Topic: *„New ways for the practical simulation of rotomoulded parts“*

Authors: Prof. Dr.-Ing. Harald Hansmann / Christian Boss, M.Eng. / Andreas Wenzel, M.Eng. / Kay Dietze, M.Eng.

Christian Kehrberg, M.Eng. (Speaker)

- Who are we and why are we here?
- Motivation and Methodology
- Details and Background
- Results and Application Possibillities

An innovative development company in the Hanseatic City of Wismar

- Founded in 1995; affiliated to University of Wismar
- Director: Prof. Dr.-Ing. Harald Hansmann
- Chairman: Nico Laufer, M.Eng.
- Legally and economically independent institution (charitable)
- 22 employees, 8 students (July 2018)

A recipe for innovations? We say: YES!

IPT promotes and undertakes research, development and transfer of knowledge and technology in the field of plastics technology for the benefit of economy and society.

As a competent research partner, ipt accompanies and supports development projects from the initial concept formulation stage to the production-ready solution.

Our business units are:

- Product development
- Process development
- Material development
- Materials / component testing

The question of the questions in Rotomoulding

„How does the powder flow inside the mould?“

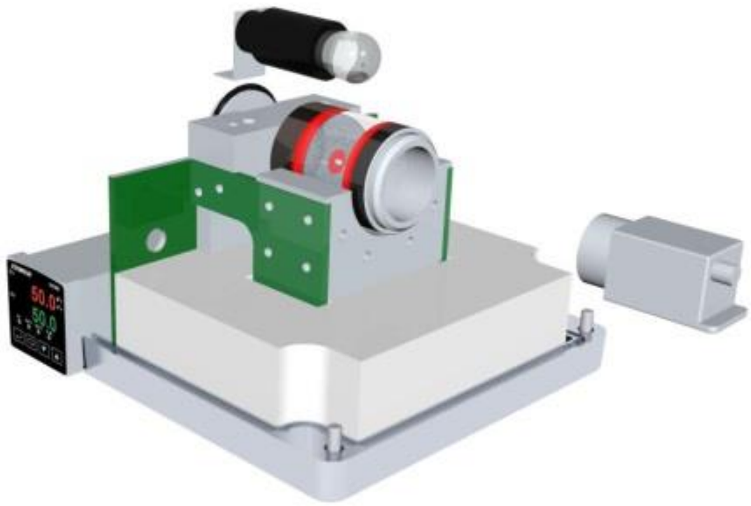
*by courtesy of **Emano Kunststofftechnik GmbH***

- We wanted to understand and visualize the behaviour of the powder
- Therefore we needed analytical devices and empirical lab trials

Visualization of the sintering and flow

- Two in-house developed lab machines give us an insight into the „mould“

RoMo*Lab*



RoMo*Rheo*

Visualization of the sintering and flow

- Two in-house developed lab machines give us an insight into the „mould“

RoMo*Lab*

Material: REVOLVE 6405U (Matrix Polymers)

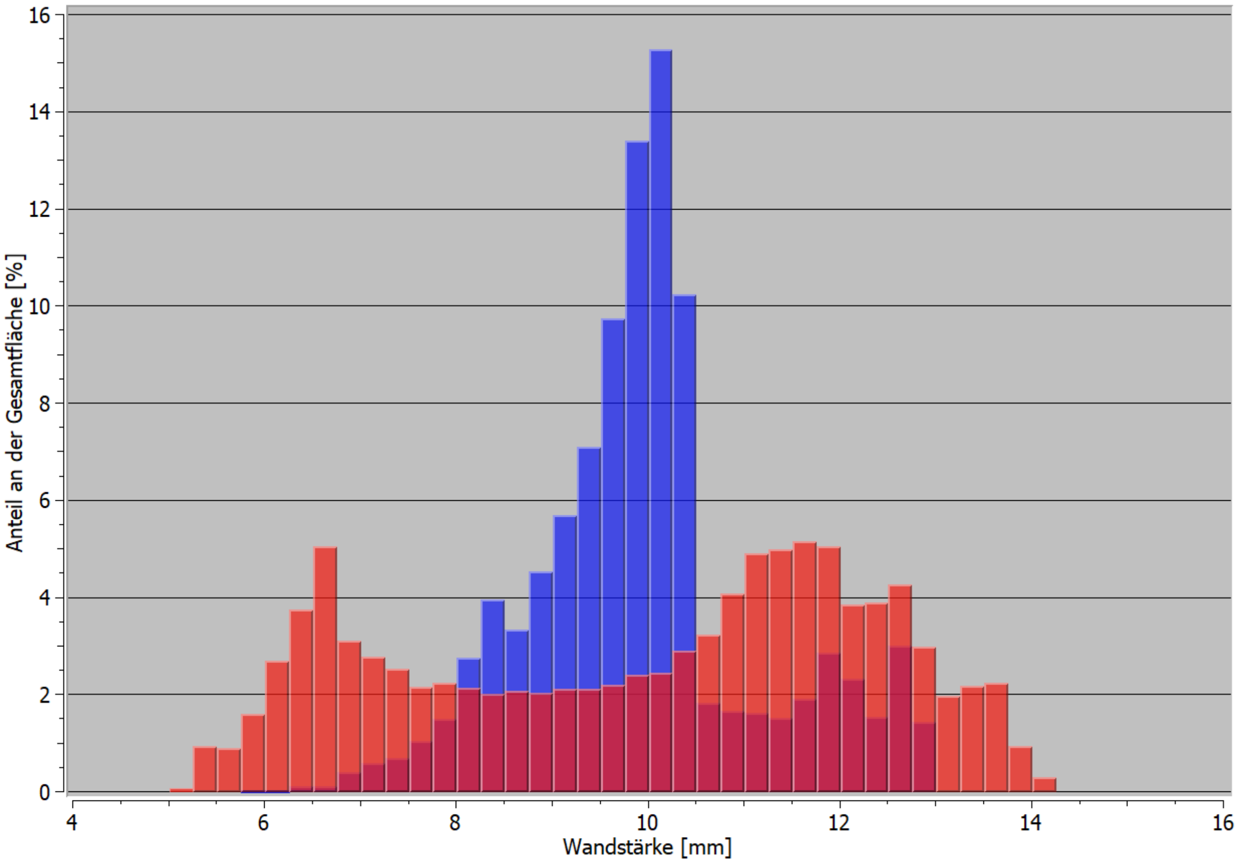
RoMo*Rheo*

What was the finding?

