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Today's Ideas – Tomorrow's Technologies in Injection Moulding

SINTEF Technical Seminar for the Injection Moulding Industry
20/21. April 2010, Oslo
Dipl.-Ing. A. Neuß
Institute of Plastics Processing at RWTH Aachen University (IKV)

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The Institute of Plastics Processing

Institut für Kunststoffverarbeitung (IKV)

Founded in 1950, supported by a Sponsors' Society

Associated with the RWTH Aachen University

Sponsors' Society with 257 members (one third foreign companies)

- raw material producers
- machine manufacturers
- plastics processors
- research institutes
- associations

Staff of IKV :

- 70 scientific employees
- 55 employees in laboratories, workshops and administration
- 220 student workers

(As of August 2009)

IKV-Locations in Aachen

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Pontstraße 49-55
Management and Executive Board
Injection Moulding
PUR-Technology
Training/Skilled Crafts

Seffenter Weg 201
Composites
Extrusion and Further Processing
Part Design/Materials Technology
Centre for Analysis and Testing of Plastics

Key features of the IKV research programme

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THERMOPLASTICS, THERMOSETS, ELASTOMERS, COMPOSITES, SPECIAL MATERIALS

INJECTION MOULDING, EXTRUSION, BLOW MOULDING, COMPRESSION MOULDING, SPECIAL PROCESSES

	material data, material models	CAD, CAE, design rules	CAD, CAE, design rules	production planning, PPS, machine selection	SPC, statistic experimental design	
PRODUCT REQUIRE-MENTS	material selection	product layout and design	layout of moulds, dies and machines	production analysis of complex interconnected processes	quality assurance	PRODUCT
	material innovations	product prototype	mould or die / machine prototype, CAM	measuring, controlling, adjusting and optimisation of process values	testing sensor systems	

ENVIRONMENTAL PROTECTION, RECYCLING

PRODUCTION PLANNING, PLANT ORGANISATION

Injection Moulding Department

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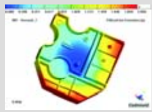
Process Technology

- special IM processes
- process combinations
- special materials
- key technologies

Simulation



- process simulation
- inner part properties
- integrative simulation
- special IM processes

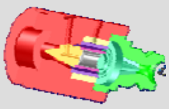
Mould Technology

- temp. control concepts
- process control
- special IM processes
- Rapid Prototyping/Tooling

Company organisation

- benchmarking
- intercompany comparison
- technical consulting
- process analysis

Machine Technology



- drive concepts
- IM of micro parts
- IM of foamed parts
- water injection technique

Polyurethane Technology

- processing of rigid and flexible foams
- mould technology
- reinforced polyurethane

Process Technology
Special Injection Moulding Processes

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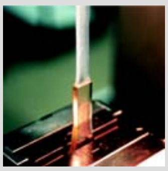
Multi-Component Injection Moulding



2C-tensile test bar

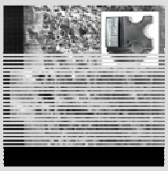
- overmoulding
- sandwich moulding
- hybrid technique
- bond strength
- process combination

Fluid Injection Technique (FIT)

two-layer media duct

- gas injection technique
- water injection technique
- projectile injec. technique
- process analysis
- selection of material
- injector technique and -design

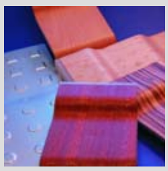
Foam Injection Moulding (FIM)



structural foam

- process development
- process analysis
- selection of material
- part- and mould design
- CESP

Back Injection Technique

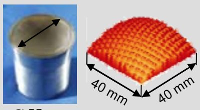


high-value decor materials

- back IM
- back I-CM
- back FIM
- process analysis
- high-value decor materials

Process Technology
Key Technologies

Nano- and Micro-Technology



∅ 55 mm
mould insert with micro structure
left: mould insert
right: measurement by Microglider

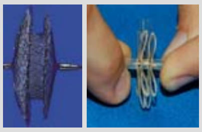
- IM & I-CM of functional structures/structured parts
- injection moulding of micro parts
- machine technology
- plasticising concepts for small amounts of plastics

Plastics Optics

lens made of plastics

- process analysis of IM and I-CM
- mould technology
- analysing quality with regard to inner, geometrical and optical properties

Medical Engineering



cardiac septum closure-system
left: old, Nitinol-meshwork
right: new, absorbable polymer

- development of new products and adapted process chains
- development of implants: resorbable and loaded with biological active additives

Plastics/Metal-Hybrids

source: LANXESS AG
plastics/metal-hybrids

- combination of injection moulding die casting within one machine and one mould
- development of mould and machine technology

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- Combination of PUR and Thermoplastic Material using Sandwich Moulding
- Summary and Outlook

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Introduction

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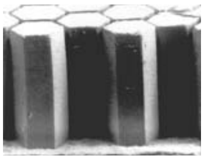
Micro Technology by Injection Moulding

micro parts



nano- & micro structures

Hollow Parts by Injection Moulding

Fact

- The standards of parts in terms of design and functionality as well as demands for economical, resource efficient productions often cannot be fulfilled by conventional materials and manufacturing methods.

