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PROCESSING RELATIONSHIPS OF HYBRID POLYMER-METAL COMPOSITES IN THE INJECTION MOULDING PROCESS

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MOTIVATION AND TARGETS

- The target of combining metal and plastic parts is to reduce the total weight and to generate desired properties.
- Evaluation of the influence of the manufacturing parameters.

MANUFACTURING AND TEST METHODS

- Amorphous thermoplastic (PA12 Grilamid TR 60), aluminium (EN AW-1050A) and as coating material technicoll 9110.
- Shear edge test and sample for the test, Fig. 1
- Different manufacturing parameters are used (melting temperature, holding pressure and mould temperature), Tab. 1.
- Optical analyses with a macroscope (Leica Wild M 420), a microscope (Leica DMRE) and a scanning electron microscope (Zeiss).

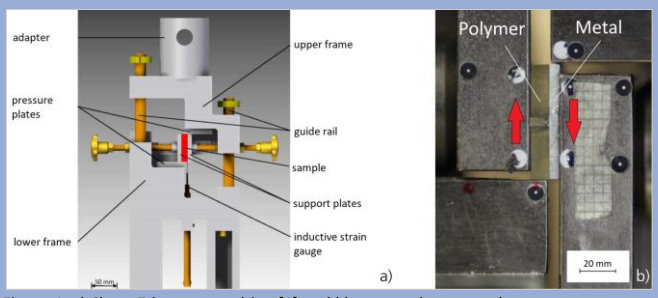

Figure 1: a) Shear Edge test machine [1] and b) mounted test sample.

RESULTS

Optical Analysis

- Polymer residues on the surface of the aluminium sheet after the shear edge test, the polymer is marked in Fig. 2a).
- Near the interface, the polymer structure shows cracks, Fig. 2b).

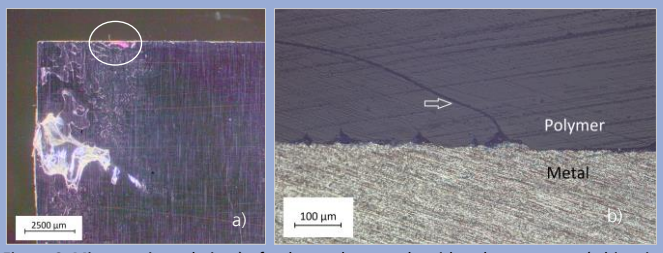

Figure 2: Microscopic analysis: a) of a shear edge sample with polymer arrears (white circle), b) of the interface with a crack structure inside the polymer like a drop-shaped structure [2].

Influence of the manufacturing parameters

- Increasing the whole temperature of the tool, higher shear strengths of the samples were reached.
- Adhesive connection between polymer and metal changes between the area close and far from the sprue, Fig. 3.
- During the shear edge test, the samples show two fracture forms, ductile and brittle, respectively, Fig. 4.

Table 1: Manufacturing parameters of the samples.

Sample	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15
Melting temp. /°C	290	290	290	290	290	350	350	350	350	350	320	320	320	320	320
Mould temp. /°C	60	100	60	100	80	60	100	80	80	80	60	100	60	100	80
Holding pressure /bar	300	300	650	650	475	475	475	300	650	475	300	300	650	650	475

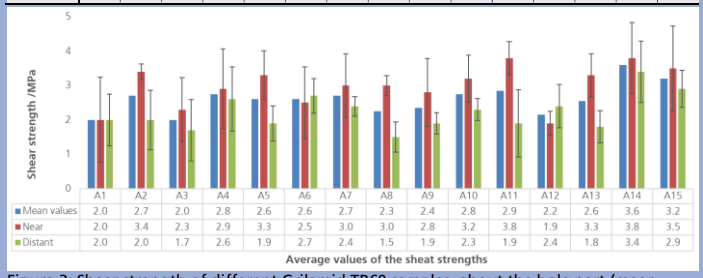

Figure 3: Shear strength of different Grilamid TR60 samples, about the hole part (mean values) and near according to further away from the sprue.

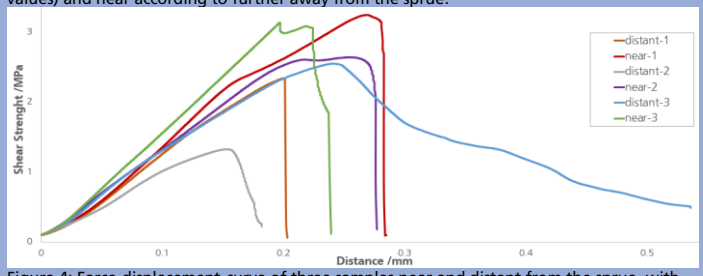

Figure 4: Force-displacement-curve of three samples near and distant from the sprue, with manufacturing parameters of A13.

DISCUSSION AND CONCLUSION

- Melting temperature, holding pressure and mould temperature have an influence on the shear strength of the hybrid.
- The final shear strength of 3.4 MPa is low in contrast to literature values of 17 MPa [3].
- Lower shear strengths were established with increasing length of the melt path.
- The drop-shaped cracks inside the polymer structure are influenced the structure behaviour of the samples.
- The process-structure-property relationships of hybrid polymer-metal composites can be modified during the injection moulding process.

Literature References

[1] *K. Weidenmann, L. Baumgärtner, B. Haspel, Materials Science Forum 2015, 825–826.*
[2] *A. Schwarz, Master Thesis, Karlsruhe Institute of Technology (KIT), 2019.*
[3] *E. Saborowski, A. Dittes, P. Steinert, T. Lindner, I. Scharf, A. Schubert, T. Lampke, Materials (Basel) 2019, 18.*