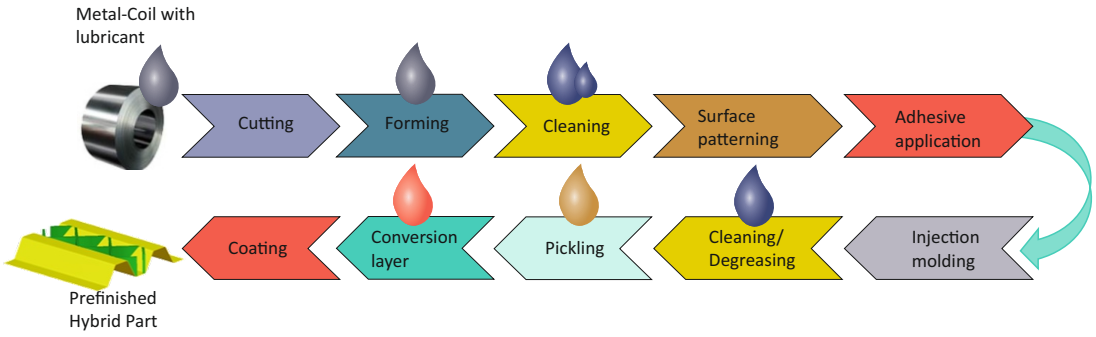
Powder coatings as latent reactive adhesive layer for material bonded hybrid structures

With regard to the aimed E-mobility and connected lightweight construction demands, but also for instrument manufacture and plant construction as well as vendor parts for several industrial areas (e.g. white/brown goods), multi-material hybrids have become more and more important in recent years. Additionally, for industry 4.0 lean, robust and cost efficient process chains in combination with wide variability for the process integration for joining of hybrid structures are required.

State of the art and motivation

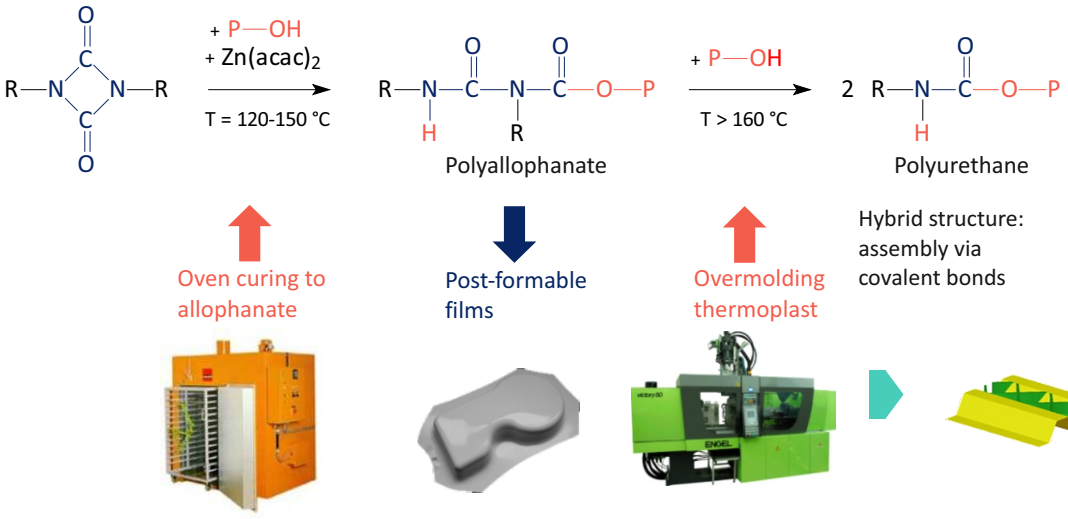
The combination of metal and plastic for structural hybrids usually is made of traction and form fitting by punctual force transmission or elaborated adhesion promoter systems, whereby changes in temperature and far apart expansion coefficients strongly limit the hybrid durability. Material bonded joints and simultaneously tension-equalizing multi-material hybrid parts that are made of originally incompatible materials, can only be fabricated by additional process steps via (reactive-) adhesive bonding so far. However, additional expensive cleaning and pretreatment steps are necessary for the substrates just before the glue application.



