %
- Country rules and regulation, brand approvals

Those factors make quality
of input material crucial!!!

- Flake quality is key for our customers to successfully selling R-PET to preform producers!!!
- Thus be aware of quality of washline!
 - Not every technology is applicable!



Required flake quality for food contact material:

- Moisture content: max 0,4 – 0,6 %
- PVC content: max. 5 ppm
- PET oil bottles: max. 5 ppm
- Label / glue content: max. 10 ppm
- HDPE / PP content: max. 20 ppm
- PET dust: max. 1 %
- Metal content: max. 20 ppm
- Coloured PET flakes: max. 30 ppm
- pH value: neutral
- Other contamination: max. 10 ppm
- Flake size: max. 8 – 10 mm

Current situation and trends

Starlinger Recycling Technology

Situation food contact approvals

Summary and Conclusion

Q & A

Possible sources of recycling material



In-house waste

- Usually clean and dry, possibly printed
- All types of form and shape depending on material
- Materials are in general not mixed
- Material management is in the hands of the re-user
- Reuse in the same application, down-cycling or selling pellets

Post-industrial waste

- All types of form and shape
- Depending on handling material can get dirty, wet and mixed
- Tolling recycling (producer runs risk to get contaminated material back) or sold for other applications (e.g. fibres à injection moulding)

Post-consumer waste

- Collected material (e.g. PET bottles) to be ground and washed
- Usually wet (max. 4 %), often printed
- Beware of PVC and abrasive contamination
- Reuse in all types of applications (e.g. film, injection moulding)

Different ways to achieve food-grade material

- Food-contact flakes
- Solid-stating of flakes
- Solid-stating of flakes, extrusion and pelletising
- Extrusion of flakes, pelletising and solid-stating

The application is the key.

- Flakes are usable for extrusion processes (e.g. strapping, sheet, low-tenacity fibres) as filtration is possible.
- Pellets are recommended for injection moulding (e.g. pre-forms) and high-tenacity fibres. Issues: stable IV required, filtration not possible.

Regrind vs. Regranulate



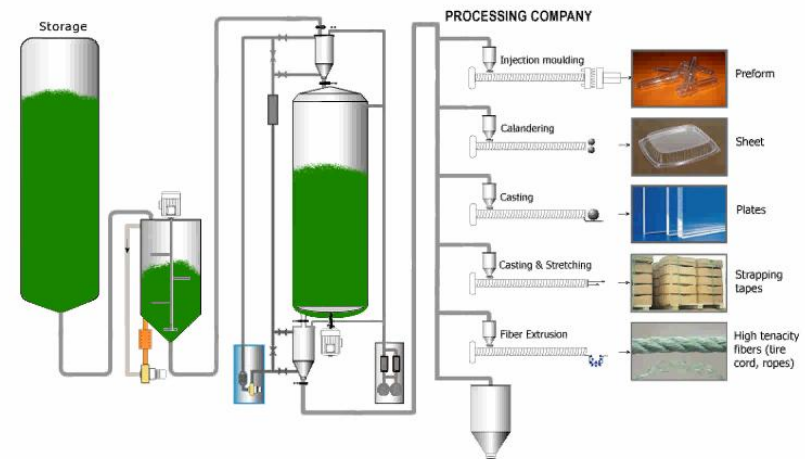
Regrind

vs

Regranulate

+	Thermal history à degradation	~
-	Higher dust content à gels	+
?	Conversion costs depending on throughput, technology	?
-	Quality irregularity	+
~	Contamination (solid, volatile)	+
-	Necessity of insensitive melt filtration of production extruder	+
~	Irregularity of material to be fed into production extruder	+
~	Mixing with virgin resin	+
-	Pellets like virgin material (density, IV)	+
	R-PET can be easily replaced by virgin PET	+

- Description
 - Solid stating of flakes
 - Continuous process with vacuum reactor
- Application
 - Strapping bands
 - Injection moulding