Current Situation

- Special injection moulding processes are gaining importance:

  ➔ more than 100 special processes!

  Multicomponent IM, Fluid Injection Technique, Backmoulding, Foaming, Insert-, Outsert- and Hybrid Technique etc.

[PME fluidtec GmbH, Röchling Automotive]

General Trends in Manufacturing Technologies

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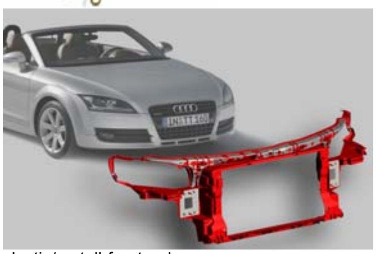
door trim panel



plastic/metall-frontend

General Trends

- Demand for increased value added
- Limits between different material classes and manufacturing methods have been shifted increasingly.
- Result: hybridisation of production technologies

  ➔ Hybrid products

  Combination of different materials in one part

  Example: multi-component technology; insert-, outsert-technology

  ➔ Hybrid processes

  Combination of (special-)processes in order to produce assembly groups of different material components under reduction of the process chain.

  Examples: Skinform®, Dolphin®, Exjection®

[BASF SE, KraussMaffei Technologies GmbH, LANXESS AG]

Potentials of Hybridisation – Combination of Different Polymers

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toys

medical care

white goods

automotive

Multi-component injection moulding

- Production of mouldings, which consist of two or more – with regard to colour or mechanical properties etc. – different polymers
- Production normally with one mould

Success factors

- Directed integration of several functionalities such as
  ➔ value appeal,
  ➔ design,
  ➔ haptics,
  ➔ sealing function, ...
  in one moulding.
- Reduction of the process chain, potential of rationalisation

[Geobra Brandstätter GmbH & Co. KG, M+C Schiffer Dental Care Products GmbH, Hofmann Innovation Group AG, BMS AG]

Potentials of Hybridisation – Combination of Different Materials and Processes

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belt cover

door trim panel

handle

headrest

Skinform®

- Production of combinations, which consist of a thermoplastic and a PU component
- Combination of injection moulding with PU reaction injection moulding (RIM)
- Manufacturing in a multi-component mould

Sucess factors

- Production of high-value polymer surfaces particularily with regard to soft-touch and scratch-resistance
- Freedom of design
- Reduction of the process chain
- Series-production process

[KraussMaffei Technologies GmbH, Schenk Plastic Solutions GmbH]

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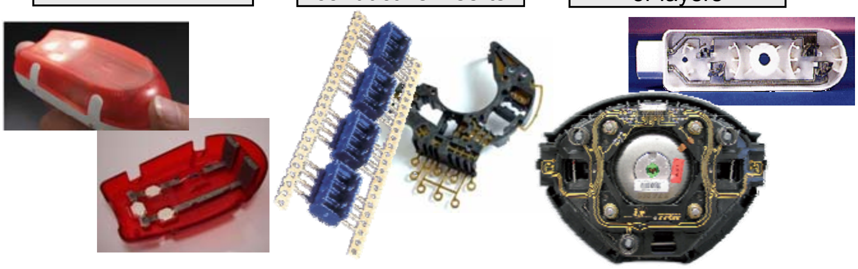
State of the Art in the Production of Electrically Conductive Plastics Parts

Production of electrically conductive parts for conductor tracks, connectors, sensors etc.

- Application of electrically equipped plastics
- Encapsulation / back injection of electrically conductive inserts
- Superimposing of electrically conductive paths or layers



[Oechsler AG, TRW Automotive, 3D MID e.V., Engel Austria GmbH]

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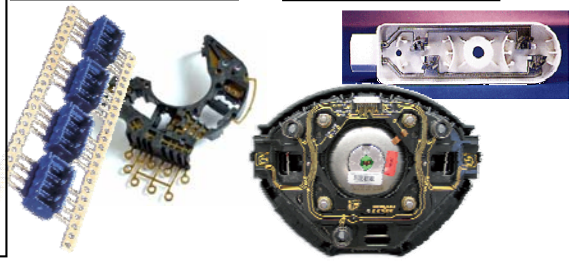
State of the Art in the Production of Electrically Conductive Plastics Parts

Hybrid Materials

- Incorparating of fillers like carbon black or graphite on a compounding line
- Processing on a standard injection moulding machine
  - Electrical conductivity is lower compared to metal
  - High filler content leads to a disadvantegeous flow behaviour
  - Achievable minimal cross-section of tracks

Production of electrically conductive parts for tracks, connectors, sensors etc.

