SUPPORT MATERIAL DEVELOPMENT FOR THE ARBURG FREEFORMER®

ISBBB 2018 - Guelph / Canada

iwk INSTITUTE FOR MATERIALS TECHNOLOGY AND PLASTICS PROCESSING

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Outline

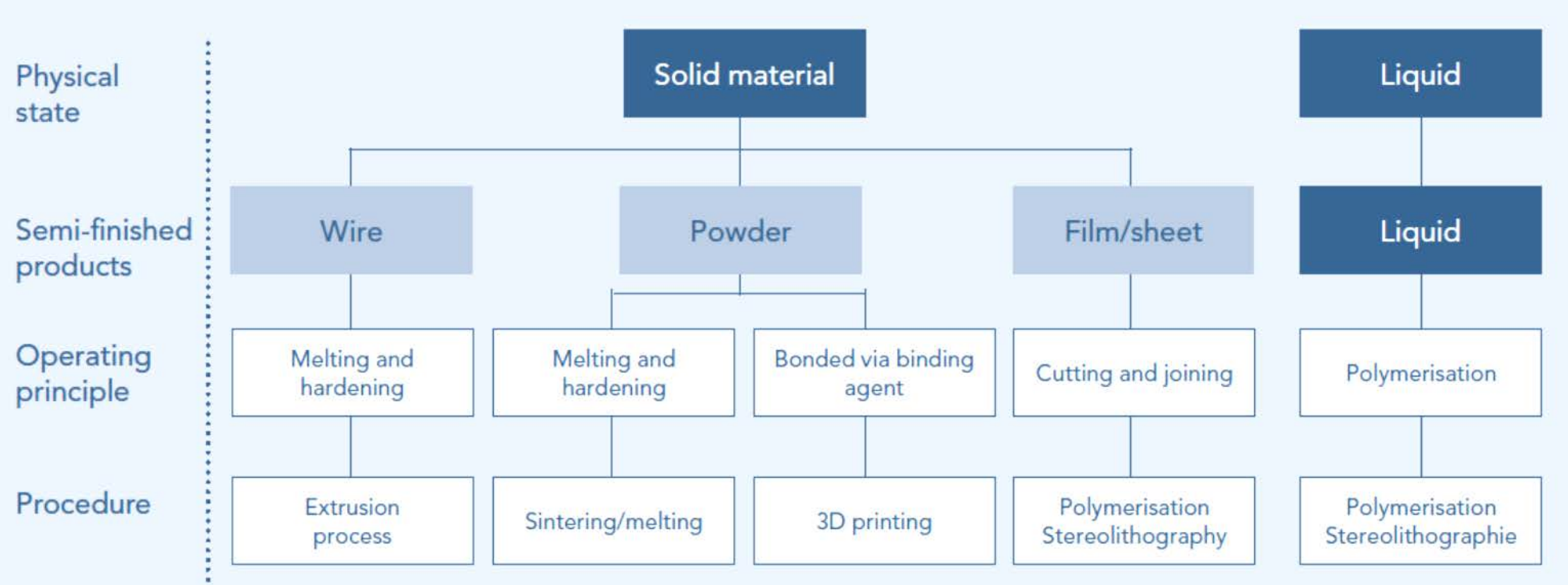
- **HSR/ IWK**
- **Additive Manufacturing**
- **FFF**
- **Compounding**
- **State of the development**
- **Outlook**



University of Applied Sciences Eastern Switzerland
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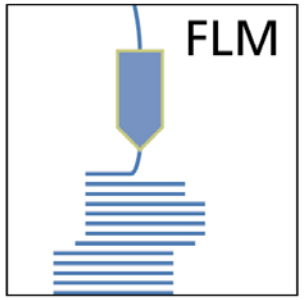
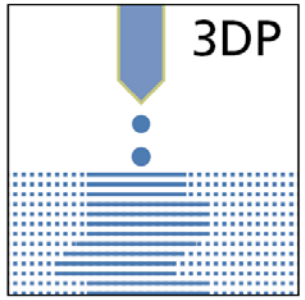
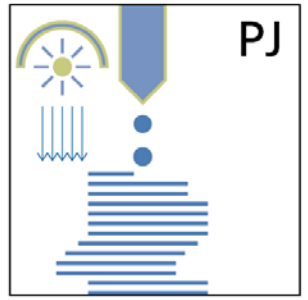
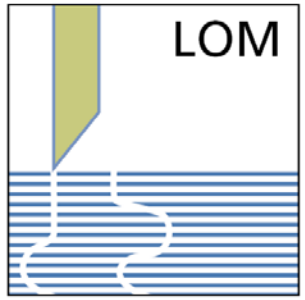
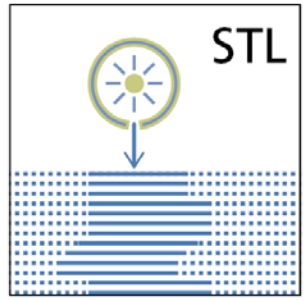
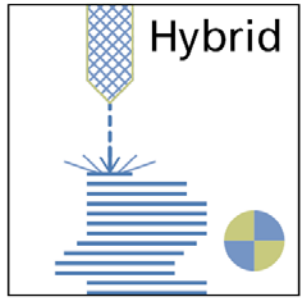