Current situation and trends

Variety of approaches for BtB






Situation food contact approvals

Summary and Conclusion

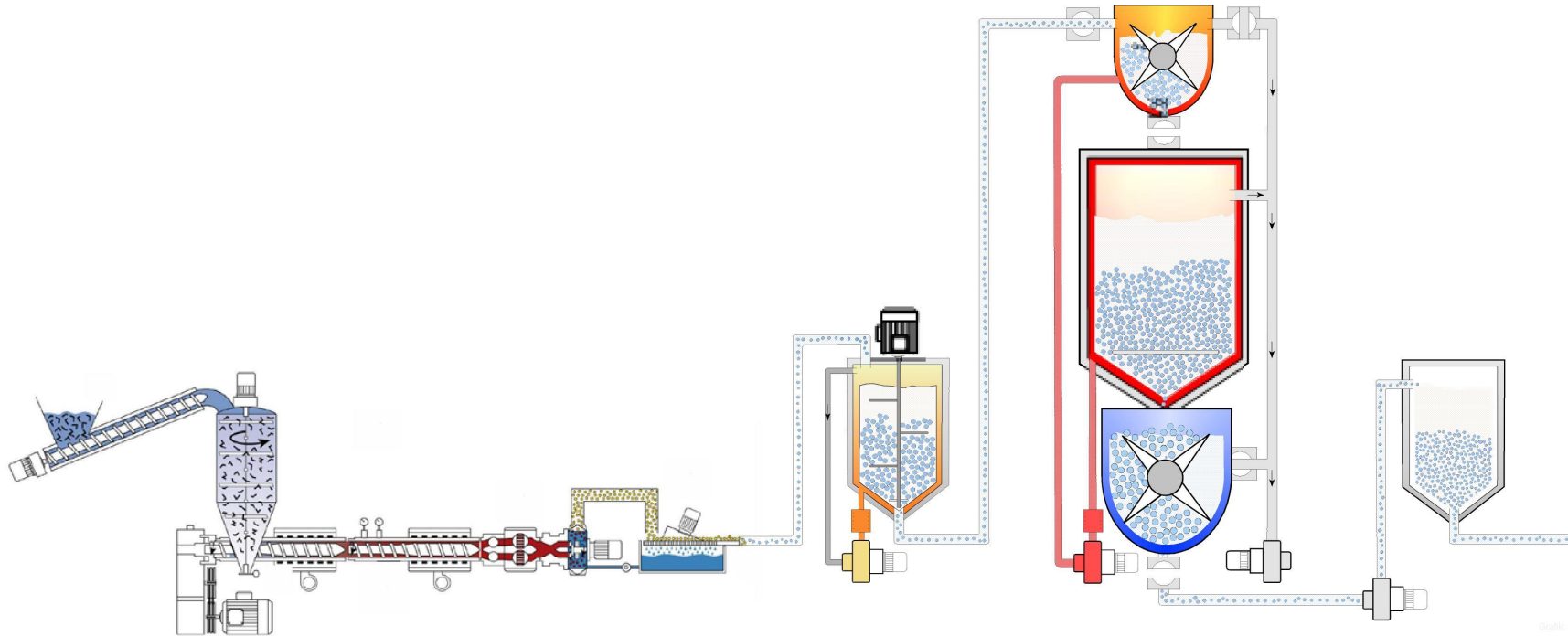
Q & A

Appendix 2: Recostar Product Overview



<p>Recostar Compact</p> 	<p>Recostar Basic</p> 	<p>Recostar Universal</p> 	<p>Recostar PET / PET iV plus</p> 	<p>SSP iV plus Solid State Polycondensation</p> 
<ul style="list-style-type: none">■ Inline Edge trim recycling	<ul style="list-style-type: none">■ LDPE, HDPE, LLDPE Blow and Cast Film■ BOPP■ Especially for wet materials■ EPS, XPS	<ul style="list-style-type: none">■ LDPE, HDPE, LLDPE Blow and Cast Film■ BOPP■ Fibers from PE, PP, PA and Polyesters	<ul style="list-style-type: none">■ In-house bottle or pre-form flakes■ Post consumer bottle flakes after washing line	<ul style="list-style-type: none">■ Increase of IV of Pellets from PET and PA■ Decontamination according to FDA for Post consumer materials

