Engineering Failure Analysis xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Engineering Failure Analysis

journal homepage: www.elsevier.com/locate/engfailanal

Static and fatigue tests of bimetal Zr-steel made by explosive welding

Mariusz Prażmowski [a,*], Dariusz Rozumek [a], Henryk Paul [b]

[a] Opole University of Technology, Faculty of Mechanical Engineering, Mikołajczyka 5, 45-271 Opole, Poland
[b] Polish Academy of Sciences, Institute of Metallurgy and Materials Science, 25 Reymonta St., 30-059 Krakow, Poland

ARTICLE INFO

Article history:
Received 18 October 2016
Received in revised form 21 December 2016
Accepted 28 December 2016
Available online xxxx

Keywords:
Explosive welding
Fatigue crack
Failure analysis

ABSTRACT

The paper presents the test results of the microstructure, mechanical properties and fatigue cracks obtained for zirconium-steel bimetal under cyclic bending. The research was carried out for initial state bonds, i.e. immediately following explosion welding. The results of mechanical and structural investigations of the intermediate layers were presented. Using scanning electron microscopy (SEM) allowed the initial identification of the forming phases. In order to determine changes in the value of strengthening, microhardness tests of both the weld and the joined plates were performed. Specimens of rectangular cross section were fatigue tested. In the tested specimens, the ratio of heights of base and overlaid materials was h_1: $h_2 = 2.5$: 1. In the specimens, the fatigue crack growth was parallel to the applied load. The specimens exhibit the uniform crack growth at both sides of lateral surfaces. Among composite fractures in the zirconium and steel, transcrystalline cracks are dominating.

1. Introduction

Safe and economical operation of different devices strongly depends on construction materials. Independent of the structure type, conditions and work environment, the devices require very good materials. Construction elements of industrial systems can be subjected to radiation, aggressive influence of the cooperating medium (water, liquid metals, gas of liquid salts), high pressure, vibration or high temperature gradients. The destruction of materials by those agents leads to a shorter operating time of particular systems and possible break-downs. Thus, the application of suitable materials or material compounds of special properties seems to be very important.

In many cases, explosive welding is applied for production of laminar systems. It allows obtaining durable, continuous joint of two or more materials of similar or different mechanical properties. They are usually materials which cannot be joined with traditional methods of welding [1–3]. Obtaining such a connection requires very careful selection of parameters of explosive welding, i.e. the energy of explosion, detonation velocity v_D and the distance between the joined plates h. These parameters directly influence the velocity of displacement of the collision point v_C and the collision angle β (between base and flyer) of plates, and the formation of the inverse flux. The distance is selected so as to assure that the flyer plate collides with the base plate after acceleration to suitable collision velocity v_P [4–6]. The application of insufficient parameters, below the limit values, can lead to discontinuity or a lack of connection. Whereas the application of excessive parameters, above the critical values, causes pitting of the joined plates surfaces, and consequently the formation of areas of joint penetration of high hardness and brittleness [7–9],

* Corresponding author.
E-mail address: m.prazmowski@po.opole.pl (M. Prażmowski).

http://dx.doi.org/10.1016/j.engfailanal.2016.12.022
1350-6307/

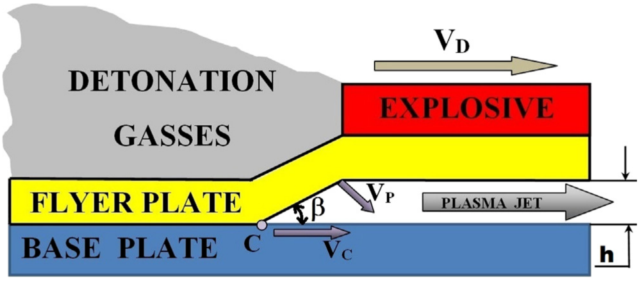

Fig. 1. Explosive welding process and its parameters.

unfavourable from the point of view of the connection quality. The occurrence of intermetallic phases influences properties and the operating life of the produced systems.

In [10] you can find the test results for fatigue crack growth in a carbon steel/stainless steel composite obtained by explosive welding of specimens subjected to three-point bending. During the fatigue tests, two kinds of cracks were observed. They often were developing from the carbon steel, and rarely from the stainless steel. The experimental results indicated that there was a remarkable reduction in crack growth rate when the crack crossed the interface.

The aim of this paper is the presentation of influence of structural changes in the bond zone of zirconium-steel bimetal made with explosive welding on the static and fatigue life.

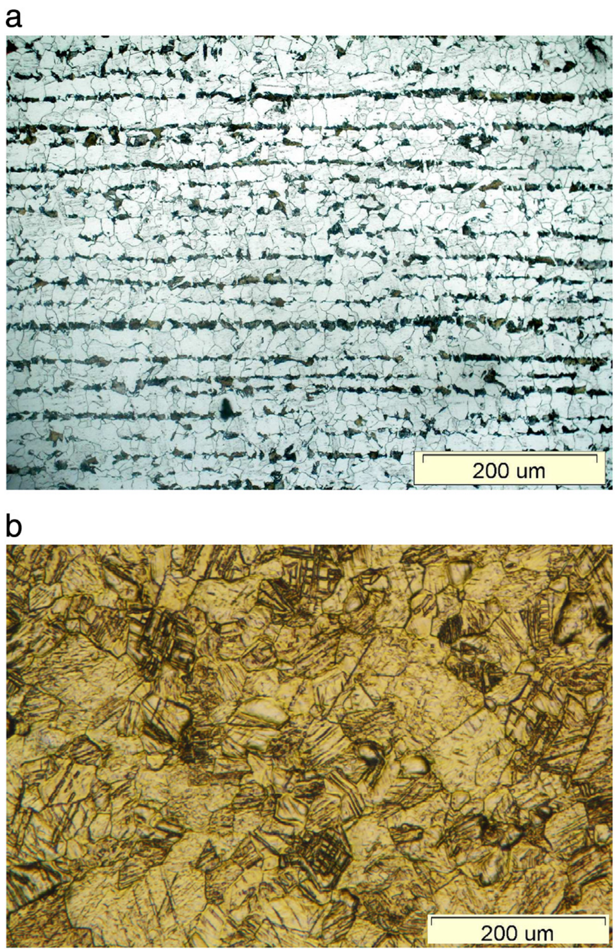

Fig. 2. Microstructure of: (a) steel P265GH, (b) zirconium Zr 700, magnification 200×.

Please cite this article as: M. Prażmowski, et al., Static and fatigue tests of bimetal Zr-steel made by explosive welding, Engineering Failure Analysis (2017), http://dx.doi.org/10.1016/j.engfailanal.2016.12.022