MAY 31 – JUNE 3, 2016

ISBBB 2016

Sustainable Bioeconomy to Marketplace

14th International Symposium on Bioplastics, Biocomposites and Biorefining

Guelph · Canada

New Developments in Compounding Biomaterials

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HSR HOCHSCHULE FÜR TECHNIK RAPPERSWIL

FHO Fachhochschule Ostschweiz

iwk INSTITUT FÜR WERKSTOFFTECHNIK UND KUNSTSTOFFVERARBEITUNG

Content

- **IWK - Institute of Material Science and Plastics Processing**
- **Overview of the Compounding systems**
- **Process needs, machine requirements**
- **New developments in Compounding**
  - Feed Enhanced Technology
  - Feeding of Liquids
  - Injection Nozzles
  - Side Degassing
- **Project presentation “FluidSolids”**

Welcome to the Hochschule für Technik, Rapperswil
Part of the University of Applied Science Eastern Switzerland

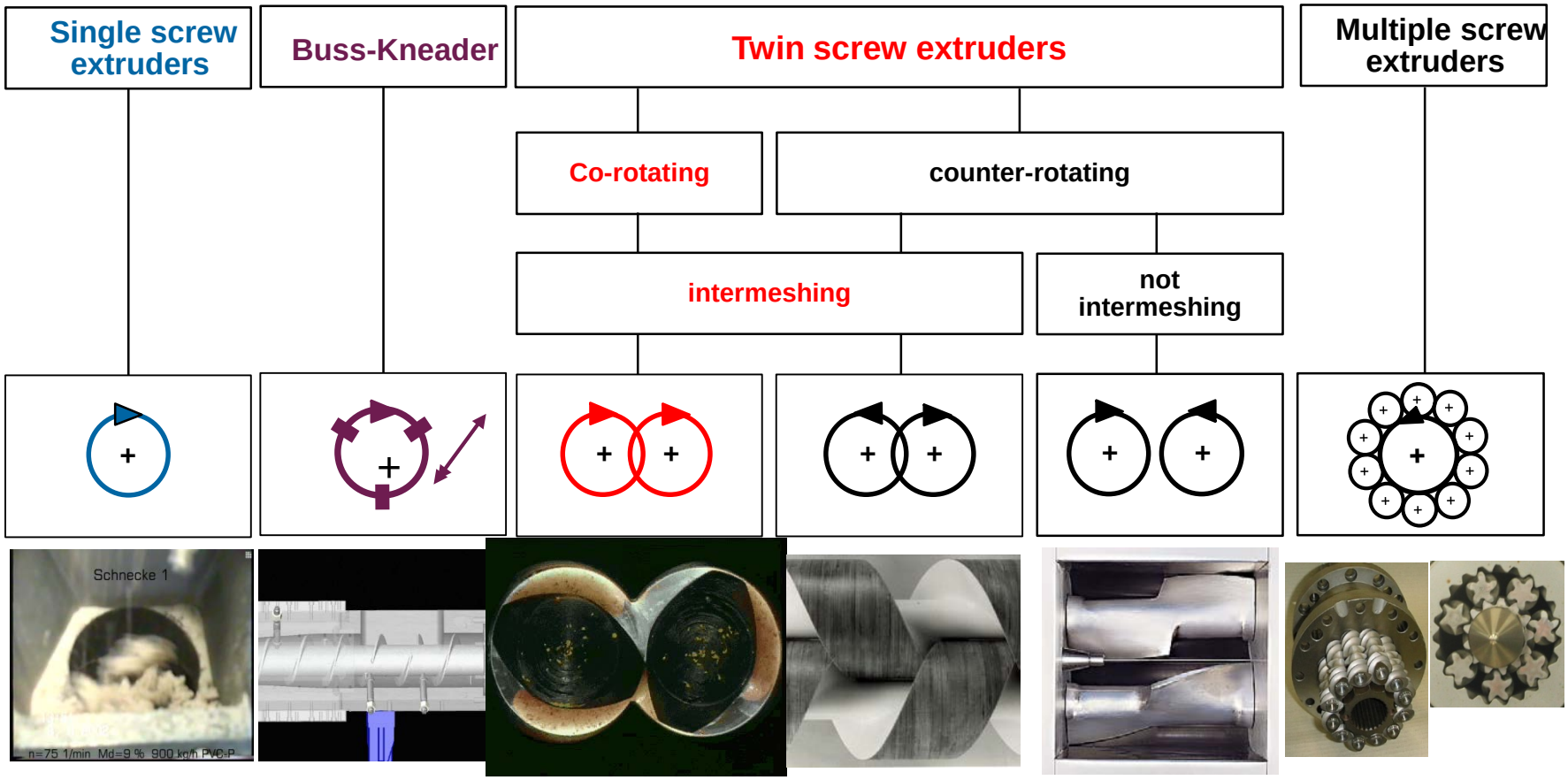
Biomaterials / Biopolymers

- **Biomaterials:**
  - Biopolymers as PLA, PHA (PHB), Starch, etc.
  - Biofibers/Biomass as **Cellulose**, Hemp, Flax, Woodfibers etc.

- **Material performance (concerning processing):**
  - Shear sensitive -> low shear
  - Temperature degradable -> low temperature
  - Moisture sensible -> good degassing behavior
  - Processed in water -> high moisture content

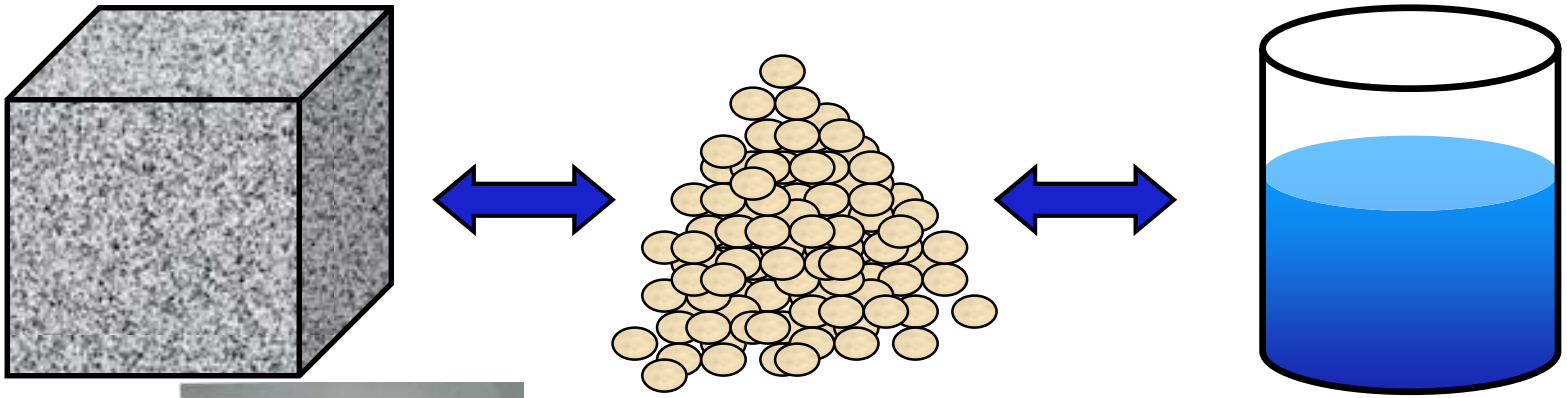
Typical steps in plastics processing

Compounding systems



Bulk material handling

- **Bulk materials are solid goods, the behavior could vary between solid goods and liquids**