Starlinger Recostar PET IV+

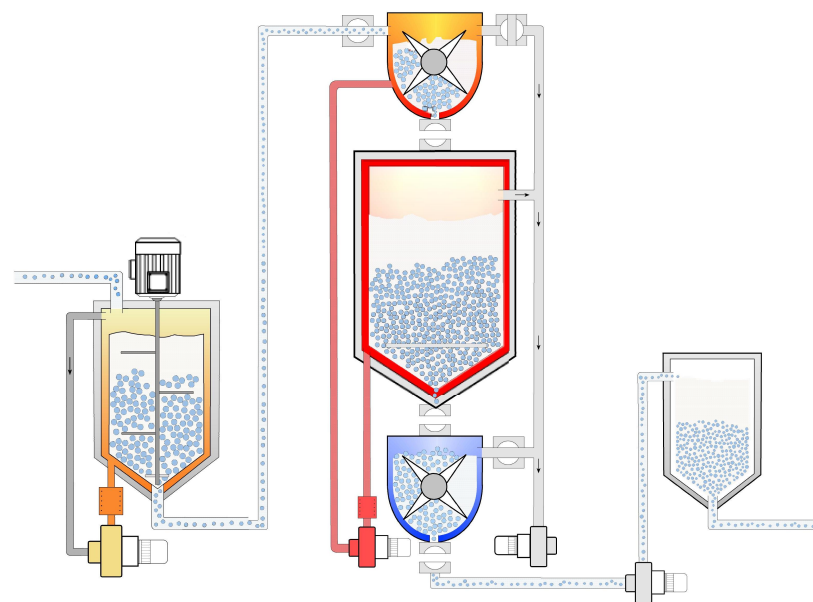


Complete system consisting of Pre-drying, Extrusion, Degassing, Filtration, Pelletising, and optionally Crystallisation and Solid State Polycondensation

- FIFO principle of pre-crystalliser (uniform pretreatment of material)
 - Preheating by means of hot air
 - Residence time approx. 90 - 120 min.
- Single screw extruder with high vacuum degassing
- Melt filtration
 - Continuous with or without back-flushing
- Pelletising systems
 - Strand pelletising (pellet temp. 40 °C, crystallinity < 0,3 %)
 - Underwater pelletiser (pellet temp. 80 °C, crystallinity < 2 %)
 - Underwater pelletiser with in-line crystallisation (pellet temp. 150 – 170 °C leads to increased energy efficiency, up to 15 % crystallinity)

