Volume 62 • Issue 1 • January 2014

Journal of Achievements in Materials and Manufacturing Engineering

International Scientific Journal published monthly by the World Academy of Materials and Manufacturing Engineering

Resistance of bimetallic plates on the dynamic cracking

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Received 22.11.2013; published in revised form 01.01.2014

ABSTRACT

Purpose: In this paper was set the aim to determine energy breaking during the impact test. As part of the work, the strength of the bimetallic plates exposed to cracking as a result of dynamic bending forces from the two layers as well as across the connection area of bimetallic plate was analyzed.

Design/methodology/approach: To determine the technological properties of this group of materials are specially intended standards but none of them do not determine how to test the impact energy of such group of materials. In this paper are presented results of such test, with macro and microscopic analysis of fracture and merging area.

Findings: Based on the results of laboratory tests can be concluded that the most exposed, X6CrNiMoTi17-12-2 - PN355NH bimetallic material, to the dynamic breaking are samples arranged according to variant a3 (i.e.. across the height of the bimetal layers merging zone).

Research limitations/implications: This work aimed to highlight the problem of the bimetallic material resistance to cracking according to different initialization direction.

Originality/value: The study attempts to identify how the material must be placed in the finished product to reduce as far as possible its exposure to crack. An important element in the correct determination of the impact of the material according to PN-EN ISO 148-1: 2010 is the appropriate cutting of notch. For this purpose, a single-pass cutter guarantying to obtain uniform parameters of fracture initiation was developed.

Keywords: Bimetals; Merging; Impact tests; Cracking

Reference to this paper should be given in the following way:

D. Rydz, G. Stradomski, A. Wierzba, Resistance of bimetallic plates on the dynamic cracking, Journal of Achievements in Materials and Manufacturing Engineering 62/1 (2014) 19-24.

PROPERTIES

1. Introduction

In recent years has been observed a continuous increase in interest and use of flat bimetallic products. From the point of view of the quality of the finished bimetallic product the most important are connecting of layers and their thickness. Existing methods of merging provide a very efficient and relatively cheap technology and process. To the most efficient and one of the best methods is counted into the explosive welding. Therefore, most of the industrial and research work on this kind of products are carried out towards analyzing the quality of the merging after welding of metals and the possibility of their further formation in plastic working processes [1-10]. In contrast, much less work concern future operating conditions of bimetallic materials. In this paper authors are trying to answer and analyze the capability to endure cracking during exposure on the dynamic loading of bimetallic plates. Determining the ability of material for the dynamic load, among others is the impact test. The study attempts to identify how the material must be placed in the finished product to reduce as far as possible its exposure to crack. An important element in the correct determination of the impact of the material according to PN-EN ISO 148-1: 2010 is the appropriate cutting of notch. For this purpose, a single-pass cutter guarantying to obtain uniform parameters of fracture initiation was developed.

2. Objective, material and scope of the research

In this paper was set the aim to determine energy breaking during the impact test. As part of the work, the strength of the bimetallic plates exposed to cracking as a result of dynamic bending forces from the two layers as well as across the connection area of bimetallic plate was analyzed. Plating layer in the test samples was the X6CrNiMoTi17-12-2 stainless steel while the base layer PN355NH whose chemical composition is shown in Table 1. Bimetallic sheets were formed by the explosive welding (Figure 1) [4-6]. The high of base layer in the impact specimen was 6 mm while the plating layer 4 mm. Both steels are often used in parts exposed to varying operating conditions, i.e. dynamic loads or elevated temperatures. Table 1 present chemical composition of the examined materials.

Bimetallic sheets were formed by the explosive welding, on the Figure 1 is presented a scheme of such technology and view of merged product.

The notches were incised with device UV L71-UV of the Time Group Inc. (Fig. 2a). The way the notches cut by one-pass vertical cutter guarantees a uniform notch in the entire volume of the material. Prepared samples were subjected to Charpy impact on the hammer JB-W300A (Fig. 2b) at ambient temperature [10,11].