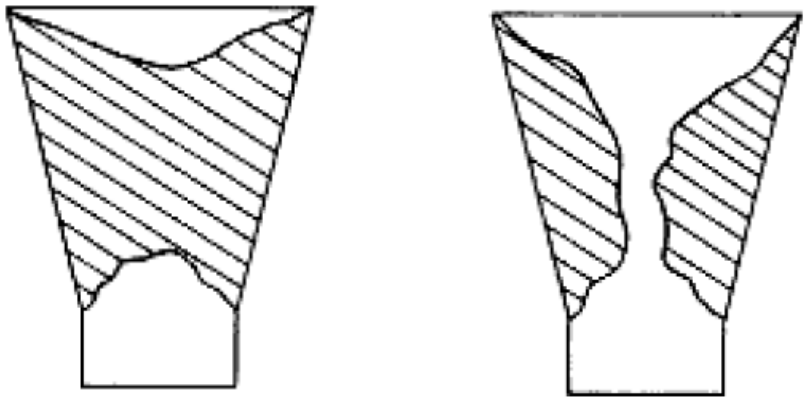


solid

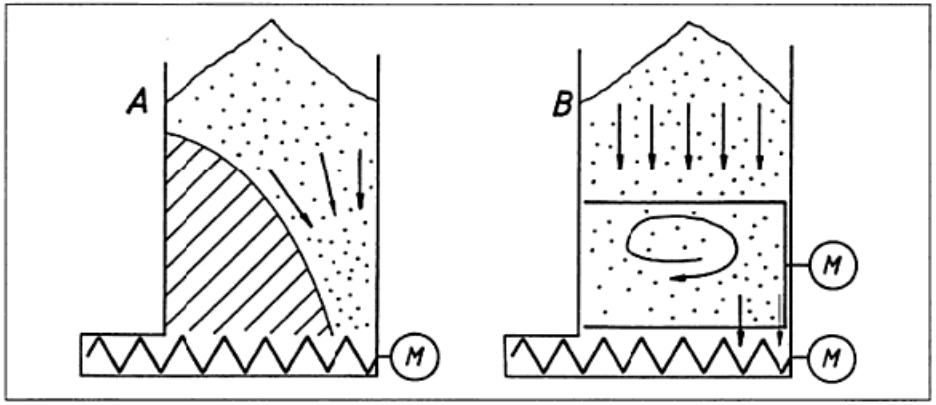
bulk

liquid

Bulk material handling



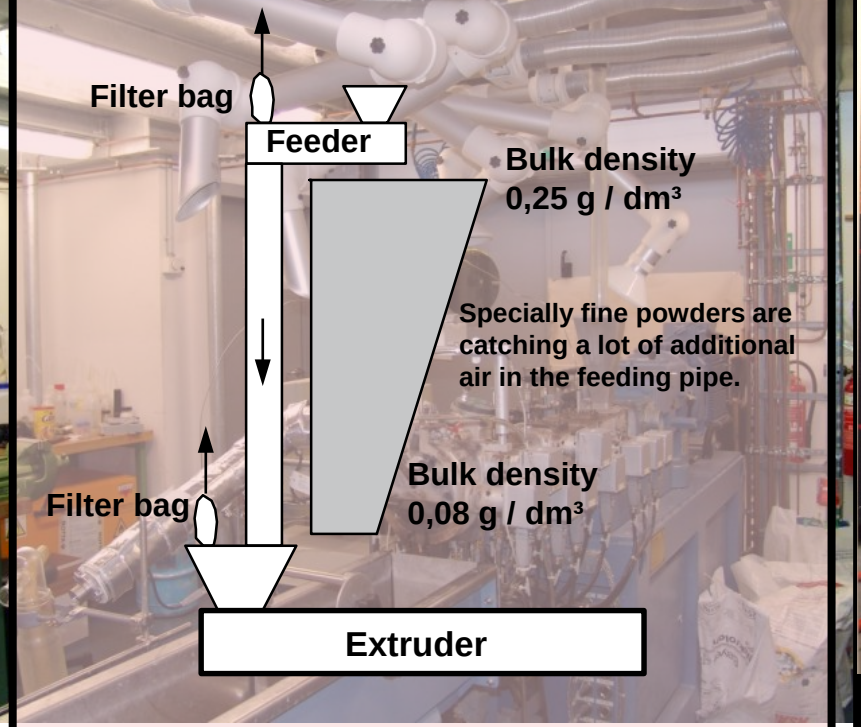
Bridgebuilding or flow problems in the hopper



Feed section design

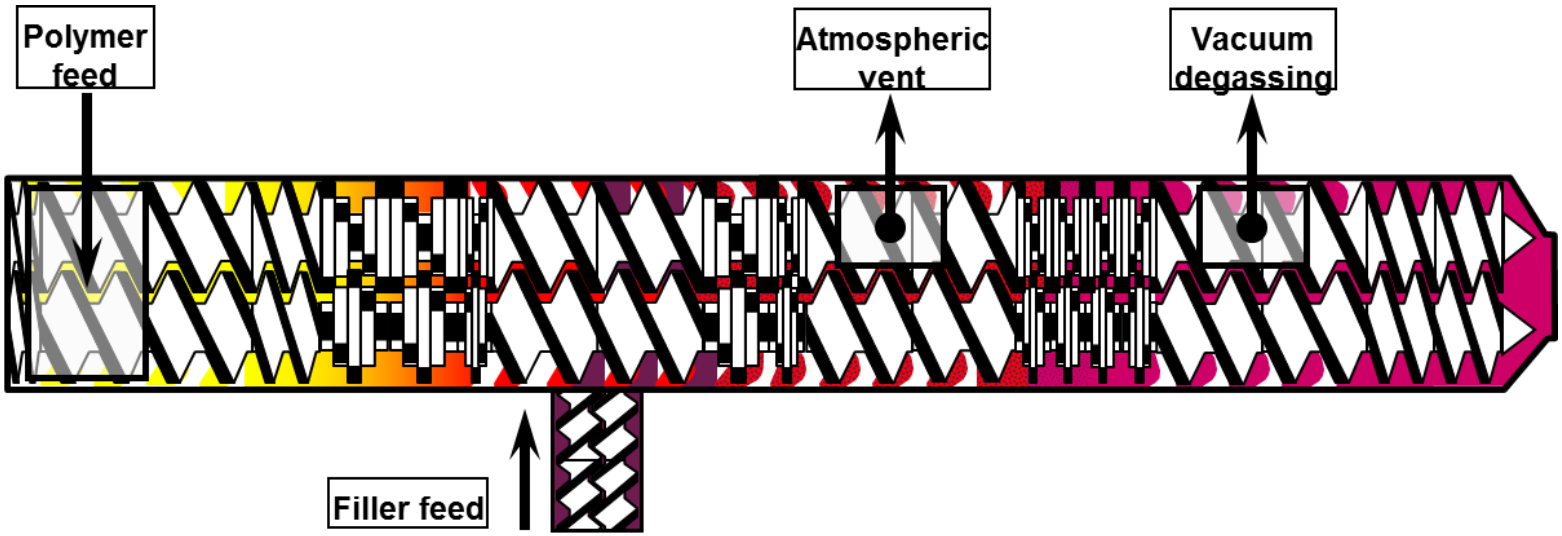
Feed section: feed limitation

Wrong design



Correct design

Co-rotating Twin Screw Extruder / process section

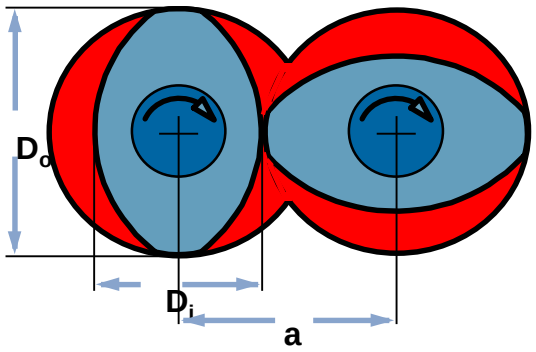


Feeding section	Melting section	Conveying section	Mixing section	Venting section	Homogen-section	Degassing section	Metering section

