Stamp forming of Thermoplastic Automated Fiber Placement blanks: influence of layup parameters on part quality

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Abstract. Compared to thermoplastic processing chains based on conventional woven organo sheets, stamp forming of unidirectional fiber-reinforced materials offers opportunities such as enhanced part performance by tailored fiber architecture, or economic and ecologic benefits by scrap reduction. However, before stamp forming, stacks need to be built layer-wise from tape material and subsequently consolidated to a blank, which is cost-, time- and energy-consuming. Thermoplastic Fiber Placement technology is able to layup tape material and consolidate the laminate up to a certain degree at the same time. The aim of this study is to investigate the influence of the degree of consolidation obtained during layup on the part quality of formed parts, and compare these results to parts made from preforms that were consolidated in a separate step.
Specimens were manufactured with a Coriolis AFP machine. Wedge-peel testing was examined to determine correlations between nip point temperature, feed rate, layup tool temperature and degree of bonding. Nip point temperature was found to govern the consolidation quality. Based on the results, parameter sets were defined to manufacture stamp forming preforms. The forming experiments were conducted with an infrared heating system and a hydraulic heating press, process parameters were kept constant. A 2D flat plate and 3D cone geometry were investigated. The processed parts were characterized by thickness measurements, optical 3D scanning and mechanical three-point-bending testing. Alongside, microsections were prepared and void content was measured at all processing states. After stamp forming, no significant differences were found between parts made from preforms with good and poor degree of bonding regarding the topology measurements and mechanical performance. However, differences were found regarding the obtained porosity values. Results prove the capability of this processing chain to produce high-quality parts from preforms that were layed up at high layup speeds, or that even show poor consolidation.

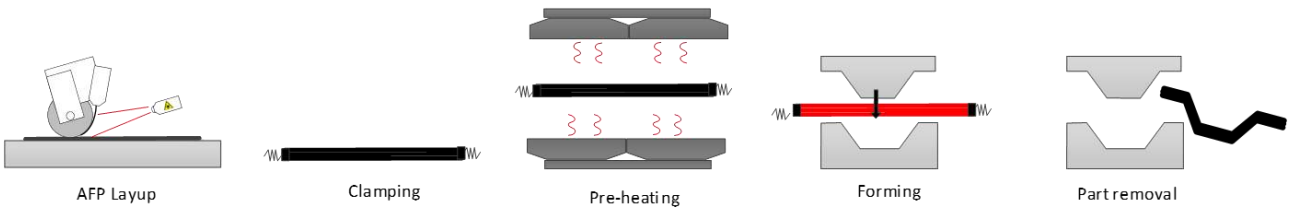

Figure 1: Processing chain investigated

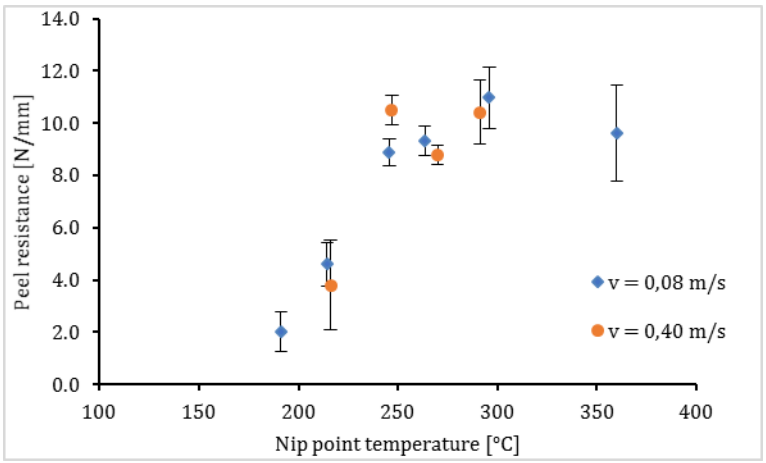

Figure 2: AFP degree of bonding analysis by wedge-peel testing: peel resistance [N/mm] over nip point temperature [°C]