- When we saw the motion of the powder, we realized that:
  - there is no powderpool (no liquid behaviour)
  - but an avalanching flow between two angles
  - and the sintering happens very fast and constantly
- Resultant we developed our own mathematical model to describe the powder flow and sintering behaviour (just considering the powder flow and no thermodynamics)
- Comparatively this model was simple and allows very fast simulations (many runs in a short time)

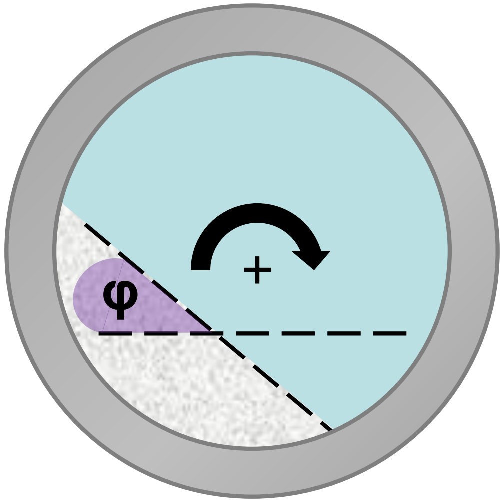
An idea was born

- Let‘s develop a new simulation software to calculate rotational speeds, which allows unique wall thicknesses in a narrow distribution

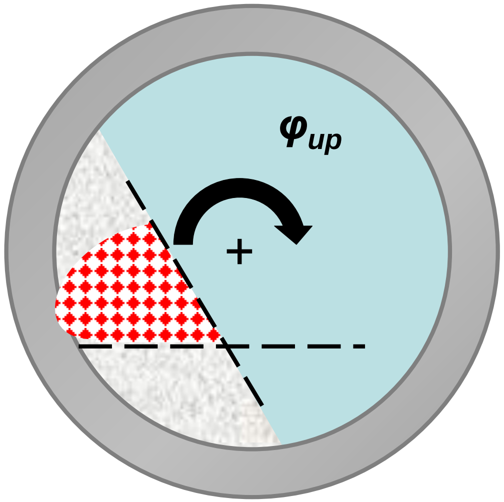


The lab trials has shown

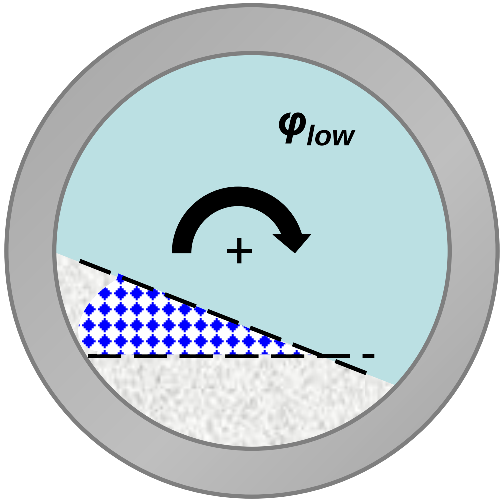
- **RoMo***Lab* – constantly growing wall thickness, when a critical inner surface temperature is achieved
- **RoMo***Rheo* – there is dynamic repose angle $\boldsymbol{\varphi}$ or rather an upper and a lower angle – the powder flows between them ($\boldsymbol{\varphi_{up}} \rightarrow \boldsymbol{\varphi_{low}}$)



