Chapter 13
Joining Sheets to Tubular Profiles by Tube Forming

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ABSTRACT

This chapter presents an innovative forming process for joining sheet panels to tubular profiles at room temperature. Finite element analysis and experimentation are utilized to understand the deformation mechanics of the process, to identify the operational feasibility window, and to discuss the capabilities across the useful range of working conditions. The feasibility of the proposed joining process is demonstrated by presenting conceptual applications and industrial prototypes comprising a seat-back bottom frame and an automotive hand-brake system. Results show that joining sheets to tubular profiles by means of tube forming can successfully replace conventional joining technologies based on mechanical fixing with fasteners, welding, or structural adhesive bonding.

INTRODUCTION

Conventional technologies for joining sheets to thin-walled tubes encompass mechanical fixing with fasteners (nuts and bolts or rivets), welding and structural adhesive bonding. Although these joining technologies are very different of one another, their universe of applicability is limited by aesthetic, physical, chemical and mechanical requirements.

The utilization of mechanical fasteners usually suffers from unwanted aesthetic features, corrosion problems or functional difficulties related to the maximum effort that nuts, bolts and rivets can support safely. Welding has similar problems to those mentioned for mechanical fasteners plus specific difficulties related to the heat-cooling cycles and to the weldability of materials namely, dissimilar materials (e.g. joining steel or alu-

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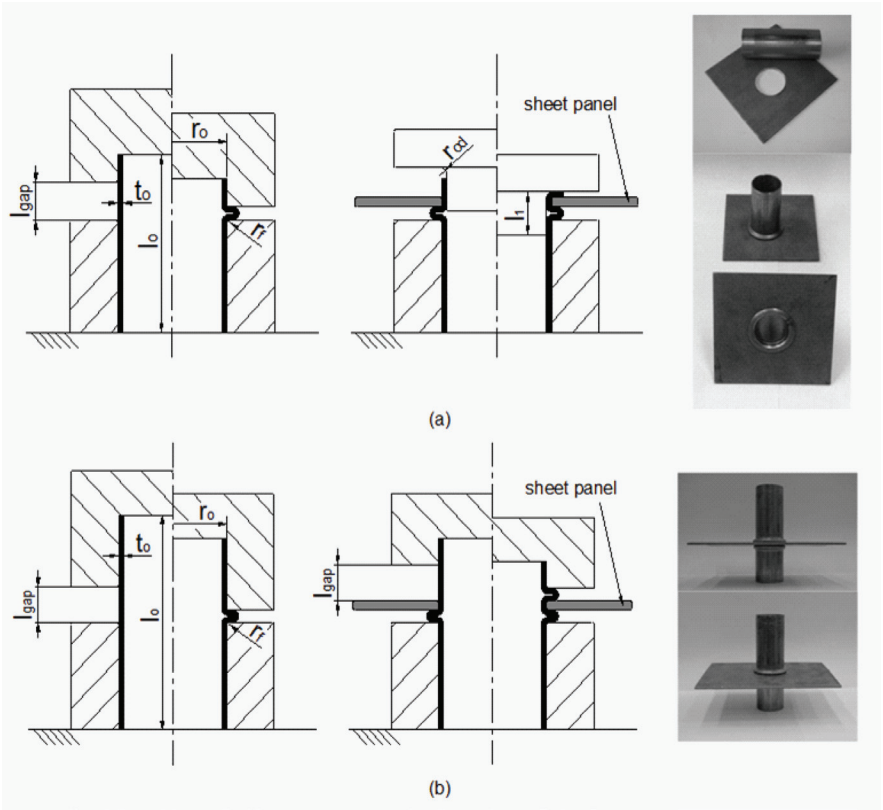
minium tubes to aluminium or copper sheets). Structural adhesive bonding offers engineers the possibility of joining different types of materials while improving aesthetics by avoiding rivets and bolt heads. However, adhesives require careful preparation of the surfaces where they are to be applied and may experience significant decrease in performance over time and in the presence of hostile environmental conditions (e.g. prolonged expose in moist environments).

This chapter presents an alternative technology for joining sheets to thin-walled tubes that is capable of ensuring a more efficient utilization of raw materials and a better end-of-life management of products than currently available technologies based on mechanical fixing with fasteners, welding and structural adhesive bonding. The technology is built upon the fundamental modes of deformation of tube forming and is schematically described in Figure 1 for two different operative setups; compression beading followed by external inversion (Figure 1a) and two-stage compression beading (Figure 1b).

In case of Figure 1a, compression beading promotes collapse of the tube under local buckling and gives rise to an axisymmetric bead. This mode of deformation is ensured by forcing the upper against the bottom tube end while leaving a gap opening in-between the dies that support/hold the tube. External inversion clamps the tube to the sheet panel placed on top of the bead. This mode of deformation is accomplished by compressing the upper free end of the tube with an appropriate external inversion punch. In case of Figure 1b, clamping the tube to the sheet panel is ensured

Figure 1. Joining sheets to tubes by tube forming. a) Compression beading followed by external inversion and b) two-stage compression beading



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