

New Achievements in the Field of Impulse Processing Technologies

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Abstract

The outcomes of research in the field of application of high pressure in a process engineering are stated. The high pressure is created by impulsive sources of energy, such as explosion of condensed explosive substances and gaseous detonatable mixtures.

Application of high pressure created by explosion for technological processes of sheet forming parts from metal and non-metal materials is considered. In the latter case, the mechanical properties in the process polymerisation of composite materials in the outcome of the impulsive loading significantly rise. The impulsive high pressure has a significant impact on handling - compressing of powder materials, on manufacture of special products, foundry forms and on destruction of rods in molten products.

Keywords:

Explosive forming, Impulse forming

1 Introduction

The review of existing methods of high impulse pressure deriving and practice of their technological application is given in the present work. The outcomes of an application of rigid and gaseous charges explosion for leaf forming of details and also for compaction discrete materials are stated. It is shown that a great expanding of the given technologies possibilities is possible at the expense of special dynamic effects. The use of impulse power sources is expedient for complicated items, which manufacturing by traditional methods is hardly hampered or generally is impossible.

2 High-Speed Processes

Various kinds and sources of energy are used for the realisation of technological processes of high-speed materials processing (Figure 1). With their help, impulses of high pressure with specific amplitude-temporary performances are received.

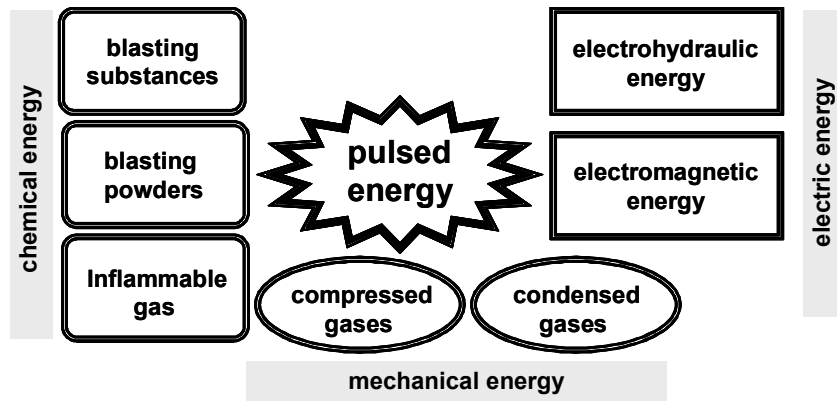


Figure 1: Sources of impulse energy

Blasting explosive substances was received the greatest application for the technological purposes. These substances have the highest specific accumulated energy. Depending on performances of impulse, the explosion can be used for the form modification, separation of a material, items mounting, covers plotting, and modification of materials properties (Figure 2)

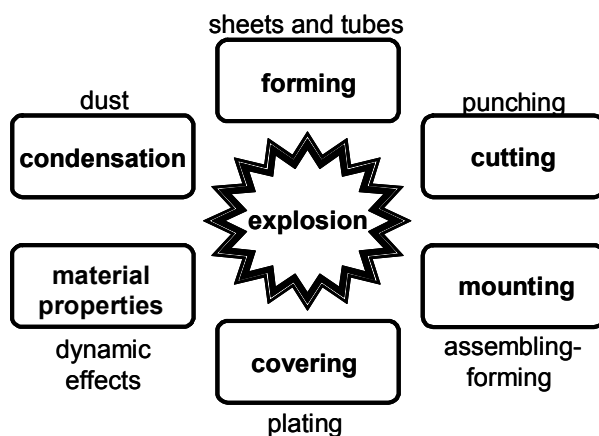
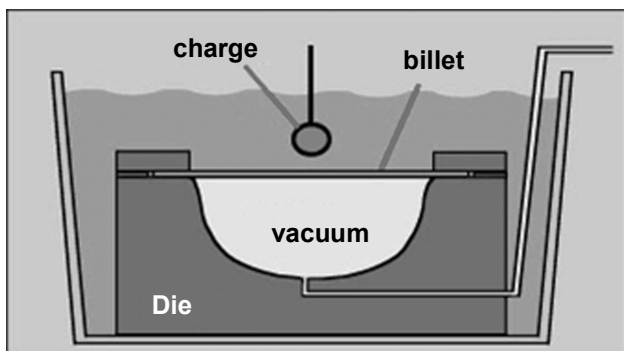


Figure 2: Areas of explosion energy use

The impulses of high intensity (explosion) are effective in operations of separation and over modification of materials properties (synthesis). For shaping operations try to use impulses with slanting performances. These impulses receive by damping explosive waves of pressure or by application of gaseous power sources.