Additive Manufacturing Process Overview



The fundamental principles of additive manufacturing processes (Source: based on: Gebhardt, A.: Generative Fertigungsverfahren: Additive Manufacturing und 3D Drucken für Prototyping – Tooling – Produktion. München, Wien: Carl Hanser Verlag, 4. Auflage, 2013)

Overview of possible additive manufacturing processes

						
Fused Layer Modeling / Freeformer / Multi Jet Modeling (FDM, FLM, AKF)	**Selective Laser Melting / Sintering** (SLM, SLS, EBM)	**3D-Printing** (3DP)	**Polyjet Modeling** (PJ, PJM)	**Laminated Object Modeling** (LOM, LLM)	**Stereo-lithography** (SL, STL, DLP)	**Hybrid Machines**
plastics (+ filler material)	metals (SLM), plastics or similar	quartz, metals, plastics	photopolymers, waxes	paper, plastics, carbon fiber	photopolymers (+ filler material)	metals
models, prototypes, consumer goods	prototypes, small batch series, repairs, tools	models, prototypes, casting molds	models, prototypes, casting molds	models, casting molds	models, prototypes	repairs, single parts, small batch series

3D-Printing activities at IWK



Twin screw compounder
Dosing & mixing equipment
Pelletizer
Material modification
Water-soluble support material



Technologies: APF (Freeformer) & FDM/FFF
Material qualification
Process optimization
Post-processing
Application development



MATERIAL DEVELOPMENT

3D PRINTING & QUALIFICATION

ADDITIVE MANUFACTURING @IWK

FILAMENT EXTRUSION

TESTING & CHARACT-ERIZATION





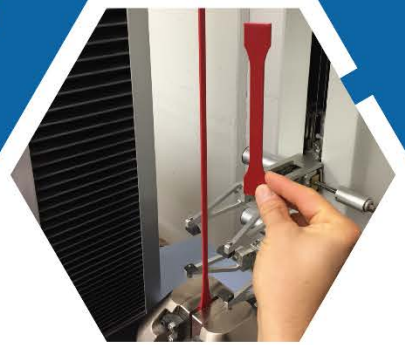


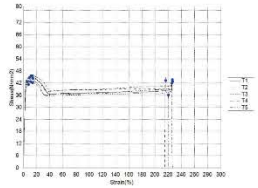
GOLD AWARD Material

CREAMELT 3D PRINTING MATERIALS



Single screw extruder
Double line cooling section
Double line filament winder
Laser measuring system
Packaging station



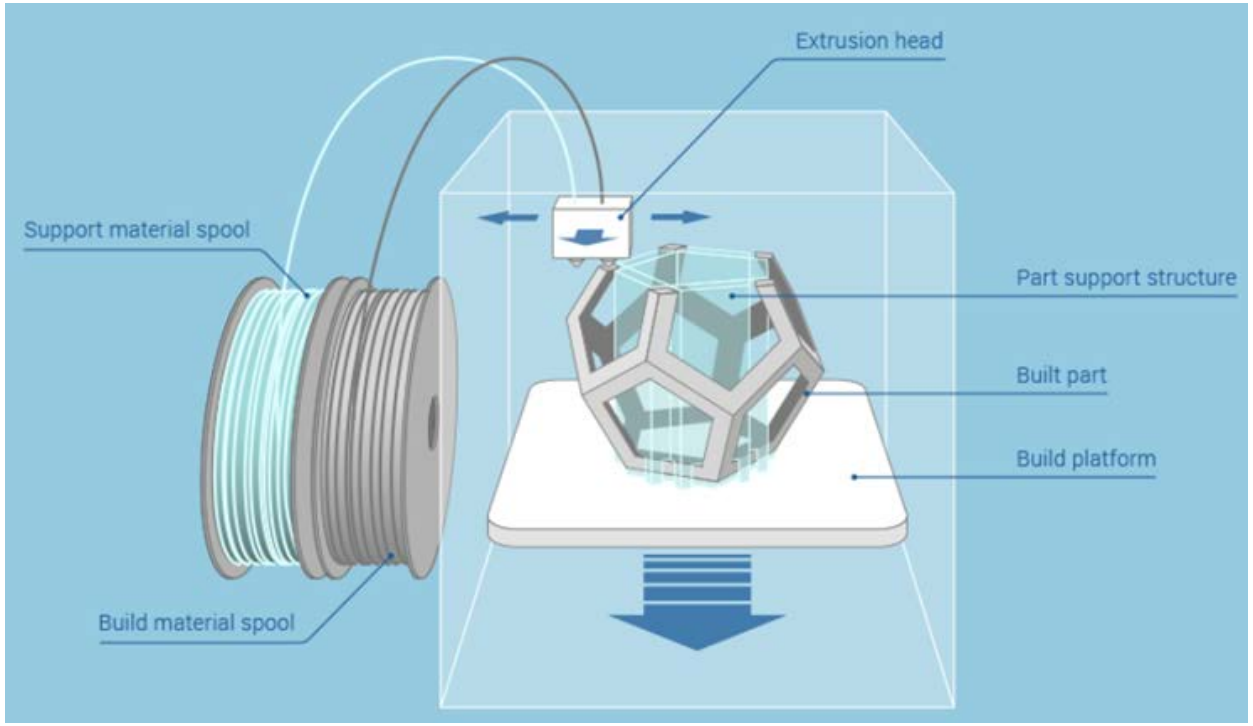


Mechanical properties (tensile, impact, etc.)
Optical microscopy
Thermal characterization
Capillary rheometry
Application testing