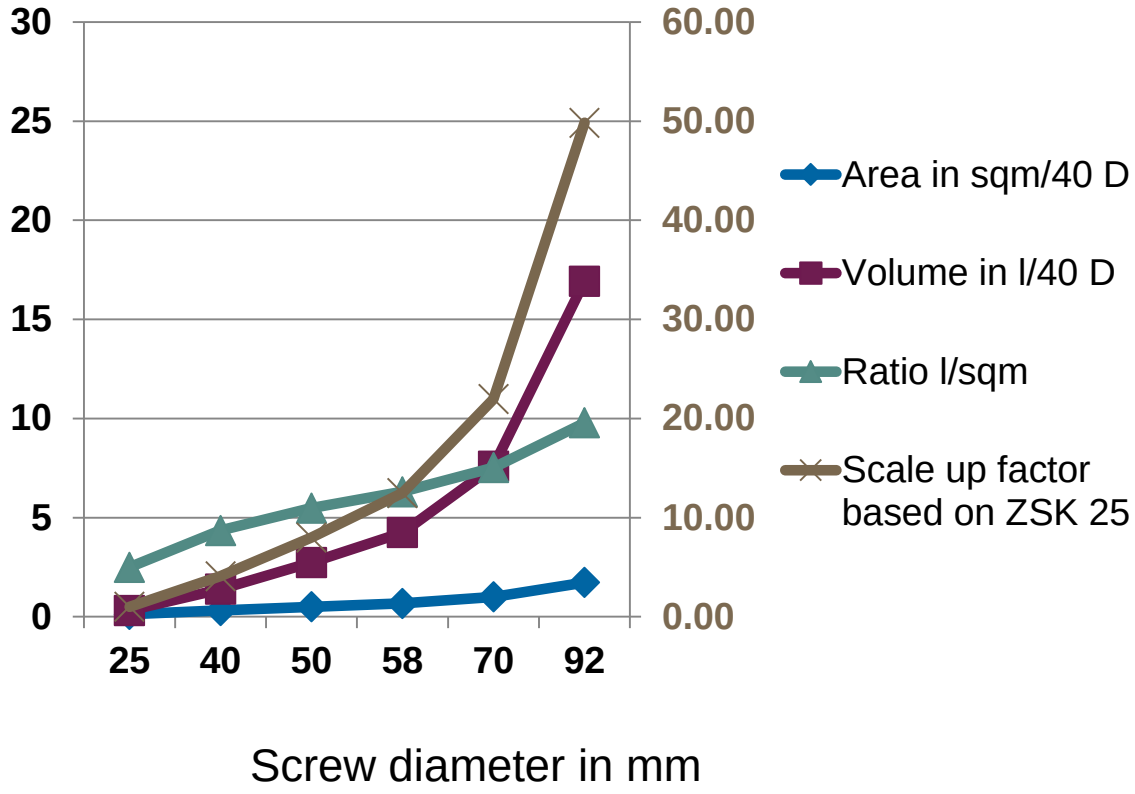
$$Process\ Length = \frac{L}{D_a}$$

Scale up – Influence of cooling and heating

Cooling or heating surface versus volume or throughput



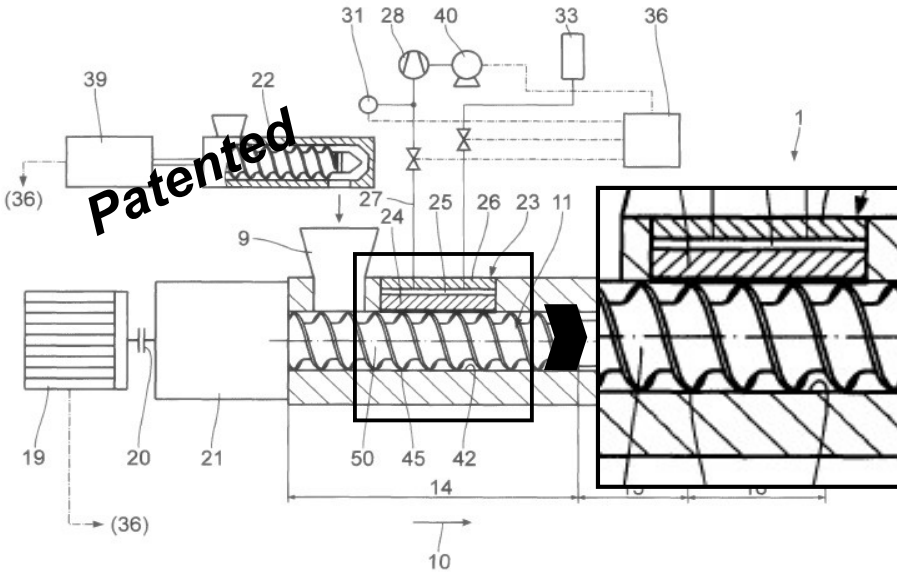
$$Diameter\ Ratio = \frac{D_a}{D_i}$$



Feed Enhancement Technology

FET: Technology to increase the throughput of feed limited products

Solids conveying is improved by applying vacuum in the feed zone to a wall section which is porous and permeable to gas



This wall section is realized by an insert with a filter membrane installed in an open barrel.

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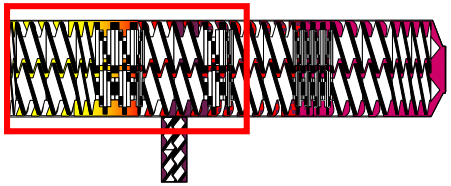
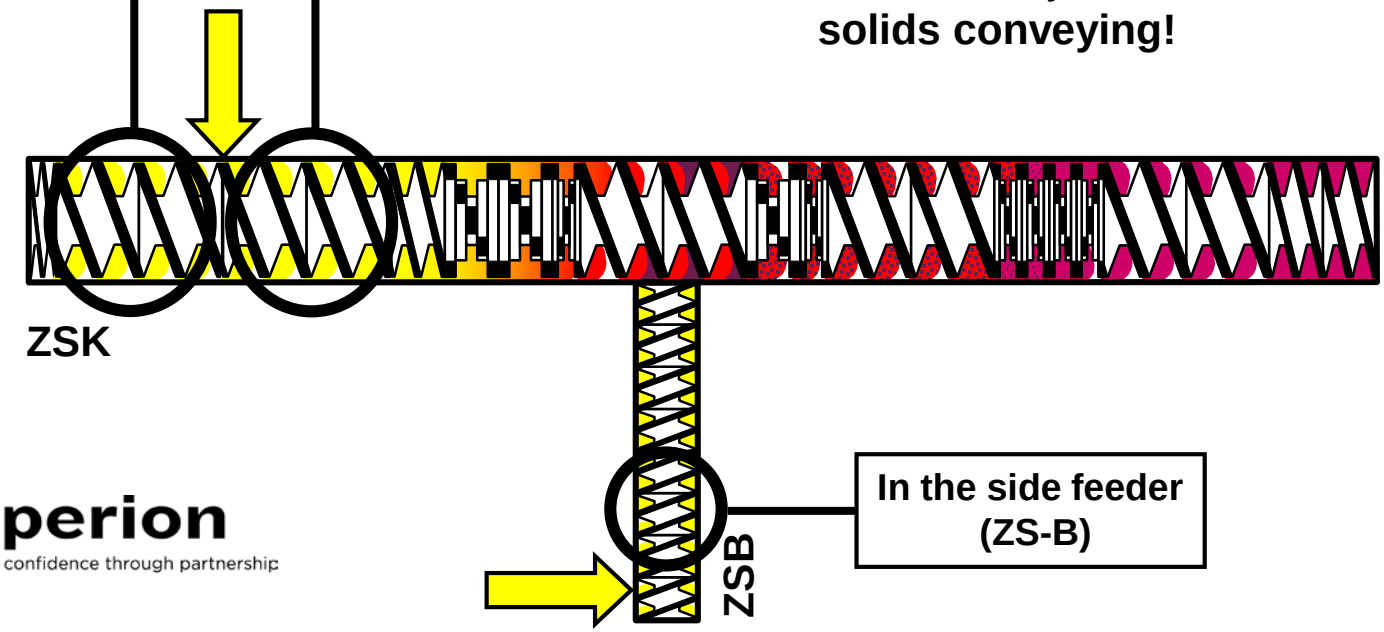
FET Installation possibilities



In the feed section of the ZSK upstream of the feeding point

In the feed section of the ZSK downstream of feeding point

FET can only be used for **solids conveying!**



In the side feeder (ZS-B)

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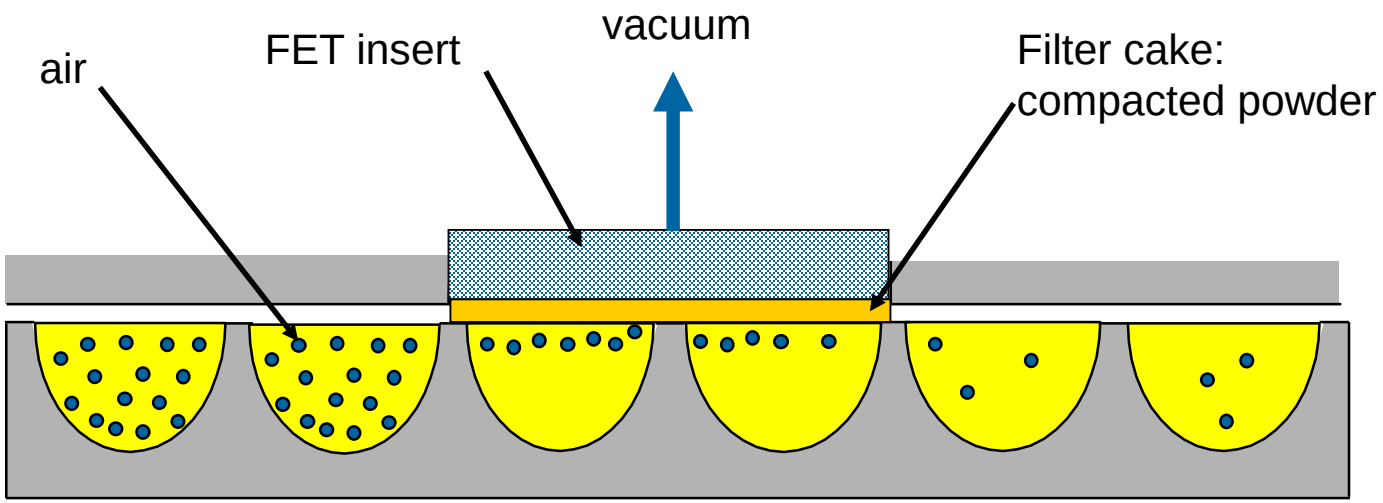
FET Mechanism



