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Numerical simulation and experimental analysis of vacuum brazing for steel/cermet

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Abstract

The finite element method and processing experiments were used to investigate the influence of the brazing process on residual stresses and the microstructural and mechanical property changes of dissimilar joints. In the present investigation, tool steel (90MnCrV8) and cemented carbide (WC–10Co) were brazed in a vacuum using ductile filler. The calculated results show that the residual stresses developed during the cooling process are very high so that the strength of the ceramic/metal brazed joints is decreased. The maximum peak stress is located in the filler–cermet interface. The finite element method is an effective method to predict the stress distribution of dissimilar joints. The expected improvement on the shear stress of the joints by optimizing the brazing time was confirmed by the experimental results.

Keywords: A. Joining; C. Diffusion; C. Mechanical properties; Cemented carbide; Microstructure

1. Introduction

The advantages of tool steel are high hardness and high mechanical resistance. However, these steels are used in the manufacture of cutting tools and structural applications at elevated temperatures [1]. Because no single tool material combines all of the required properties, an important challenge in the design and processing of engineering materials is to combine incompatible properties of materials in the same component. One of the materials that could complement tool steels may be cermets. Cemented carbides used in tool making are mostly joined in one way or another to a steel tool blank [2]. The different thermal stresses during the cooling step of this process and the damage to the microstructures in the materials rule out the possibility of using fusion welding techniques. To overcome these problems, bonding processes in solid state, such as brazing, are used [3].

Residual stresses are generated in a brazed joint due to the material mismatch between the base material and filler metal [4], which can decrease the structural strength [5,6], increase the susceptibility of a joint to fatigue damage, stress corrosion cracking and fracture [7]. In order to prevent the possible root causes of stress in the joints, it is necessary to evaluate the initiation potential and growth rate in the dissimilar joints via residual stress assessment [8]. Therefore, estimating the magnitude and the distribution of the residual stress and discussing the influencing factors on the early design of these dissimilar joints are deemed necessary [9]. The residual stress in the structures is influenced by many factors, such as the brazing temperature, material mismatch, pressure loading and brazing gap.

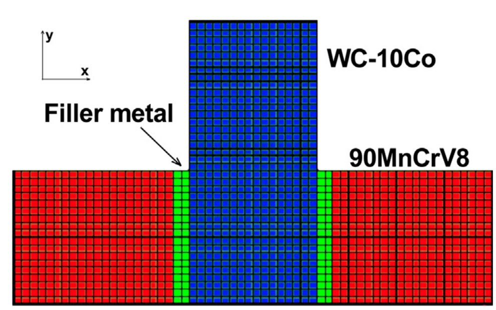

Fig. 1. Two-dimensional finite element mesh of brazed joint.

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Table 1
AISI 01/UNE 90MnCrV8 composition.

Elements	C	Mn	Si	P	S	Cr	V	Fe
wt%	0.910	1.980	0.170	0.015	0.009	0.430	0.080	Bal.

