ADVANCED EXPLOSIVE METALWORKING INDUSTRIAL TECHNOLOGIES

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Abstract. Application of the High Energy Formings (HERF) technologies meets the principles of the Industry 4.0. The flexibile HERF technologies represent a new paradigm in the field of production of knowledge-based more components materials, furthermore manufacturing of special component parts: the processing of the materials is carried out directly, by high speed, high energy shock waves, without using energy transforming equipment as hydraulic presses etc. The energy sources of the HERF technologies, the high explosives can be utilized for many metalworking techniques. The three main type of the explosive metalworkings practised by us are the explosive welding and cladding, the explosive tubeforming and the explosive compaction of powders and granulates. The paper briefly introduces the principles, the practices furthermore the application possibilities of the three main types of the explosive metalworkings mentioned above.

1. Introduction

The term "Industry 4.0", originates from a project in the high-tech strategy of the German government. The characteristics given for the German government's Industry 4.0 strategy are: the strong customization of products under the conditions of highly flexible (mass-) production. Industry 4.0 fosters what has been called a "smart factory". Application of the High Energy Forming (HERF) technologies using the energy of high explosives meets these conditions.

A high explosive is a compound which, when subjected to heat, impact, friction, or shock, undergoes very rapid, self-propagating, heat- producing decomposition. This decomposition produces gases that exert tremendous pressures as they expand at the high temperature of the reaction. The work done by an explosive depends primarily on the amount of heat given off during the explosion. All commercial explosives except black powder are high explosives. The high explosives can be utilized for many metalworking techniques as the explosive welding/cladding, the explosive tubeforming and the explosive compaction of powders and granulates [1].

2. Explosive cladding

- ***What is the explosive cladding?***

Practically „explosive cladding" is the name of the technology serving for manufacturing two- or more layers plates and sheets by explosion.

- ***Principle of the explosive cladding***

Explosive cladding is a solid-state process in which controlled explosive detonations force two or more metals together at high pressures, resulting a high-quality metallurgical bond between the colliding surfaces (Fig.1). The bonding zone of the two metals has a characteristic wave-form.

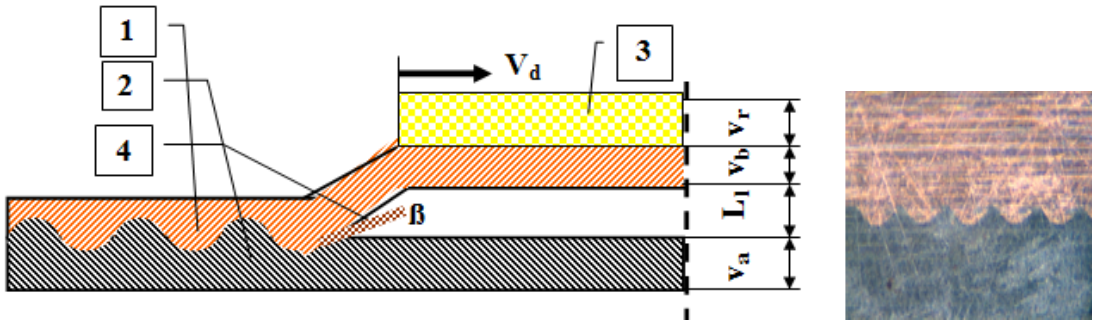

Fig.1: Principle of the explosive cladding: 1-clad plate, 2-base plate, 3-high explosive, 4-jet and the picture of the bonding zone (MgB superconductor + copper bimetallic)

The major advantages of the explosive cladding process in comparison the conventional ones are that bond can be created between normally incompatible metals (e.g. aluminum and steel).

- ***Possible applications of the explosive cladding***

The electrical industry, the vehicle production, the nuclear technique use many special multi-component materials, and component parts as two- or more-layer cladded plates, sheets, wires and component parts [2],

[3]. Applying conventional metal processing techniques as stamping, clamping, machining on explosively cladded two- or threelayer metals, different component parts can be manufactured as bimetallic washers, thermobimetals, superconducting joints etc.

3. Explosive tube forming

- ***What is the explosive tube forming?***

  Technology where directed shock waves are used for manufacturing shaped parts of metallic tubes.

- ***Principle of the explosive tube forming***

  The shock waves acting on the inner or outer surface of the tubes cause the plastic deformation of the metals, forcing them into the properly forms.

- ***Possible applications of the explosive tube formings***

  Manufacture of formed heat exchanger tubes with elevated efficiency, where the pressure created by the detonation acts on the outer surface of the metal tube.

4. Explosive powder compaction

- ***What is the explosive powder compaction?***

The explosive compaction process is generally used for compacting ceramics and metal powders into various shapes. The shock wave generated by the detonation is transmitted to the material powder and generates two main effects, the joining effect of high shock pressure and the effect of high temperature, which lead to the increase of the sample density and cohesion [4].

- ***Principle of the explosive compaction***

The basic requirements for explosive compaction are a tube-form metal container filled with powder or granulate around which an explosive (powder-form, plastic, cord-form or liquid) is spread. Detonating the high explosive results in a shock wave acting on the metallic container, reducing its diameter which results the compaction of the powder or granulate.

- ***Possible applications of the explosive compaction***

The explosive compaction process is generally used for compacting ceramics and metal powders into various shapes. By applying the properly calculated and directed shock waves on powders or powder-mixtures special tasks can be realised as:

- preparation of metallic matrix composites reinforced with ceramic and carbide particles aiming at creation of reinforced structural materials
- special material composition can be manufactured by explosive powder compaction and subsequent processing as extrusion and wire drawing
- manufacture of aluminum sheathed boron carbide controlling rods for nuclear reactors

Conclusions

- The explosive metalworking technologies use the energy generated by an explosive detonation to form the metal workpiece. These processes can deliver a great deal of flexibility in the metal-forming processes.
- The explosive metalworkings can compete
  - with the roll cladding in the field of manufacturing two- or more layer metals
  - with the conventional hydro-forming, hot-stretch forming in the field of manufacturing special tubular form parts
  - with the static and isostatic pressing in the field of preparing special more component parts of powderform metals, ceramics and mixtures of those
- But we have to consider that the explosive metalformings serve not for replacement but for completion the conventional metalworking technologies.

References

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