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UPSETTING OF BIMETALLIC COMPONENTS IN CLOSED DIE

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Abstract: *Metal forming technology has been applied to effective production of metallic components in various fields. One of the newer metal forming techniques is so called „joining by forming“. With this method two or more separate parts are joined together using plastic deformation. Self-piercing riveting, clinching and coin and medal production are some of the joining by forming operations, which have been successfully applied in industry. The present study is bound to a process of joining of two bimetallic axi-symmetric components from various materials by upsetting bimetallic components in a closed die. The external component is a ring and the central part is a cylinder – like element. By upsetting those two elements in closed die, inseparable workpiece has been obtained. Therefore, two different cases (geometries) have been investigated. In the first case the simple ring and profiled inner cylinder are combined while in the second case vice versa combination is applied. Also, forming load, material flow and filling of joint section were analyzed. The process has been investigated experimentally. In short, current investigation has yielded considerable insight into the process of joining two metallic components.*

Keywords: – bimetallic axisymmetric component
– closed die
– forming load

1. INTRODUCTION

Joining two or more components into one inseparable unit/assembly by using metal forming operations has been frequently applied in the industry, especially in the automotive and electronic industry. There exist different principles on which “joining by forming” are based.

Self-piercing riveting technique, Figure 1, [1] has been widely applied in the manufacture of thin wall structures and lightweight constructions, as an alternative solution to welding. In this process, two sheet metals are joined together by the additional component – rivet.

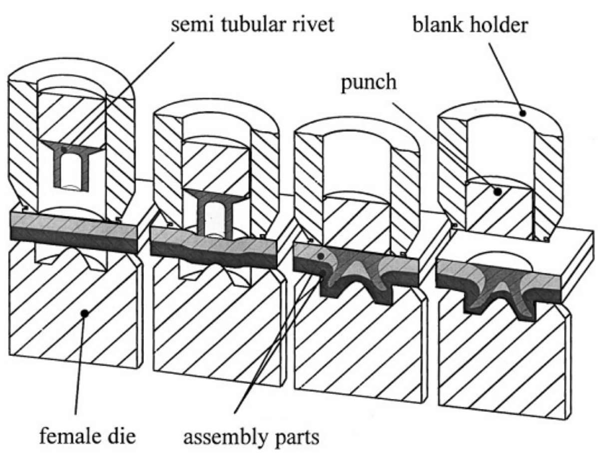


Figure 1. Self-piercing riveting technique [1]

Joining sheets are placed on the lower (female) die and pressed by the blank holder. The rivet is then pressed by the punch and it pierces the top sheet. During further penetration of the rivet into the lower sheet, spread forming, according to the shape of the female die, takes place. In this way, inseparable interlocking of two sheet metals is produced.

Angular joining by hydroforming [2] enables the unseparable connection between two tubular elements. The process strategy is illustrated in the Figure 2. On the bulge top of a horizontal tube (a „male component“), a vertical tube element (a „female component“) is placed. In the next step a „male component“ is set under hydraulic pressure and the axial force, which causes its expansion in the radial direction until male and female components have been joined. By further increasing the internal hydraulic pressure inside the „male component “an inseparable bond between two tubular elements has been created.

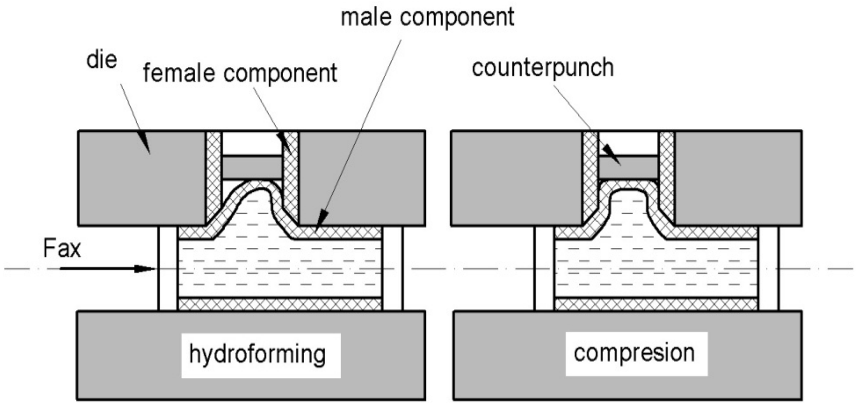


Figure 2. Angular joining by hydroforming [2]

Manufacturing of bimetallic coins, medals and similar products can also be performed by "joining by forming" technology [3, 4]. Although coins and like bimetallic components are more expensive to produce than one-piece coins, they are safer, i.e. "fake proof" and therefore they are applied in many countries of the world. As an example, an Italian 500 Lira coin is shown in Figure 3.