dynamic repose angle φ

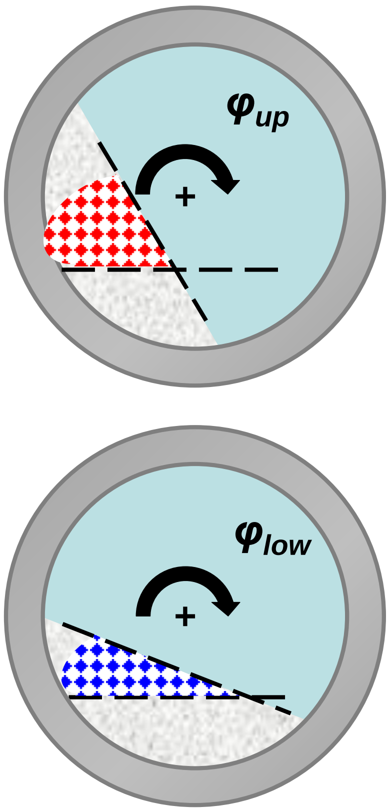


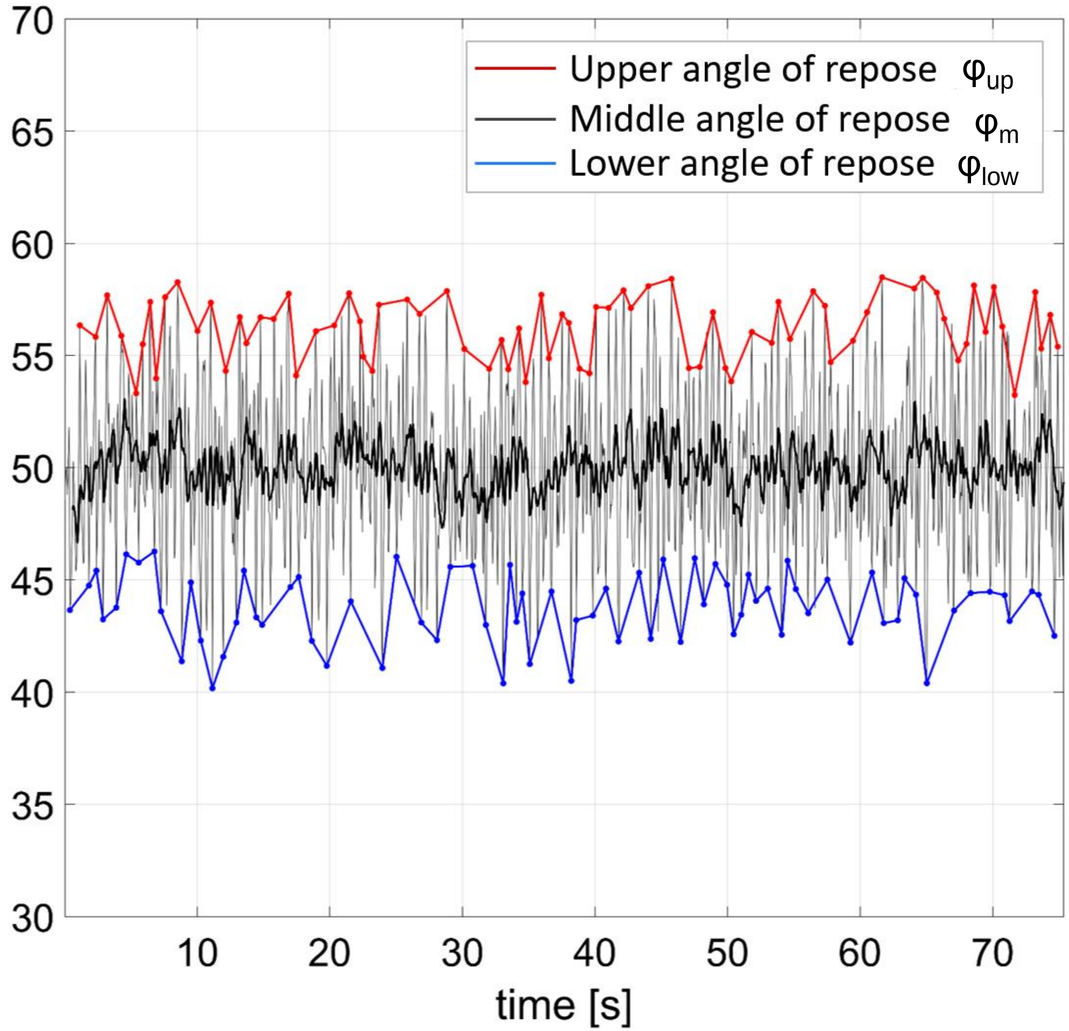
$\boldsymbol{\varphi_{up} > \varphi_{low}}$



