Insertion behavior study of multi-material self-piercing rivet joints by means of finite element simulation

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Abstract. Over the last few years, fuel economy improvement has driven the use of efficient multi-material structures in the car industry. The combination of dissimilar materials, such as metal-metal and metal-polymer, is a complex issue that requires the use of different and emerging joining techniques. In this context, self-pierce riveting (SPR) is an extremely suitable technique for joining two or more metal sheets, particularly when other techniques are not applicable. SPR requires short manufacturing times and provides both high strength and high fatigue resistance. Yet, this technique still faces some hurdles, such as joining Ultra High Strength Steels (UHSS) with high strength low ductility aluminium alloys, which can result in sheet metal tearing or rivet cracking. Suitable process parameters, including the rivet size and the die profile, are usually obtained through a physical testing procedure to satisfy the required joint specification. This is both expensive and time consuming. Finite element simulations of SPR are being increasingly used to reduce the number of physical tests and to estimate the tensile strength of the joint. The capability to accurately simulate aluminium to aluminium riveting has been demonstrated in recent studies. However, very few simulation studies have been conducted on the riveting of UHSS to aluminium, mainly because this type of joint is a relatively new customer demand driven by the rapid adoption of mixed material car body structures. New rivet designs have recently been developed for joining UHSS to aluminium, these rivets have increased column strength and increased stiffness to enable piercing through UHSS materials. In this study the insertion behavior of these higher strength rivets has been simulated and numerical analysis has been conducted to investigate the influence of the key process parameters on the joining result. Experimental results were used to calibrate the initial simulations then a selection of joints were made and simulated to compare the results.