

Methods of Increase of Ductility in Explosion Shaping of High-Strength Sheet Material

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Abstract

The outcomes of research on the increase of ductility of low-ductile materials are indicated in this work. Dynamic effects of increase of materials ductility and special technological methods are used to obtain by a method of explosive forming high-strength details. On the one hand, these methods are based on the increase of stability of the shaping process. On the other hand, they are based on the use of mass forces for additional submission of a material from a flange. The features of explosive forming also allow for an effective application of a universal equipment with special inserts from plastic mixture.

Keywords:

Explosive forming, Impulse forming

1 Introduction

The decrease of weight with simultaneous increase of automobile and aircraft details strength and reliability requires a more and more broad use of the new complicated form constructions from high-strength materials. The high-strength materials have as a rule deferred ductility, which makes the manufacturing of the details with complicated geometry by traditional methods difficult. The problem is decided by the application of forming during some transitions with intermediate thermal treatments, or by the application of methods of forming in a hot condition. Both variants essentially complicate technological process and increase its cost. Besides sheet materials with the previously created stratified structure the heat up to the temperature of the transformation phase is unacceptable. For prototypes and small series manufacturing the method of explosive forming offers new possibilities and technological methods.

2 Technological Methods

It is known that a number of materials, including high-strength ones, shows on high velocities large ductility [1]. The increase of ductility is observed in the limited range of deforma-

tion velocities. The further velocity increase again results from the material blistering. Therefore, it is very important during the designing of technological process not only to take into account dynamic material properties instead of a static one, but also to correctly select a velocity of loading. The velocity of loading is determined by a type of a source of impulse energy used (Figure 1) and by the amplitude-time characteristics of the impulse (Figure 2).

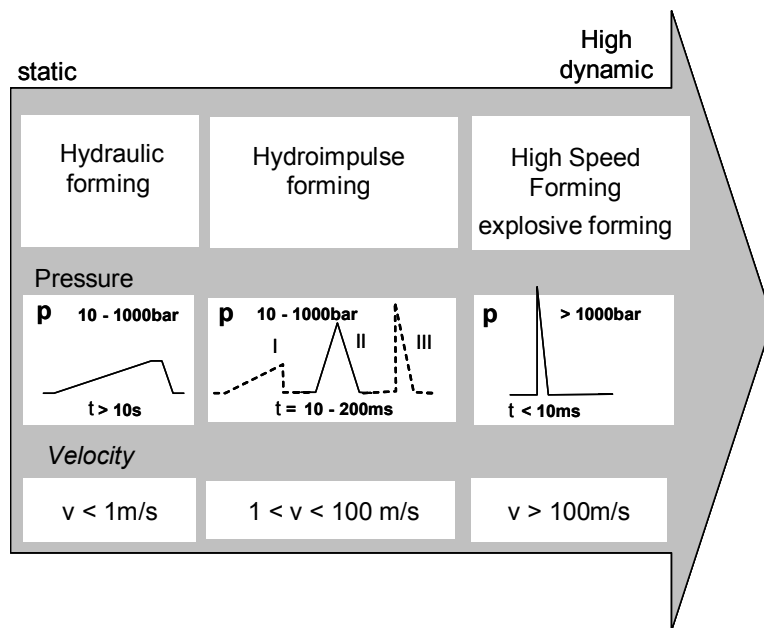


Figure 1: Systematisation of impulse power sources

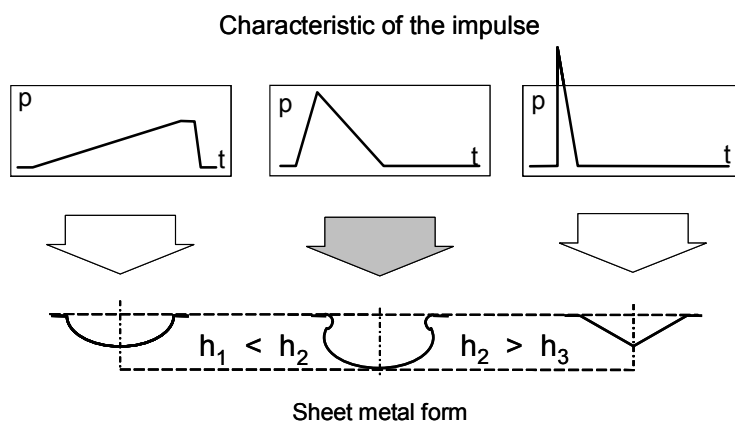


Figure 2: Influence of impulse characteristics

When an optimum velocity of deformation is selected it is possible to realise a deep draw-forming of details from materials which are difficult to deform during one technological transition (Figure 3).