Fused Deposition Modelling (FDM) / Fused Filament Fabrication (FFF)

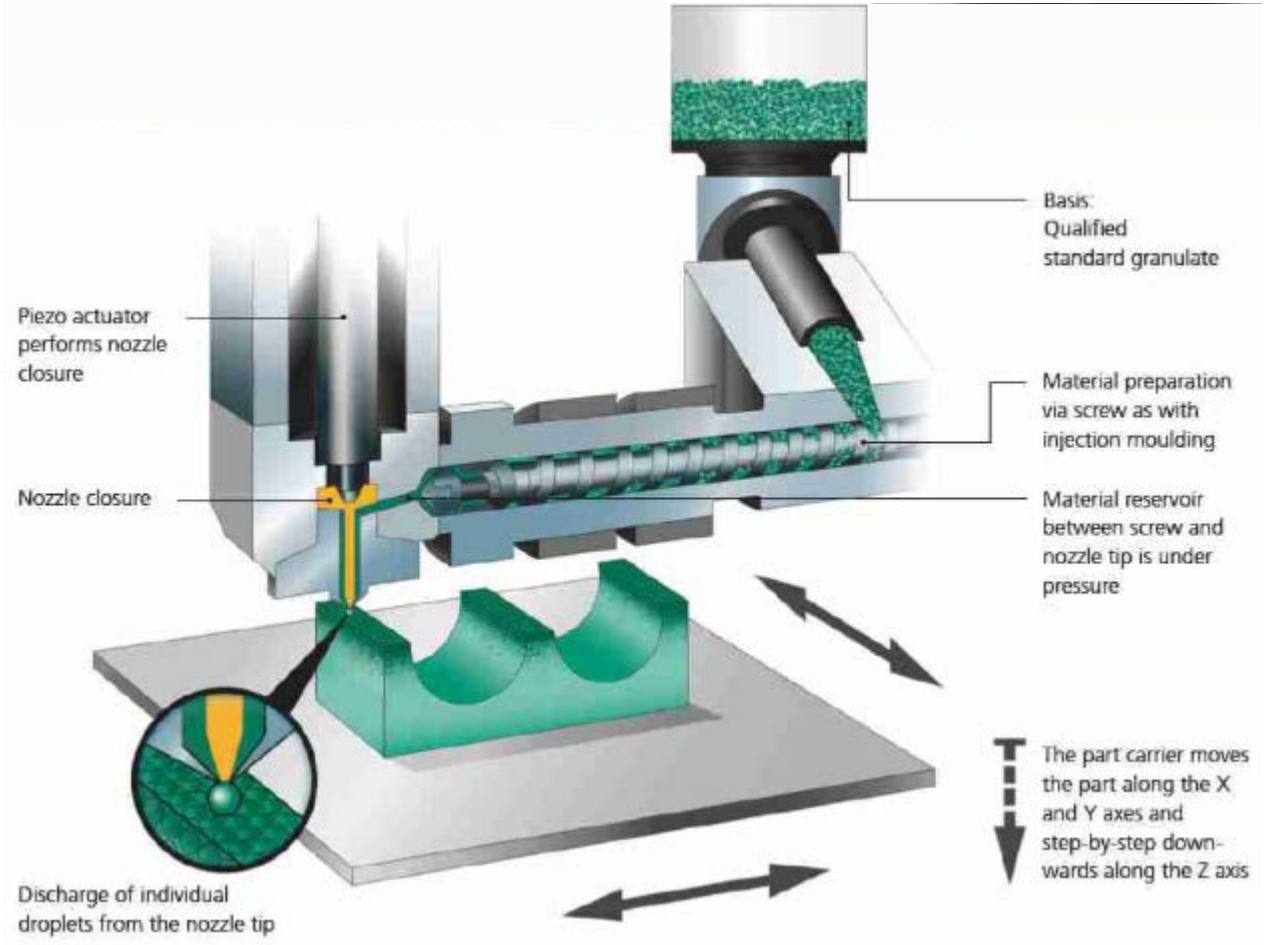
- **Building material:** thermoplastic filament on a coil
- **Mode of action:** Heating up in an extrusion head and cooling down on a building platform (like extrusion)
- **Possible materials:**
  - ABS, PLA, PC, PET, PA12, PA6, PP, TPU, etc.
- **Characteristics:**
  - Layer thickness between 0.05 and 0.4 mm
  - Sometimes support structures are needed (on big overhangs)
  - Possible distortion
  - cheap acquisition costs
  - large variety of possible materials
- **Related procedures:**
  - Arburg Plastic-Freeforming (AKF)



Picture source: additivly.com

Arburg Plastic-Freeforming (AKF)

- **Building material:** thermoplastic granules
- **Mode of action:** Heating up through plasticizing (like injection moulding) and droplet formation with a
  piezo actuator and a gate nozzle
- **Possible materials:**
  - Commercial plastic granules: ABS, PC, PA12, PLA, PP, TPU, etc.
- **Characteristics:**
  - Commercial plastic granules
  - large variety of possible materials
  - Precise material discharge
  - 70-80% of the mechanical strenght compared to injection moulding