Effects:

- air is removed → higher bulk density
- friction is changed in the area of insert

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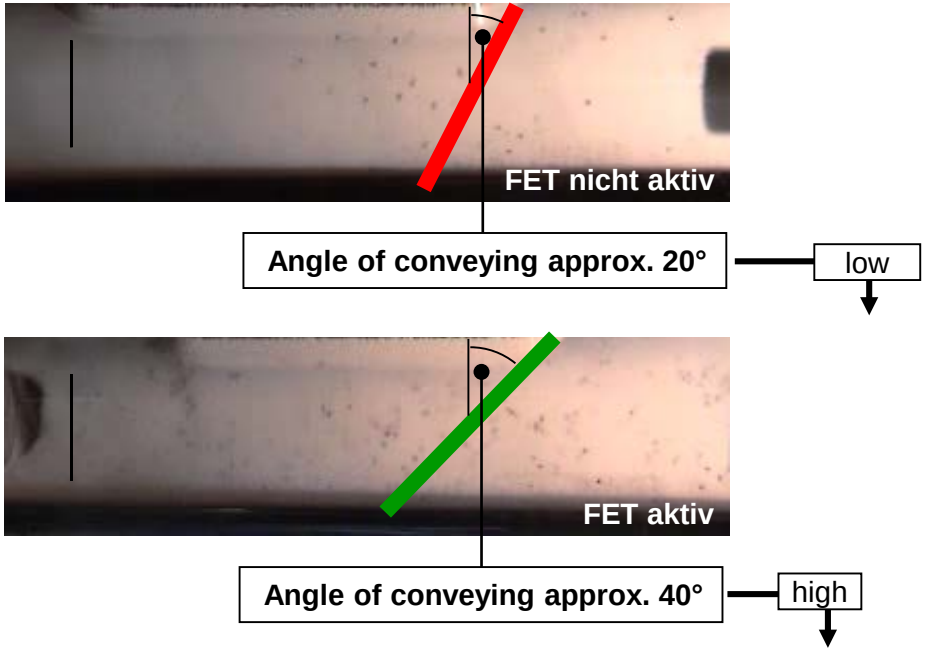
FET Mechanism



Friction and higher bulk density increase the conveying angle:

Conveying angle ↑ → capacity ↑

$$Q = F * H * n * \varepsilon * \eta * \gamma$$

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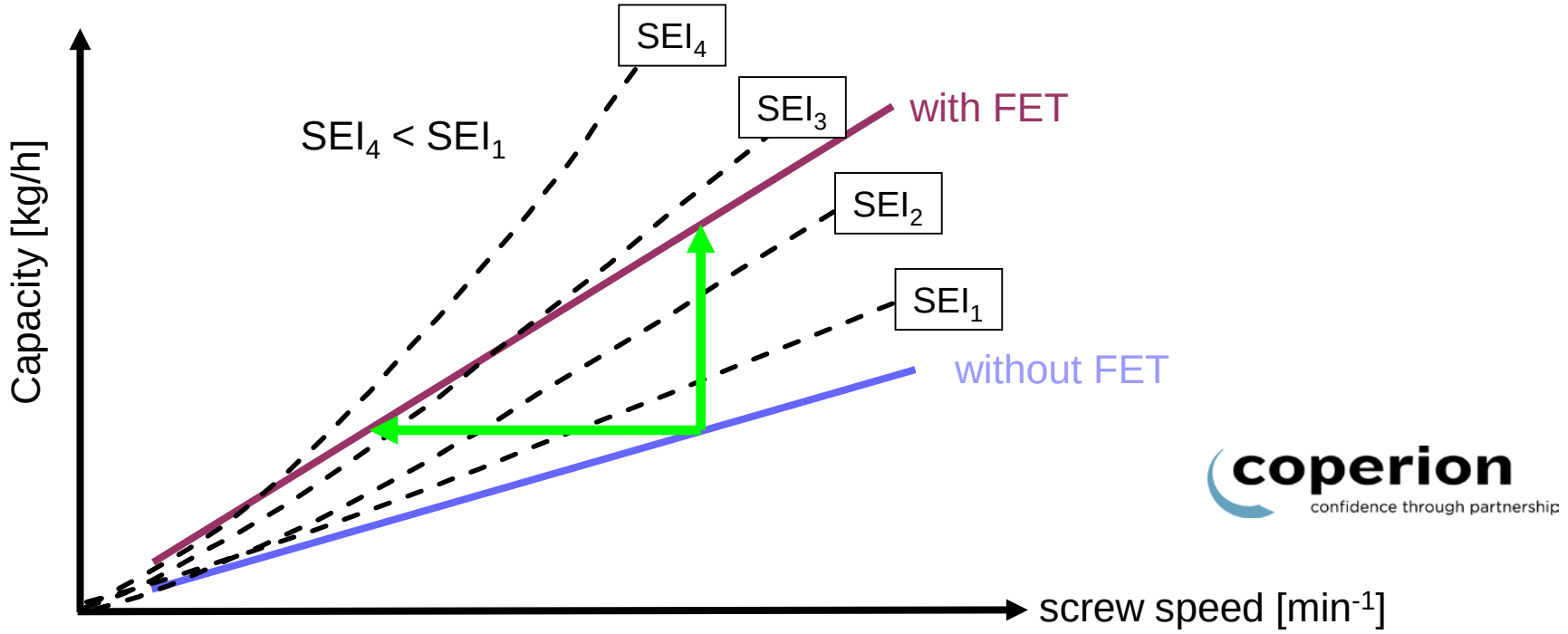
FET Mechanism

SEI can be reduced by:
- increasing capacity at same screw speed
- reducing screw speed at same capacity



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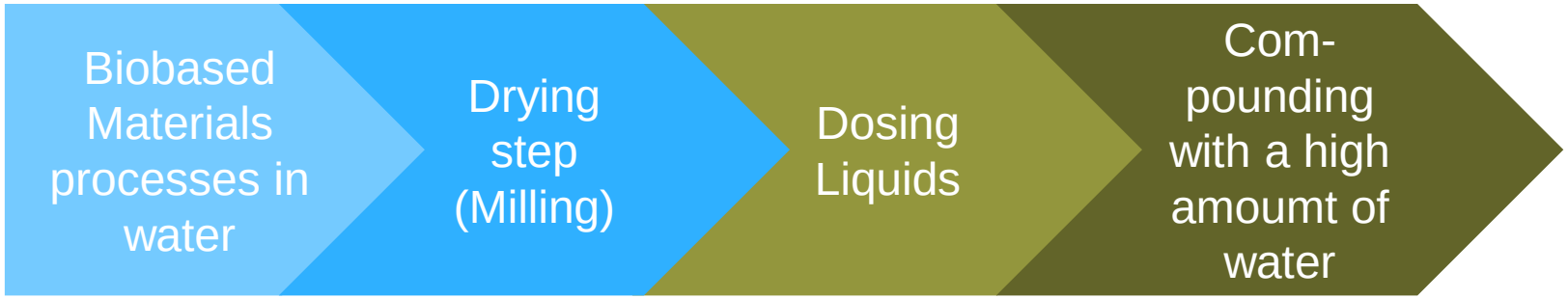
Biobased Materials processed with water