Table 1.
Chemical composition of examined materials

Material	C	Mn	Cr	Ni	Mo	Ti	Si
X6CrNiMoTi17-12-2	0.041	1.82	16.62	10.5	2.0	0.32	0.46
PN355NH	0.17	1.37	0.06	0.02	0.003	0.003	0.36

a) b)

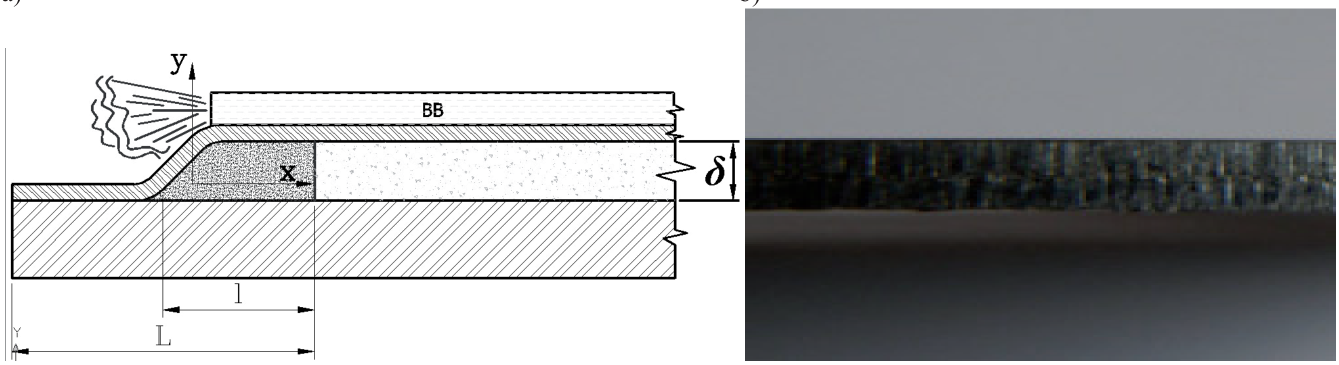

Fig. 1. Scheme of expolsive welding (a) and sample of biematlic plate (b) obtained with such technology

a) b)

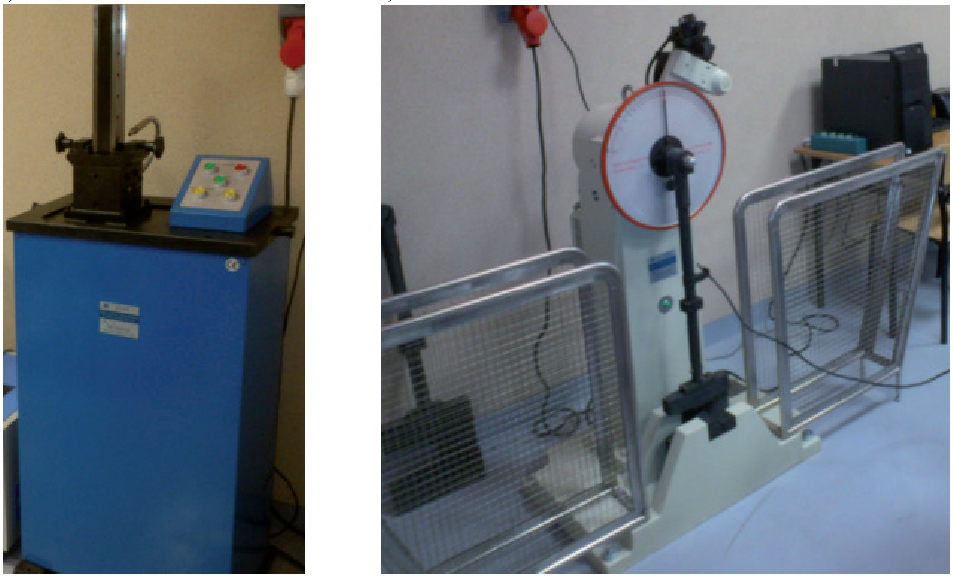

Fig. 2. The devices used during tests a) noches cutter UV L71-UV, b) Charpy impact on the hammer JB-W300A

Table 2.
The test results for the three variants of samples arrangement during the impact test

Sample No.	The arrangement of the sample	The impact value, J/cm^2	Impact energy KV_2, J
1.	Notch cut from the steel PN355NH (a1)	209.7	167.7
2.		183.0	146.4
3.		204.3	163.5
average		199.0	159.2
4.	Notch cut from the steel X6CrNiMoTi17-12-2 (a2)	209.4	167.6
5.		214.4	171.5
6.		225.9	180.7
average		216.6	173.3
7.	Notch cut across the height of the bimetal sample (a3)	155.7	124.6
8.		175.0	140.0
9.		160.0	128.0
average		163.6	130.9

3. Results and discussion

To the laboratory study were made 3 samples of 3 variants. In the first variant (a1) the notch was cut from the carbon steel PN355NH layer, in the second variant (a2) from the layer of chrome-nickel steel X6CrNiMoTi17-12-2 in the third variant (a3), across the bimetallic plate merging. The table 2 present obtained results.