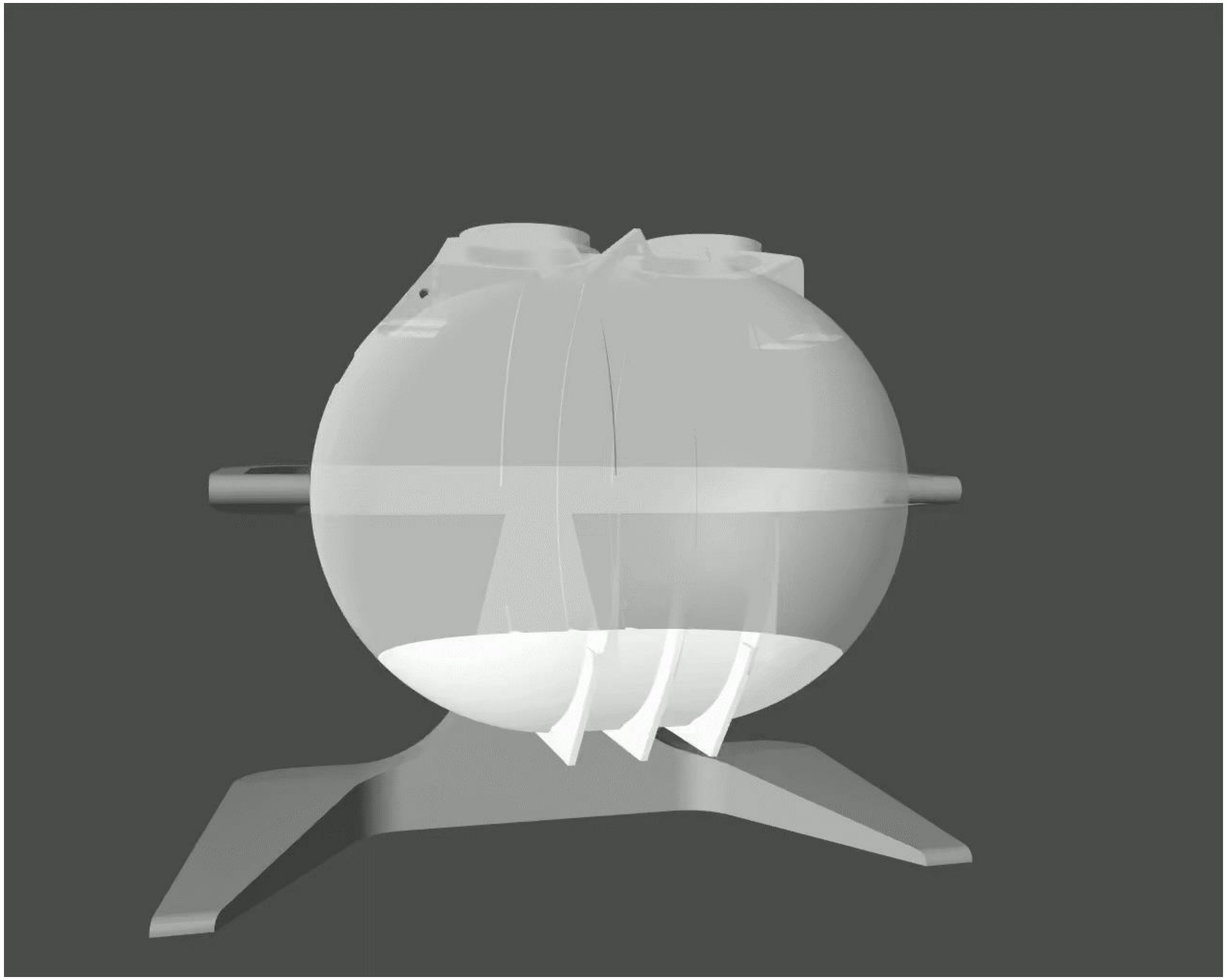
The lab trials has shown

- **RoMo***Rheo*



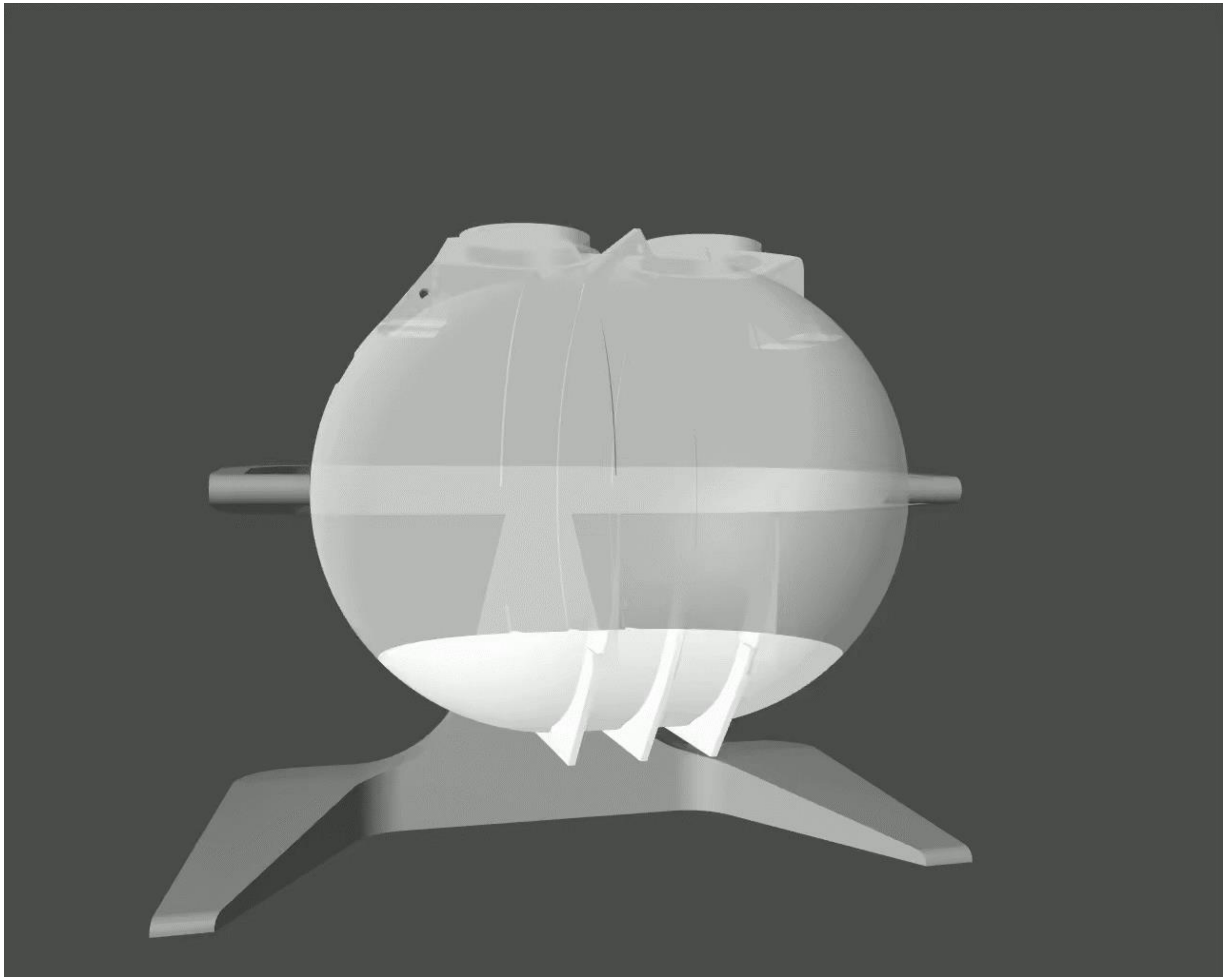


Influence of these flowing behaviour



by courtesy of ***Premier Tech Aqua Germany***

Influence of these flowing behaviour



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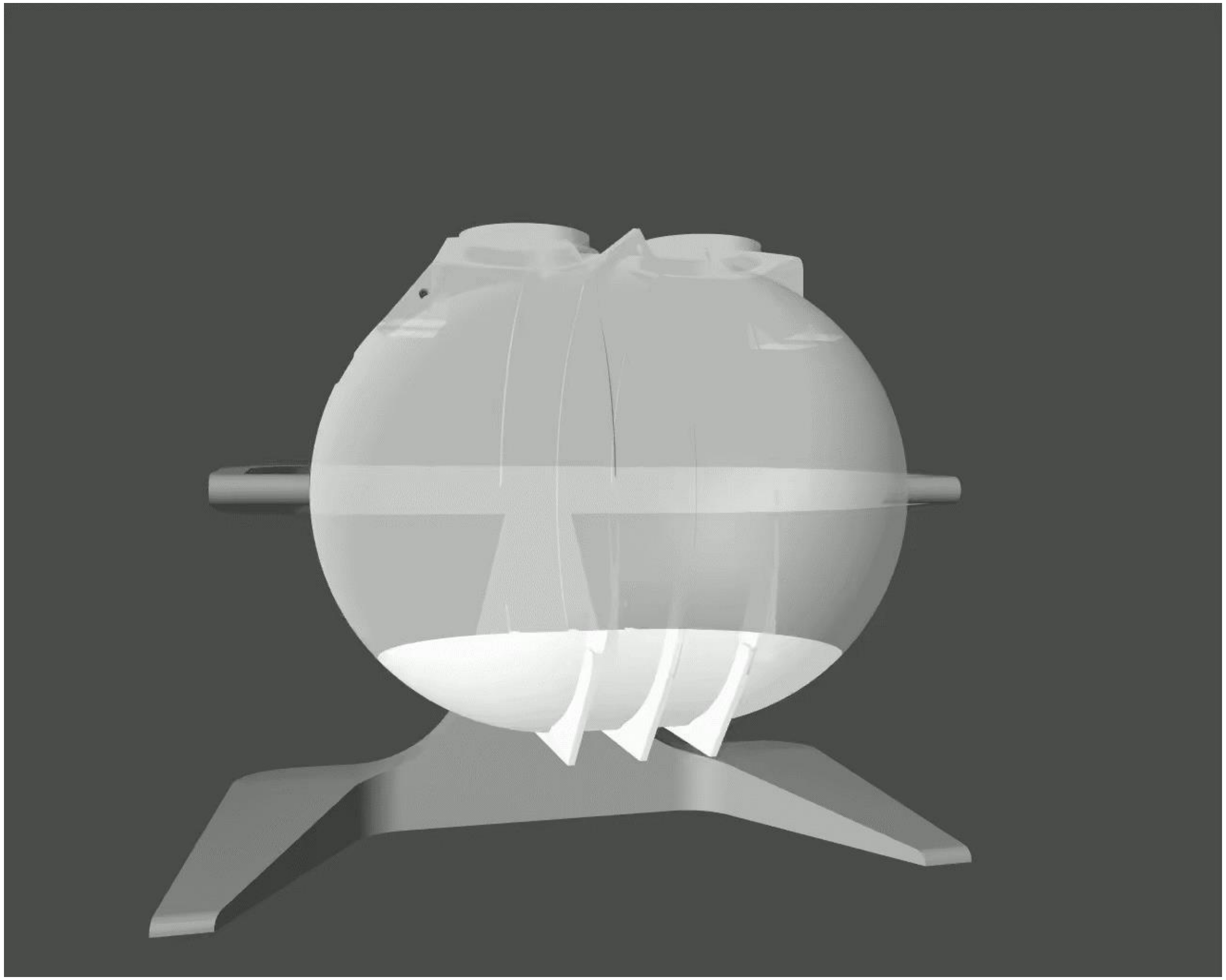
Influence of these flowing behaviour