Steps in material preparation for the compounding process

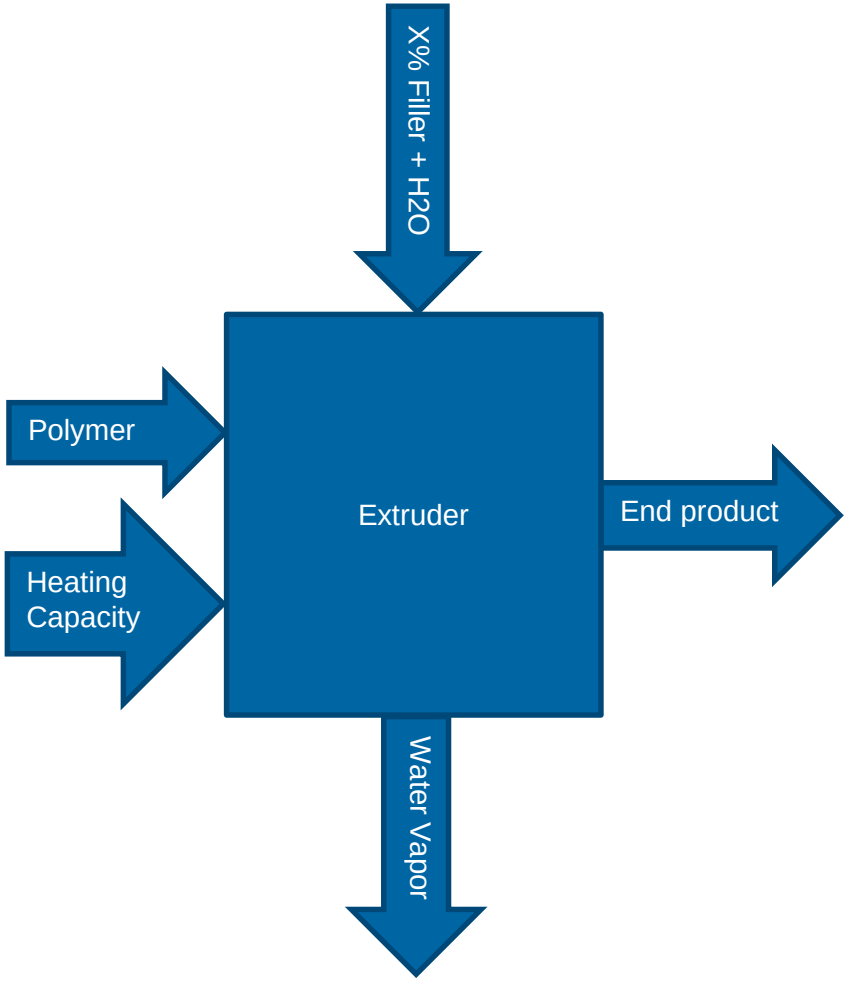


Challenges with water based fillers

By adding Filler and water into the extruder, the water evaporates and cools the polymer down.

Energy input is needed, that the aggregate state of the polymer doesn't change. Polymer should not "freeze"

(Energy input caused by conveying or mixing is not calculated.)



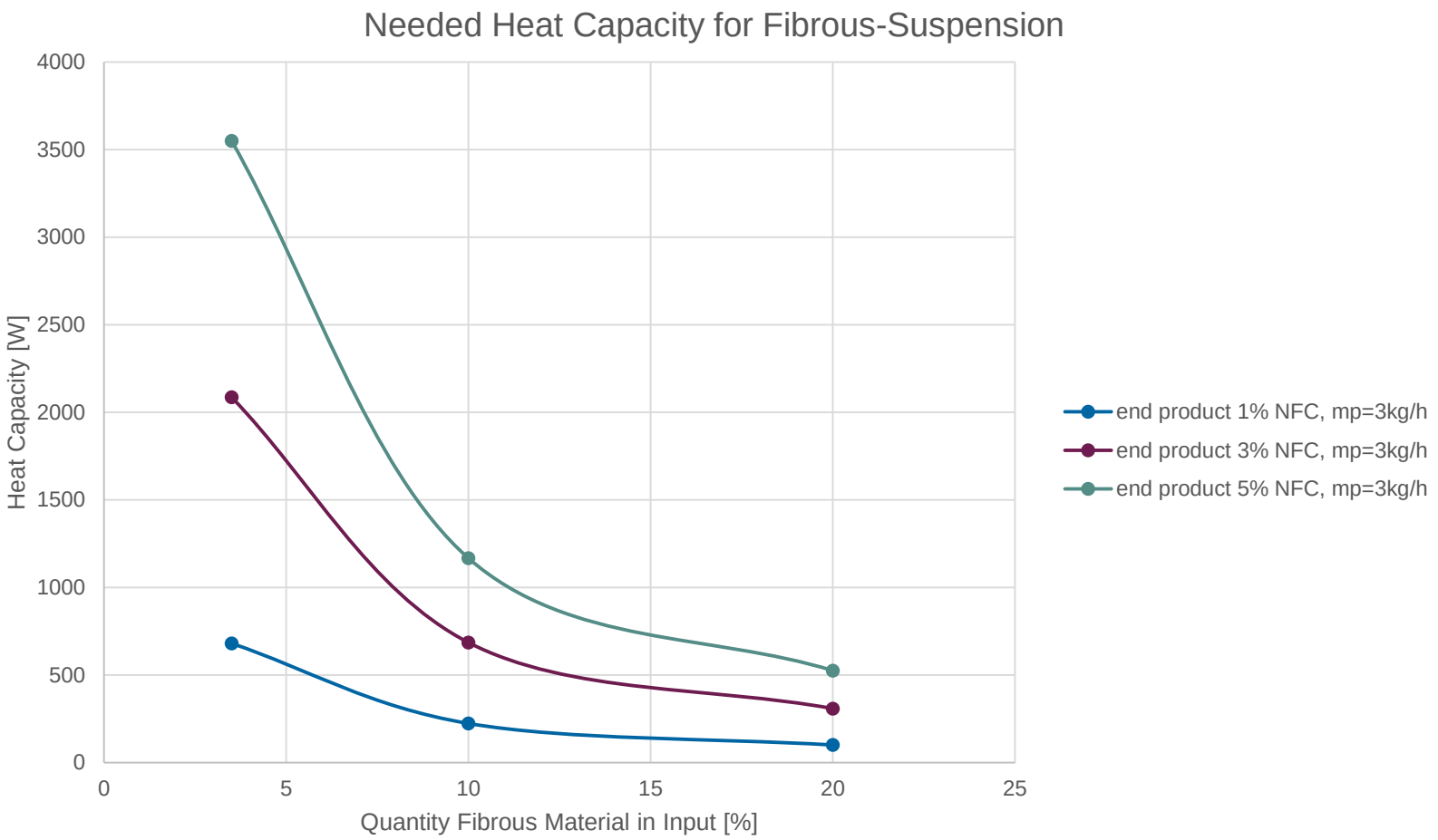
Compounding water based Fillers/Fibers

A calculation tool

		Input				Final Product		
		3.5% Fiber + H2O			melted Polymer			
		Fiber+H2O	Fiber	H2O	Polymer	Compound		Unit
Quantity		100	3.5	96.5		5.00	NFC	%
Density	ρ	1.2						kg/dm3
Volumetric Flow	V	3.76						l/h
Mass Flow	m	4.51	0.16	4.35	3.00	3.16		kg/h
		0.00125	0.00004	0.00121	0.00083	0.00088		kg/s
Room Temperature	T1	20	20	20	20			°C
Operating Temperature	T2	200	200	100	200			°C
Melting Point	Ts				150-160			°C
Enthalpie (20°C to 100°C)	Δh			2591000				J/kg
Specific Heat Capacity	c_p	4092.78	1550	4185	1200			J/kgK

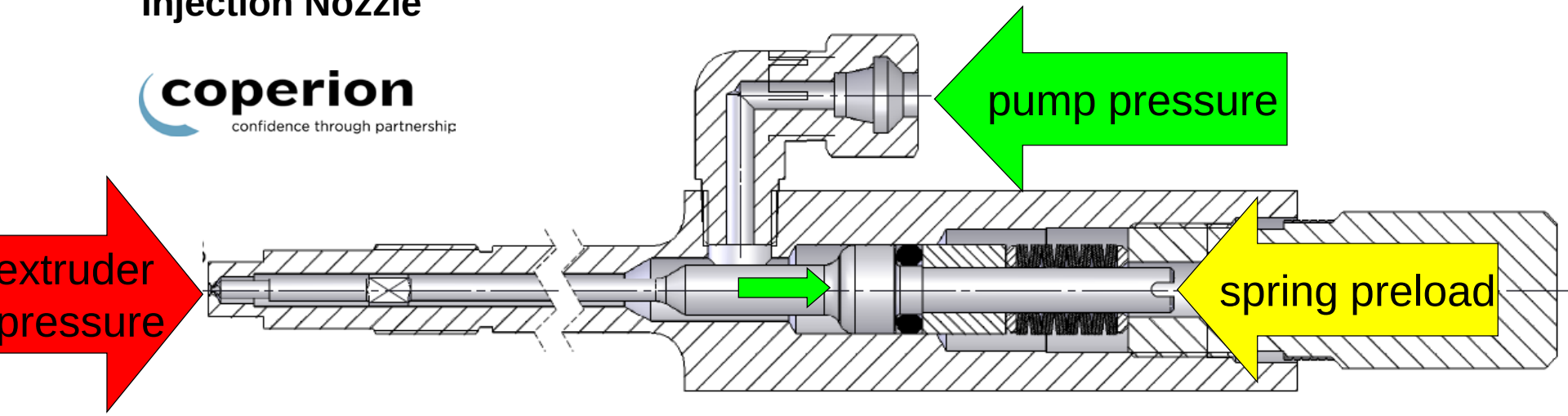
Heat Flows of:		Result	Unit
Heating Capacity	Hh	3549.94	W
Polylactide	Hp	180.00	W
Input NFC+H2O	Hin	0.00	W
Output Water Vapor	Hw	3537.70	W
End product	Hpnfc	192.24	W
Temperature Endproduct	t	200.00	°C

