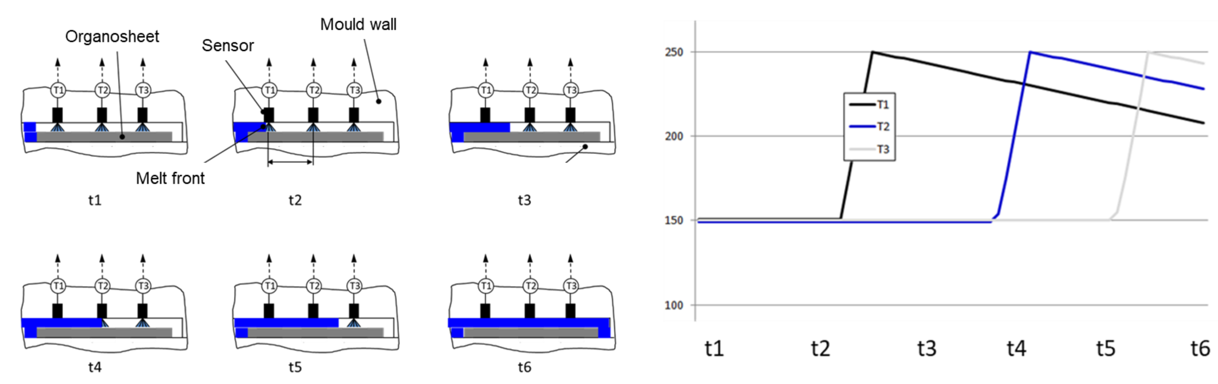
ONLINE PROCESS MONITORING IN HYBRID INJECTION OVERMOULDING

Authors: Michael Petrich, M. Sc., Christoph Hoffmeister, Dipl.-Ing., Prof. Dr.-Ing. Axel S. Herrmann

FASERINSTITUT FIBRE BREMEN

Motivation

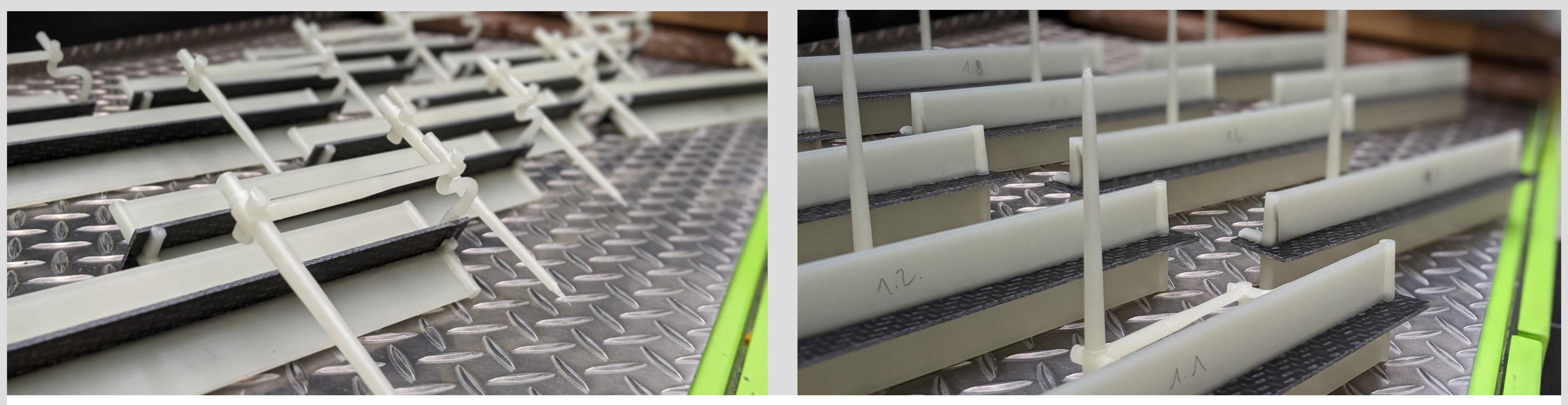
- Hybrid injection overmoulding combines properties of organosheets and injection moulding:
  - Excellent mechanical properties
  - High degrees of geometric freedom and short cycle times
- Strength of hybrid structures is primarily determined by the interface between insert and injection moulding compound
- Use for safety-critical parts (e.g. aerospace primary structures) is hindered by incomplete understanding of the process and lack of quality assurance



Operating principle of sensor-based process monitoring

Goals

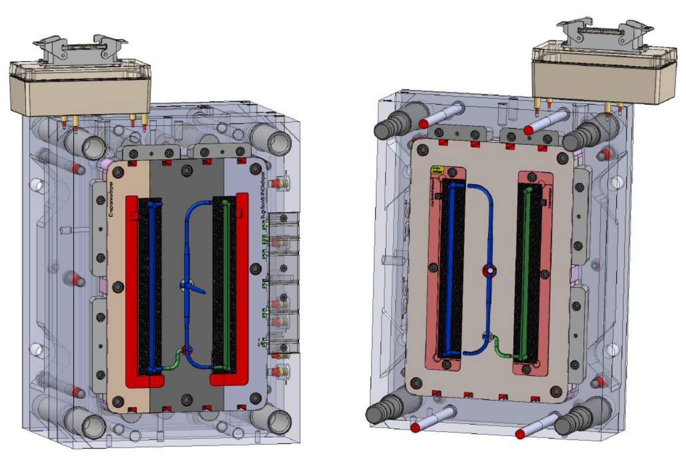
- Tool development for fabrication of specimen and online process monitoring
- Measuring of decisive process variables inside the mould cavity via integrated sensors
- Evaluation of tool and sensor system through a statistical test plan
- Study effects of various machine and process parameters on measured in-cavity process variables and bonding properties
- Definition of a process window for the complete bond formation between insert and injection moulding compound as a basis for quality assurance