Figure 3: The reservoir from a material Dual-Stahl RVS 1.4462 stamped by explosion (size 280 x 380 mm; 1,8 mm thickness)

Despite of a high velocity of a strain and connected to it local heating of a material, the initial stratified structure is saved in a material down to destruction during of large plastic deformations (Figure 4).

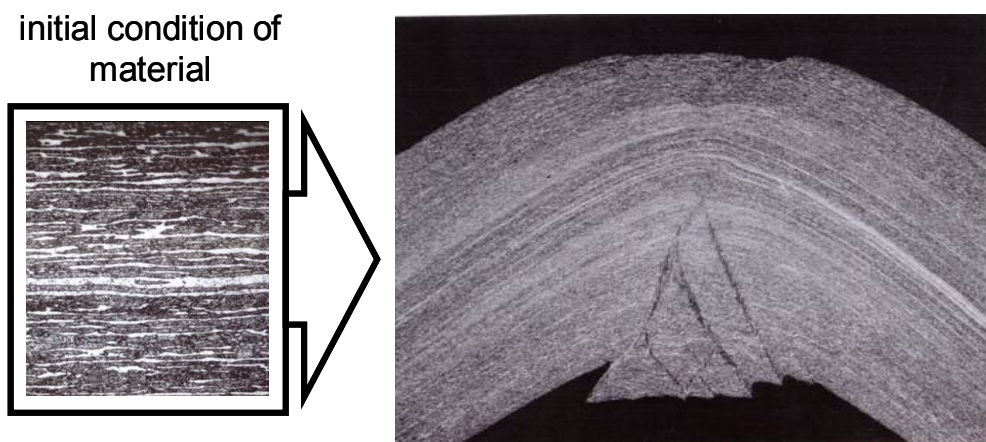


Figure 4: A structure of a material RVS 1.4462 before and after explosion forming

During the explosion forming a problem of dynamic loss of stability and formation of tucks acquires special significance. For providing a stable high-strength material shaping, it is necessary to create very large stretching gains in a sheet. If it fails to be made with the help of traditional methods there is the need to resort to special technological methods. Made-up closure of a billet outline with the purpose of increasing its stability is one of them. This method means that the nonclosed flat shells are stamped pairwise, using the billet of the closed cylindrical form. In Figure 5 the example of a flat shell with a radius of a curvature 6,5 m from a high-strength material GLARE® is shown. This material is a stratified aggregate from aluminium A2024 reinforced by fiber glass. Its deformation by traditional methods is very hard.

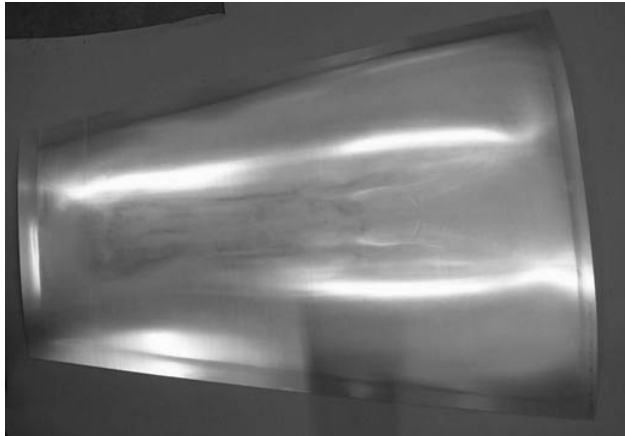


Figure 5: A flat shall from a material GLARE®

For manufacturing such details it is expedient to use a method of made-up closure of an outline. The billet for simultaneous forming of several details represents the cylinder. After dispensing the cylindrical billet by explosion in an equipment (Figure 6) and deriving of a preformed material, the details of a double curvature can be cut out from it.

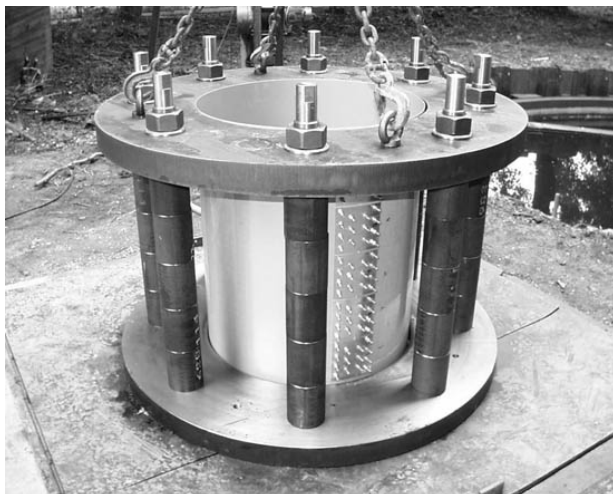


Figure 6: A closed outline billet and equipment for its dispensing by explosion

The given technological method is used for forming flat details from very thin sheets. It is effective for holding of free flanges of billet and prevention of crimps formation.

