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Study of Weld Quality in Explosive Welding Process by Finite-Element Method and Ultrasonic Testing

Ali Moarrefzadeh

Faculty member of Department of Mechanical Engineering, Mahshahr Branch, Islamic Azad University, Mahshahr, Iran.

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ABSTRACT

Explosive welding is a solid state welding process that produces a weld between two components by high velocity impact, aided by controlled detonation of an explosive. In order to produce uniform and consistently good quality welds the welding parameters are to be optimize. This study consists of two parts, the first part of the explosive welding process was modeled in ANSYS software and an optimum temperature field, is obtained. The factors which cause localized heat gain and control the process. The approach to model metal surfaces is an example of a problem dealing with the influence of the finite element method has been used. AUTODYNE purpose of the program is that the dynamic model is used ANSYS software. In the second part, the first part is actually complementary. Ways to try to generate heat and increase the impact of the collision and impact force and the results of the survey analysis software environment used to increase weld quality and productivity. Finally, optimal results in terms of mechanical and metallurgical weld ultrasonic testing method for controlling the size and quality of weld to be examined. Responses obtained from the temperature field and ultrasonic testing process determines the effect of each of the parameters to be optimized using this explosive welding process payments.

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INTRODUCTION

Explosion welding (EXW) is a solid state (solid-phase) process where welding is accomplished by accelerating one of the components at extremely high velocity through the use of chemical explosives. This process is most commonly utilized to clad carbon steel plate with a thin layer of corrosion resistant material (stainless steel, nickel alloy, titanium, or zirconium). Due to the nature of this process, producible geometries are very limited. They must be simple(Fig. 1). Typical geometries produced include plates, tubing and tube sheets.

Explosion welding can produce a bond between two metals that cannot necessarily be welded by conventional means. The process does not melt either metal, instead it plasticizes the surfaces of both metals, causing them to come into intimate contact sufficient to create a weld. This is a similar principle to other non-fusion welding techniques, such as friction welding. Large areas can be bonded extremely quickly and the weld itself is very clean, due to the fact that the surface material of both metals is violently expelled during the reaction.

A major disadvantage of this method is that an expansive knowledge of explosives is needed before the procedure may be attempted. Explosion welding is therefore far less commonly used than fusion welding alternatives.

Bonding Parameters:

The proper bonding parameters for a specific metal combination depend upon the metal types, thicknesses and their mechanical properties. assure a strong, high quality ductile bond. The impact conditions during the angle bonding are related by the following equation:

$$V_c = V_D \frac{\sin\beta}{\sin(\alpha+\beta)} = V_D \frac{\sin\beta}{\sin\gamma}$$

Corresponding Author: Ali Moarrefzadeh, Faculty member of Department of Mechanical Engineering, Mahshahr Branch, Islamic Azad University, Mahshahr, Iran.
E-mail: a_moarrefzadeh@yahoo.com

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Where:
Vc = collision velocity
VD = detonation velocity
Vp = plate Collision velocity
α = preset angle
β = dynamic bend angle
γ = collision angle

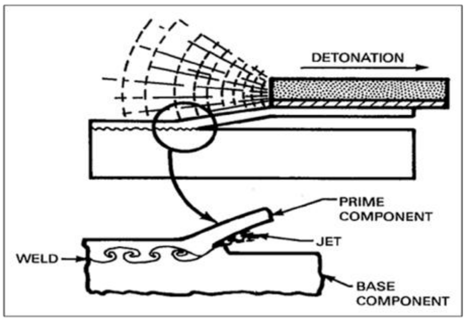

Fig. 1: Explosion welding (EXW) process.