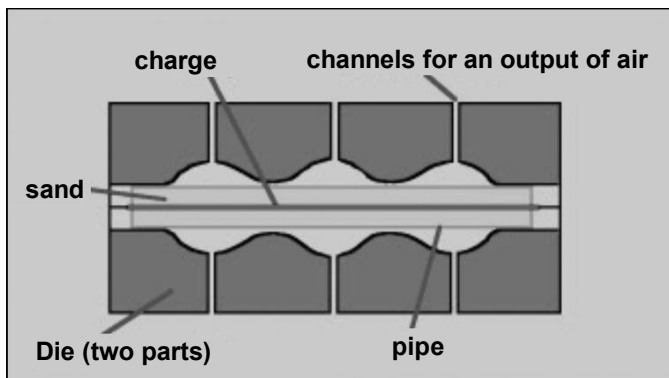
3 Technologies of Explosive Forming

The schematic diagrams of explosive forming of a sheet details (Figure 3) and pipes (Figure 4) give submission about some variants of the process.



explosive forming of sheet metals

Figure 3: Schematic diagram of leaf formings by explosion



explosive forming of pipes

Figure 4: Schematic diagram of pipes dispensing by explosion

The charges of the simplest forms, such as spherical (Figure 3) or linear (Figure 4), are usually used, though for details with a local relief the application of complicated three-dimensional charges and certain sequences of their initiation (Figure 5) is justified.



Figure 5: The complicated form charge in micropool to be destroyed

The transmitting medium is as a rule liquid (Figure 3, 5) or discrete (Figure 4). Technical water is used as a liquid medium, and wetted sand is mainly used as a discrete medium. Other types of transmitting media, for example jelly-like and elastic, allow to control impulse performances over a wide range, however their application is limited because of a high seller's price and low stability.

Explosion forming is realised in stationary pools (Figure 6), in reusable pools (Figure 7), or in micropools to be destroyed (Figure 5).



Figure 6: Stationary pool for explosion forming



Figure 7: Reusable microtank

A main advantage of explosive forming is the use of simplified cheaper equipment. Equipment made of concrete, raw-wood, plaster, or simple-work alloys is widely used in practice of explosive forming. The surface quality of an equipment can be improved at the expense of covers from plastic masses and easily be changed on intermediate transitions by use of inserts from plasticines (Figure 8).

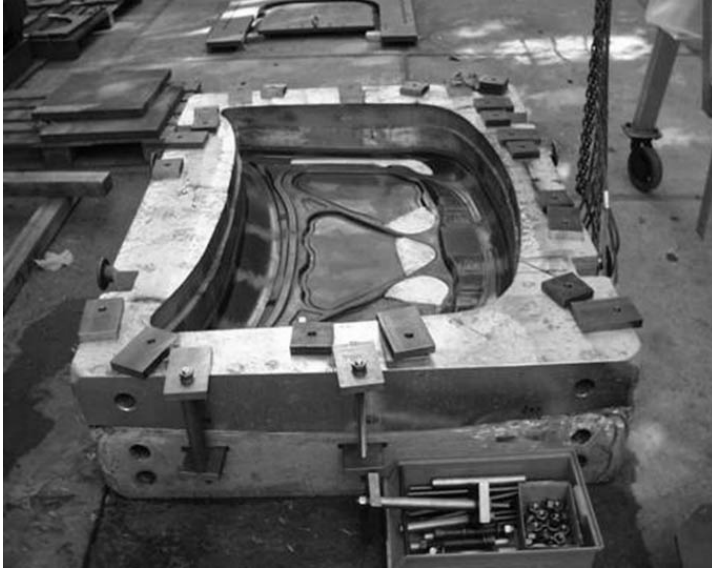


Figure 8: An example of an equipment for explosive forming

4 Outcomes

As a rule, explosive forming is effectively applied in small-scale and single production of details for a chemical mechanical engineering, power, aircraft building, and space technology.



Figure 9: Details made by explosive forming

The explosion forming gives good outcomes in the prototype manufacturing in the motor industry, too. The application of the simplified equipment, the possibility of forming of a different thickness billets from various materials on the same equipment is especially attractive to the designers which are developing new models of cars.



Figure 10: *The prototypes of details for motor industry*

Apart from traditional cold explosion forming, works on hot sheet metal details forming from low-ductile titanium alloys are conducted. By combined effect of dynamic pressure and thermal effects it is possible to receive details with unique properties.



Figure 11: *Details from low-deformable alloy stamped in a hot condition by explosion*

The experimentally established effects of significant increase of titanium alloys plasticity show that the phenomenon of "superplasticity" is exhibited not only over very small, but also over high velocities of a strain.