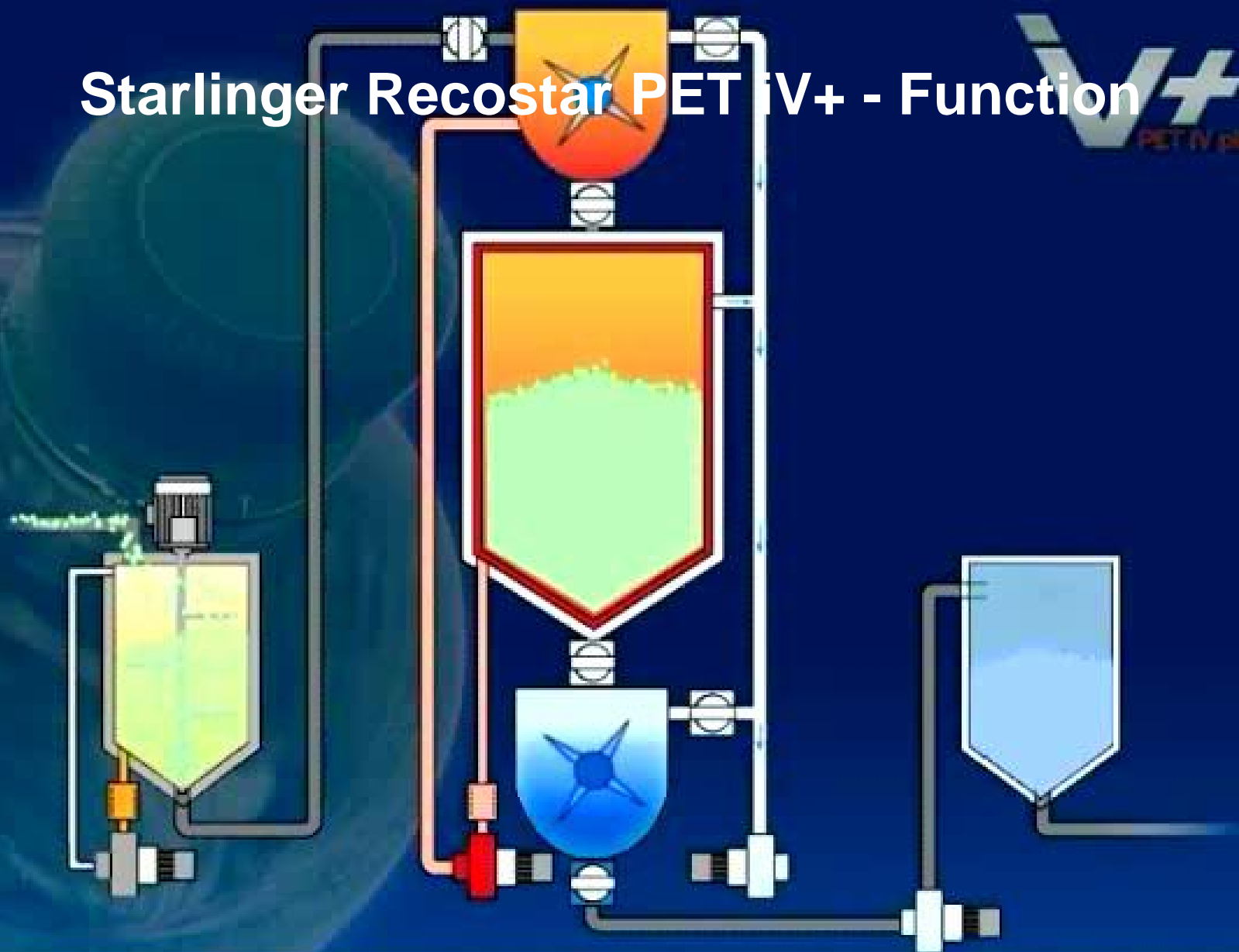
- Description of pellets:
 - Regular, amorphous re-granulate with resin-like flow characteristics
 - Minimal IV loss during extrusion due to ideal pre-treatment
 - IV degradation approx. 0.02 – 0,05 [dl/g]
 - Humidity max. 0,1 %
- Application for:
 - Fibres (up to 100 %)
 - Film (non-food grade, up to 100 %)
 - Injection moulding parts (non-food grade, up to 100 %; in-house waste – food-grade, up to 30 %)
 - Strapping (up to 100 %)

- Air-heated crystalliser to dry, heat and crystallise the pellets
- Transportation of hot pellets to preheater by vacuum
- Heating under high vacuum to reaction temperature
- Automatic release into the reactor without loss of vacuum
- Storage of pellets for an adjustable reaction time under heat and vacuum
- Residence time defines IV increase
- Release of material into a cooling chamber