- Encapsulation / back injection of electrically conductive inserts
- Superimposing of electrically conductive paths or layers



[Oechsler AG, TRW Automotive, 3D MID e.V., Engel Austria GmbH]

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Hybrid Processes

- Production of electrical conductive tracks with a electrical conductivity in the range of metal
- Ampacity can be adapted to the specific application
  - Different processes feature a high level of complexity due to several manufacturing steps
  - Process chains frequently comprise costly and/or time-consuming process steps like die cutting, bending, electroplating and mounting
  - Limitations in productivity, processing properties or the level of achievable geometrical part complexity

[Oechsler AG, TRW Automotive, 3D MID e.V., Engel Austria GmbH]

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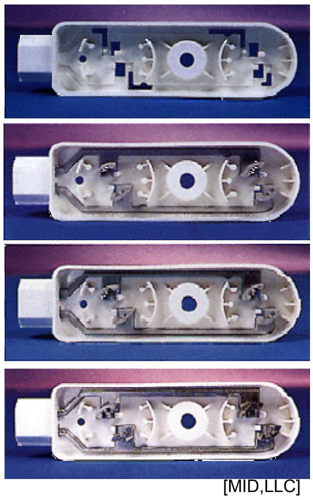
Production of a Rear Light Housing as MID Component

1. Injection moulding of the housing using PS+PC+ABS Blend which is not suitable for metallisation (non-catalytic)
2. Addition of a catalytic path made of PES by overmoulding
3. Chemical pretreatment of the PES path for consecutive metallisation
4. Metallisation of PES path with copper and nickel



[MID,LLC]

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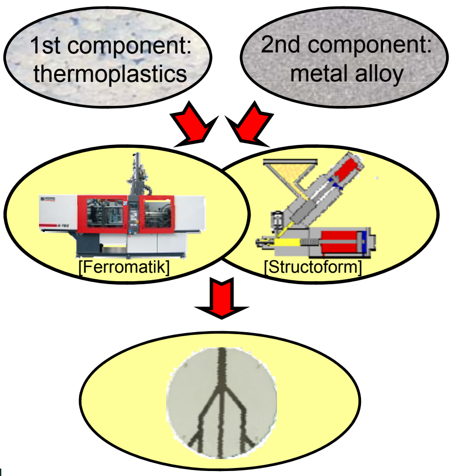
New Approach for the Production of Electrically Conductive Parts



- Direct production by combination of injection moulding of plastics and die casting of metals to create a new hybrid multi-component primary forming process with one mold and one machine

➔Extension of an injection moulding machine by elements of a die casting machine (ancillary unit)

Challenges:

- Process and mold technology
- Bond strength
- Selection of Materials
- …

Selection of Materials

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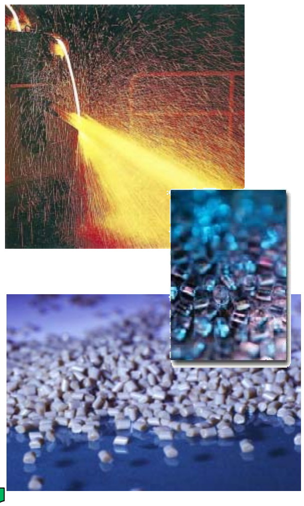

- The thermoplastic carrier plate, produced in the first process step, should not be thermally degraded or mechanically loaded in an admissible way.

➔ Thermoplastic materials have to have a sufficient heat resistance. Typical materials are e.g. polyamide (PA) or polyethersulphone (PES).

- The melt temperature of the metal, processed in the second step has to suit the one of the thermoplastic materials.
- Low melting alloys consisting of tin, zinc and bismuth are applied.
- With an adequate combination it is possible to realise melting points between 50 °C and 250 °C.

