A Review Paper onResistance Spot Welding of Austenitic Stainless Steel 316

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Abstract

Resistance spot welding has vital applications its main function is for joining gadget in Car Company and a regular automobile includes more than 3000 spot welds when current is passed through the welded work pieces the heat is produced due to resistance. This heat is used for melting the metal. Resistance spot welding is a high speed process, where in the actual time of welding is small fraction of second and it is one of cleanest method.

I. INTRODUCTION

Resistance welding is an extensively implemented joining method. In this chapter a brief overview is specified to resistance welding generation, observed by means of an overview to mathematical modelling of process and objectives of the thesis.

A. Fundamentals of Resistance Welding

Resistance welding holds that department of welding art in which welding heat in components to be welded is produced through resistance offered by those parts to passage of an electrical current [1], referring to Fig. 1.1. It dates back to a couple of century ago, begun with Thomson's work in 1880 [2] [3]. Nowadays resistance welding has advanced into one of most state-of-the-art automatic welding procedures, broadly implemented in industry.

B. Heat Generation

Joule heating is foremost heat source in resistance welding. When an electrical cutting I is passing through a conductor, heat may be produced in conductor. According to Joule's law, $Q=I^2Rt$

Where

Q = heat evolved [J],

R = overall ohmic resistance [Ω],

I = welding current [A],

t = time [s].

Besides Joule heating, other thermo-electrical phenomena occur, which include the Peltier effect and the Thomson effect [4] [5] in the resistance welding method.

Peltier impact, named after French physicist Jean C. A. Peltier, is phenomenon in which course of current influences weld high-quality due to extraordinary Fermi degrees of metals to be joined.

C. Resistance Spot Welding Sequence

The spot-welding process consists of a sequence of discrete events that arise over a brief time period as proven in Figure 1.2 [6]. During "squeezing", electrode pass collectively; force is carried out from a pneumatic cylinder and reaches its preset steady state value. Weld force will make two work pieces contact well and then provide right faying resistance for heat generation. Second step of RSW is known as "welding", when welding current is conveyed by electrodes to work pieces; it generates energy to melt contacted elements of work pieces to form nugget. Real time closed-loop manages is implemented all through this step, which is supplied through welding power supply. Last step of a RSW welding is "hold", which is likewise referred to as "cooling time". Reason of this step is to maintain molten nugget of work pieces for a certain time frame till it cools down and become a strong and solid nugget. Welding force remains employed on this step to keep the joints. To finish, upper electrode is lifted up allowing work pieces to be moved away and gets geared up to begin next weld.

It has been indicated that nugget formation and improvement can be characterized as a feature of

welding variables by following the principle stages [7]:

- Initiation of nugget,
- Rapid nugget increase,
- Steadily lowering increase,
- Possible weld metal expulsion.

As the contact resistance is strongly stimulated by pressure, electrode force is believed to be a critical component affecting procedure, especially at early level inside heating cycle [8]. Higher electrode force commonly reduces contact resistance on electrode-sheet interface and, for this reason, might lower heat/temperature at surface, which may additionally minimize tendency of expulsion.

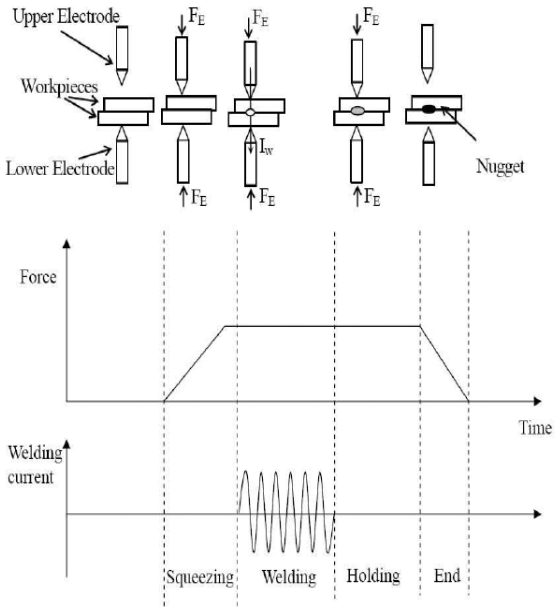

Figure1.1: The procedure of RSW

Therefore, electrode force determines maximum nugget diameter without expulsion whilst electrode geometry is kept regular [9]. By delaying expulsion, growing electrode force can broaden method window for a successful welding. However, a massive force minimizes weld resistance requiring higher current levels growing cost of process. Further, a big electrode force leads in damage of electrode and might lead to excessive surface indentation, that's often unwanted all through micro-joining or precision welding.