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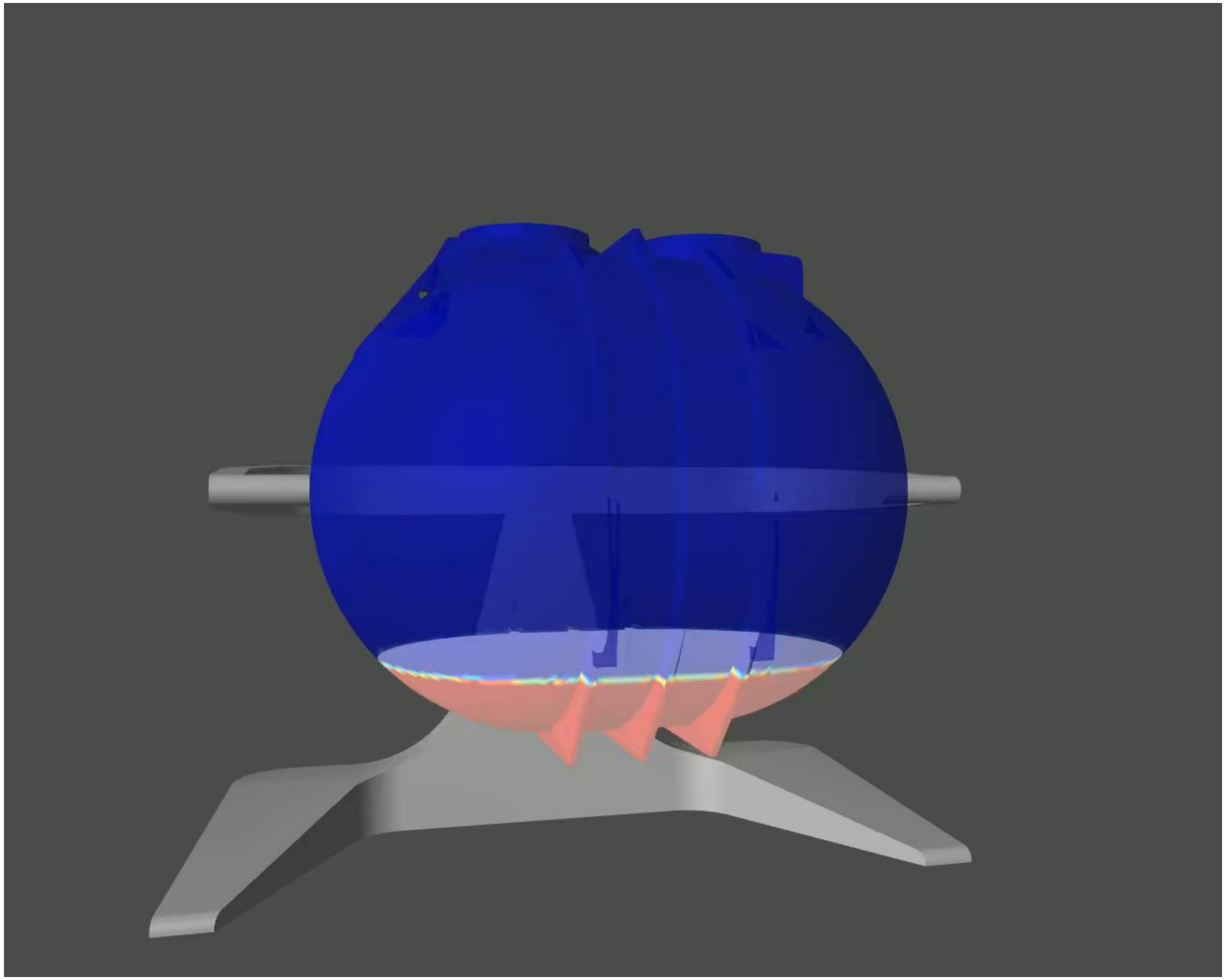
Influence of these flowing behaviour