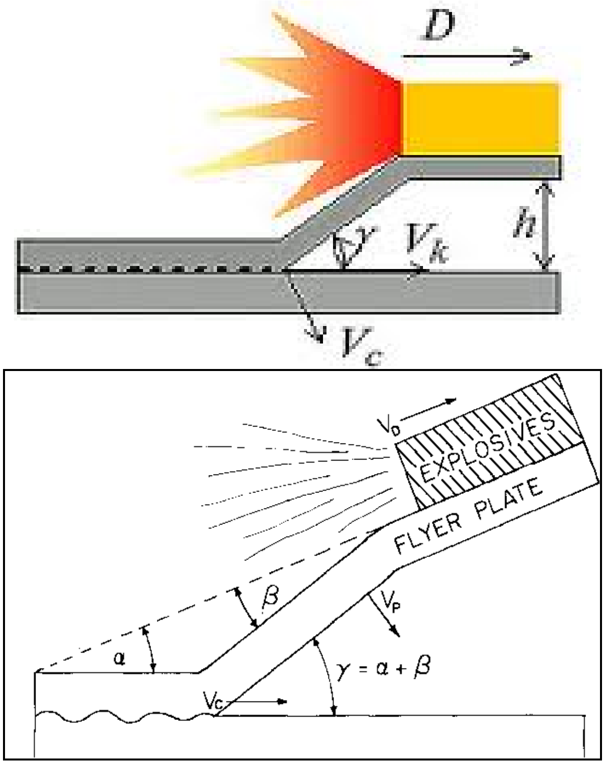

Fig. 2: Explosion welding equation.

Sonic velocity of cladding material can calculated using:

$$k = \frac{E}{3(1-2\nu)} \qquad V_s = \sqrt{\frac{k}{\rho}}$$

Where:
K = adiabatic bulk modulus
ρ = cladding material density
E = Young’s Modulus of cladding material
ע = Poisson’s ratio of cladding material

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Explosive Welding Mechanism:

In the explosive welding process, the metal plates are made to collide obliquely with each other at a high velocity with the use of explosive. The impact causes the two metals to come into intimate contact such that metallurgical bonding takes place across the interface. As the detonation of the explosive proceeds, a scavenging action occurs between the two mating surfaces, due to jetting. The jet formation aids metallurgical bonding in two ways: first, it causes the breakup of the contaminant surface film and expels it from the point of collision and it exposes virgin surfaces, which are brought into close contact as a result of collision.

Ultrasonic Testing:

In ultrasonic testing (UT), very short ultrasonic pulse-waves with center frequencies ranging from 0.1-15 MHz and occasionally up to 50 MHz are transmitted into materials to detect internal flaws or to characterize materials. A common example is ultrasonic thickness measurement, which tests the thickness of the test object, for example, to monitor pipe work corrosion.

In ultrasonic testing, an ultrasound transducer connected to a diagnostic machine is passed over the object being inspected. The transducer is typically separated from the test object by a couplant (such as oil) or by water, as in immersion testing. However, when ultrasonic testing is conducted with an Electromagnetic the use of couplant is not required.

There are two methods of receiving the ultrasound waveform: reflection and attenuation. In reflection (or pulse-echo) mode, the transducer performs both the sending and the receiving of the pulsed waves as the "sound" is reflected back to the device. Reflected ultrasound comes from an interface, such as the back wall of the object or from an imperfection within the object. The diagnostic machine displays these results in the form of a signal with an amplitude representing the intensity of the reflection and the distance, representing the arrival time of the reflection. In attenuation (or through-transmission) mode, a transmitter sends ultrasound through one surface, and a separate receiver detects the amount that has reached it on another surface after traveling through the medium. Imperfections or other conditions in the space between the transmitter and receiver reduce the amount of sound transmitted, thus revealing their presence. Using the couplant increases the efficiency of the process by reducing the losses in the ultrasonic wave energy due to separation between the surfaces.

Linear scanning of welds:

Manual ultrasonic weld inspections are performed using a single probe, which the operator “rasters” back and forth to cover the weld area. Many automated weld inspection systems use a similar approach (see Figure 3a), with a single probe scanned back and forth over the weld area. This is time consuming, since the system has dead zones at the start and finish of the raster.