Welding current is another important variable affecting nugget formation and enlargement as power produced is proportional to square of welding current [10].

D. Features of Process

In latest decades some new approaches such as laser welding and clinching, have changed a few traditional resistance welding programs. Yet resistance welding still stands out against several joining strategies because of its specific features.

- **No unnecessary materials are wanted**. Resistance welding removes uses of unimportant substances which includes filler rods, fluxes, rivets and other added materials; this indicates not only material saving but additionally higher excellent in many instances due to the fact metallographic of weld isn't always complex by addition of extraneous materials.
- **Mechanical force is applied.** Mechanical force is present before, for the duration of and after application of electric current. Heat and pressure collectively decide final output. That is why those approaches also are known as resistance pressure welding. In fusion welding processes for instance laser welding, TIG welding, and many others. No mechanical force is carried out. While in cold welding, only pressure is present, there's no utility of heat. Application of force results in many compensations. On the handy, elements are pressed together and deformed earlier than welding. So geometry versions are permissible in work pieces. In evaluation, shape error in elements may also lead to extreme excellent hassle in some other approaches like laser welding. Additionally, force, which leads to plastic deformation, in mixture with welding heat refine grain structure, for that reason creating a weld with physical houses, in maximum cases, identical to the parent metal, and every so often even superior.
- **High manufacturing velocity:** Resistance welding is characterized by using short welding time — commonly among 10 and

500 ms. High productivity is one of advantages from resistance welding.

- **Good best of products:** With resistance welding high quality of products can be completed, both in look and physical quality.
- **Elastic and easy to automate:** On the opposite hand, resistance welding machines are available in a huge range of sizes, as is referred to in advance; on the opposite hand, standard sorts of welding machines can be utilized for numerous specific varieties of welds by making use of specific electrodes and tooling. And it is straightforward to put to mass manufacturing with automotive industry as a famous instance.

Particular traits of resistance welding have kept system within forefront of producing enterprise, continuing refinements in device and improvements in techniques have paved manner for more efficient manufacturing and better quality of products. The possibilities for resistance welding strategies seem comfy inside foreseeable future [40].

II. RELATED WORK

L. Tsai et al. (1992) attempted to model resistance spot welding method and simulated it using finite element code ANSYS. Mechanical behaviour of system coupled with transient thermal responses during spot welding used to be analyzed. Weld nugget formation in resistance spot welding of ASS 347 grade austenitic stainless steel of equal and unequal thicknesses and in addition of ASS 347 austenitic chrome steel to ASS 1045 carbon steel was once studied. Finite element model took under consideration, mechanical behaviour as good as transient thermal responses of resistance spot welding [11].

S. Aslanlar et al. (2008) represent the effects of welding time on the tensile-peel strength and tensile-shear strength of welding joints in electrical resistance spot welding of chromate micro-alloyed steel sheets having 1.2 mm thicknesses were investigated. The electrode pressure was fixed at 6 KN. The welding joints were exposed to tensile-peel and tensile-shear tests, and the effect of welding time on tensile-peel strength and tensile-shear strength was researched by using related period diagrams. The optimum welding times were obtained [12].

Rusinski E. et al (2004) investigates briefly the effect of diameter of spot weld on structural characteristics. The strength of spot welded structures is studied under compression considering effect of diameter and pitch of spot weld. FEA study is also carried on same structures taking into account physical and geometrical nonlinearities. The strength of spot welded structure is precisely determined under the test of compression. The information regarding structural details including all the parameters of the spot weld are referred for the study of vibration analysis of plates with spot welded stiffeners [13].

Palmonella M. et al (2003) studied two types of the spot weld structures are CWELD and ACM-2. It is shown in this paper that natural frequencies of proposed structures are very sensitive. These structures are mainly useful for many sheet metal applications to optimize the design. In this paper the techniques of model updating in structural dynamics are used to analysis and to improve CWELD and ACM-2 model. Guidelines are given for the model updating and implementation mainly in application of an automotive body in white (BIW) model. It has thousands of spot welds and major influence on the structural dynamics of the whole body [14].

Murat et al. (2004) have studied on resistance spot weld ability of galvanized interstitial free metal sheets with austenitic stainless steel sheets [15].