In the Figure 3 is presented photomicrograph of the connection area after explosive welding. Microscopic analysis of this region showed that the entire length of the area is uniform and shows no signs of loss of stability. The image highly visible wavy merging zone obtained during explosive welding.

Figure 4 shows the breaking area of samples with an enlarged area of the cracked connection zone.

On the basis of presented in Fig. 4 bimetallic PN355NH + X6CrNiMoTi17-12-2 samples breaks fractures can be concluded that essentially in the entire volume of sample are visible malleable crack. Analysis of the breaking area didn't showed any breach of cohesion beyond the rupture zone, which shows that the technique used to connect is correct. Very interesting is observed in the sample 4 four characteristic fault in the merging zone. This area is not disrupted as can be seen in Figure 4 (magnification 25x), this indicates that the zone is characterized by a higher joint strength than steel X6CrNiMoTi17-12-2. In the sample 2 crack propagation occurs uniformly in the entire volume of the material include the joint area. Very interesting is the fact that there are accumulation in the sample 8. The most interesting is the fact that in the sample 8 exist of damming along the merging zone. This can prove that the crack initiation is from the notch and propagate from the side walls to the center (merging zone). This zone is characterized by higher resistance than the constituent materials are destroyed as the last this can be the response for observed damming on the entire length of the cracking zone. At this point it should also be noted that this sample was characterized by the lowest breaking resistance.