During the manufacturing of details with large depth of relief, the high-strength material reaches the limit of its deformable abilities. The depth of a relief as a rule is unequal and hardly located. Therefore, simultaneously with a shortage of material in the most deep places there is a problem of "wasting material" in places with small depth of a relief. The technological methods indicated below are directed on the control of a material streaming during an explosion forming.

The method of made-up breaking of an outline and forming of the closed details from billets of the nonclosed form is used for dispensing of rigid envelopes and profiles when material is insufficient for a full detail's molding. The ring frame (Figure 7) is formed by explosion from a nonclosed billet with an overcloak of an additional material.



Figure 7: A ring frame from a material A2024 T3

The method of a forced gathering of a material on an additional relief will be realised with the help of special inserts in a technological equipment (Figure 8). During the explosive forming these inserts can be executed from soft ductile materials due to a high velocity of deformation. They save the form during of impact with billet and deform it. The inserts are deleted on consequent technological transitions. Gathered on inserts the additional material is used for a main contour shaping.

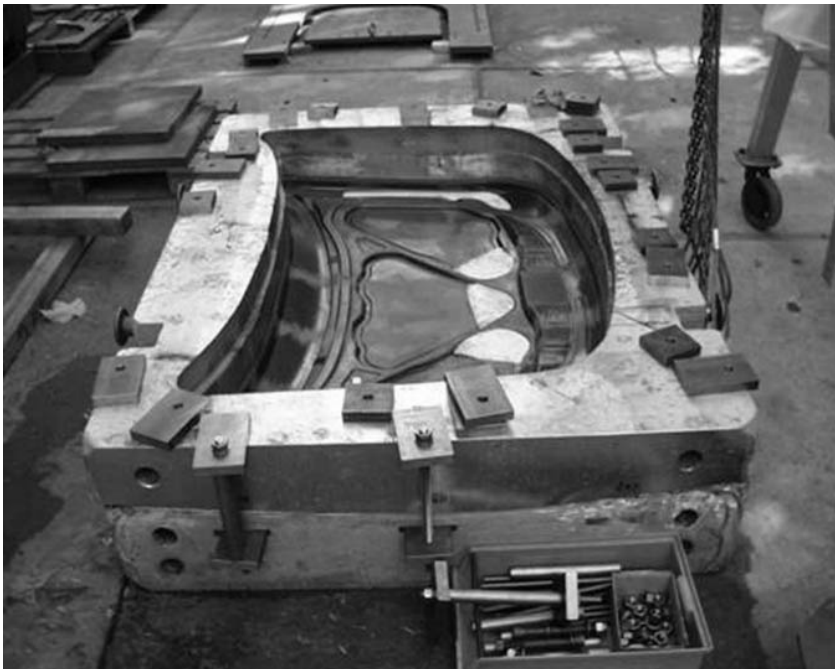


Figure 8: An equipment for explosion forming with technological inserts from plasticines

The dynamic character of details deformation during the explosion forming allows to use a technological method that is specific only for high-speed processes. pressure of explosion and force of friction about an equipment The dispersed up to large velocities billet as a whole and its separate sites are acted by explosion pressure and force of friction about an

equipment together with the mass forces. The mass forces are used for additional pushing of a flange (Figure 9) and thus for improving the conditions of deformation [2].

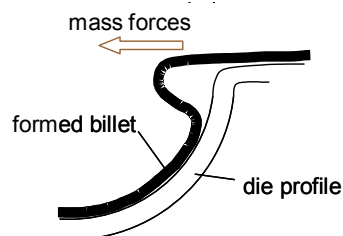


Figure 9: The scheme of submission of a flange at the expense of mass forces

At the expense of the given technological method use it is possible to obtain details of the unique form for one technological transition (Figure 10).



Figure 10: An equaliser of a torus form obtained from cylindrical billet

3 Conclusions

The use of special technological methods during the explosion forming allows to expand the possibilities of a technique and mould complicated details from high-strength materials successfully. The optimum selection of amplitude-time performances of an impulse provides the maximum use of the materials deformation ability. The additional stretching gains are created and stability of the shaping process is increased by the closing an outline of sheet billet. Thus, it is possible to stamp details of a very small curvature. The redistribution of a material in correspondence with the depth of a detail's relief is achieved by special inserts and control of a field of a load.

References

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