Compounding water based Fillers/Fibers



Injection Nozzle Technology

Injection Nozzle



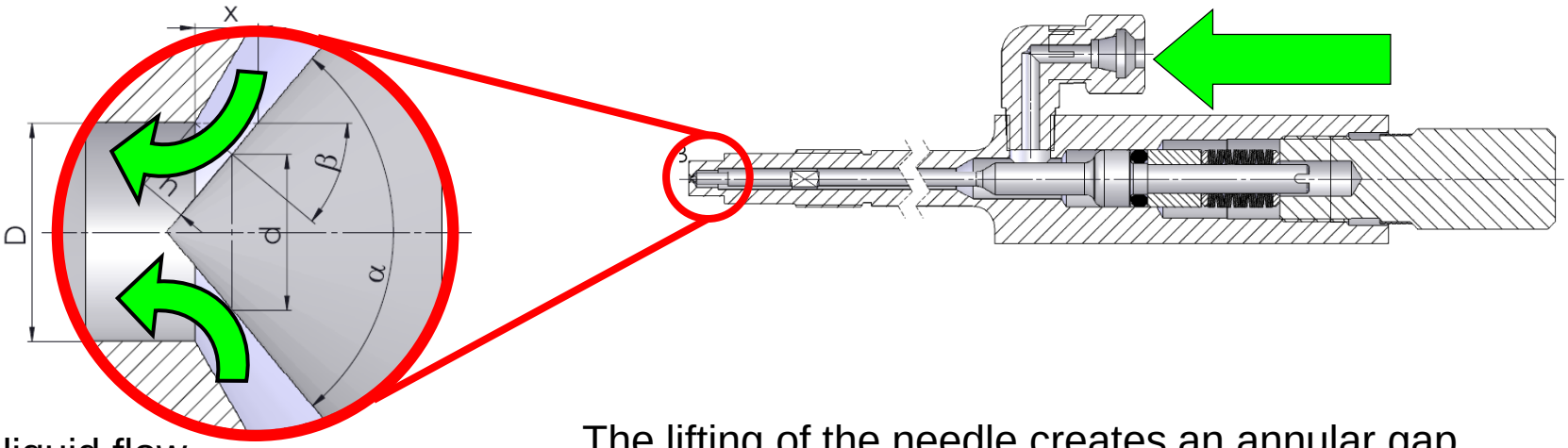
- **the spring load must be adjusted according to the extruder pressure to prevent entering of melt**

for opening, the pump pressure must be bigger than the spring preload

extruder pressure ≤ spring preload

spring preload ≤ pump pressure

Injection Nozzle Technology



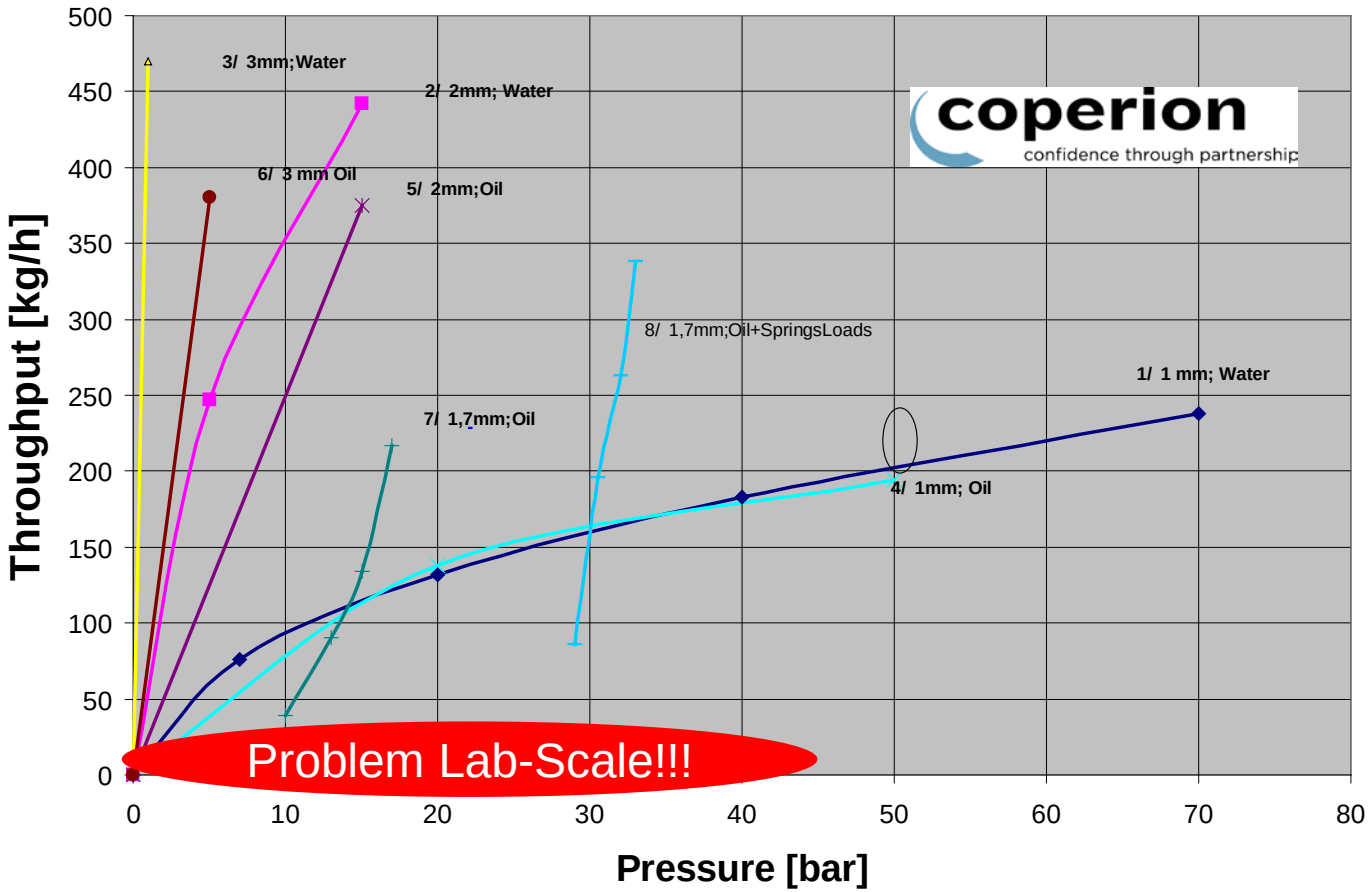
liquid flow

The lifting of the needle creates an annular gap.

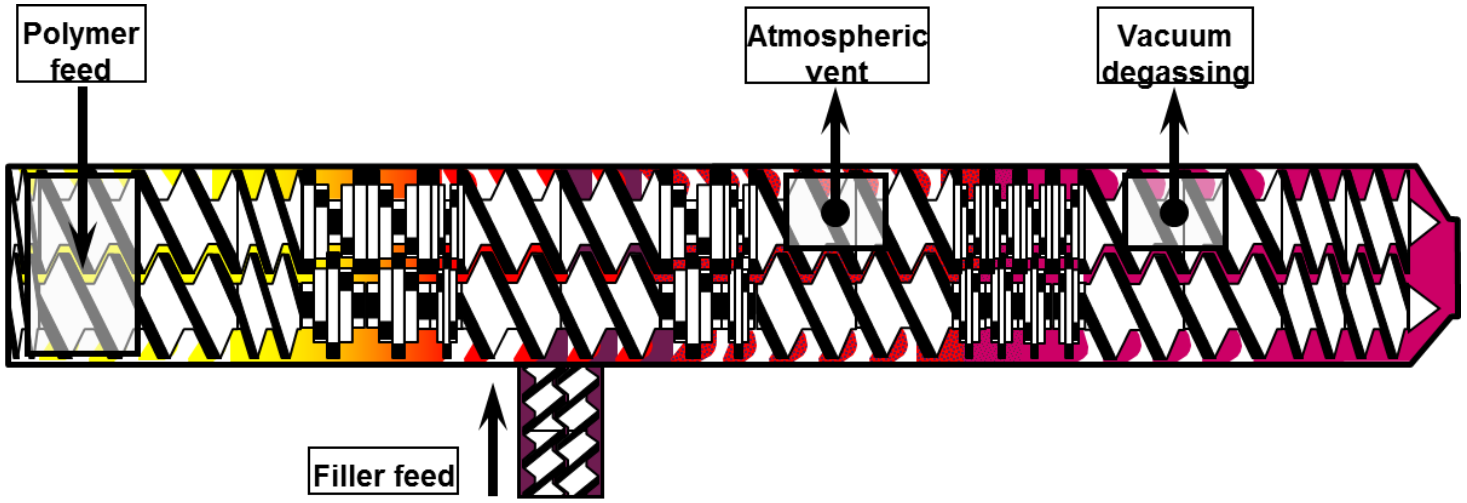
Only a small axial movement of the needle is necessary to create the full crosssection area.