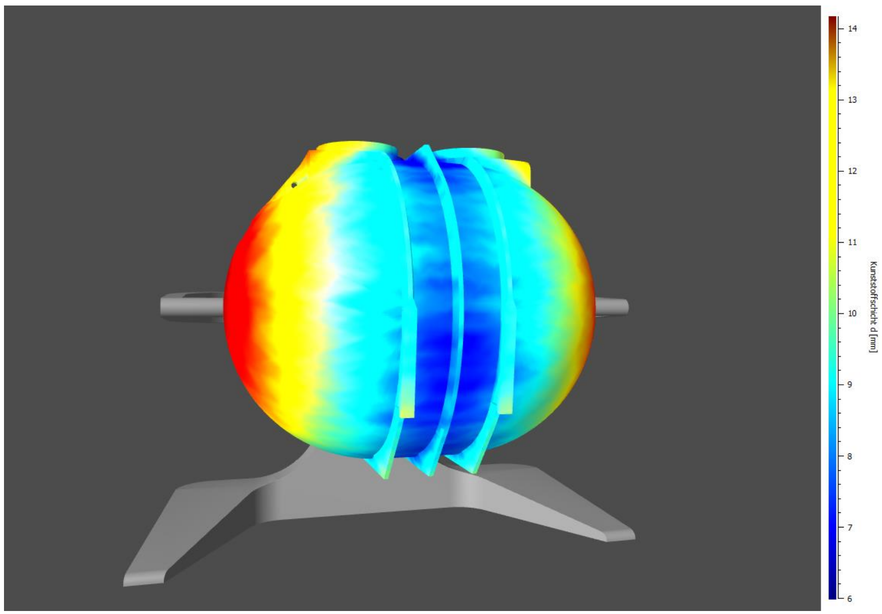


by courtesy of ***Premier Tech Aqua Germany***

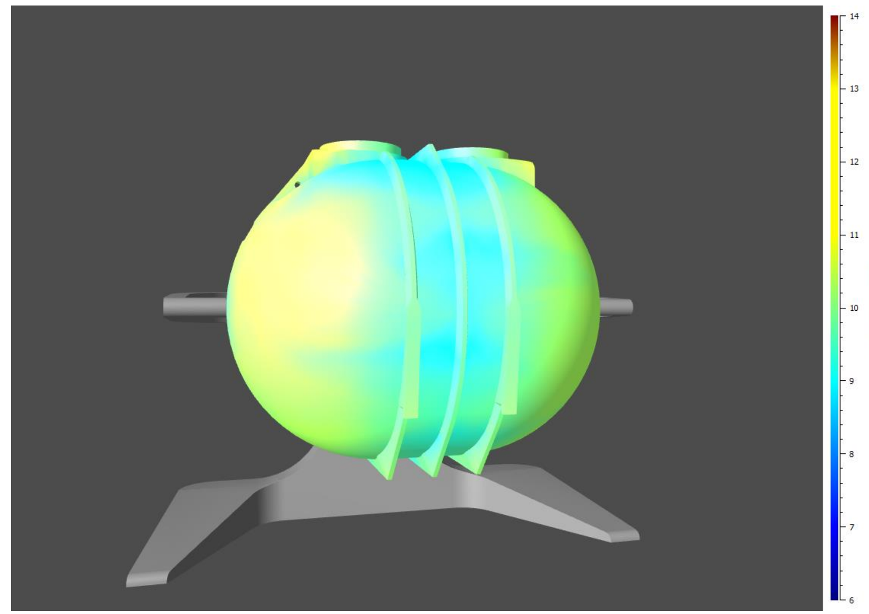
A new simulation software - **RoMo***Simulate*

- Essential advantage is the extremly fast simulation
  - That allows many simulations in a comparatively short time
  - That enables automatically operating optimization algorithmes like so-called „genetic algorithmes“:
    - Principle of the Darwinian evolution theory
    - „Only the fittest survive!“ = the optimized parameters
  - Random combination of the values of machine parameters, e.g. speeds, reversing time
    - Parameter are hybridized (100 hybrids are the 1. generation)
    - These hybrids are compared with each other (e.g. standard derivation)
    - The 10 fittest values are hybrizied again (next 100 are the 2. generation)
    - And so on… up to thousands of generations (duration: 3 … 4 hours)