Electrical Conductivity of Different Materials Compared to the Alloy MCP200

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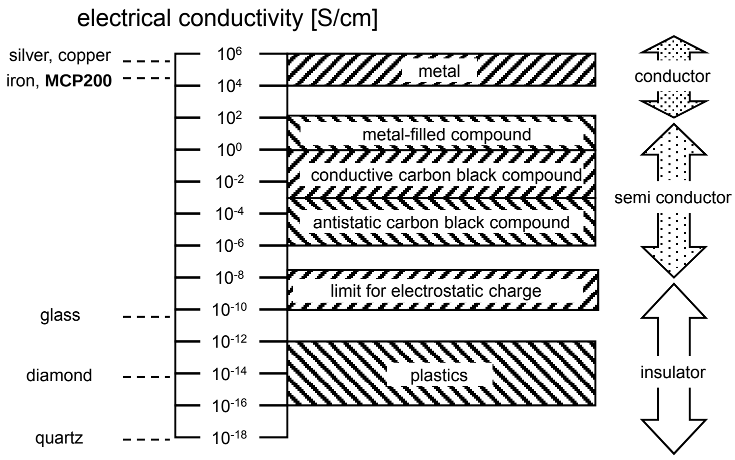

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Properties of the Low Melting Metal Alloy Compared to a Standard PA 6

	PA 6	MCP 200
viscosity η [Pa*s]	30 - 120	0.01 - 0.03
thermal conductivity λ [W/(m*K)]	0.29	61
specific heat capacity c_p [kJ/(kg*K)]	1.95	0.24
thermal diffusivity a [mm^2/s]	0.13	35

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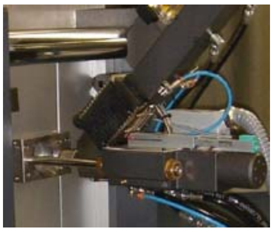
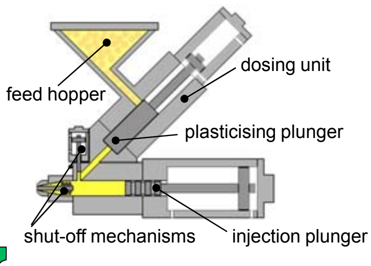
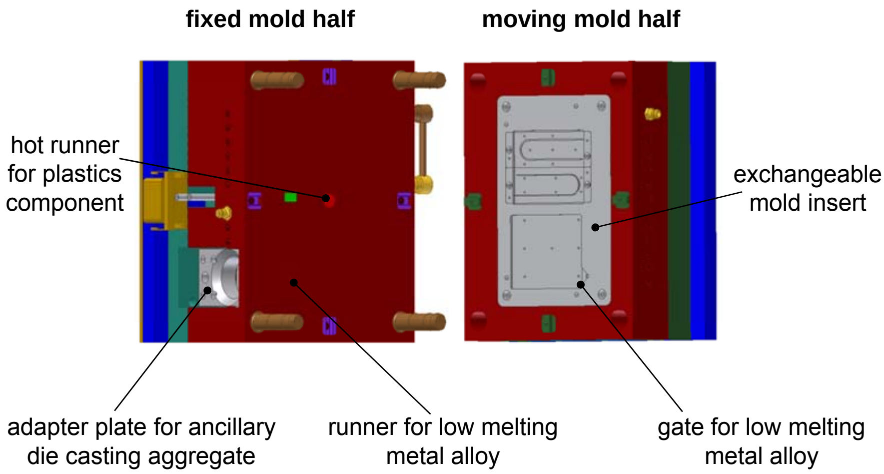
Development of an Aggregate for Die Casting of Low Melting Metal Alloys





- The ancillary aggregate combines elements of a die casting and a micro injection molding unit
- Combination of plunger dosing system and plunger injection system in a piggyback configuration
- Optimization for the processing of small shot wheights
- The sealing between plunger and barrel as well as between mould and ancillary aggregate has been optimized for an reproducible processing of the low-viscosity metal alloy
- Material is fed as pellets
- The unit is attached sidewise to the injection molding machine (Ferromatik K-Tec 200 S/2F) in L-configuration

Mold Technology for the New Hybrid Process



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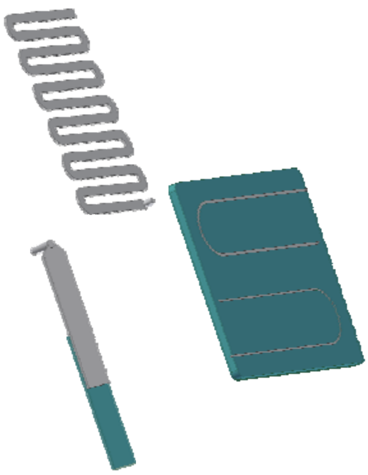
Main Aspects of the Investigation



Processing of the low-melting metal alloys
- Identification of optimal processing conditions of the low melting metal alloy
- Target parameter: achivable flow length

Electrically conductive plastics parts
- Implementation of the hybrid multi-component process
- Achivable cross-section of the metal track / ampacity of the electrically conductive track
- Contacting of adjacent components (e.g. copper wires)