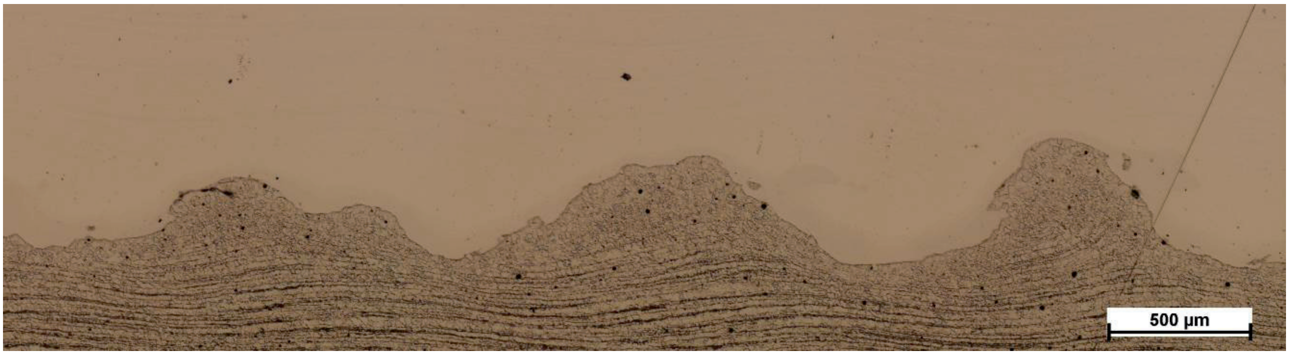

Fig. 3. Photomicrograph of the merging area of the analyzed bimetal. Mag. 50x

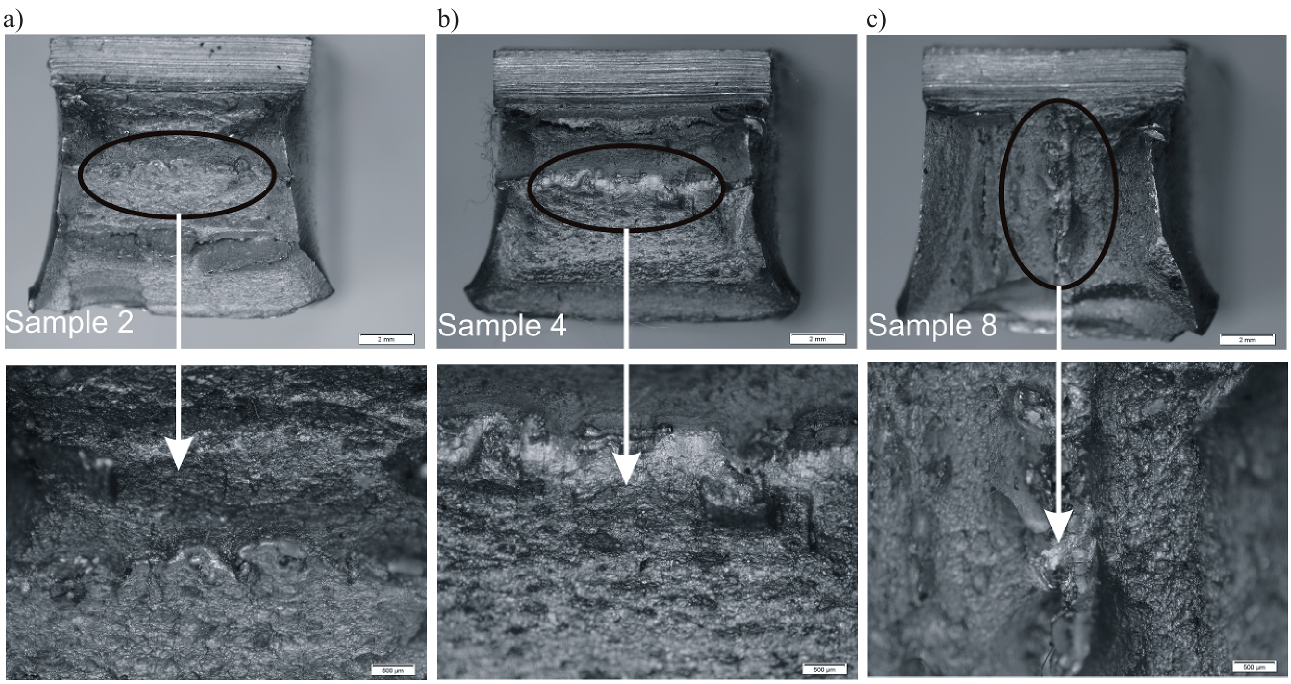

Fig. 4. The breaking area of samples, a) notch cut from the steel PN355NH a1, b) notch cut from the steel X6CrNiMoTi17-12-2 a2, c) notch cut across the height of the bimetal sample a3

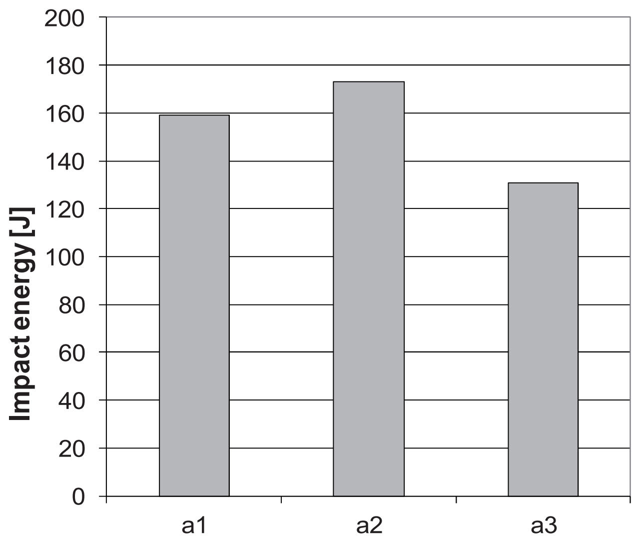

Fig. 5. The average value of energy used to break the sample with a single strike for three considered variants of a1, a2 and a3

Based on the laboratory results presented in Figs. 4 and 5, can be stated that the greatest resistance to the dynamic bending forces have samples arranged according to variant II (a2). In contrast, the most vulnerable to cracking have samples arranged according to variant III (a3). Therefore, the arrangement of layers of bimetal in the finished product is not insignificant and should be guided by the purpose of both bimetal and a possible threat to breaking during operation.

4. Summary

Bimetallic products are subject to many laboratory tests having regard to, inter alia, analyze material properties, quality of connection, etc.. In contrast, there are no many works related to the determination of the strength of bimetallic flat products to the dynamic forces causing cracking. This work aimed to highlight the problem of the bimetallic material resistance to cracking according to different initialization direction. Based on the results of laboratory tests can be concluded that the most exposed, X6CrNiMoTi17-12-2 – PN355NH bimetallic material, to the dynamic breaking are samples arranged according to variant a3 (i.e.. across the height of the bimetal layers merging zone).

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