Phenomena Of Forming And Failure In Joining Hybrid Structures – Experimental And Numerical Studies Of Clinching Composites And Metal

Julian Vorderbrüggen[1, a)], Benjamin Gröger[2, b)], Robert Kupfer[2, c)], Maik Gude[2, d)], Gerson Meschut [1, e)]

[1]Laboratory for Material and Joining Technology, Paderborn University, Paderborn, Germany
[2]Institute of Lightweight Engineering and Polymer Technology, Technische Universität Dresden, Dresden, Germany

[a)] Corresponding author: julian.vorderberueggen@lwf.upb.de
[b)] benjamin.groeger@tu-dresden.de
[c)] robert.kupfer@tu-dresden.de
[d)] maik.gude@tu-dresden.de
[e)] gerson.meschut@lwf.upb.de

Abstract. To increase the level of lightweight constructions, hybrid components made of glass fiber reinforced thermoplastics (GFRP) and metals are used increasingly in automotive and aviation applications. For joining such materials, both adhesive bonding and mechanical joining processes are in the focus. Clinching processes are particularly suitable to attain positive locking and permanent, non-detachable joints. Without using any additional components high levels of lightweight construction will be achieved. Conventional clinching processes are limited for such purposes due to the reduced ductility of GFRP at room temperature. For this reason, a novel thermally supported joining process is developed for thermoplastic GFRP-metal components using an innovative split die, based on the clinching process known from metallic materials. Hereto, offsetting and subsequent upsetting can provide a non-detachable joint in a single-stage process, without further joining elements and pre-holes. Furthermore, the metallic material is not broken, so that media tightness is still guaranteed. In this paper the influence of the process temperature and the die design on the material structure as well as the load carrying capacity of clinched metal-GFRP components is presented. Additionally, approaches for a simulation-based process development to identify an appropriate heating strategy and the associated process parameters are discussed. The heating is initiated in a defined area around the joining zone with the aim of a controlled softening of the thermoplastic matrix close to the melting temperature, whereby a low-damage fiber displacement during the clinching process is ensured. Using the finite element method estimates the process windows and limits. Based on this, a virtual manufacturing tool design can be performed with the aim to minimize damages in the joining zone. The evaluation of joint-induced fiber damages is carried out with the aid of imaging techniques such as computer tomography and microscopic specimens.