Figure 3. An Italian 500 Lira bimetallic coin

The production of bimetallic coins includes following steps:

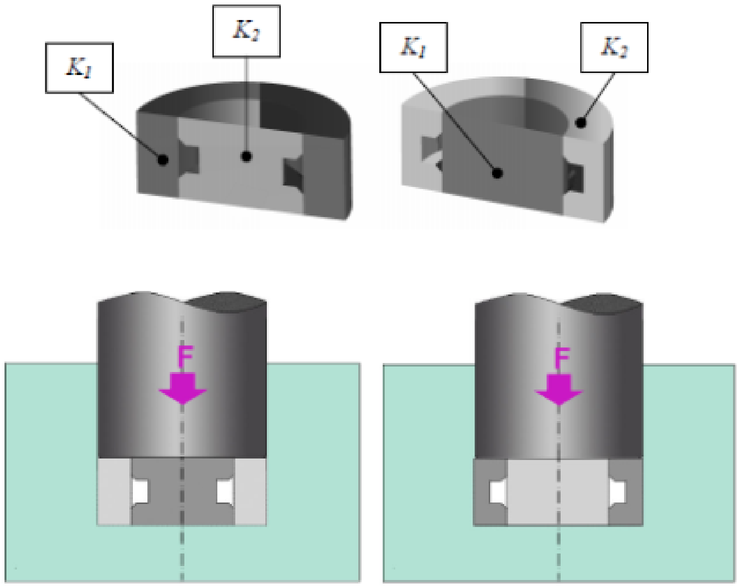
- Manufacturing of two elements to be joined: an internal central part and an external ring - like part
- Joining of the aforementioned two components in an inseparable way by so called "minting" operation. This compression operation is carried out in closed die [5, 6].

Within the scope of this investigation, the process of joining bimetallic axi-symmmertic components in two different combinations (models) has been conducted. Figure 4 represents the following models:

Model A – a simple ring (an outer element) and a profiled inner cylinder and

Model B – a simple inner cylinder and a profiled outer ring.

This analysis is concerned with the Model A representing a simple ring and a profiled inner cylinder. Experimental researches were performed in order to investigate the material flow and load requirement under the compression of two elements which are to be joined, elements from two different materials.



Model A Model B

Figure 4. Two models of bimetallic joining

2. EXPERIMENTAL INVESTIGATION

Joining process of two components is carried out by upsetting the central part of the ring in a closed die (Figure 4A). Dimensions of both components are given in Figure 5.
The material and flow curve of the components are:

- inner cylinder: C1531 (C45E);
  $$K = 289.671 + 668.779 \cdot \varphi^{0.3184}.$$
- outer cylinder: C1221 (C15E);
  $$K = 276.44 + 397.715 \cdot \varphi^{0.317}.$$

The experiments were performed in the hydraulic Sack & Kiesselbach press of 6300 kN. Upsetting was conducted in the closed die that was pre-stressed with three shrink rings. In Figure 6, the outer ring and the inner cylinder before assembling and placing into the die are shown.

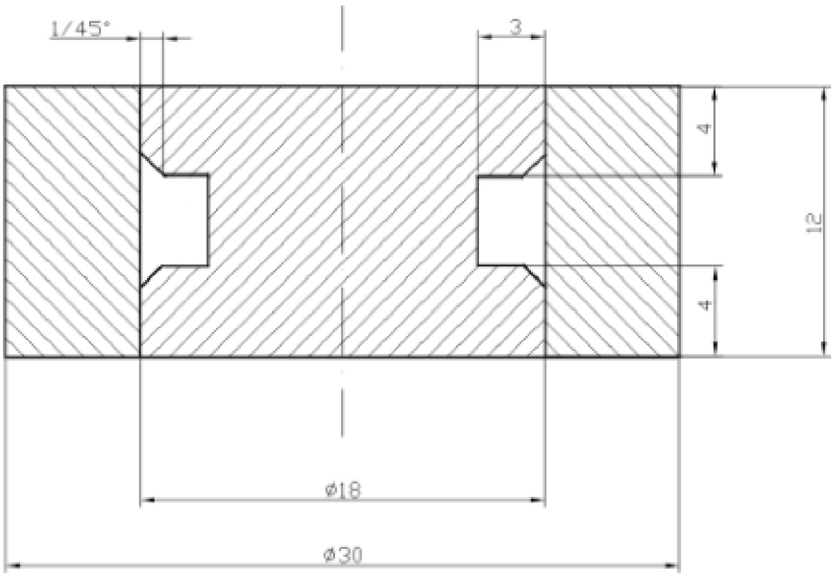


Figure 5. Dimensions of bimetallic components

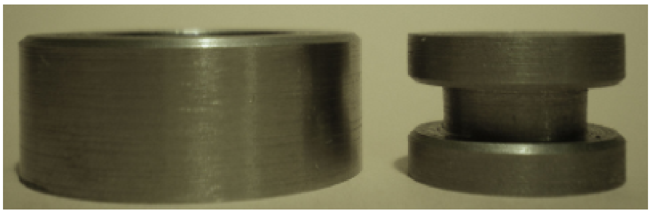


Figure 6. Bimetallic components

In order to have an insight into the material flow in different places of the upsetting process, four initially identical assemblies of inner and outer components were upset in separate trials with four different loads: 900 kN, 1200 kN, 1400 kN and 1600 kN. After that, compressed unit was taken out from the die and was cut through meridian plane (Figure 7). In this way, the material flow (cavity filling) was made visible.