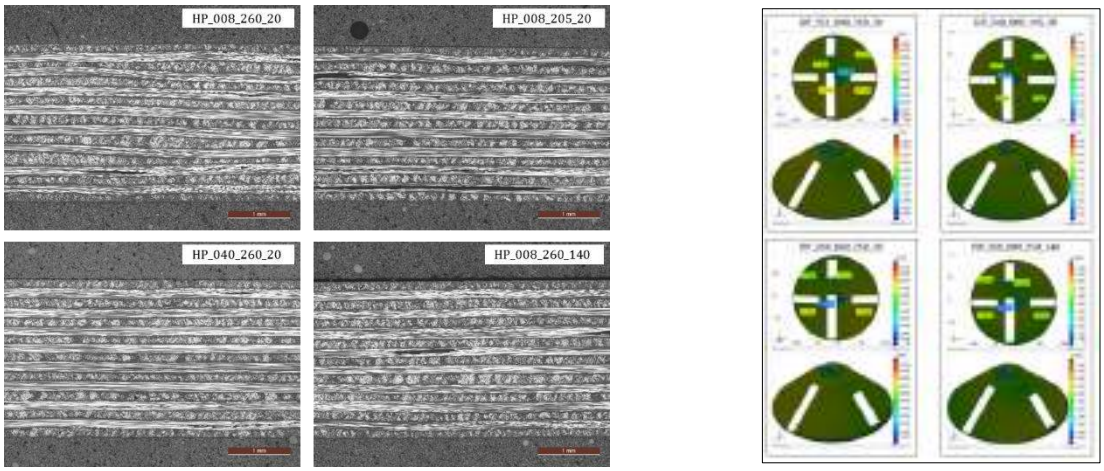

Figure 3: Stamp forming part characterization: microsections & 3D scanning

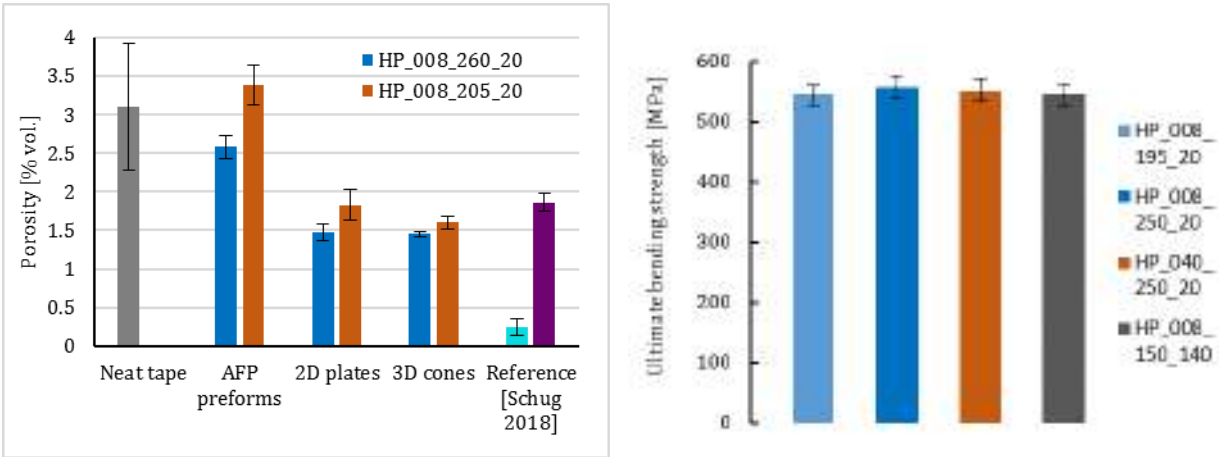

Figure 4: Stamp forming part characterization: porosity & 3-point bending