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Fatigue behaviour of tensile-shear loaded clinched joints

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Abstract

The present work concentrates on the static and fatigue behaviour of tensile-shear loaded joints obtained by clinching, a rapidly developing cold welding technology for thin sheets used is in automobile, electronic and house hold appliances industries. The project primarily dealt with static, fatigue and residual strength tests, which showed a good fatigue behaviour of the clinched joints. Fractographic observations showed three different failure modes whose occurrence depends on the maximum applied load and on the stress ratio. Results were supported by FEM analyses showing that the failure regions of the clinched joints correspond to those with high stress concentrations.

Keywords: Clinching; Mechanical joining; Sheet metal; Joining strength

1. Introduction

Developing lightweight structures and high productive rates are two of the main goals for the automotive, electronic and house hold appliances industries. Recent years have seen the development [1,2] of a new generation of interesting industrial mechanical joining techniques for thin sheets, such as self piercing riveting, short pipe riveting and clinching, as an answer to the drawbacks of more traditional spot welding. Basic studies on the static mechanical behaviour are present in literature for these new technologies: see [3] for self piercing riveting [4], for short pipe riveting [5–9], for clinching and [10] for a comparative investigation on the tensile-shear behaviour of the different techniques. However, very few papers deal with the fatigue behaviour: see [11–13] for the case of clinching.

The present work concentrates on clinching, a cold welding technology for thin sheets which is rapidly developing in the industries mentioned above (Fig. 1a). This type of joint is obtained (Fig. 1b) by a round or

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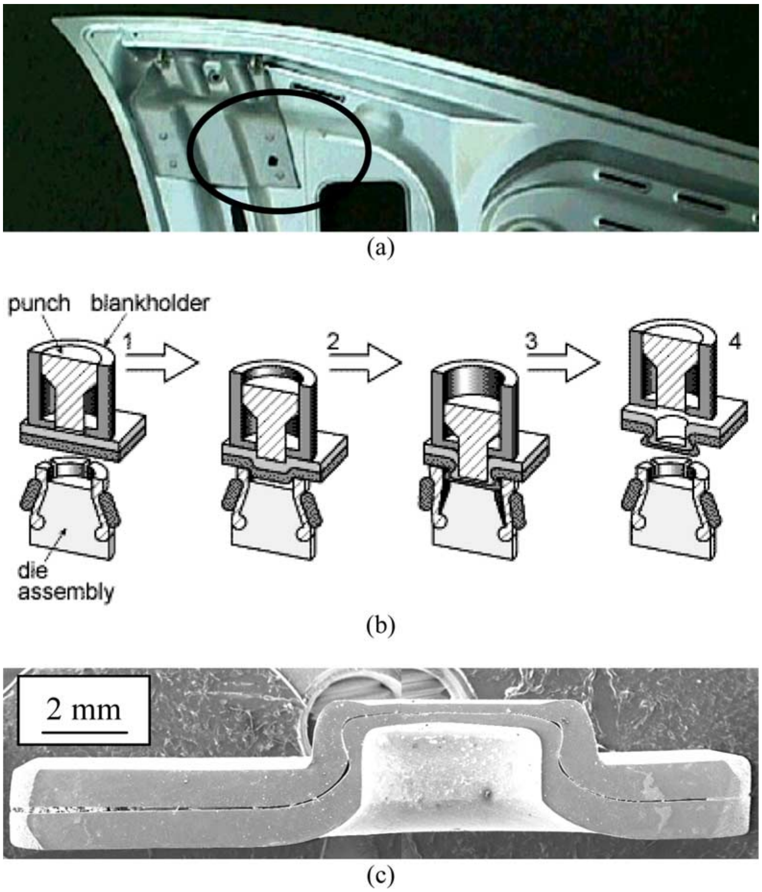

Fig. 1. Clinching technology: (a) application in automotive industry (Car bonnet—courtesy of Porsche AG), (b) technological process (Clinching process—courtesy of BTM Corporation) and (c) section of a "clinched point" showing the indentation.

square punch which, by punching material into a die, forces a slip in the sheets and the formation of a local permanent set (indentation), as shown in Fig. 1c. The tools are designed in order to create an undercut which guarantees the mechanical interlock between the sheets. Depending on the geometry of the adopted tools, different types of clinching can be obtained [5]: in the present work, the Straight-Wall-Style Solid Die type will be considered.

Clinching technology allows [5] the joining of two or more metal sheets (made of the same or different materials and up to a total joint thickness of about 5–6 mm) regardless of surface condition (painted, lubricated, coated or oxidised) and without any edge preparation. After the joint has been made, there is no need for repainting the sheets or performing stress relieving treatments.

Compared to other joining techniques, clinching is a fast process, easy to automate and thus particularly suited when high productivity is needed. One of the main features of the clinching process is the absence of thermal flow during joint forming and the avoidance of residual stresses induced by thermal distortion and grain coarsening. Moreover, since no welding materials are used, there are no supply or storage costs and the chemical contamination of the joint is lower. The absence of fumes, emissions and high currents also ensures a low environmental impact. Finally, the quality of the joint can be investigated with simple non