Injection Nozzle Technology

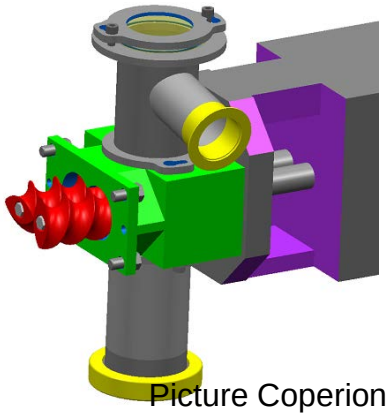
Characteristics for throughput



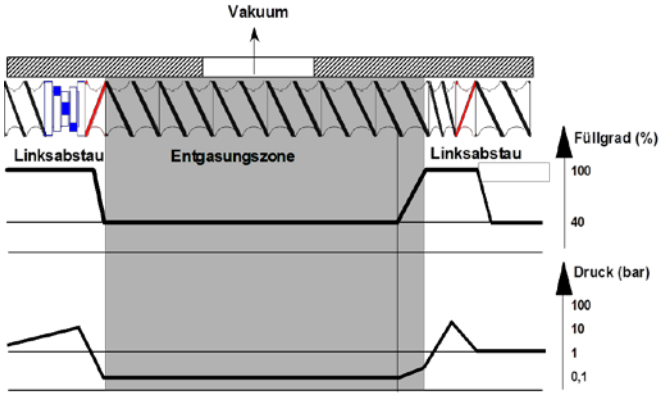
Degassing of the process section / Side Degassing Unit



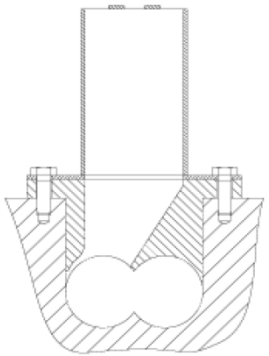
Feeding section	Melting section	Conveying section	Mixing section	Venting section	Homogen-section	Degassing section	Metering section



Picture Coperion

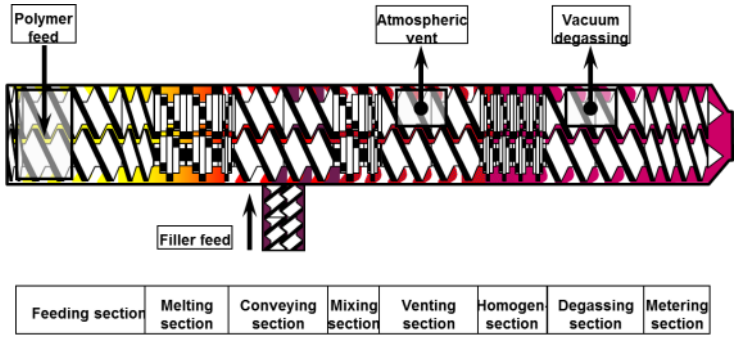


Venting Port



Process optimization Compounding

- Goals
  - Analysis of the current process
  - Optimization of system configuration (screw design, position of feeding, process parameters, …)
  - Operating tests
- Partners
  - FluidSolids AG, Zürich
- Funding
  - Public and Private



Schweizerische Eidgenossenschaft
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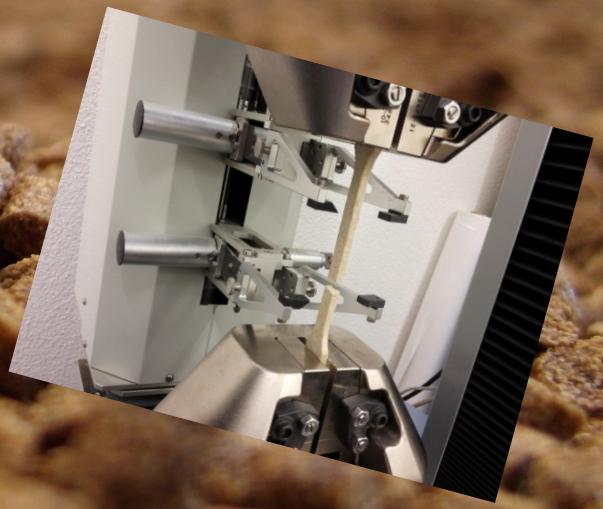
Kommission für Technologie und Innovation KTI