Bond strength between plastics and metal
- Improvement of the bond strength using surface modifications (e.g. structuring, plasma)
- Identification of significant parameters

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Main Aspects of the Investigation

Processing of the low-melting metal alloys

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Electrically conductive plastics parts

- Implementation of the hybrid multi-component process
- Achivable cross-section of the metal track / ampacity of the electrically conductive track
- Contacting of adjacent components (e.g. copper wires)

Bond strength between plastics and metal

- Impact of macro-/micro geometry on the bond strength
- Identification of significant parameters

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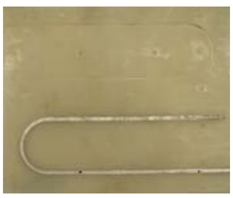
Production of a Plastics Part with an Integrated Electrically Conductive Track

PA 6.6 carrier plate

PA 6.6 carrier plate with a conductive track of MCP



Step 1

- Injection moulding of the plastics carrier plate
- Geometrical dimensions: 105 mm length, 125 mm width, 4 mm thickness
- Material: Schulamid 66 MV 3

Step 2

- Transfer of the carrier plate (by the machine operator) to the second cavity

Step 3

- Overmoulding of the plastics carrier plate with a conductive track made of the low melting metal alloy MCP 200

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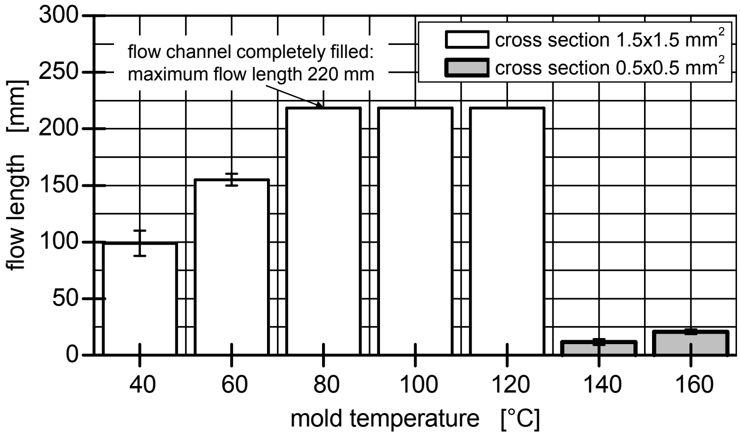
Results of Current Investigations – Plastics Parts with Electrically Conductive Tracks



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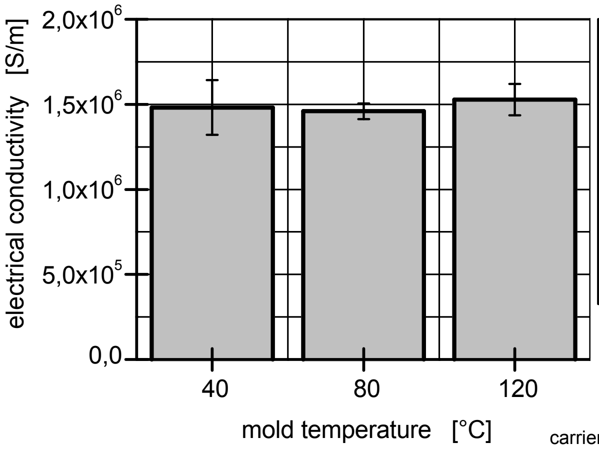
Results of Current Investigations – Electrical Conductivity



$$\sigma[S/m] = \frac{I}{U} \cdot \frac{l}{A} [\frac{1}{\Omega \cdot m}]$$

$\sigma =$ electrical conductivity

$\frac{U}{I} =$ electrical resistance

$l =$ length

$A =$ cross section

carrier plate with electrically conductive track
l = 65 mm; A = 1.5x1.5 mm²

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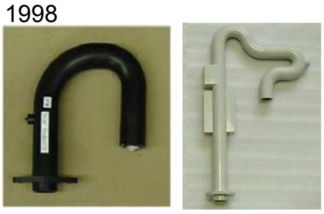
„New" Process Variant of the Fluid Injection Technique „Projectile Injection Technique" (PIT)

1998



[RP TOPLA Limited,Japan]

2006

[Röchling Automotive]

Initial Situation

- Process was first-time described in japanese patents in the middle of the 90s.
- Sporadically applied until now, first application in Europe in 2006
- Prospects and limitations are barely known so far. (e.g. feasible diameters, direction changes)

