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STRUCTURE AND PROPERTIES OF SANDWICH MATERIALS AFTER EXPLOSIVE CLADDING

STRUKTURA A VLASTNOSTI SENDVIČOVÝCH MATERIÁLŮ SPOJENÝCH VÝBUCHEM

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Abstract

Protective of metal surface has significant role in application of materials in corrosion medium. Usual used stainless steels in the case of heavy products are very expensive. From this reason often is sufficient create thin layer from this material on the surface of usual material. One of methods applied for creating such sandwich materials is explosive welding application. Application of explosive welding enables bonding of different, mutually unweldable metals.

Paper discusses the possibility of joining selected materials by explosive cladding. Paper presents results of investigations with two layers explosively formed sandwich composite consisting of different composition joint (steel – steel, Cu(Zn), Ti). Generally, the welding collectors are metal composites having e.g. steel layer from one side and titanium layer from the other. It has been proved that elaborated parameters of explosive system ensure complete welding all regions near the join. The microstructure changes of this area have been investigated using light microscopy. Microhardness through the join represents the mechanical properties of this one.

Key words: Sandwich metals, explosive cladding, structure, properties

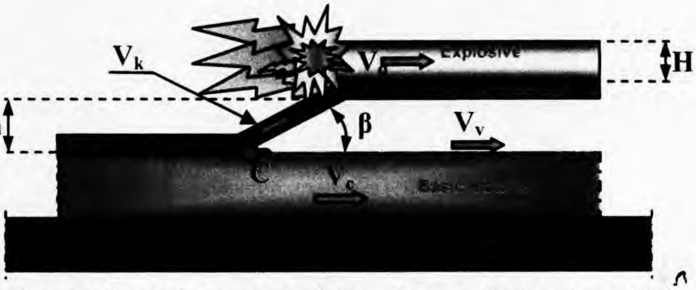
1. Introduction

Surface protection belongs to important processes ensuring efficient and economical use of materials in products and structures. Method of explosive welding of one material to another is one of many applicable methods, became recently very popular and it is frequently used, as it brings about many advantages. Use of this method considerably reduces costs of material and makes it possible to join materials, which cannot be otherwise joined together (e.g. Ti – steel and others).

This is a manner of cold joining of metallic materials by pressure. Pressure of welding is determined by the controlled explosion, which uses energy of blasting means – explosive welding, or explosives shaped according to the form of the welded material, surface welding - cladding. It is possible to weld by explosion almost any metals. Thickness of the clad layer can vary from several tenths of millimetre up to 18 mm. At explosive welding two materials are joined by the pressure generated at detonation of an explosive placed on the top surface of the welded material. Position of materials at welding can arranged in be parallel or crossways. The course of explosive welding is schematically shown in Fig. 1. At passage of detonation wave, the joined material is immediately deformed by velocity detonation and it falls at the velocity v_k on the basic stable material. The place of impact of the joined materials C moves in direction of detonation by the velocity v_c and it represents at the same time the velocity of welding. At present a joining arranged in parallel is used in most cases at welding, i.e. $\beta = 0$. The main kinematic parameters of welding are velocity of detonation $v_{d.}$ velocity of shifting of the joined material v_v, and velocity of welding (collision) v_k.

Pressure waves created by the explosion on the surface of the joined material propagate in all directions from the focus at the same velocity.

After completion of explosive works the joined materials are cleaned and degreased. This is followed by diagnostic examination of possible occurrence of defects of the joined materials by ultra-sound testing. The structure is also subjected to metallographic testing in order to obtain more information about quality of the bond on the sample taken from the area of the joint of materials. The presented work represents the first stage, in which characteristics of joints of investigated materials, including micro-hardness behaviour over the area of the joint, were studied.



v_v – velocity of air, v_k – rate of impact, v_d – velocity of explosion, v_c – velocity of welding, β – angle of welding of material.

Fig. 1 Course of explosive welding [2]

2. Evaluation of micro-structure and micro-hardness of the joined material

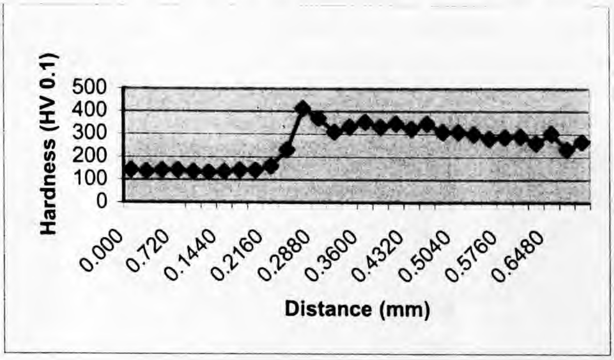
The following materials were joined by the above mentioned method of explosive welding: steel CrNi(18/10) + Ti with dimensions (110+6) x 2600 x 2600 mm, and brass + steel with dimensions (35+6) x 680 x 1500 mm, steel CrNi(18/10) + carbon steel with dimensions (90+6) x 1800 x 1800 mm, from which the samples were taken for determination of structure and micro-hardness of the joined material. The samples with dimension 20 x 20 x 40 mm were taken by mechanical cutting in order to prevent change of micro-structure of the material. These samples were after usual metallographic preparation etched in accordance with metallographic procedures for the used materials. Structure of the zone of the joint in a section perpendicular to the surface was observed on the light microscope Neophot II. Evaluation of micro-hardness was made on the LECO LM 2000. Character of the joint of the above mentioned materials in non-etched condition is shown in Fig.2.