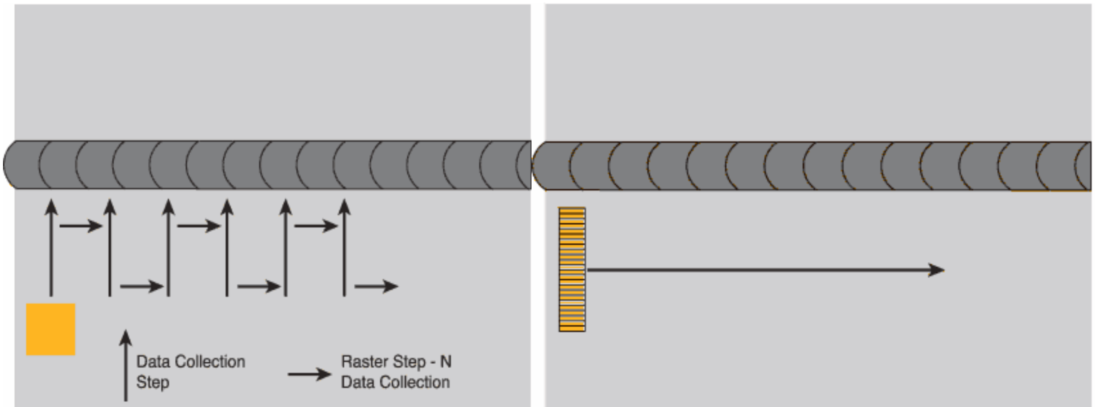

Fig. 3: a (left), conventional raster scanning; 3b (right), linear scanning

In contrast, most multi-probe systems and phased arrays use a “linear scanning” approach (see Figure 3b). Here the probe pan is scanned linearly round or along the weld, while each probe sweeps out a specific area of the weld.

The simplest approach to linear scanning is found in pipe mills, where a limited number of probes inspect ERW pipe welds.

Phased arrays for linear weld inspections operate on the same principle as the multi-probe approach; however, phased arrays offer considerably greater flexibility than conventional AUT. Typically, it is much easier to change the set-up electronically, either by modifying the set-up or reloading another; often it is possible

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to use many more beams (equivalent to individual conventional probes) with phased arrays; special inspections can be implemented simply by loading a set-up file.

Inspection Techniques:

Since they are very flexible, phased arrays can fulfill many different inspection techniques from standard ASME to zone discrimination to TOFD to “specials”.

Asme Raster Scans:

Figure 4 shows a phased array set-up for standard ASME raster scans using two separate angles in pulse-echo.

The arrays are angled on wedges to optimize energy as well as reduce wear and damage. Phased arrays can perform inspections at multiple angles, plus TOFD.

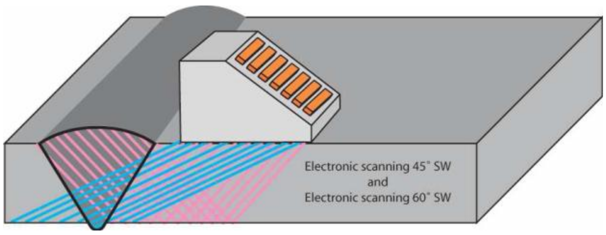

Fig. 4: Schematic showing phased arrays performing ASME raster scans.

RESULT AND DISCUSSIONS

This study consists of two parts, the first part of the explosive welding process was modeled in ANSYS software and an optimum temperature field, is obtained. The factors which cause localized heat gain and control the process. The approach to model metal surfaces is an example of a problem dealing with the influence of the finite element method has been used. AUTODYNE purpose of the program is that the dynamic model is used ANSYS software.

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Ultrasonic A-scan examination was found to be very precise in detecting the presence of delimitation in the weld joints. This has also been imaged and confirmed using C-scan technique.

Conclusion:

The quality of the explosive bonds that have been fabricated is found to be acceptable for the fabrication of heat exchanger and the electrolytic cells in terms of bond strength. Responses obtained from the temperature field and ultrasonic testing process determines the effect of each of the parameters to be optimized using this explosive welding process payments.

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