5 Alternative Power Sources

Despite of all advantages mentioned above, the application of blasting explosive substances is connected to special safety requirements. Therefore, impulse technologies based on alternate power sources, such as compressed gases and combustible gas mixtures, develop still faster. The use of combustible and compressed gases is possible in usual industrial conditions, though realised impulses are lower than over explosion. Within the framework of the programme DFG research of hydroimpulse forming processes, which is the perspective for the introduction under traditional production is carried out [1] During hydroimpulse forming the pressure in a transmitting medium forms by impact of the previously dispersed skew body. A schematic diagram and appearance of a unit for hydroimpulse forming are shown in Figure 12.

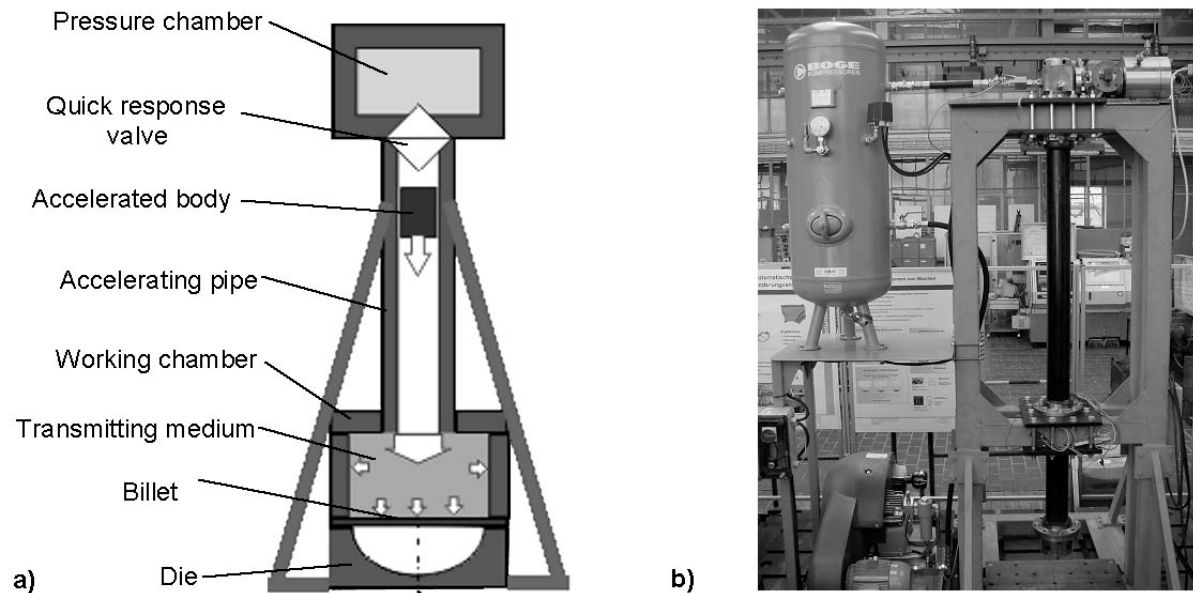


Figure 12: Schematic diagram a) and appearance b) of a unit for hydroimpulse forming

The hydroimpulse forming is effective for manufacturing small dimensions details with open (Figure 13) and closed (Figure 14) outlines.

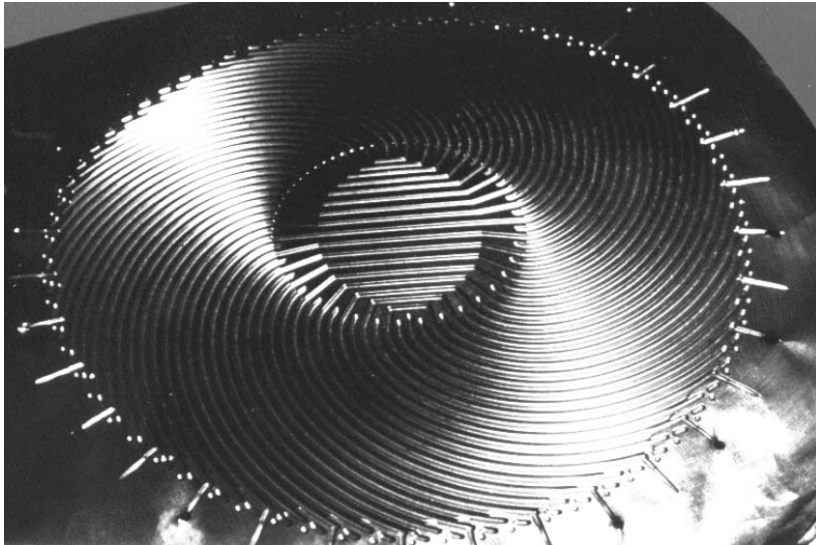


Figure 13: A details of the heat exchanger



Figure 14: An equaliser

Other rather perspective source of impulse energies are the combustible gas mixtures. Possessing lower denseness of energy and velocity of a detonation than blasting explosive substances, the mixtures of combustible gases are optimum for forming shaping operations and compaction of powders (see [2,3] for more details).