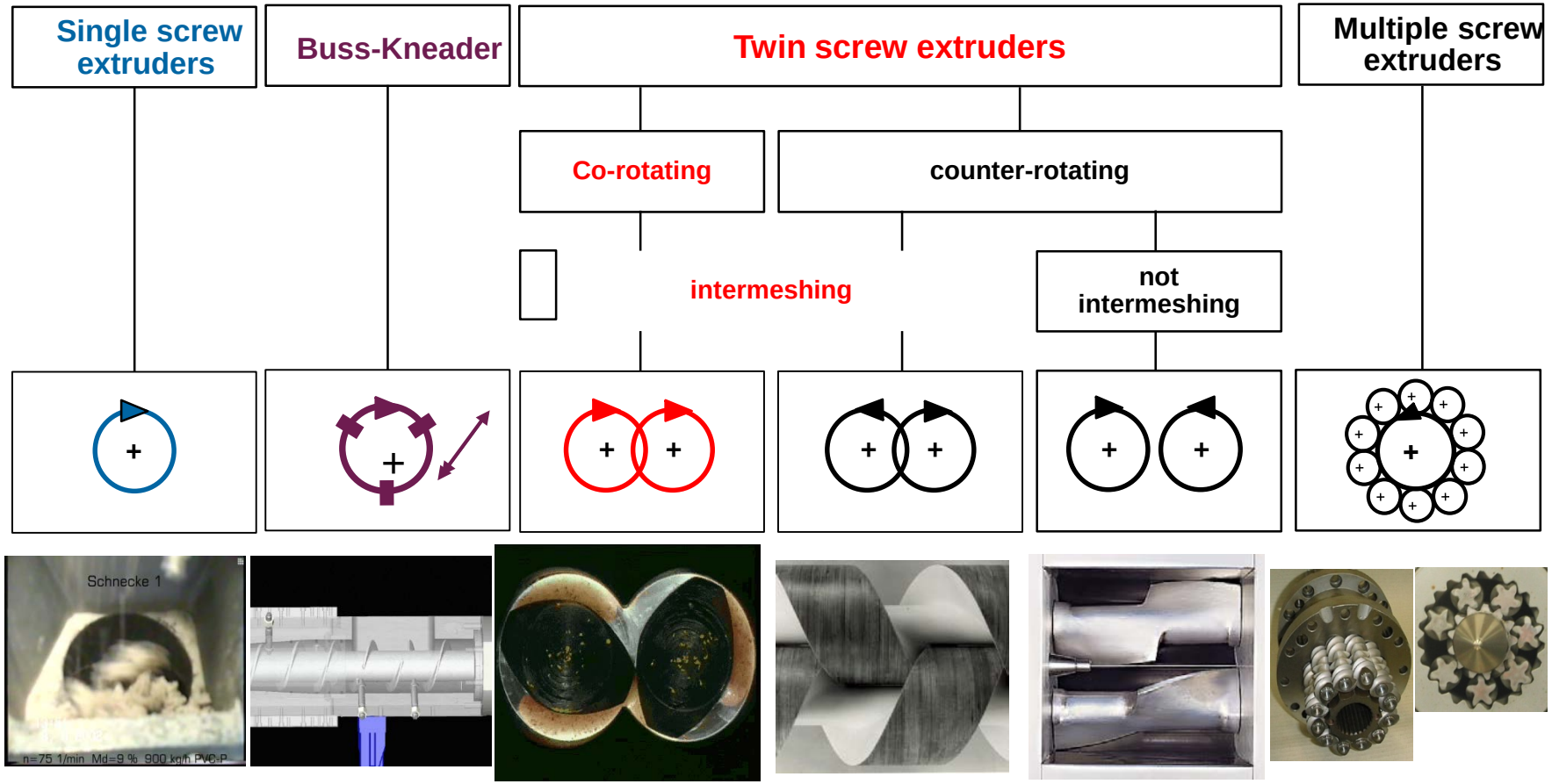


Bildquelle: ARBURG

Requirements for Support Material (Arburg)

- Additive Manufacturing with plastic materials
- Thermoplastic processing with a die diameter of 0.2mm is mandatory
- Water soluble with a weight loss around 0.5 gram per hour
- Good adhesion to the building platform
- Good adhesion to different building materials for the desired parts
  - Without visible residues
- Good mechanical properties, so that no support material can break during the building process
- Good heat resistance for an optimal support effect at building room temperatures from 80°C to 110°C
- Dissolved material should be able to be disposed of via sewerage
- Optimal form of the granules
- Also usable for Fused Filament Fabrication (FFF)