Sucess factors

- Reduced wall thickness compared to conventional FIT
  - ➔ Reduction of material costs
  - ➔ Reduction of cycle time
- Only constant flow diameters are feasible, but increased freedom of design regarding shape and size of flow diameter
- Simplified injector technology is applicable

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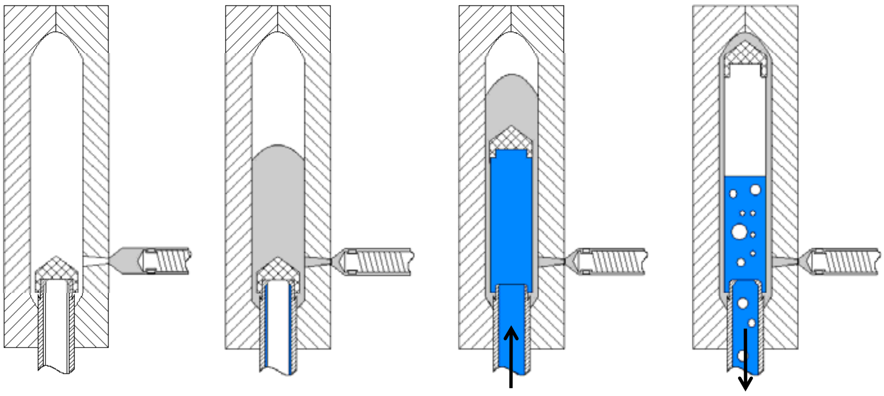
Schematic Process Sequence of the Projectile Injection Technique (PIT)



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Exemplary Comparison of the Formation of the Hollow Space between WIT and PIT

WIT

PIT

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Combination of Special Injection Moulding Pocesses Fluid Injection Technique + Multi-component Moulding

Intitial Situation

- FIT has gained significantly in importance, since it has contributed overcoming the conventional shape limits of IM, e.g. pipes, handles etc.
- For some applications one material cannot fulfill all necessary mechanical, optical, chemical or thermal properties.
- Materials often have to be modified in order to achieve good processing properties for FIT.

Aim

- Combination of multi-component injection moulding with FIT in order to produce highly integrated parts with specific local properties made of different polymers using a shorter process chain.

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Combination of special injection moulding processes: sandwich moulding + fluid injection technique

Problem

- The full potential in production of elongated hollow articles is not taped yet.
- Fluid injection technique is not applicable to all thermoplastics.

Aim

- Boost in the functional density, e.g. diffusion barrier in media ducts.
- Choice of material for the skin and with it for the moulded part independent of the applicability to fluid injection technique.

Solution

- Systematic combination of sandwich moulding and fluid injection technique.

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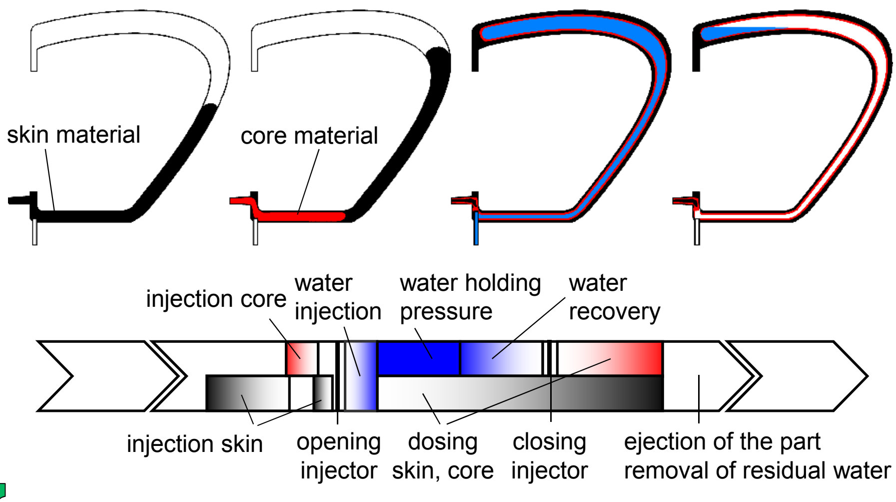
Combination of sandwich moulding with the short shot process



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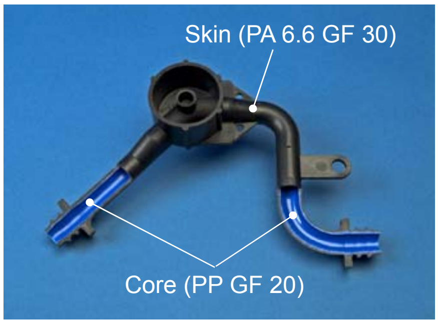
Sandwich moulding + fluid injection technique Motivation

