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ScienceDirect

Procedia Structural Integrity 5 (2017) 422–429

Structural Integrity Procedia

www.elsevier.com/locate/procedia

2nd International Conference on Structural Integrity, ICSI 2017, 4-7 September 2017, Funchal, Madeira, Portugal

High cycle fatigue properties of explosively welded laminate AA2519/AA1050/Ti6Al4V

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Abstract

The paper presents preliminary results of high cycle fatigue properties, including fatigue cracking of layered laminate AA2519/AA1050/Ti6Al4V. The test material was obtained by the method of explosive bonding in direct configuration AA2519/Ti6Al4V with the intermediate layer using a AA1050 alloy. The study tested influence of the applied heat treatment on the mechanical properties of the laminate. Load applied during the tests was oscillating sinusoidal with the stress ratio R=0.1 and constant load frequency equal to 20 Hz. The tests were performed at five levels of stress amplitude dependent on shape of samples. Assumed as the criterion for the end was the number of cycles at specimen failure or when number of cycles was equal to 5 million repeats. The results indicated the beneficial effect of the applied heat treatment. The results showed an increase the fatigue of the heat-treated samples, both notched and smooth samples. The results of electron microscopy studies of surface fatigue fracture allowed to determine the location of sources of fatigue cracking, which in the case of samples without heat treatment were in the area of border merger Ti6Al4V/AA1050. Sources of cracking in the elements after the heat treatment were located within the edge of the samples.

Peer-review under responsibility of the Scientific Committee of ICSI 2017

Keywords: explosive welding, composite laminates, Al/Ti composites, highcycle fatigue ;

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2452-3216
Peer-review under responsibility of the Scientific Committee of ICSI 2017
10.1016/j.prostr.2017.07.191

1. Introduction

Currently, there is a tendency to seek new materials characterized by, among others, favorable performance in relation to the materials used so far. These requirements are increasingly meet laminates, composites, including layered composites, the development of which involves the use of ever newer and more effective bonding techniques. One of the techniques of joining materials, complementing traditional methods, is a technique of explosive bonding, which allows to combine materials with different mechanical properties, for example, not welded metals and lightweight alloys. Explosive joining of metals allows to manufacture laminates which are successfully used in the electro-mechanical industry. Usage this type of composites, as a construction material seem, in the light of the analyzed literature is very promising especially where the use of another type of connection is impossible or unprofitable. Materials used for mechanical structures are often subjected to varying periodical loads. Under these conditions, there may be a variety of damage to both the material-laminated components and their connection zones. A common example of this type of destruction of composites is the occurrence of exfoliation called delamination. Such cracks formed within the composite layer can significantly decrease the strength locally in particular tensile and flexural strength. The results of literature analysis indicate a fairly large group of publications on laminates Al-Ti. Most of these works concern on the mechanical properties of the explosively bonded material and structure of the attachment zones. Much attention is paid to the formation and influence of intermetallic precipitates such a Al_3Ti on the properties of laminates [1-3]. Delamination formed in the middle of the wall thickness divide the laminate into two sub laminates. It can reduce twice the rate up of bending strength of the total laminate cross section. Particle formation Al_3Ti increase the risk of creating a discontinuity of the material structure and the stress concentration due to a process of forming precipitates. They can act as a notches that increase the probability of occurrence of cracks and delaminations [4-8]. A number of published studies devoted to heat treatment of layered laminates eg. Al-Ti, which causing stress relaxation caused by the explosive bonding process. Heat treatment described in [9] brought the expected results, but also caused a change in the microstructure of aluminum alloy. Heat treatment of laminates Al-Ti results in oxidation of the composite and its impact on the physical properties of the material has been devoted to the work [10]. The analysis of research allows to assess the possibilities of application of the laminates Al-Ti obtained by explosive welding method only in the construction of statically loaded. In a few of them issues of destruction of the laminates as a result of cyclic loading were described [11-12]. They cause local hardening of the material, which significantly increases the resistance of the laminate on the dynamic effects of foreign bodies [13-16]. This is undoubtedly important, allowing to characterize the laminate as a construction material that could be used for mechanical structures.

Nomenclature

N_f	Number of cycles
N	Cycle number
σ_{max}	Stress amplitude

2. Materials and experimental details

The tests involved a layered composite formed by explosive welding of base materials in the form of AA2519 aluminum alloy and Ti6Al4V titanium alloy with the intermediate layer of AA1050 alloy (Fig. 1).