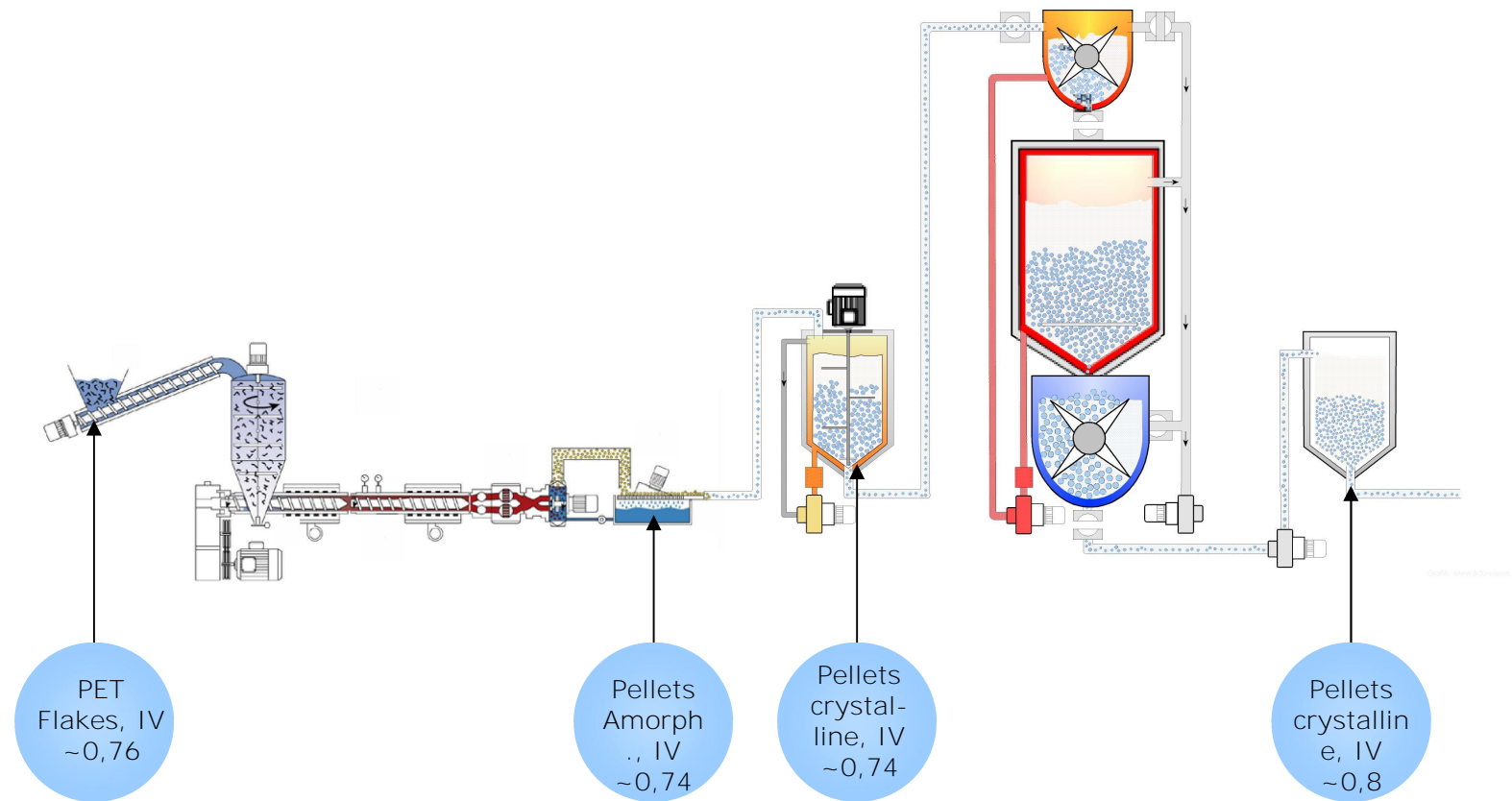
Quelle: www.starlinger.at

Starlinger Recostar PET IV+ - Function



solid state polycondensation

- Low investment costs compared to other technologies
- Advantageous transformation costs to increase IV
- Use of energy from the previous step
- Supply of complete line to achieve food-grade R-PET from flakes
 - Extrusion / filtration / pelletising / solid stating
 - Options available to adjust to customer requirements
- Different sizes available
- Residence time adjustable, independent of extrusion
- Modular system – several SSP parallel depending on output and required IV
- Small footage and height requirements
- No external water and air treatment required
- Plug & Play system - delivered fully equipped with oil & vacuum system and fully electric



- Adjustable IV increase depending on residence time
- IV increase of 0,01 – 0,02 dl/g per hour
- Reduction of acetaldehyde, crystallinity of up to 40 %
- Decontamination of recycled material
 - FDA LNO, Austrian Approval, several others pending

Description of Recostar PET IV+ R-PET:

- Intrinsic viscosity: adjustable (depending on IV of input material and residence time in SSP)
- Acetaldehyde: less than 1ppm (residence time in SSP > 6 hrs)
- Physical status: crystalline
- Colour b-value: depending on input material
- Melting point: approx. 245 °C
- Bulk density: approx. 770 kg/m³
- Weight of 100 pellets: approx. 2 g (adjustable)
- Dust content: max. 0,1 %
- Humidity: max. 0,4 %
- Decontamination: FDA non objection letter (residence time in SSP > 6 hrs; cleansing efficiency 96 % - 99 %)

Application for:

- Bottles (food grade, up to 100 %)
- Film (food grade, up to 100 %)
- High-tenacity fibres (up to 100 %)
- High-tenacity strapping (up to 100 %)

Recostar PET iV+

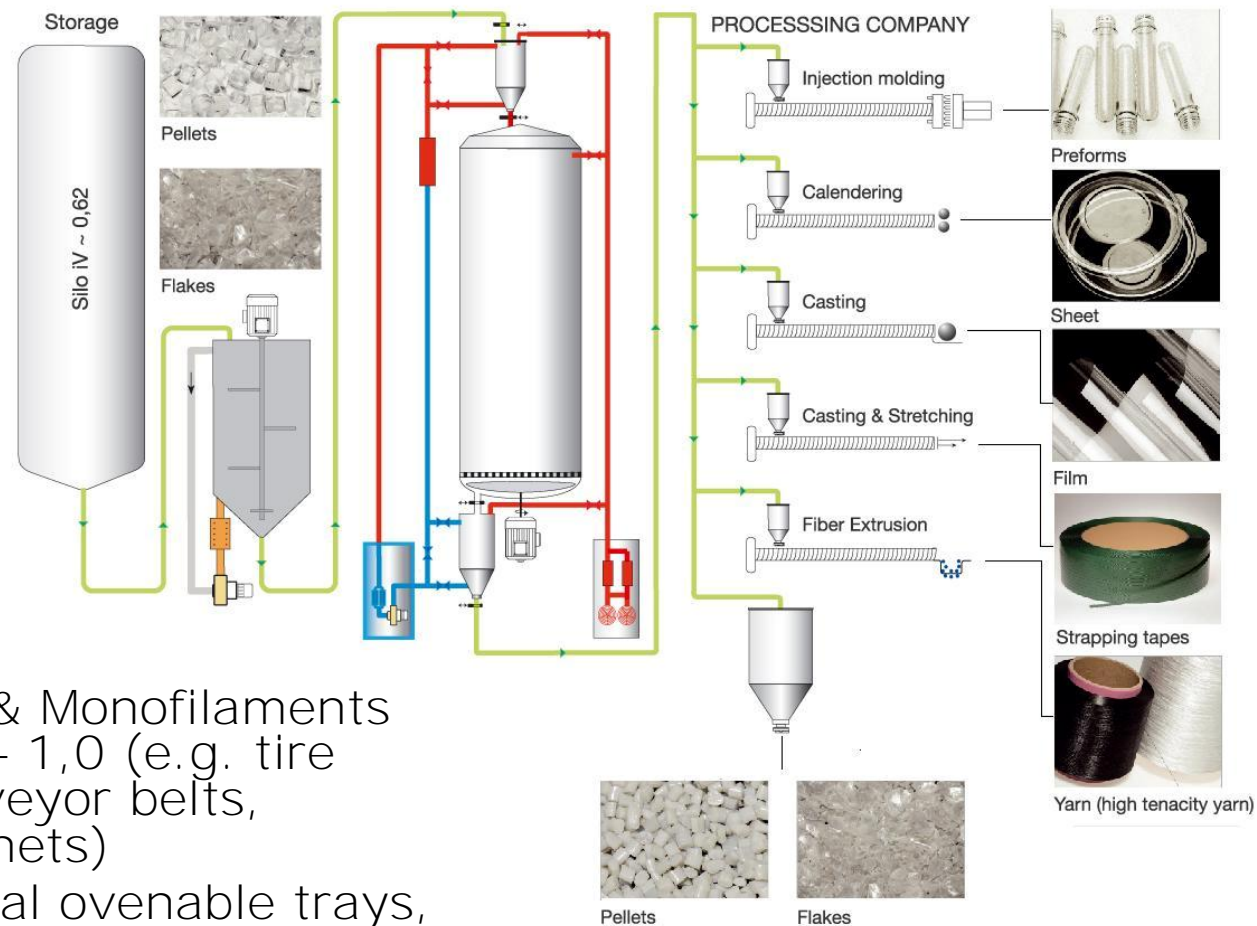


Extruder Ø	Output	iV+
65	150 – 200 kg/h	1 SSP à 250 kg/h
85	250 – 300 kg/h	1 SSP à 250 kg/h
105	400 – 550 kg/h	2 SSP à 500 kg/h
125	600 – 800 kg/h	3 SSP à 750 kg/h
165	900 - 1200 kg/h	4 SSP à 1000 kg/h



- PET-Bottle Flakes \Rightarrow used for bottles:
 - 6 hour residence time in SSP -> adjustable IV, AA < 1 ppm
 - Up to 100 % re-granulate (depending on clarity required, application, quality of flakes), typical 30 % (clear bottle)
 - Food-grade application approved
- PET-Bottle Flakes \Rightarrow used for food contact film:
 - 6 hour residence time in SSP -> adjustable IV, AA < 1 ppm
 - Up to 100 % re-granulate (depending on clarity required, application, quality of flakes)
 - Food-grade application approved

No apparent difference in extrusion process and characteristics of finished product!!



High Tenacity Yarns & Monofilaments
with an IV of 0,9 – 1,0 (e.g. tire
cords, ropes, conveyor belts,
tarpaulin, fishing nets)

Sheet (e.g. C-PET dual ovenable trays,
foamed PET)

Refineries for specialties

Preforms (too early)

Current situation and trends

Variety of approaches for BtB

Starlinger Recycling Technology

Summary and Conclusion

Q & A

- FDA Letter of non-objection (LNO) is a national approval (USA)
 - But indicates that a proof of quality has been achieved
 - Basis / bench-mark for other national approvals
 - Accepted in many countries