Elevation of functionalities, i.e.
diffusion barriers of media conveying lines



„Oil pipe“: D = 20 mm, L = 500 mm

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Interesting Material Combinations for Multi-layered Media Conveying Lines

Outer layer

- Good mechanical properties for functional components and pipes, such as stiffness, impact strength, tensile strength and bursting strength
- Heat distortion temperature
- Flame resistance

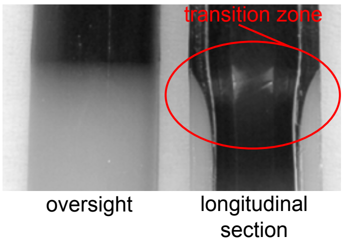
➔PA 6 GF 30, PA 6.6 GF 30, …

Inner layer

- Good suitabilty for the FIT-process
- Rather smooth fluid channel surfaces
- Barrier properties

➔PA/PP-Blend, reinforced; PA, reinforced, …

Combination of special injection moulding processes: biinjection moulding + fluid injection technique



Problem

- Media ducts are frequently composed of different plastic segments in order to meet the requirements.
- Present processing techniques (e.g. 3D-blow moulding + sequential coextrusion) are complex and problematical in terms of a reproducible material transition.

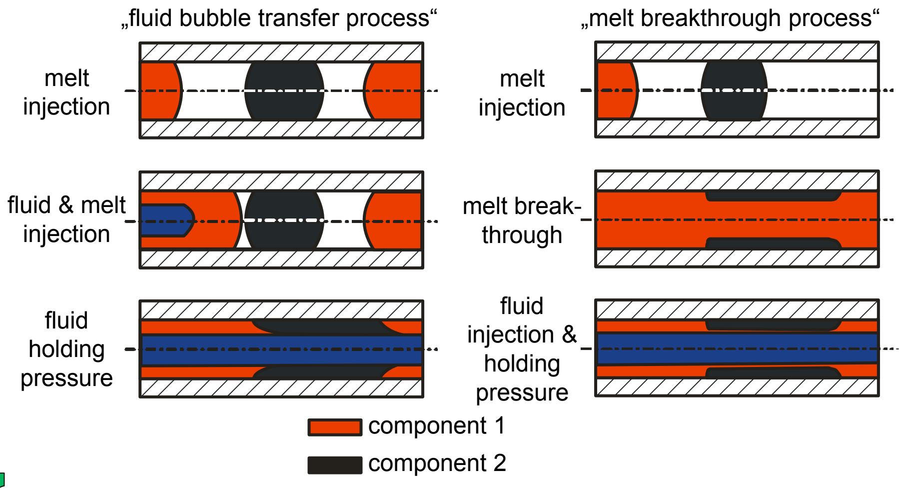
Aim

- Development of a process for the production of hollow plastics parts with axial different properties (e.g. flexibility, optics, strength).

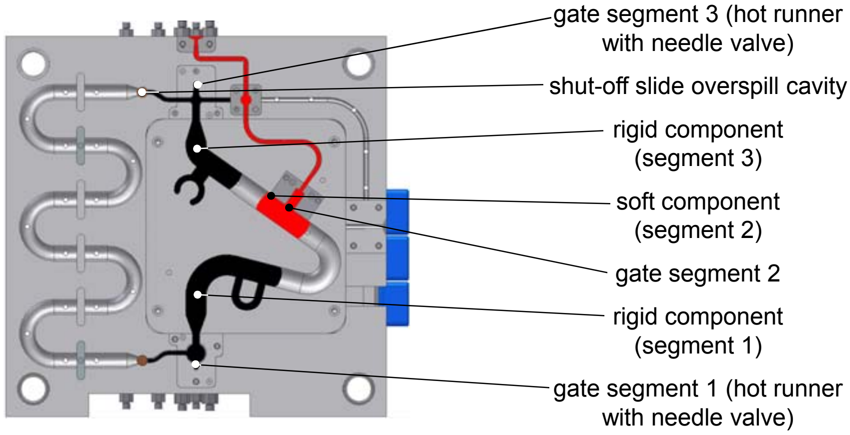
Solution

- Systematic combination of biinjection moulding and fluid injection technique.