Plastics processing: Compounding



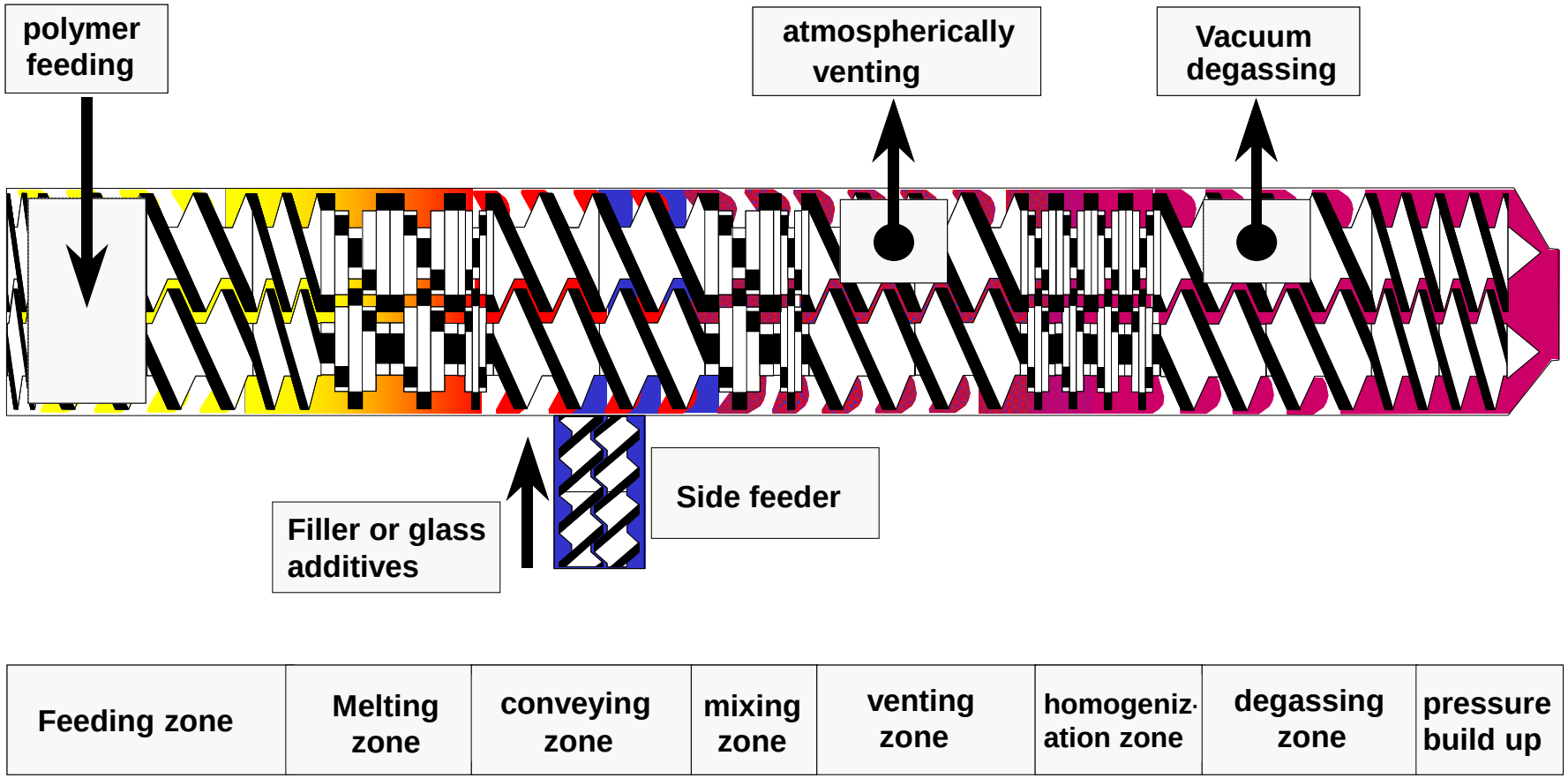
Quelle: Coperion GmbH

Infrastrucure at IWK for material development: Compounding

- **Compounder Coperion ZSK26**
  - Co-rotating twin-screw extruder (Ø26mm)
  - Processing length 44xL/D
  - Modular and flexible process part design/ screw configuration
  - Side feed and side degassing
  - Gravimetric dosing and volumetric fluid dosing
  - strand, underwater and air pelletizing