State of the art process chain for hybridization via glue application

Multi-functional powder coatings as latent reactive adhesive

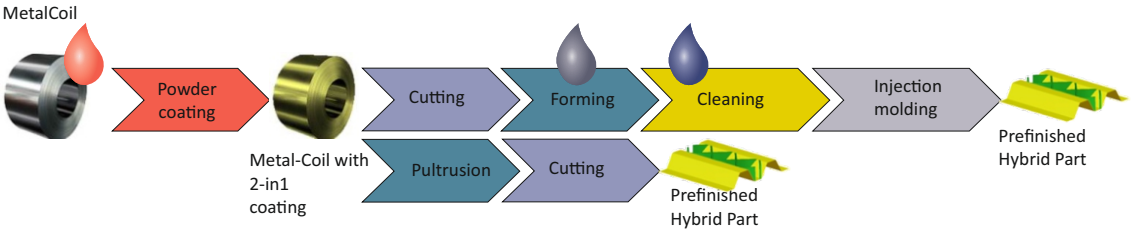
Highly flexible (deep draw able) and weather resistant powder coating basic formulations were enhanced in a manner, that an additional chemically latent reactive joining function for a covalent bonding beside corrosion protection, surface refinement and formability was integrated into the layer. The basis for this was the development of a special catalyst resulting in a selective two-step curing of specific powder coatings in the past.
By using this curing mechanism for powder coating layers, robust, material bonded multi-material-hybrid structures can be achieved easily.



Two-step powder coating curing mechanism in context to hybrid formation

Material- and technology development

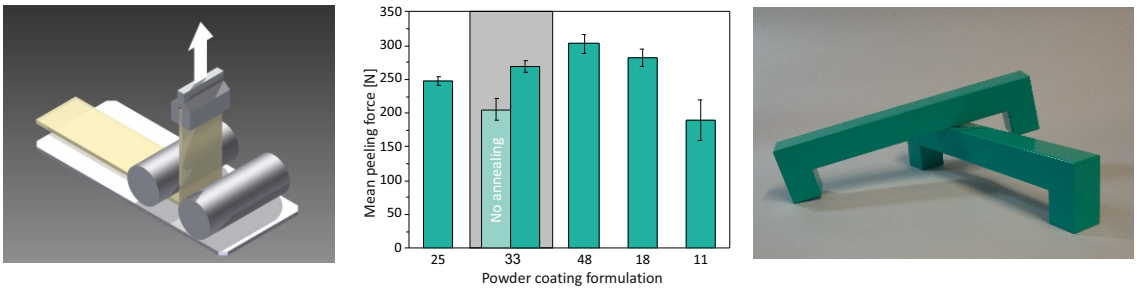
This function integration leads to a drastic shortening of the existing process chain for the fabrication of multi material-hybrid-structures together with saving resources, energy and money.
Material bonded joints can be generated for example by injection or thermal molding as well as pultrusion process.



Innovative process chain shortening for material bonded multi-material hybrids: top via injection molding, bottom via hybrid pultrusion

Example 1:

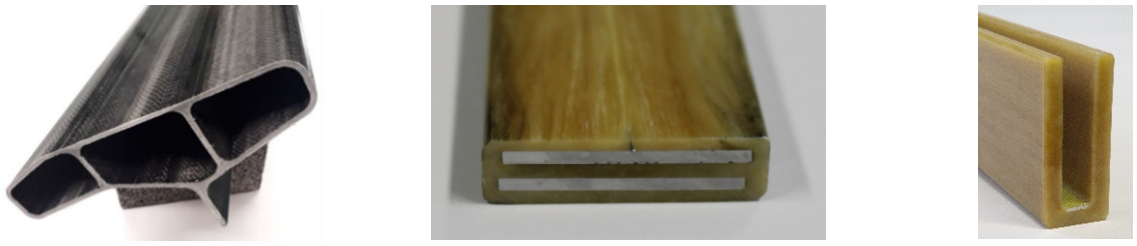
Material-bonded multi-material structures (metal-powder coating-thermoplastic) based on powder coating pre-coated Al-coil and hybrid formation via injection molding



Peeling force of various powder coating formulations for the use as latent reactive adhesive: Al + powder coating layer + TPU realized by injection molding, demonstrator component (right)

Example 2:

Material-bonded multi-material structures (metal-powder coating-FRP) with powder coating pre-coated steel-coil, GF reinforced epoxy matrix and hybridization via hybrid pultrusion



Various metal- GF-thermoset hybrids: demonstrator side sill (left), demonstrator with 2 metal inserts (center), demonstrator slide rail (right)

Contact

Leibniz-Institut für Polymerforschung Dresden e. V.
Department Materials Engineering
Dr. Michaela Gedan-Smolka
E-Mail: mgedan@ipfdd.de
T +49 (0)351 4658 448

Department Processing Technology
Dr.-Ing. Ines Kühnert
E-Mail: kuehnert@ipfdd.de
T +49 (0)351 4658 368

Hohe Straße 6 . 01069 Dresden . Germany
www.ipfdd.de

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