Project: FluidSolids® - Impressions

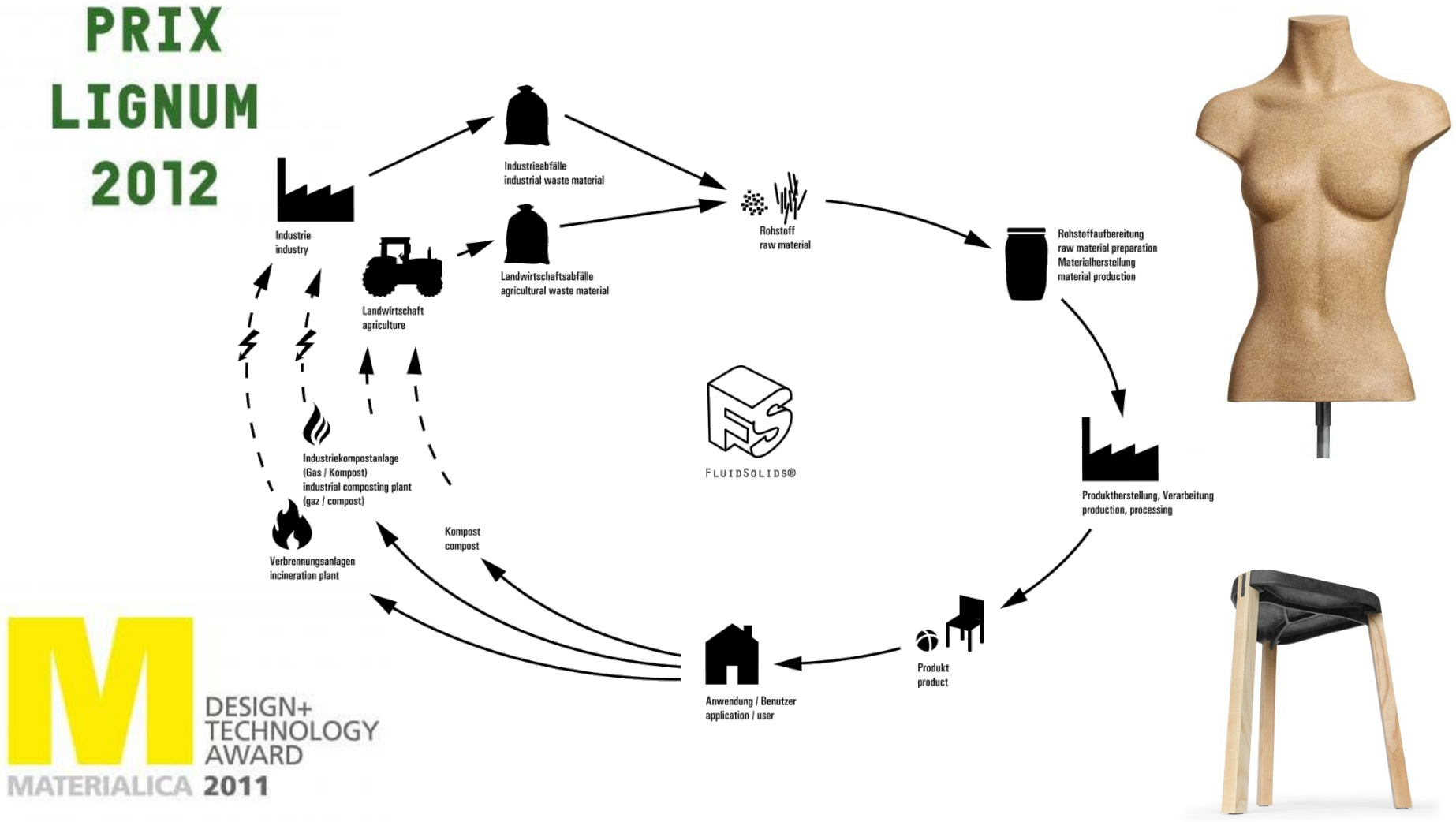
FLUIDSOLIDS®



Project: FluidSolids®

FLUIDSOLIDS®

PRIX LIGNUM 2012

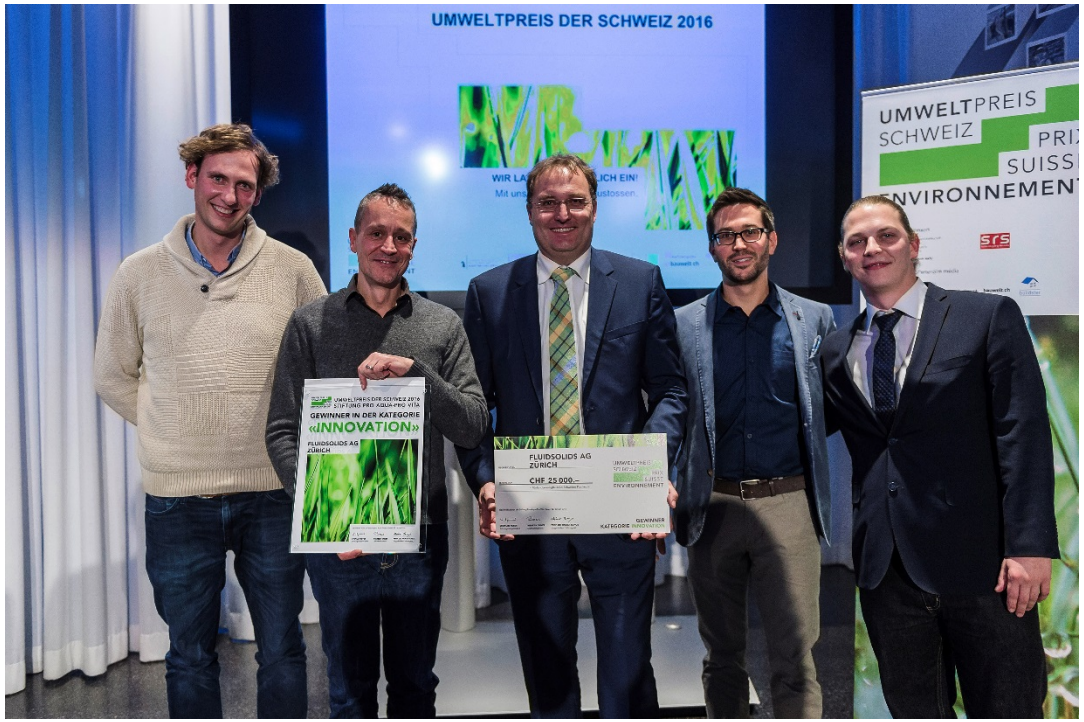


DESIGN+ TECHNOLOGY AWARD MATERIALICA 2011

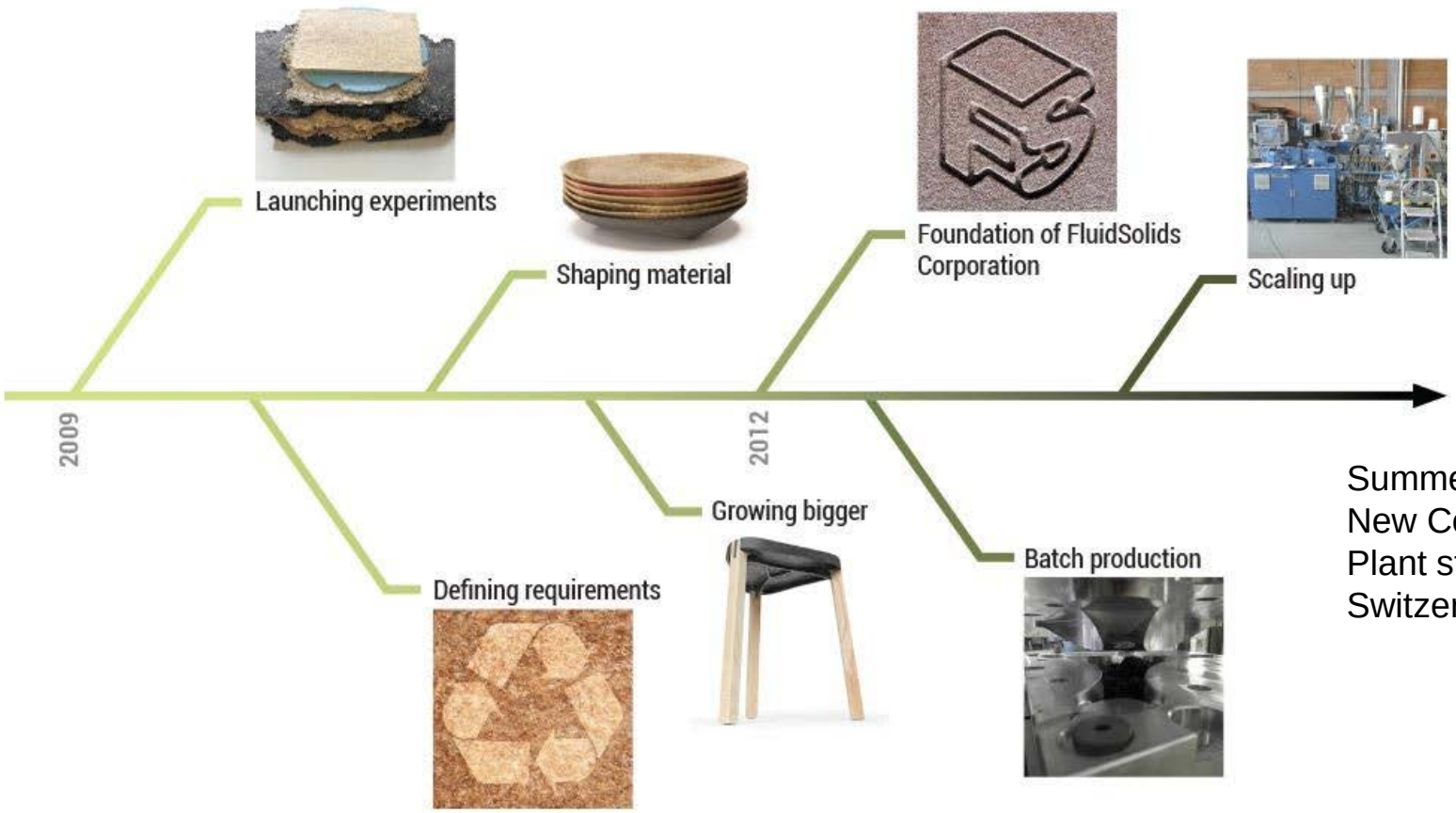
Project: «FluidSolids®»

Umweltpreis der Schweiz 2016

Environmental Award of Switzerland 2016



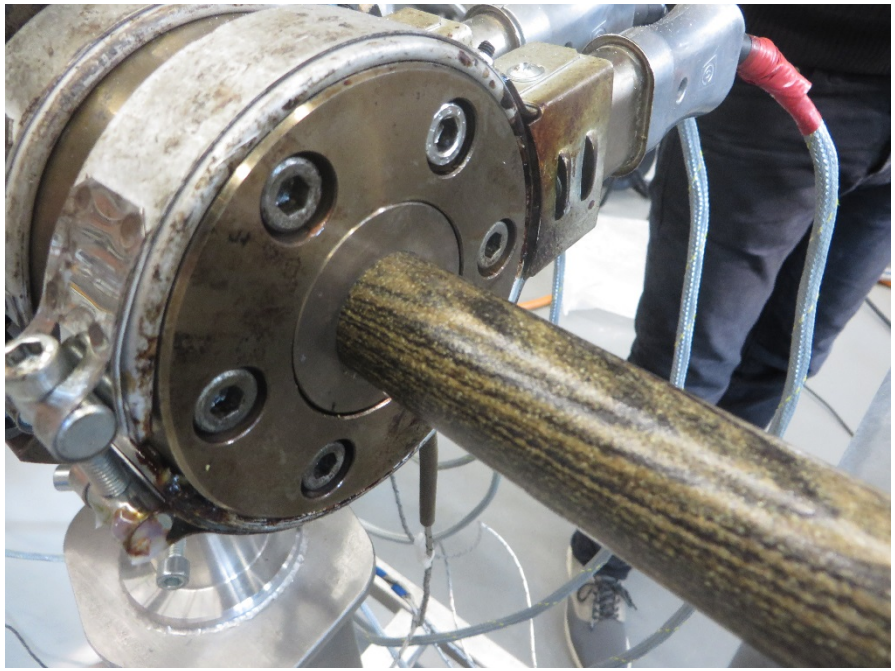
Project «FluidSolids»



Summer 2016
New Compounding Plant starts in Switzerland

Project «FluidSolids»

Extrusion trials at the IWK Lab



Thank you very much for your attention!

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