 - Often threshold for brand approval
- Approvals include / exclude different things
 - FDA: also includes non-food bottles
 - European: only if once approved for food contact (e.g. soft drinks)
 - Limit of R-PET to be used (some up to 100 %)
- Country rules and regulation
 - Check your local rule
 - Distinguish approval of technology / of recycling company / of end-product produced with R-PET

US food-contact approval

- FDA Letter of non-objection (PNC 244 - Letter from June 4, 2004)
- ... *RECOSTAR iV plus Process* is capable of effectively removing contaminants from PET resin to *levels safe for food contact use*
- ... *Use of PCR-PET for all Food Types under Conditions of Use 'E' through 'G' (as described in Tab. 2 in CFR 176.170)*
- ... valid when *Feedstock consists of Food and / or Non-Food Containers* obtained from Deposit and Curbside Recycling Programs

Austrian food-contact approval

- Letter from March 6, 2006
- Allows '*PET-Regranulate, which has been produced on a Recostar iV plus – Technology of Starlinger*' for the production of packaging fit to take mineral water, fruit lemonade, lemonade, syrup, alcohol free fruit juice and fruit nectar as well as solid goods without greasy content on the surface

Others (country and brand approvals) pending

Current situation and trends

Variety of approaches for BtB

Starlinger Recycling Technology

Situation food contact approvals

Q & A

- PET industry is a living organism – watch the trends
- Variety of approaches available to reuse post-consumer bottle waste
- Starlinger has 'The comPETitive Edge' to achieve food-contact approved R-PET
- Application of R-PET in high-level products is economically required and proven
- Be aware of different approvals to use R-PET in direct food contact

**STARLINGER & CO. Gesellschaft
m.b.H.**

Sonnenuhrgasse 4
AT-1060 Vienna, Austria

Tel.: +43 1 59955-0

Fax: +43 1 59955-25

email: sales@starlinger.com

Starlinger Export GmbH

India Liaison Office

811A-812 Block "E"

International Trade Tower

Nehru Place

IN-110019 New Delhi, India

Tel.: +91 11 41617821

Fax: +91 11 41617822

email: stacoindia@eth.net