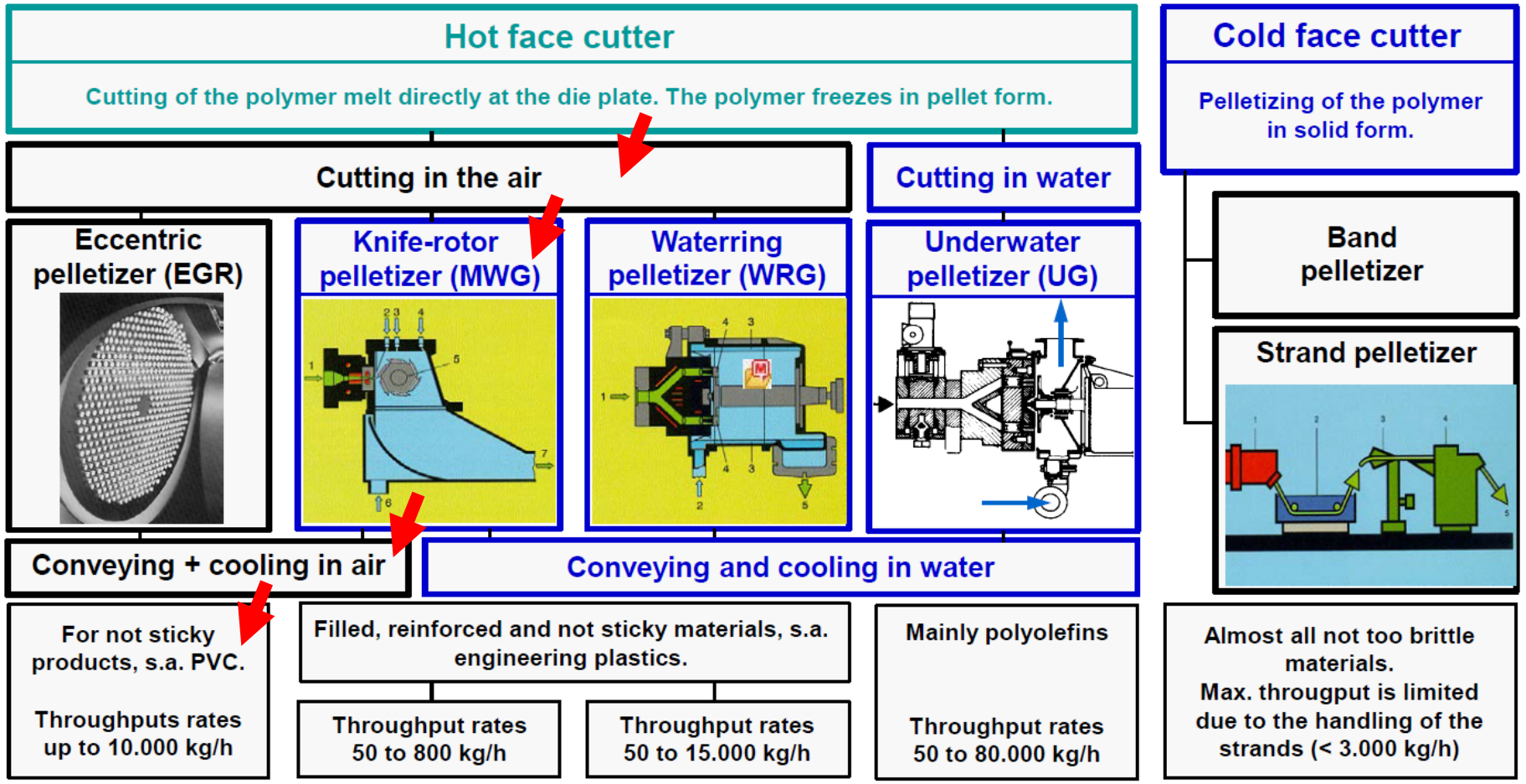


Plastics processing: Compounding



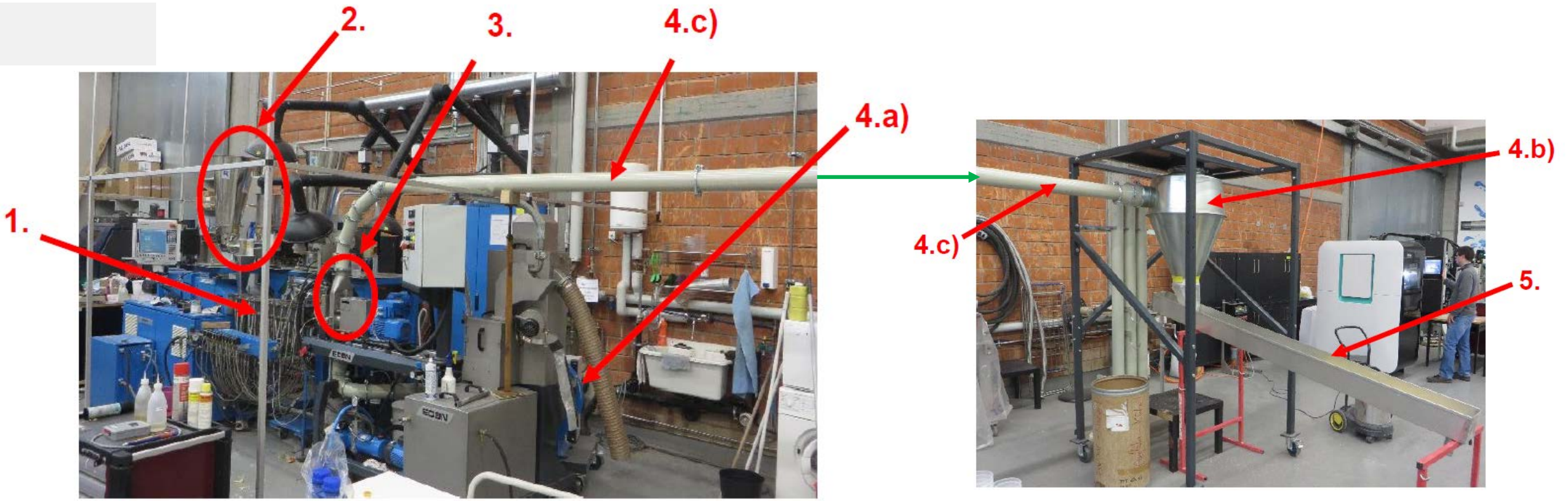
Plastics processing: Pelletizing

- Different types of Pelletizing systems



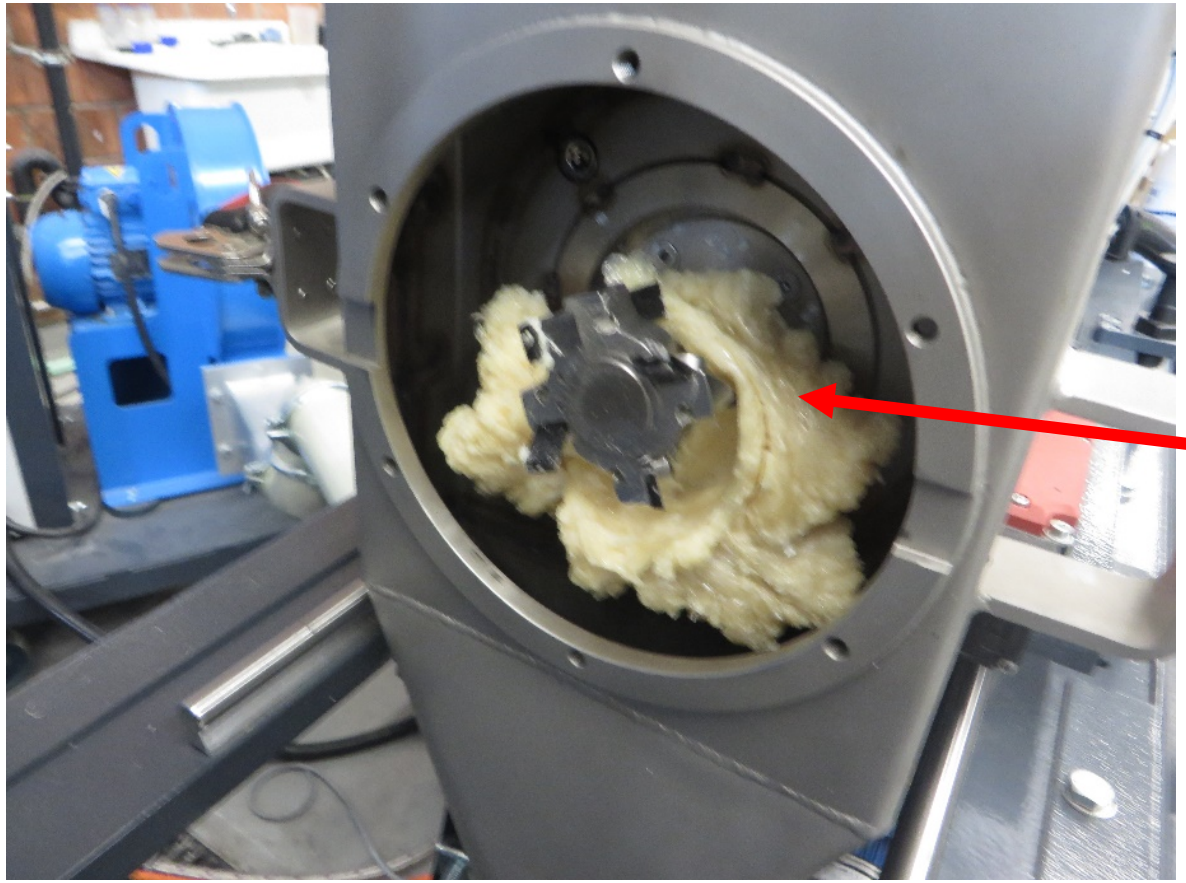
Because of the water soluble behavior of the material, the Pelletizing has to be a hot face cutter and a cooling in the air stream (red arrows).

Compounding of water-soluble support materials



1. Co-rotating twin-screw extruder ZSK 26
2. Gravimetric dosing system
3. Knife-rotor-pelletizer (hot face cutter)
4.a) Fan
4.b) Discharge cyclone