A new simulation software - **RoMo***Simulate*



real process

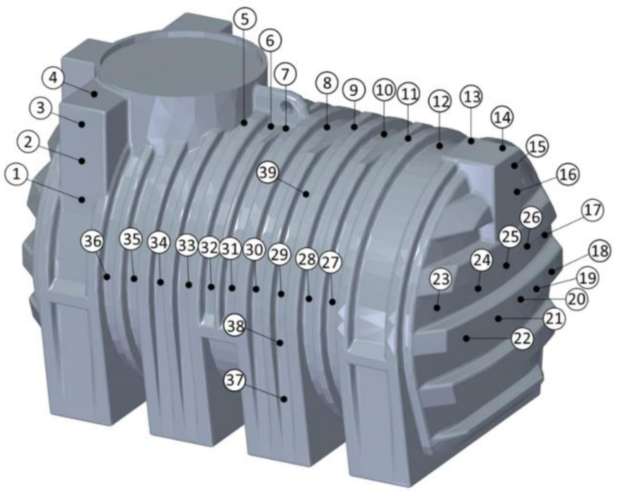


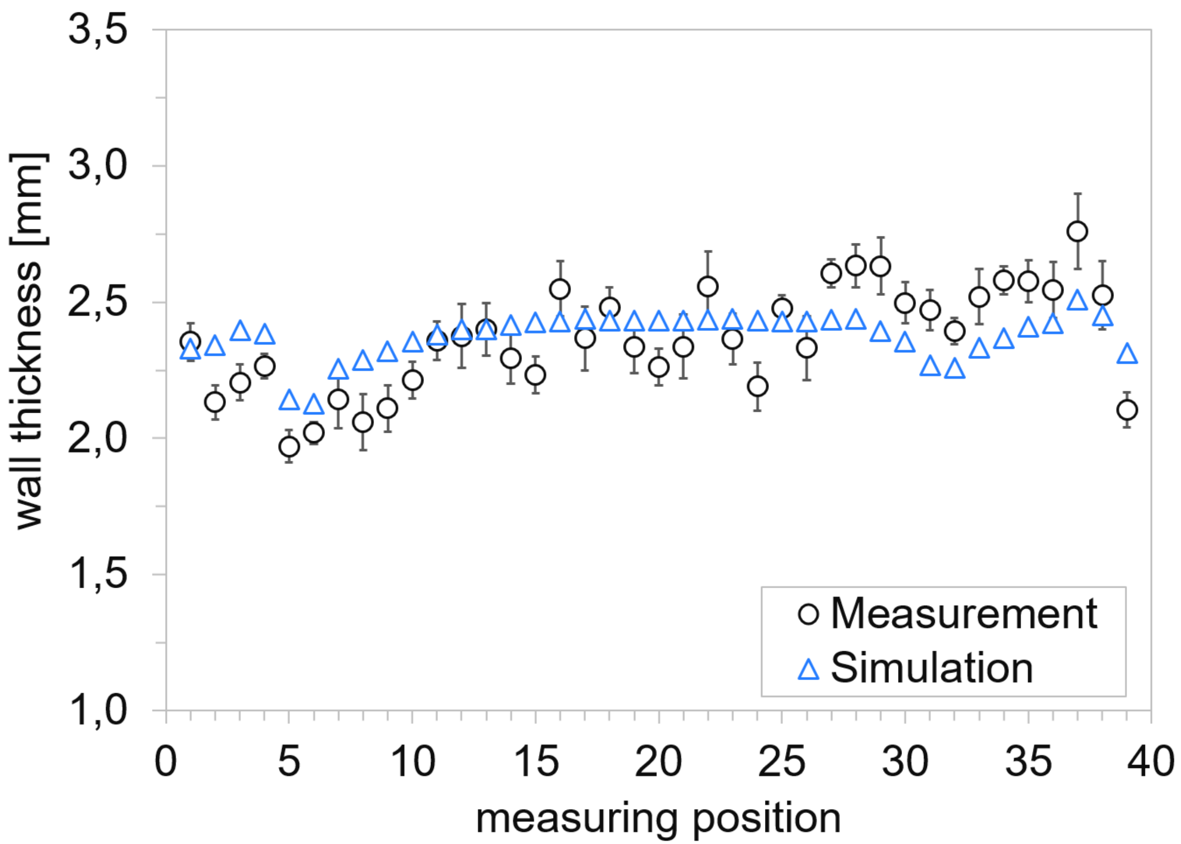
genetic optimized

by courtesy of ***Premier Tech Aqua Germany***

A new simulation software - **RoMo*Simulate***

- Proofing the calculated optimized values in real process
- 39 defined positions on the tank were measured with ultrasonic





In cooperation with our partner:

Das Institut für Polymertechnologien e. V.

What will also be possible soon - **RoMo*Simulate***

- Expanding the simulation with Rock‘n‘Roll Moulding and Rotomoulding Robots…

In cooperation with our partners:

Lettmann

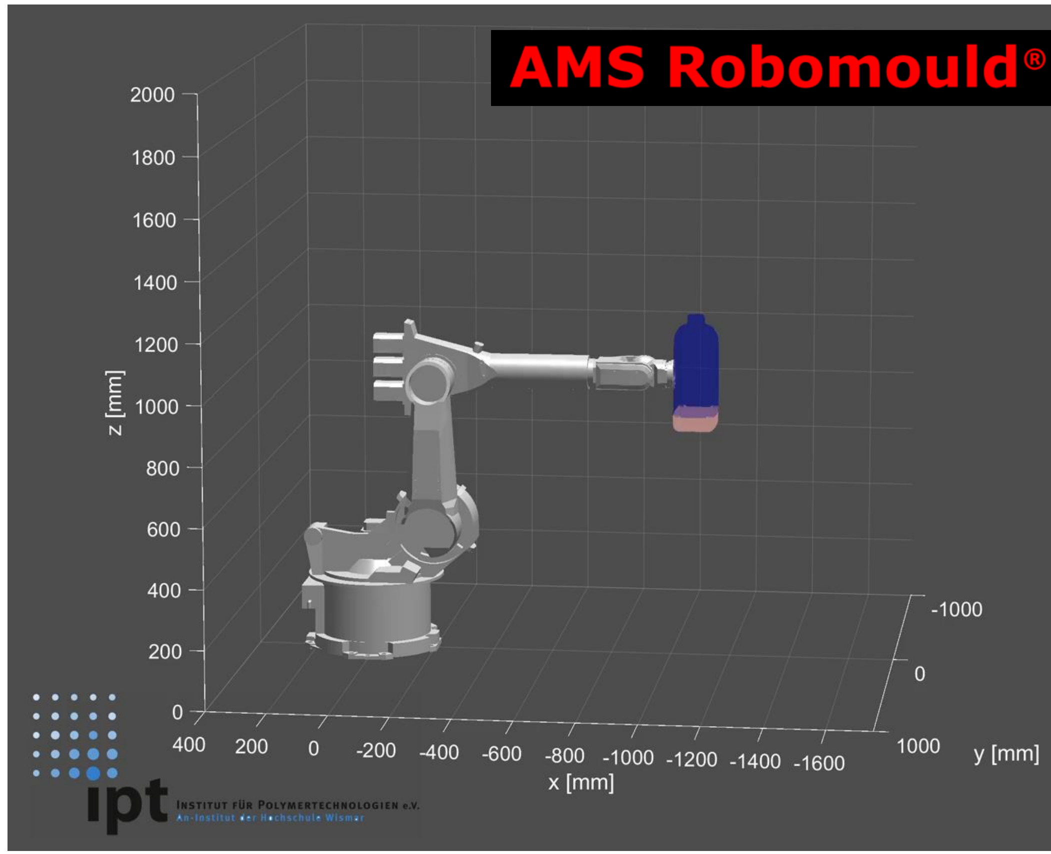
CZ PLAST
ROTOMOLDING SINCE 1997

Further cooperation partners:

PREMIER TECH AQUA

emano

CEMO
für sicheres Lagern



What will also be possible soon - **RoMo***Simulate*

- … and with RotoTower Moulding ***(RotoEvolution)***

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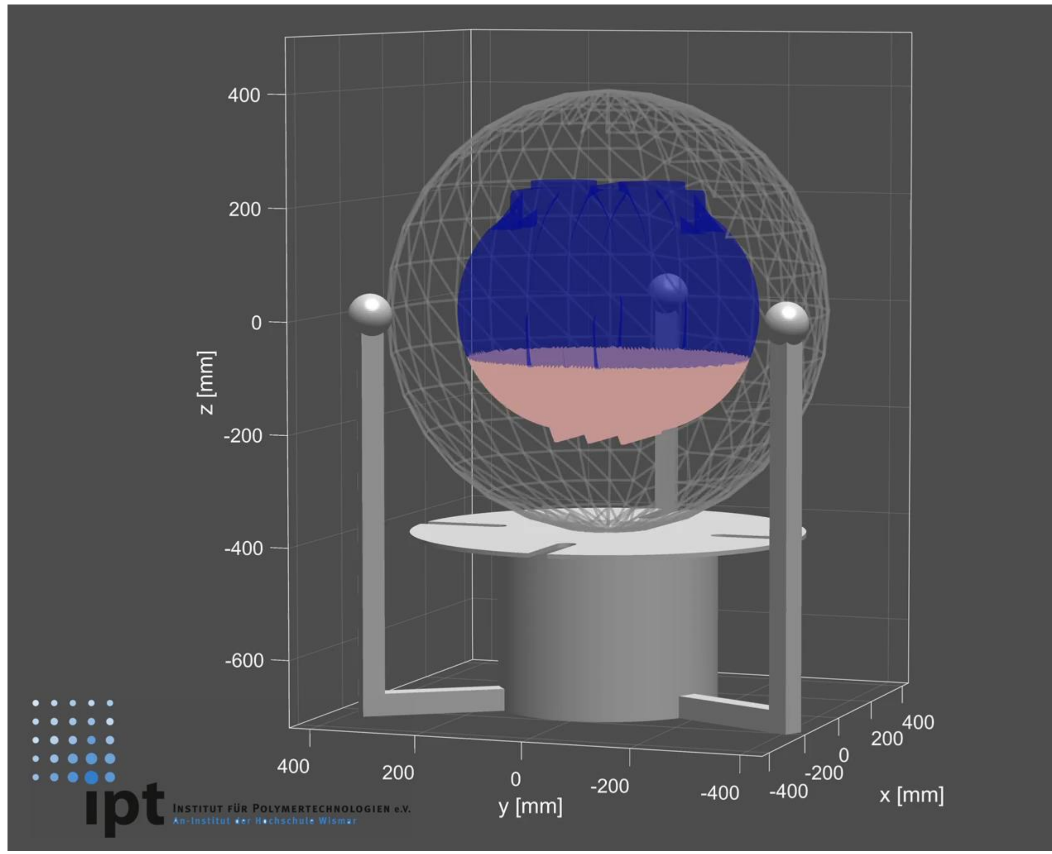

ipt

Thank you very much –

Feel free to visit us in Germany!

Mechanical properties	
Determination of tensile properties	according to DIN EN ISO 527
Determination of compressive properties	according to DIN EN ISO 604
Determination of flexural properties	according to DIN EN ISO 178
Determination of Charpy impact properties	according to DIN EN ISO 179
Hardness Testing	
- Shore A hardness	
- Shore D hardness	according to DIN EN ISO 868
Determination of fatigue properties under dynamic loading	
- tension / compression	
- four-point bending	
- three-point bending	
- torsion	Electropuls E10000 (Fa. Instron Industrial Products)
Determination of creep behaviour	
- flexual creep by four-point loading	
- standard atmosphere (23 °C / 50 % rel. Humidity)	according to EN ISO 899-2

thermal Properties	
Heat distortion temperature (HDT)	according to DIN EN ISO 75
VICAT – softening temperature	according to DIN EN ISO 306
Determination of oxidation induction time / temperature (OIT)	according to DIN EN 728
Diffential scanning calorimetry (DSC)	according to DIN EN ISO 11357
Thermomechanical analysis (TMA)	according to ISO 11359
Determination of dynamic mechanical properties (DMA)	according to DIN EN ISO 6721, DIN 52612, DIN EN 12667, ISO 8302
Thermal conductivity	according to DIN EN ISO 22007, lambda – meter, Hot – Disk TPS 1500

rheological properties	
Determination of the melt mass-flow rate (MFR), melt volume-flow rate (MVR) of thermoplastics	according to DIN EN ISO 1133
Polyamides - Determination of viscosity number	according to DIN EN ISO 307
termination of the viscosity of polymers in dilute solution using capillary viscometers for: - Thermoplastic polyester (TP) homopolymers and copolymers	according to DIN EN ISO 1628
Determination of flow and viscosity functions of polymers using	according to ISO 11443
- Extrusion slit capillary rheometer	Plasticorder LAB-station
- High pressure capillary rheometer	Smart RHEO 5000
- Rotational rheometer	Haake Mars III
Determination of specific volume as a function of temperature and pressure (pVT)	according to ISO 17744
- Piston apparatus method	

characterization of powders and microgranules	
Determination of particle size (sieve analysis) of plastic materials	according to ASTM D 1921, DIN ISO 3310-1
- mesh size: 80, 90, 150, 160, 212, 250, 300, 425, 500, 600 µm	
Determination of apparent density, bulk factor, and pourability of plastic materials	according to ASTM D 1895, EN ISO 60, DIN EN 12047, EN ISO 6186
dynamic angle of repose (temperature – speed – dependet)	RoMoRheo (Fa. Institut für Polymertechnologien e.V.)
Digital microscopy	VHX 2000D (Keyence Microscopes Europe)

furthertest	
Colorimetry using spectrophotometer	according to DIN 5033
Determination of solid state density by Gaspycnometry	according to DIN 66137
measuring contac angles (1 test liquid)	according to DIN 55660
Determination degree of crosslinking (SOXLETH-extraction)	according to DIN 16892
Determination of the fibre-, resin- and void contents	according to DIN EN 2564
environmental simulation / aging test	climatic exposure test cabinet, CTS Light climate test cabinet Typ CL - 60/1500 BF-Sun
Contact angle measurement (Drop shape analysis)	DSA 100 (Fa. Krüss GmbH)
Optical 3D-measuring	Mitutuyo Quick Vision E-200 Pro