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Explosive welding of metal plates

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ABSTRACT

This paper describes a study of explosive welding of metal plates. The properties of a locally prepared mix of 77/23 ammonium nitrate and fuel oil (ANFO) explosive and the dynamics of the plates are investigated and the results from welding tests presented. The strength of the clad plates is measured and ultrasonic inspection performed to identify and locate defects. The welding process is simulated using a finite element-based computer model. A brief description of the modeling process is given along with the results from the simulations for comparison with measured parameters.

1. Introduction

Explosive welding is generally used to bond two dissimilar metal plates and is most often used when the combination of metals makes conventional fusion welding impractical.

The technique enables very large sections of plate to be clad in a single operation. The quality of the joint is generally good with high mechanical strength and as it is a 'cold method' the bonded metals retain their pre-bond properties.

The usual arrangement for explosive welding has the two plates (flyer and base) placed one above the other separated by a distance of about one or two times the thickness of the flyer plate. The explosive, usually in powder form is placed on the upper plate inside a surrounding wooden frame. Its type, thickness and composition are selected to yield a specific energy release and a specific velocity of detonation (the speed at which the detonation front travels across the explosive layer). The explosive is detonated using a small booster charge and detonator placed at one end of the frame. The expansion of the gaseous detonation products accelerates the cladding plate across the stand off gap forcing it to collide obliquely at relatively high velocity with the lower (base) plate, Fig. 1. On impact the two surfaces at the collision zone become plastic causing a jet of both metals to be ejected from between the two plates. This jet scours and cleans the surfaces of the plates leaving clean metal amenable to bonding.

Whilst the explosive welding process is generally successful, expensive failures occur and often the cause(s) is unknown. To improve the understanding of the process a mathematical model to simulate the mechanics was developed. This paper describes an experimental study to obtain data to assist the development of this model. The charac-

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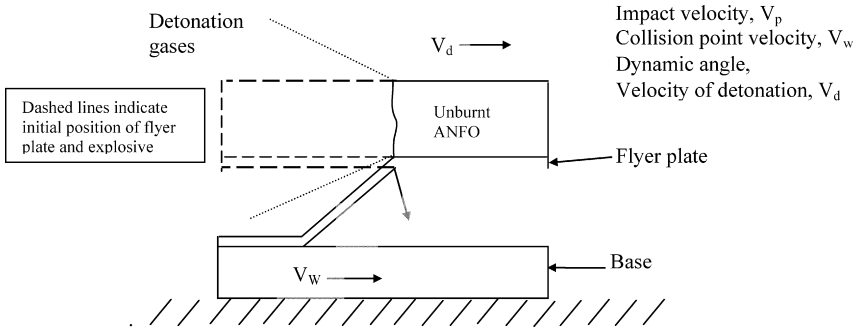
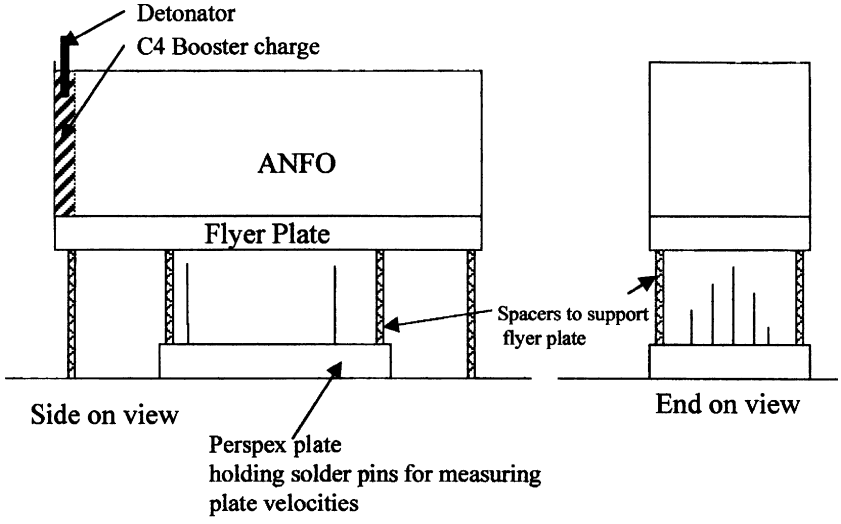


Fig. 1 – The explosive welding arrangement.

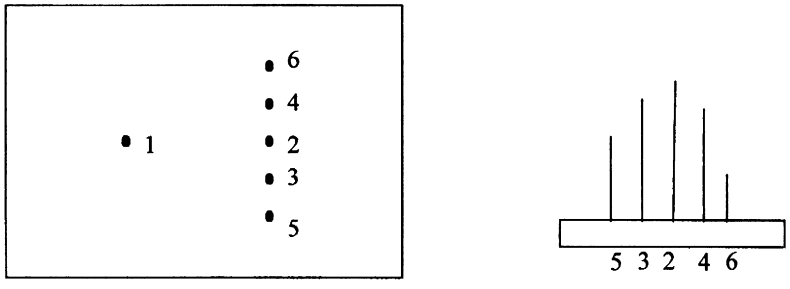
teristics of ammonium nitrate explosive are described, the dynamics of the plates examined and the results from several welding tests presented. A brief description of the modeling process is given along with results from the computer simulations.

2. Experimental procedures

The experimental program was in two phases. The aims of the first phase were to determine the velocity of detonation



(a)



Typical pin spacing and heights
Pin 1-2 spacing = 40mm
Pin 1 &2 Height = 21mm
Pin 3 Height =18mm
Pin 4 Height =15mm
Pin 5 Height =9mm
Pin 6 Height =3mm

(b)

Fig. 2 – Pin contact method for measuring flyer plate velocities. (a) Experimental arrangement, (b) pin arrangement.