a) b) c)

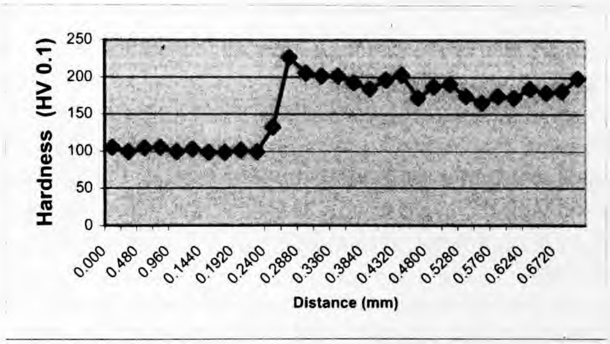
Fig. 2. Structure samples in the zone of the joint (after polishing)
a) Ti + steel CrNi(18/10), b) brass + steel , c) steel CrNi(18/10) + carbon ocel

It is obvious from the figures that the zone of the joint has on all investigated materials a character of a wave. In case of the joined materials brass + steel the peaks of waves enter deeper into brass, which is softer material.

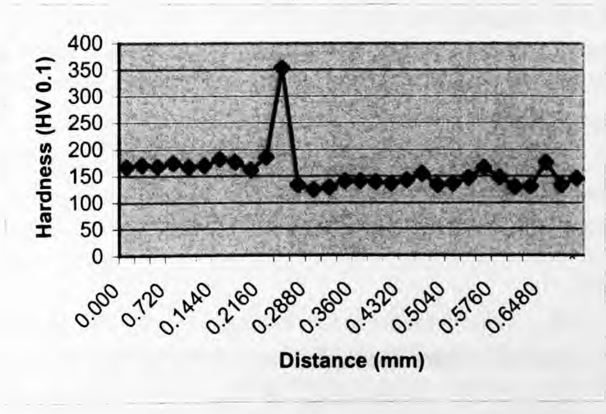
The course of micro-hardness over the joined zone at the position of the wave bottom and wave peak was also determined on all the above mentioned samples (see the example of diagrams of the course of micro-hardness HV0.1 from the zone of the wave peak in Fig. 3).



a)



b)



c)

Fig. 3. Course of micro-hardness of the above mentioned samples in the zone of the joint a) Ti + steel CrNi(18/10), b) brass + steel , c) steel CrNi(18/10) + carbon steel

As it can be seen from the figures, a strengthening of all the investigated materials occurred in the zone of the joint, especially of the basic material. The biggest strengthening occurred in the case of the joined materials Ti + steel CrNi(18/10) and steel CrNi(18/10) + carbon steel, in the joint Ti + steel CrNi(18/10) the extent of the strengthened area in the steel CrNi(18/10) was the biggest one. In the case of the joined materials brass + steel the increase in hardness was the smallest one. Detailed metallographic observation after etching is showed in Fig.4. In Fig.4a occurrence of non-homogeneities was observed also in the joint of Ti + steel CrNi(18/10). In Fig.4b has revealed in proximity of the joint on the side of brass the areas, in which re-crystallisation occurred and similar occurrence of structural non-homogeneities was detected in the case of steel CrNi(18/10) + carbon steel (see. Fig.4c). This issue will be investigated in future works. Investigation of structure will be extended by the methods of SEM, including micro-analysis of individual structural components and surface analysis (so called mapping)

a) b) c)

Fig. 4. Some detailes of the structure samples in the zone of the joint (after etching)
a) Ti + steel CrNi(18/10), b) brass + steel , c) steel CrNi(18/10) + carbon steel

3. Conclusion

The following conclusions can be drawn on the basis of the presented work:

- In collaboration with the company EXPLOMET the following materials were joined Ti + steel CrNi(18/10), b) brass + steel, c) steel CrNi(18/10) + carbon steel, including control of quality of the joined plates.
- The above mentioned materials were subjected to metallographic evaluation and determination of micro-hardness, which revealed that in the zone of the joint a deformation of materials occurs, which is manifested by an increase of micro-hardness.
- Detailed metallographic observation detected in proximity of the joints an occurrence of structural non-homogeneities, which will be investigated in future works.
- Investigation of structure will be extended by the method of SEM, including micro-analysis of individual structural components and surface analysis (so called mapping).

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