Process Variants to Produce Sequentially Composed Media Ducts



Production of a Three Segment Media Line – Melt Injection Phase



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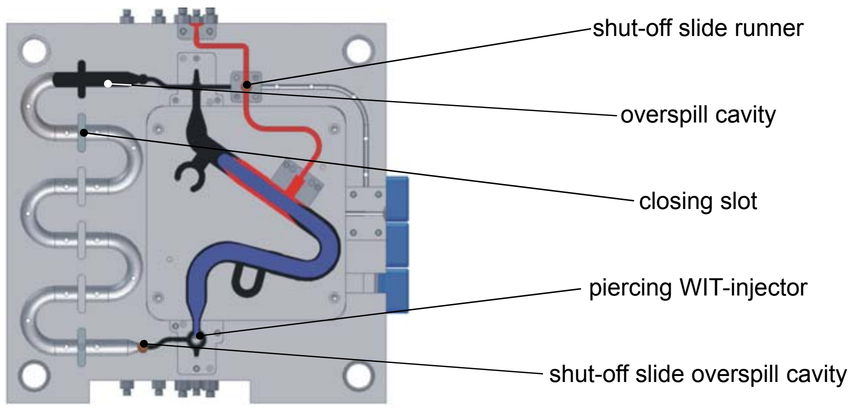
Production of a Three Segment Media Line – Fluid Injection Phase



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Outline

- Introduction
- Hybrid Primary Forming of Plastics Parts with Electrically Conductive Tracks
- Further Developments of Fluid Injection Technique – Projectile Injection Technique (PIT)
- Combination of Special Injection Moulding Processes – Fluid Injection Technique + Multi-component Injection Moulding
- Combination of PUR and Thermoplastic Material using Sandwich Moulding
- Conclusions and Outlook

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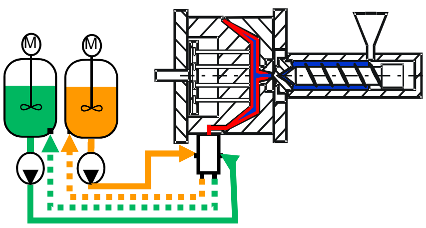
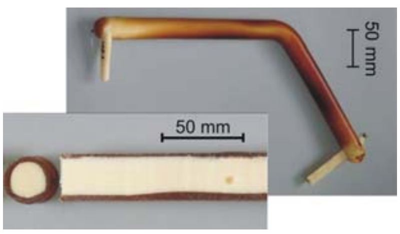
Potentials of Hybrid Products – Combination of Different Materials using Sandwich Moulding





Initial Situation

- TPE, LSR and rubber typically feature unsufficient adhesion, haptical or mechanical properties
- Production of rigid/soft-parts requires several process steps

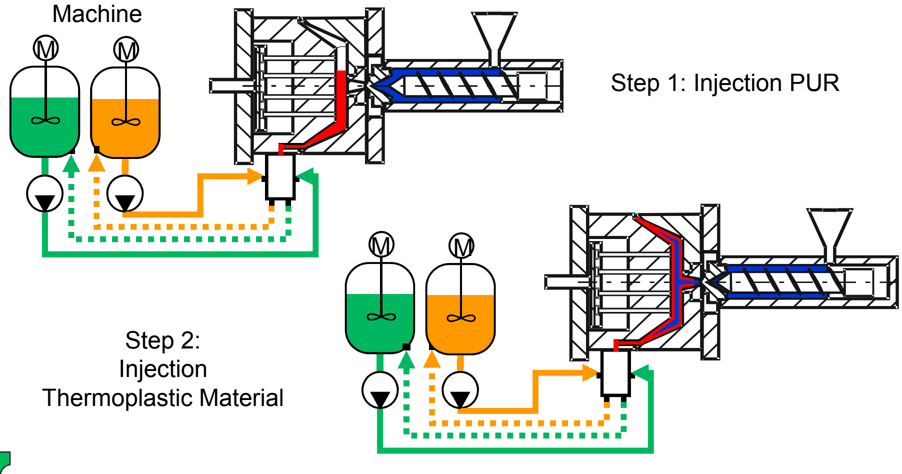
Aim

- Development of a one stage sandwich process for the production of parts with a completely closed PU-skin and a thermoplastic core.

Results

- Sandwich RIM enables the production of rod-shaped 2C-parts with constant soft-touch

Sandwich Moulding of PUR and Thermoplastics – Course of the Process



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PUR+Thermoplastic Sandwich Part

PUR: Baytec Reactive spray-on system, Bayer Material Science AG
Thermoplastic: Novodur P2H-AT, Lanxess

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Conclusions & Outlook

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- The standards of plastics parts in terms of design and functionality as well as demands for economical, resource efficient production often cannot be fulfilled by conventional materials and manufacturing methods.
- The presented innovative processes have the potential to overcome some current limitations and will complement the variety of different injection moulding processes.
- An early implementation bears the chance to achieve a significant technological and economical advantage, but requires definitely reasonable efforts.
- The IKV would be very happy to discuss both our and your today's ideas to realise the most exciting tomorrow's technologies.