Development of a novel Polymer Metal Composite for Brazing Applications

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Many industrial components and structures are manufactured by means of brazing technology. The brazing of aluminum alloys is one of the standard manufacturing processes for the industrial production of brazed standard components, which are found in many areas of everyday use e.g. brazed pipe components of vehicle air conditioning systems or distribution pipes in heat exchangers or refrigerators. Brazed aluminum components can be found in a wide variety of products in the fields of mechanical engineering and electrical engineering, where a precise deposition of the filler metal at the joint plays a central role for accurate and high quality brazing results [Mü95, Dl08]. Aluminum based braze metals are supplied usually as powders or wires. The braze powder has to be fixed in a precise way to enable a deposition onto the components to be brazed especially by complex curved structures. At present this is done by preparing pastes from the powders using aqueous or organic solutions with certain amounts of dissolved organic binders. The deposited pastes must be dried accurately, because the evaporating solvents would inevitably compromise the brazing quality and final performance as they could cause air inclusions and porosities [Mü95, Ja05].

Combining thermoplastic polymers and braze metal powder in polymer-metal composites offering new possibilities to solve these challenges [Ho13]. The solvent-free composites can be used to produce tailored made components applying thermoplastic master forming techniques. Especially the injection molding process provides an economical technique to produce customized composite preforms in large quantity.

In this research the development and production of composite preforms, made of polymeric matrix and aluminum based braze powders is presented, accompanied material modeling and process simulation.

Highly filled polymer-metal composites were compounded and further injection molded into ring-shaped parts applicable as braze metal preforms in brazing processes. As polymer matrix, low-density polyethylene (LD-PE) was used. Furthermore, aluminum-based braze metal microparticles were admixed to the polymer matrices in filler contents of 50 vol.-%, 60 vol.-% and 65 vol.-%. To evaluate the distribution of the microparticles and the interparticular interactions, SEM micrographs of injection molded composite specimen were produced. For the characterization of the residue-free decomposition of the polymer matrices TGA was used. The results show a thermal stability of the matrix and the composites up to 505 °C (see Figure 1), so that a trouble free brazing process with this novel composite is expected. The SEM pictures and the TGA measurements indicate homogeneous materials with the adjusted filler contend.

The processing of high-filled compounds via injection molding places high requirements on processing technology and processing parameters. Due to this rheological and thermal properties of LD-PE + 60 vol% Al-composite were examined for creating a simulation model. Viscosity, pvt and thermal conductivity measurements at a wide range of shear rate, temperature and/or pressure were performed. The process related effect (viscosity) of LD-PE polymer melt was enhanced up to four times by adding 60 vol% Al braze metal particles. LD-PE show increasing specific volume versus temperature, decreasing with pressure and braze particle filler content. Thermal conductivity of LD-PE was increased up to 20 times in the composite. Furthermore, thermal analysis was performed in modulated DSC to determine the specific heat capacity in wide temperature range. Viscosity and pvt-data were modeled using Cross-WLF equation and 2-domain Tait-pvt model, respectively. Simulation of LD-PE + 60 vol% Al composite was performed based on rheological and thermal properties to define processing parameters. The simulation was applied to identify the processing parameters for a high quality fabrication (e.g. without air traps) of the composite preforms. Injection molding of ring-shaped LD-PE + 60 vol% were carried out to validate the results of the simulation (see figure 2).

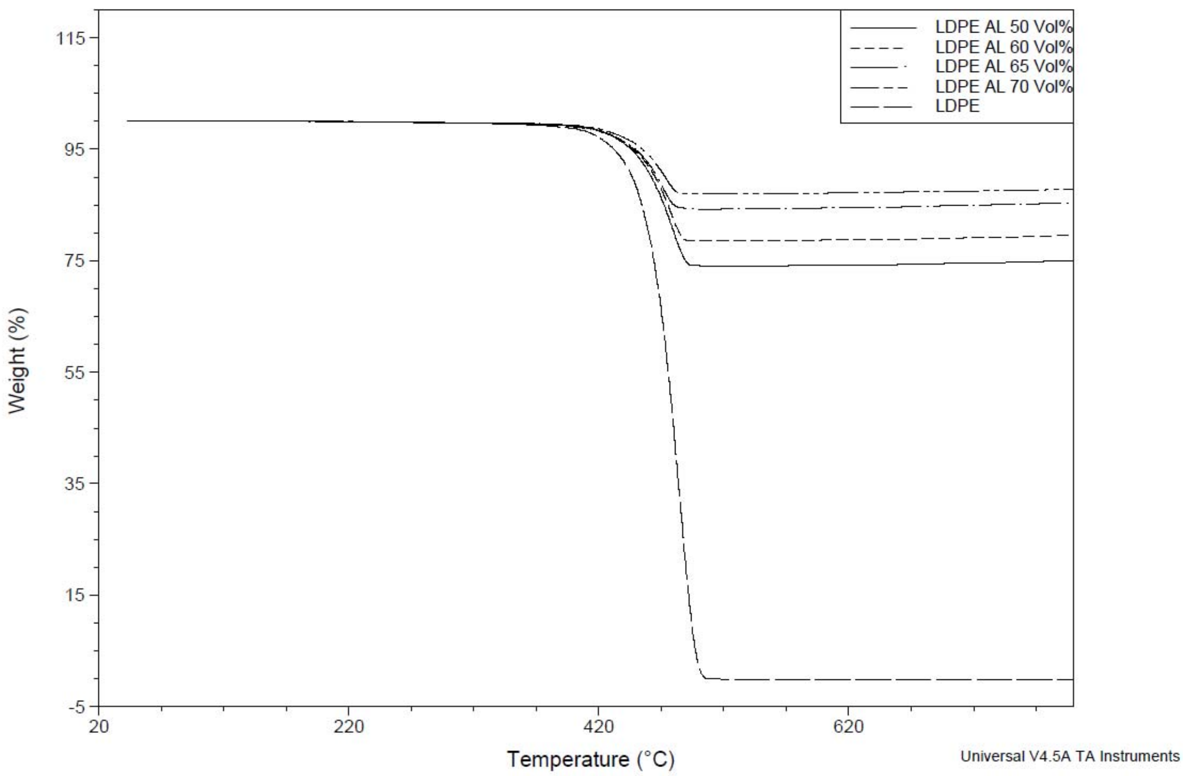

Figure 1: Thermogravimetric analysis on polymer-metal composites to determine thermal degradation behavior

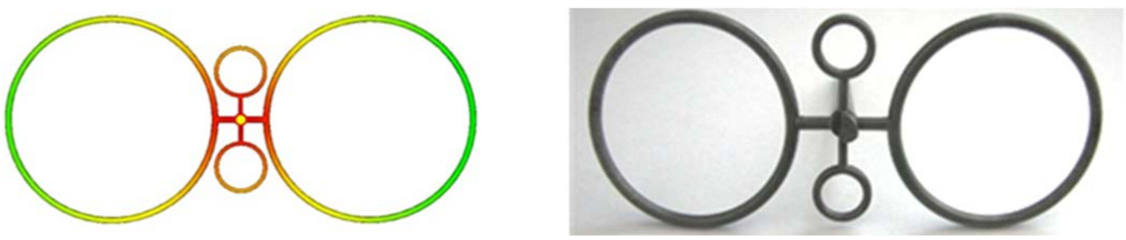

Figure 2: Flow simulation (left) and injection molded (right) ring-shaped LD-PE + 60 vol.-% Al composite preforms.

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