4.c) Air duct system (cooling section)
5. Drip tray for the granules

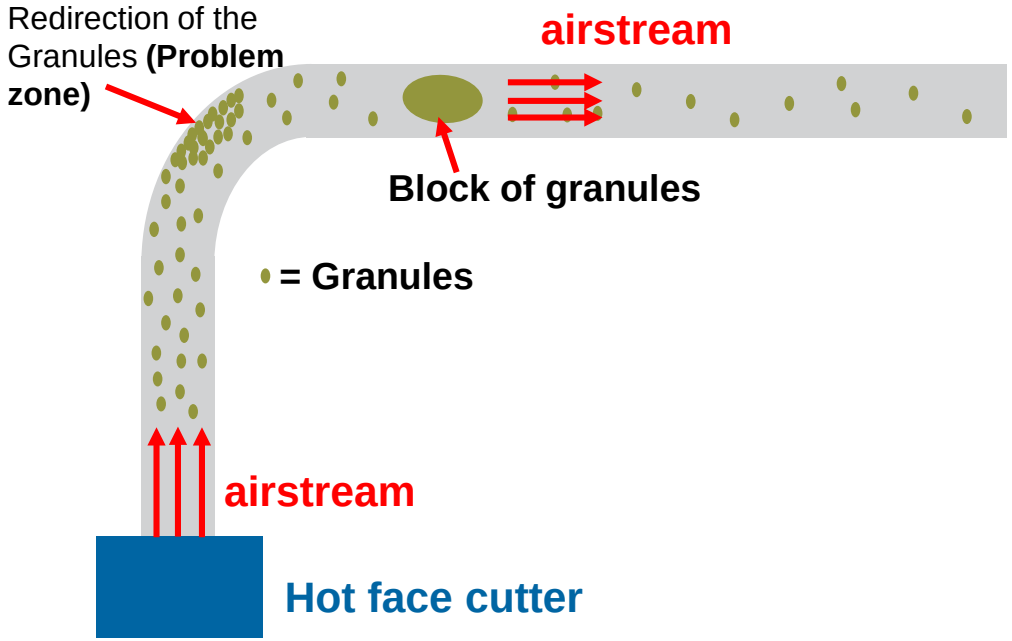
Problems with hot face cutter (knife-rotor-pelletizer)



- Possible string building because of:
  - Low viscosity
  - Blurred cutting edges
- Hot granules can glue together on this string because of the high adhesiveness of the material.
- The result is shoen in the picture left.
  - Big blocks of granules which increase the torque on the shaft of the cutting knife.
  - Block the air discharge of the granules and the cutting knife.
  - Block and stop the whole process

