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Overview on the state of development and the application potential of dieless mechanical joining processes

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In the course of ongoing development of mechanical joining technologies, different technologies were developed in the last years, where often the necessary die as contrary die was substituted by a flat anvil. Using the example of dieless clinching, the full potential of such process alternatives is visible. If the tools, as the punch or the blank-holder are modified and the necessary die is substituted by a flat anvil, then several advantages for the process alternative – the dieless clinching – emerges. For example, it is possible to produce a one-sided flat connection, which is not producible with any other joining technology. Additionally it is possible to enlarge the application potential of mechanical joining technologies as for example semi-finished parts made of magnesium can be partially heated and directly joined without an increase in process time or a reduction in the process stability. The tool's costs, the necessary tolerances and the tool wear are significantly reduced. The publication includes an overview over the state of the development and the application potential with practical examples of different process alternatives.

Keywords: *mechanical joining, clinching, riveting, flat-clinch-connection, dieless-clinching, dieless-riveting, aluminium, multi-material-design, simulation*

1. Introduction

Modern joining by forming technologies such as riveting or clinching is used increasingly in sheet-metal-processing industries because of their many advantages. Moreover these technologies are often interesting joining alternatives of new developed products with multi-material design [1–3]. Their biggest advantages are:

- high economic viability,
- wide variety of materials which can be joined similar or dissimilar,
- the absence of temperature influences to the base material in comparison to mostly used thermal technologies such as welding or brazing.

A special benefit of clinch connections is the possibility of joining without ancillary joining elements, such as rivets.

The reasons for developing dieless mechanical joining processes were manifold. The major motives are:

1. Gain improvements in process technology
   - no need of coaxial alignment between punch and die,
   - possibility to directly heat up components fast and easy by pushing them against the pre-heated flat anvil, to join even brittle materials, such as magnesium,

• reduction of space requirements inside of structures to be joined (no axial movement of die is necessary to pull out the protrusion of the die),

• reduction of tool and process costs

• die shape (see Figure 1) is expensive to manufacture and has higher tool wear than flat anvils, because flat anvil can be as hard as possible, e.g. carbide materials,

• no dependence between tool shape and joining task (material, thickness)

2. Optimization of connection properties:

• facilitated cleaning and painting of surfaces,

• reducing efforts at preparation of component flanges e.g. for sealing strips or welting,

• especially for flat clinch connections (see Figure 2e): manufacturing of one-sided completely flat connections allows a use of connection in visible areas or for piling up identical parts.

Fig. 1. conventional dies for clinch process: a) solid die, b) die with moving blades versus c) flat anvil as counter tool

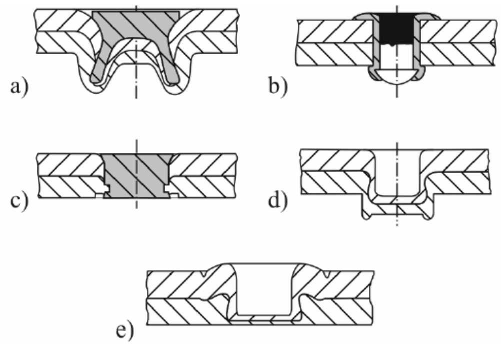

Fig. 2. Different kinds of mechanical joining Connections: a) hollow-self-pierce punch-rivet, b) blind-rivet, c) solid self-pierce punch-rivet, d) clinch, e) flat-clinch-connection

So far 4 different mechanical joining technologies have been developed and investigated, which use flat anvils as counter tool to create a form- and force-closed connection between two metal sheets. Figure 3 shows a classification of dieless joining technologies. They can be divided into processes with and without the need of ancillary parts, with or without material cutting inside of the connection and divided into connections with or without protrusions on anvil-sided component part.

The main objective was to realize a comparable technology with conventional processes with a die as counter tool, to keep the high economic efficiency and to be able to use similar joining machines. All shown technologies require an overlapping zone of the component parts for joining and at least three different tools which interact to create a mechanical joined connection. For dieless clinching [4–6], see Figure 4, in the beginning the component parts (1) and (2) are appropriate positioned between a punch (4), a blank-holder (5) and a flat counter tool – the anvil (3).