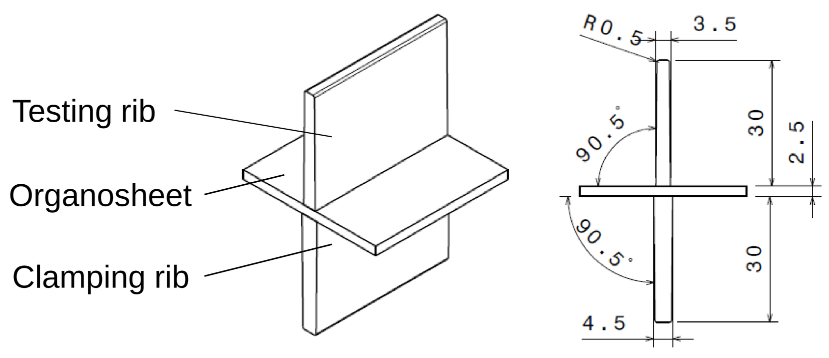
Produced specimen: PP-GF organosheet with overmoulded double rip structure

Overmoulding Tool & Test Specimen

- Test specimen for the determination of bonding properties at the interface
- Organosheet insert overmoulded with short-fibre reinforced thermoplastic rips
- Double rip geometry to prevent bending of organosheet in tensile test
- Variable tool design allows variable insert thickness, injection sequence, distance from gate and creation of weld lines
- Wide range of processible materials up to high temperature thermoplastics such as PEEK



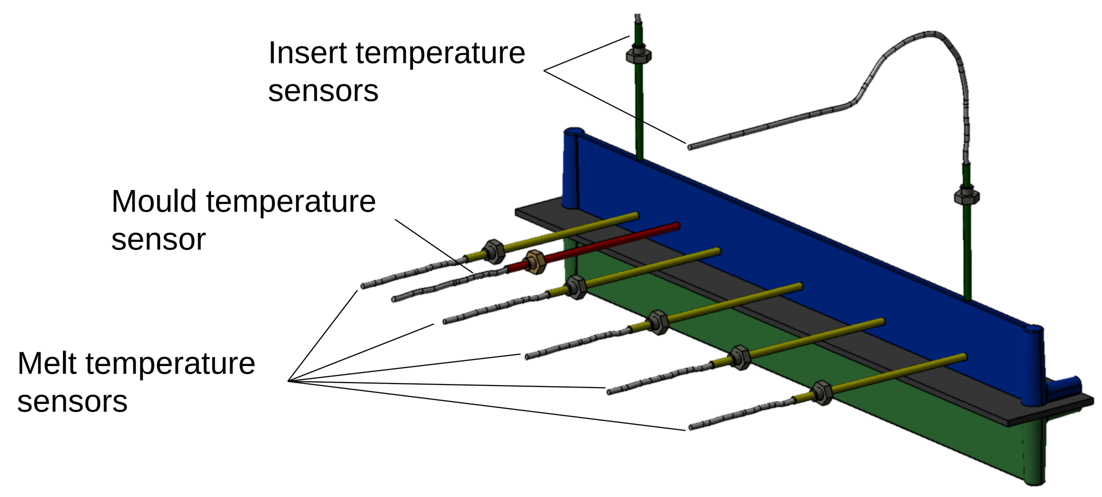
Injection overmoulding tool



Tensile test specimen

Sensor System

- Three different types and a total of eight sensors included in the tool
- Measurement of insert, mould and melt temperatures throughout the injection process
- Placement of sensors allows determination of melt flow rate in the cavity
- All sensors were provided by project partner FOS Messtechnik GmbH within the scope of the research project QuaSimOdo (Quality assurance in the overmoulding process – online)



