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CAPACITY DISCHARGE WELDING OF SMALL DIAMETER WIRES

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ABSTRACT

In spite of fact that welding technology is highly developed and definitely the most common procedure for joining materials, there are some problems when welding very thick and very thin materials. This problem is especially pronounced on welding small diameter wires. When welding small diameter wires by conventional welding processes main problem is control of melted material. When melting temperature is reached on the top of wire, the rest of wire material continues to melt. Because of this, it's difficult to keep melted metal, influenced by the force of gravity, at the joint's place.

Capacity discharge welding (CDW) is one of the unconventional welding processes often used for welding of dowels on metal part of construction made of composite structures. In this welding process, the energy required for welding, is generated by discharging of capacitors. Discharging of capacitor heats up the material at the joint point and a certain pressure squeezes smaller or larger amount of melted material and in this way results weld.

Because of all these reasons, capacity discharge welding is recognized as one of the welding processes that could give satisfactory results on field of welding small diameter wires. In this paper is presented influence of contact force of wires during welding process and heat input on welded joint properties.

Keywords: capacity discharge welding, small diameter wires, welded joint cross section area, welded joint properties

1. INTRODUCTION

Although welding processes are not strictly separated, capacity discharge welding can be considered as one of unconventional welding processes used in specific situations. One of those specific appliances, among large amount of others, is welding of dowels on composite structures.

There are large amount of possibilities to join materials: exposing them to extremely high pressure without previous heating or heating materials above melting point of parent material. Capacity discharge welding, including some other welding processes, is considered as a process which uses heat and pressure. In all these welding processes it is necessary to be achieved certain proportion of heat input (temperature) and pressure to result a welded joint, considering that it is needed to be applied lower pressure at larger point of heating.

At capacity discharge welding it is occurred partial heating of parent material which is melted by heating with electrical arc or in some other cases with electrical resistance. Heating with electrical arc, material is melting on both sides of electrical arc, in anode and cathode zone. After this, both components melted in this way, are joining using certain amount of pressure.

Intensity of pressure, which is used to assemble melted components, is very important because at low intensity of pressure it is not squeezed enough amount of melted material which results of certain unconnected areas and air intrusions. If intensity of pressure, used to assemble melted components, is too large then that results of squeezing of large amount of melted material which affects a geometry and mechanical properties of welded joint. In this paper is shown dependence between amount of squeezed material and welded joint geometry of welding parameters.

2. CAPACITY DISCHARGE WELDING

Capacity discharge welding uses heat came from electrical arc and pressure to create a welded joint between parts needed to be welded. There are two types of capacity discharge welding, contact mode welding and electrical resistance welding. Contact mode has widest appliance in welding dowels in civil engineering when dowel and workpiece are melted using heat from electrical arc after which dowel is plunged in shallow molten pool of workpiece. Pressure on dowel is achieved using spring on manual gun for capacity discharge welding.

Because electrical energy stored in the capacitor is utilized to generate the arc used to melt material, the capacity discharge welding has significant advantages such as short welding time and small distortions of workpiece.

Energy stored on capacitors, depends on capacity and voltage:

$$E = \frac{1}{2} C U^2 \qquad (1)$$

where:
E – energy on capacitor [J],
C – capacitance [F],
U – voltage [V].

When welding joint is made using contact mode, electrical arc peak on dowel sets up contact with working piece influenced by spring force and current flows through electrical arc ignition tip. On figure 1. is shown typical look of current impulse at contact mode welding.

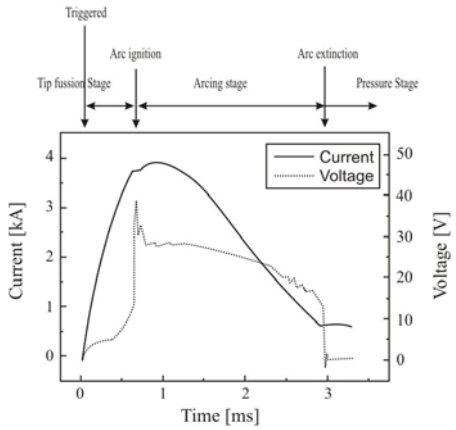

Figure 1. Typical current and voltage waveform on capacity discharge welding [4]

As demonstrated on figure 1., time of welding is very short, approximately 3 ms, in some cases can be until 30 ms, and process can be divided into three phases: melting of ignition tip, arcing and phase of pressing. During the phase of melting of ignition tip, ignition tip is heating and melting by Jules heat. During the phase of arcing, the arc is generated to melt dowel and working piece, and then the dowel is plunged in molten pool by pressure force of spring. At the end, during the phase of pressing, the arc is extinct, melted material is squeezed from pool of melted material, until solidification.