The equipment for forming gas-explosive (Figure 15) can be used in a usual technological cycle, and the process is easily automatised.

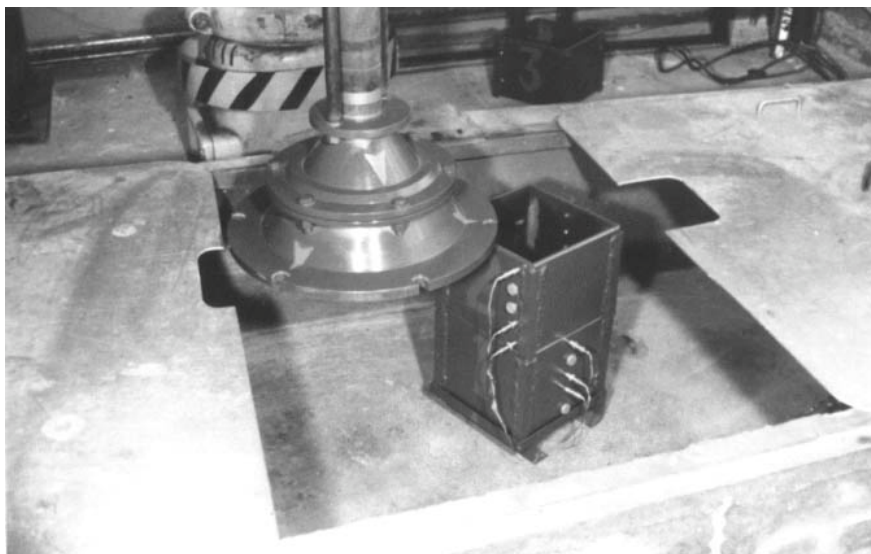


Figure 15: An example of the equipment for gas-explosive forming

6 Calculation of Impulse Forming Parameters

The approximate calculation of impulse forming parameters is carried out on the basis of a power technique for a required charges and explosion distances evaluation [4]. The detail FEM-account with allowance of material dynamic characteristics, thermal effects, inertial forces, friction over high velocities, and also cavitation and wave effects in a transmitting medium is executed with the help of the AUTODYN programme [5]. All main objects of a technological circuit (a detail, billet, technological process, equipment, and equipment) are analysed, too.

7 Conclusions

The impulse forming has the greatest advantages in manufacturing of the prototypes and single items, whose production by traditional methods is complicated or impossible. The dynamic character of a behavior of forming process results in origin of special effects, which can be used for rising deforming ability of used materials. The use of various power sources allows to select the optimal impulse in correspondence with technological process.

References

- [1] *Vovk, V. Stroppe, H. Taran, V.:* Untersuchungen zum Duktilitaets- und Festigkeitsverhalten ausgewaehlter Staehle und Al-Legierungen bei hohen Deformationsgeschwindigkeiten. In Tagungsband Elektodynamisches Impulsumformen. Dortmund 2001.
- [2] *Sabelkin V.P., Krivtsov V.S.:* Concept of Development of Technological Processes for Aerospace Equipment Parts Manufacture with Application of Impulsive Sources

- of Energy. - Proc. IV Ukraine-Russia-China Symp. on Space Sci. & Techn., Kiev, Sept. 12-17, 1996, Vol.2, p.639.
- [3] *Sabelkin V.P., Borisevich V.K., Vovk V.T.*: Industrial Application of Impulsive High Pressures in Sheet Forming with Parameters Optimization. - Proc. XI Int. AIRAPT Conf. on High Pressures in Engineering and Science, Kiev, 1987, Vol.3, p. 299-301
- [4] *Herold, K.P. Vovk, V. Taran, V. Vovk, A.*: Explosive forming of high-strength sheet material. 10-th International conference Sheet Metal, Ulster, E; 14-16. April, 2003
- [5] *Vovk, V. Taran, V. Vovk, A.*: Hidro-impulse forming of sheet metals. VI International Forging Conference Metal forming. 23 – 24 Oktober 2002. Gramado – RS, RS Brasil, S. 158-162.