Problems with air duct system

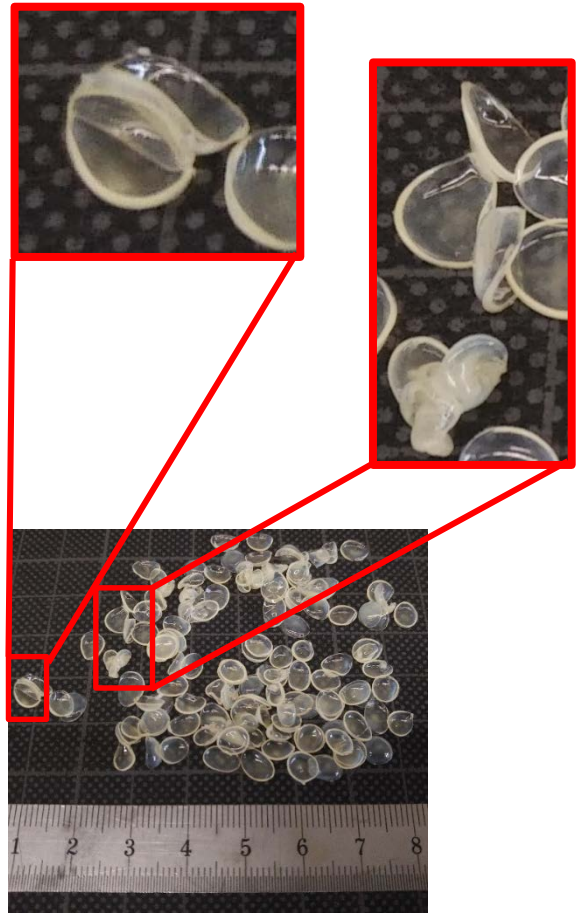




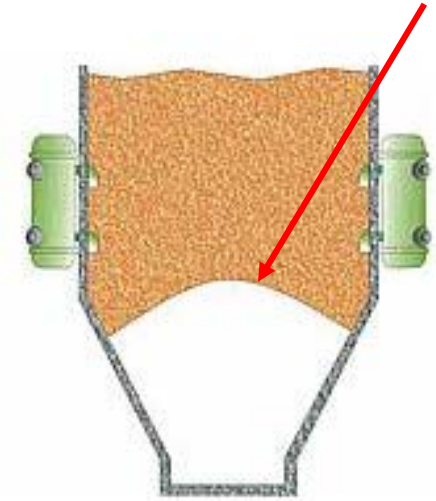


- Problem Zone = Redirection of the Granules in the Radius
  - In this Zone, the granules are heated up by wall friction.
  - The hot granules can glue together in this zone.
  - The result of this are big blocks of granules, that are discharged through the cyclone as its shown in the picture above.

Problems with glued granules and agglomerates



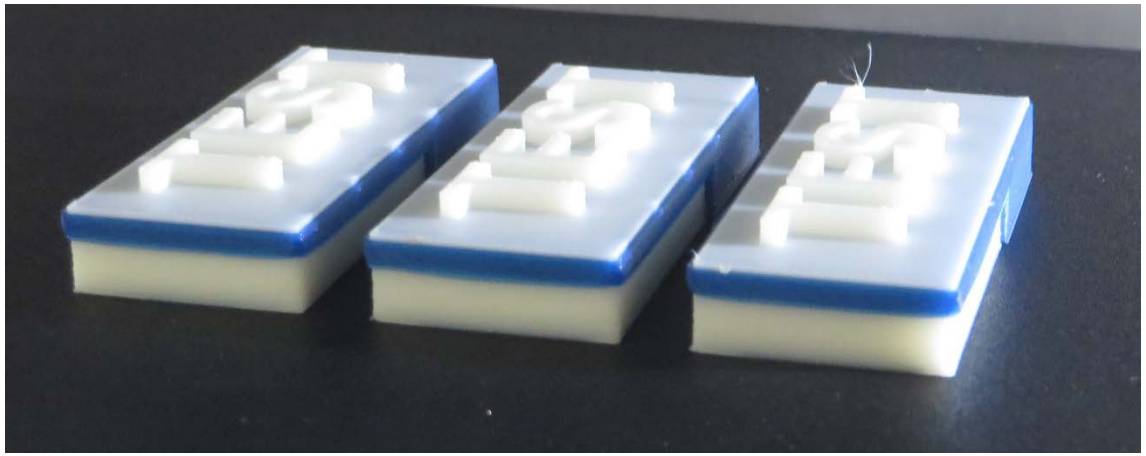
- Because of the used hot face cutter, the single granules are very hot and are cooling down slowly.
- So there is a possibility that single granules glue together and building some agglomerates.
- These agglomerates lead to problems in the feeding section of the freeformer because of «bridge building» in the feeding hopper.



Optimization of the process

Actually the following optimization steps were done:

- Change the nozzle to minimize the strand expansion of the compounded material, so that the granules getting smaller.
  - Smaller granules = faster cooling of the single granules (less agglomerate) and more globular shape
- Use coated knifes on the granulator (sharper cutting edges)
- Vary the air flow rate to reduce warming of the granules through wall slide.
- Vary the speed of the knifes to produce smaller granules.





First project successes











Project Team- development of water soluble support material



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THANK YOU VERY MUCH FOR YOUR ATTENTION

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