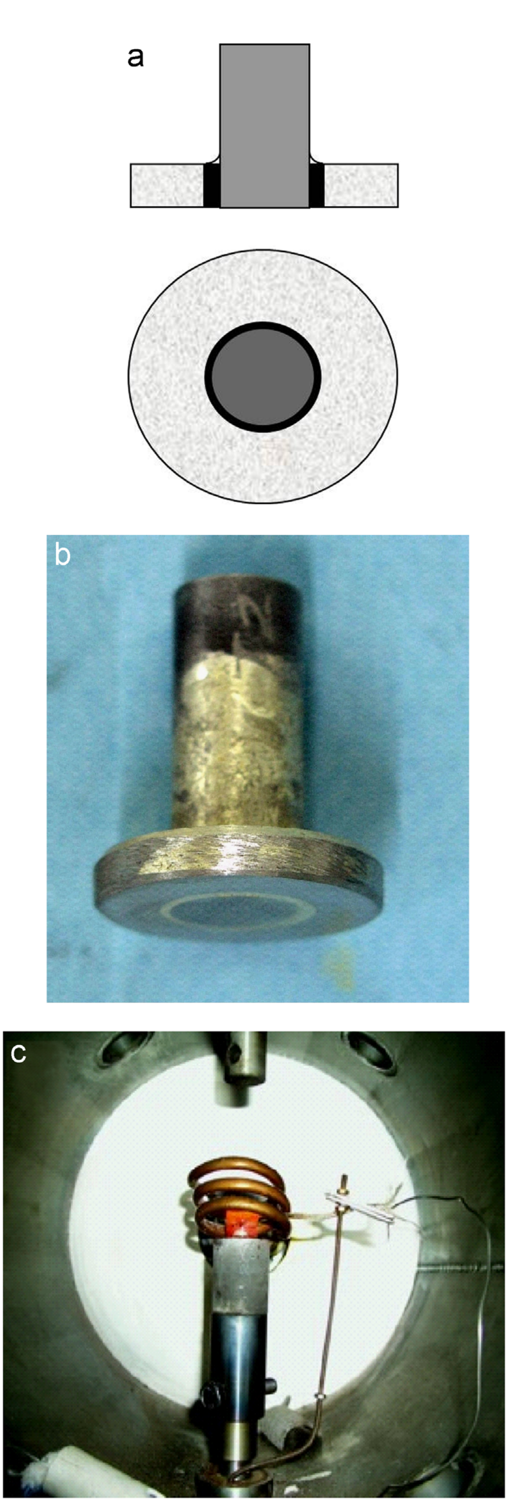

Fig. 2. (a) Schematic illustration of the test assembly before joining, (b) WC–10Co/BAg-5/90MnCrV8 brazed joint and (c) Image of brazing device.

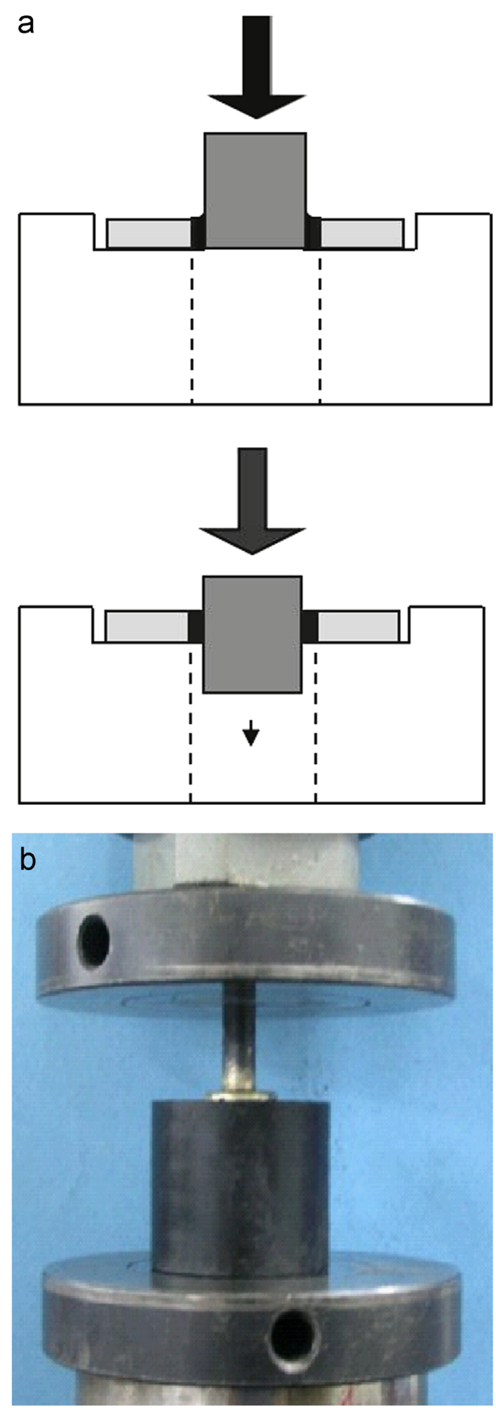

Fig. 3. (a) Schematic illustration and (b) Image of shear test device.

Numerical simulation methods combined with experiments have been widely used for the analysis and design of metal structures [10–12]. The application of finite element methods