Sensor positions inside the moulding cavity

Experimental Procedure

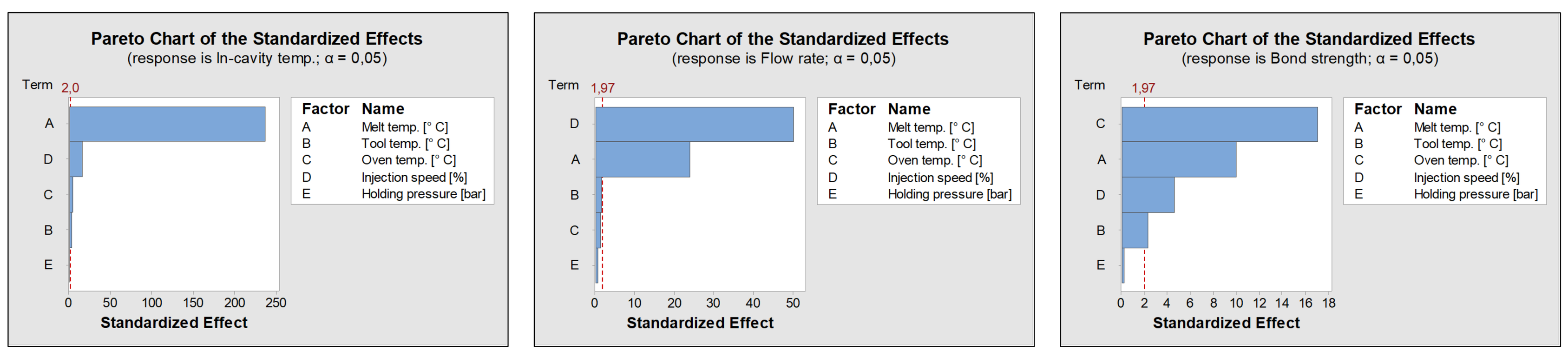
- Statistical test plan (DoE 2^5-plan with centre point; 170 parts, 850 tensile specimen) to determine effects of process and machine parameters
- Material system
  - Insert: PP-GF organosheet; 2.5 mm; Bondlaminates Tepex® dynalite
  - Injection moulding compound: PP-GF, short fibre reinforced; Borealis GB205U
- Effects on in-cavity temperature, flow rate and bonding strength investigated
- Investigated process parameters:
  - Melt temperature
  - Tool temperature
  - Oven temperature
  - Injection speed
  - Holding pressure

Process parameters	Lower level	Centre point	Upper level
Melt temp. [°C]	200	240	280
Tool temp. [°C]	20	40	60
Oven temp. [°C]	50	100	150
Injection speed.	-50 %	Standard	50 %
Holding pressure [bar]	200	300	400

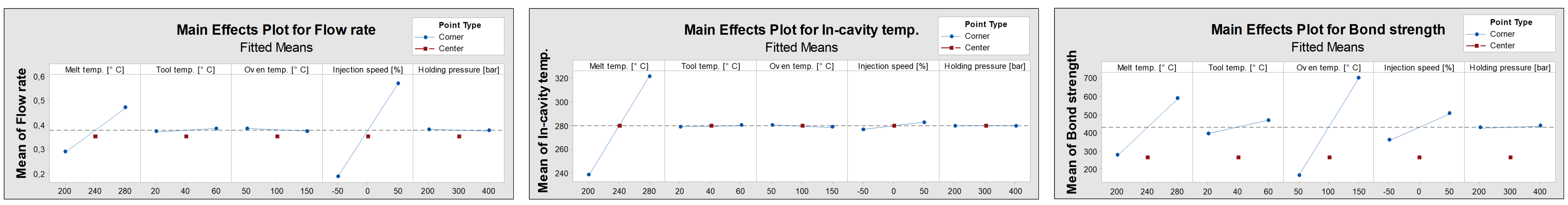
Statistical test plan (DoE 2^5-plan with centre point)

Results

- Statistically significant effects investigated:
  - for in-cavity temperature: Melt temperature
  - for flow rate: Injection speed, melt temperature
  - for interface bond strength: Oven temperature, melt temperature, injection speed, tool temperature
- The bond strength as a main quality criteria is most heavily influenced by melt and oven temperature, resulting in a higher interface temperature



Pareto charts of standardized effects for in-cavity temperature, flow rate and bond strength



Main effect plots for in-cavity temperature, flow rate and bond strength

Conclusion

- The developed test specimen is capable of indicating the effects of various process parameters on interface bond strength
- The integrated sensor system measures in-cavity temperatures of melt, insert and mould online and throughout the injection process
- Melt temperature and preheating of the insert have been identified as the most influential factors for high interface strength
- The developed process monitoring system will be transferred to high temperature thermoplastic materials within the scope of the HiQO (High Quality Overmoulding) research project
- For process validation a generic aerospace component will be manufactured
- Online measured process variables and quality assessment are stored in a electronic component file

Funding (Funding period: 01/2019 - 12/2020)

The QuaSimOdo project has been funded by the German Ferderal Ministry for Economic Affairs and Energy as part of the ZIM research program to whom we would like to express our sincere thanks.

Supported by: Federal Ministry for Economic Affairs and Climate Action on the basis of a decision by the German Bundestag

Funding (Funding period: 05/2021 - 04/2024)

The HiQO project is funded by the German Federal Ministry for Economic Affairs and Energy within the national aviation research programme (LuFo VI-1), for which we would like to express our sincere thanks.

Supported by: Federal Ministry for Economic Affairs and Climate Action on the basis of a decision by the German Bundestag

Faserinstitut Bremen e.V.
Michael Petrich, M.Sc.
Am Biologischen Garten 2
28359 Bremen (Germany)

Phone +49 (0) 421 218 59666
Fax +49 (0) 421 218 58710
Email: petrich@faserinstitut.de
Web: www.faserinstitut.de

Universität Bremen