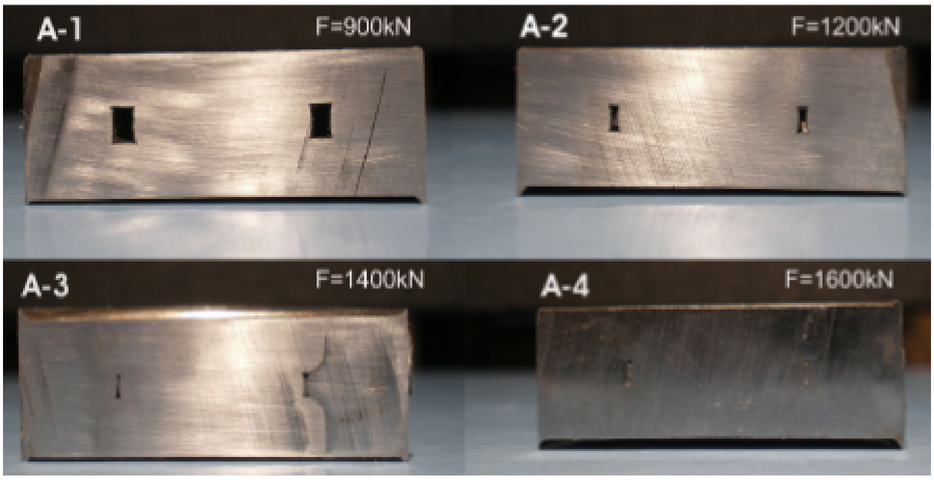


Figure 7. Cross section of cut bimetallic component

Load stroke characteristics for the first (maximal load 900 kN – Model A1) and last trial (maximal load 1600kN – Model A4) are given in Figures 8 and 9.

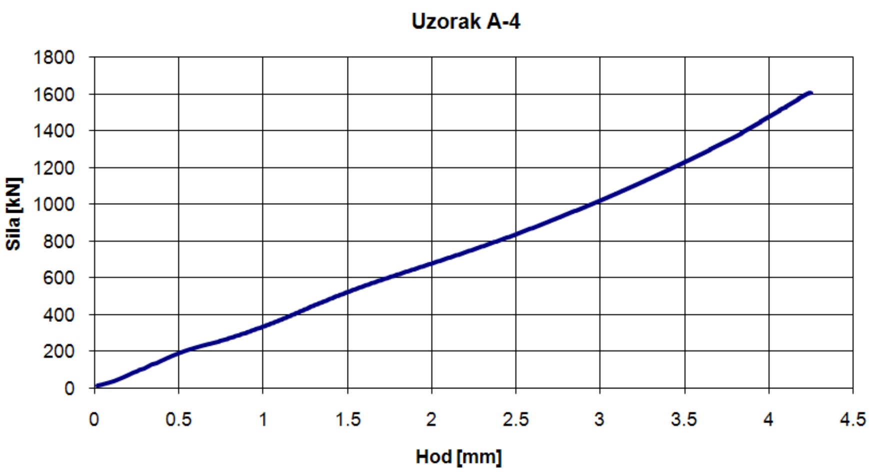


Figure 9. Load – stroke characteristic for the model A-4

3. CONCLUSION

Joining by forming axi-symetrical part from two different materials has been experimentally analyzed. The analyzed process resembles, in its main principle, to the manufacturing of bimetallic coins. In this process, the profiled central cylinder and the outer ring were put together and compressed in the closed die. The material flow (cavity filling) obtained by experiments was analyzed and discussed. As seen from experimental results shown in Figure 7, initial cavity is gradually being filled by the outer ring material, but also, to a lesser extent, by the central part material. In this way, inseparable component has been produced. The load exhibits permanent, gradual rise, with no inflexion in the curve. It should be noted that the stroke values represented in Figures 8 and 9 comprise elastic deformations not only of tooling but also of the machine on which experiments were carried out.

In further work, the influence of geometry of the initial cavity on the flow pattern as well as on the required load should be analyzed. Modelling by FE method of the process is needed and planned. The impact of friction in joining process should be investigated in detail.

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