3. EXPERIMENTAL

Butt welding of small diameter wires is not common technique of welding and it is not often used in practice. However, for some specific appliances there is a need of joining materials in this way, like at some medical equipment, at dentistry, precise technique, electronics and some other disciplines. It is more often used to join high alloyed stainless steels but it is possible to apply it for other materials or some specific alloys. As a particular problem, except specific demands on materials, it could be enhanced dimensions of elements which are supposed to be joined. Generally, there are some problems in welding technique, in joining materials of very large and very small thickness.

In this paper is described influence of pressure intensity and heat input to properties of welded joint during the capacity discharge welding of small diameter wires.
In experimental part of this paper was done capacity discharge welding of wires of Ø1 diameter and analyses of influence of pressure force during welding and heat input on geometry of welded joint. The wires that were welded are of austenitic Cr-Ni steel 19-9. The experiment was performed on three levels of pressure intensity during welding and four levels of heat input. Experimental samples were welded in argon protection atmosphere, to protect melted material from surrounding environment.

Welding device is designed in that way that the pressure force during welding is achieved by mechanism consisted of DC motor and rack. Pressure intensity has been changing during welding manipulating voltage on DC motor which is previously calibrated. Heat input has been changing manipulating capacity of capacitance bank by changing number of capacitors.

Quality of welded joint was rated through cross section area of welded joint and visual inspection of welded joints. Cross section area of welded joint is measured on magnified pictures of welded joint as shown on figure 2. For this purpose was used special software to calculate automatically area of marked sectors.

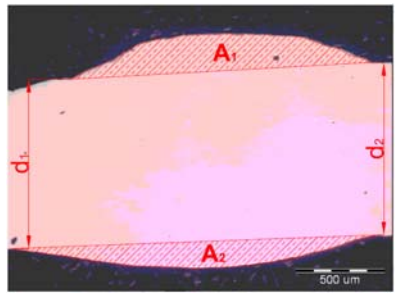

Figure 2. Calculating squeezed metal area of welded joint cross section

4. ANALYSES OF RESULTS

Results given from experiments are used to draw up diagram of dependance of squeezed metal area from heat input and contact force intensity, shown on figure 3.

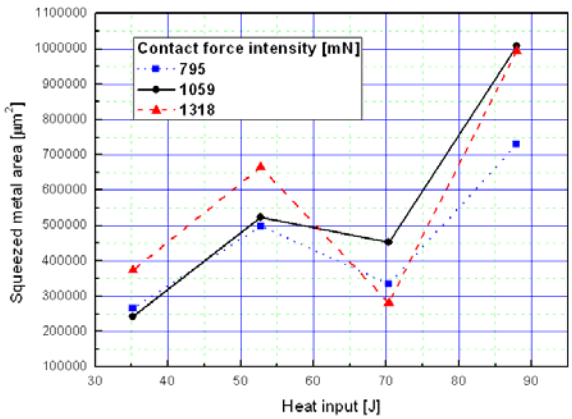

Figure 3. Dependance of squeezed metal area from heat input and contact force intensity

As shown on figure 3. amount of squeezed metal increases by increasing heat input. Altough, amount of squeezed metal slightly increases by increasing contact force intensity. However, interesting is that, all joints welded with heat input 70,34 J, have decrement of amount of squeezed metal independently of contact force intensity. This phenomenon stays unsolved. Considering geometry of welded joints, welding with small pressure intensity results with welded joints which have shape which follows wire geometry. On wire, which had prepared edge before welding, there is a part of unfilled gap. Welding with higher pressure intensities on wires results large amount of squeezed melted material which is incompact (divided into two volumes) which is unacceptable. Disadvantages mentioned above are less enhanced when pressure intensity is close to 1059 mN. Welded joints geometry welded with this pressure intensity is the most acceptable.

5. CONCLUSION

In this paper has been done analysis of dependence of welded joint properties when welding small diameter wires by capacity discharge welding process of welding parameters. In experimental part were welded wires of austenitic steel diameter of Φ1 mm. Welded joints properties are rated through visual features and geometry of welded joint. Experiment showed that, at lower pressure intensities on wires during welding, the wires, which had prepared edges, results weld with partly unfilled gap. This results of decreasing of welded joint cross section which later influences on mechanical properties of welded joint. Also, high pressure intensity on wires during welding results of squeezing large amount of melted material which is incompact or separated into two volumes. Considering amount of squeezed metal can be concluded that it increases by increasing heat input. Amount of squeezed metal slightly increases by increasing contact force intensity. However, it is interesting that all joints welded with heat input 70,34 J, have decrement of amount of squeezed metal independently of contact force intensity.

The best visual features and geometry of welded joint have those samples which were welded with contact force intensity of 1059 mN and heat input of 70,34 J.

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