M. Alenius et al. (2006) explored mechanical properties of spot welded dissimilar joints for stainless and galvanized steels. Numerous assessments have been performed to assess spot welding parameters for distinct steel joints and to characterize their mechanical properties. Spot weld capability of numerous metallic joints between stainless steels and non stainless steels was investigated on this work [16].

III. Systematic Overview

Resistance welds can be made rapidly and without difficulty. This may also result in notion that the method is less complicated than actual is. Appropriately, procedure is much complicated than it would seem before everything sight. There are a big variety of things which have effect on final consequences and some are very hard to identify experimentally. It is vital to comprehend how those parameters can have an effect on weld quality.
A systematic review of process, taking into consideration all the principle factors within process, is proven in Fig 1.2.

There are five groups of factors which decide last quality of weld, particularly work pieces, machine, electrodes, interfaces and process.
Unnecessary to say shape, size and material properties of work piece are premise to take a look at a welding process. Same is true for electrodes. Electrodes are utilized to conduct current to work pieces, convey force and help to deplete heat from area being weld. In a welding procedure what is of interest isn't the quality of the weld, but additionally life time of electrodes because, except price, damage of electrodes impacts weld quality. Interface properties are crucial in resistance welding. Contact surface among electrodes and work pieces and at faying surfaces provide electric resistivity and thermal conductivity, these parameters are dynamic and contingent on numerous additional features. Process parameters along with force, current and welding time have to be decided as a compromise of weld quality, stability and productivity. Procedure parameters are not continually simply among welding machines because of exceptional ***machine*** characteristics. Each separate welding machine has its own electric and mechanical characteristics which include its dynamic reaction to a speedy variance in current, load or motion.

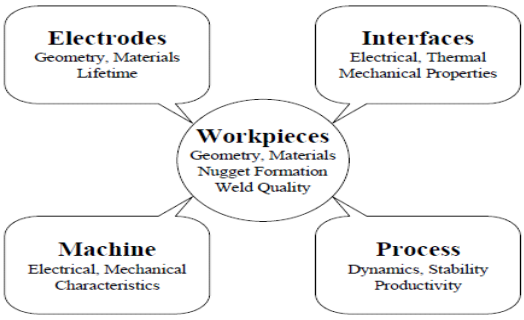

Figure 1.2 the system of parameters in resistance welding

IV. Review of Existing RSW Power Supplies

There are four distinctive sorts of energy materials used in RSW;

- Line Frequency AC Power Supply, which offers alternating current of similar frequency as input power line;
- Mid Frequency inverter energy deliver, which controls weld energy through mid-frequency switching approach;
- Direct Current Power Supply, which affords pure DC weld current through power transistors running in linear range;
- Capacitor Discharge Power Supply, which gives weld current by discharging energy saved in a capacitor bank. Typical AC, CD and DC current waveforms are exposed in Figure 1.3.

Most big-scale resistance spot-welding framework utilizes line frequency AC power supplies [15]. When an AC strength supply is utilized, output current is typically a sinusoidal waveform of equal frequency as input power line current, that is 50/60Hz alternating current AC, and heat is managed by modifying voltage and switching off current for a component of each cycle. Through utilization of silicon-controlled rectifiers (SCR), current is carried out in a managed way; therefore consequent current to work pieces appears as proven in Figure 1.3.

The real AC power supplies had been open loop controls. In order to enhance welding quality and consistency, new AC welding approach that offers closed loop control over weld current has appear, however it has poor manage potential at short cycle times. This form of power supply is typically sensitive to power line voltage alternate, which is other drawback of AC powers supply. Benefits of AC powers supply are: reliable, rugged and less expensive.

A more recent technology locating huge software in enterprise is mid-frequency DC supply. With this technique, standard 50/60 Hz AC power is first rectified, transformed to a 400 to 2000 Hz AC with an inverter, stepped down by a transformer after which rectified once more. Last stage of rectification is vital seeing that at these higher frequencies, cable impedance will be more than an order of significance greater than weld resistance. Control of quantity of power furnished is executed at inverter stage. Mid frequency DC power transformer has same motive as with weld transformer in traditional AC welder. Fundamental distinction lies inside size of magnetic iron core that transform primary current into secondary current. Since MFDC transformer operates with frequencies of 400 to 2000 Hz in preference to base 50/60 Hz, quantity of iron in core is decreased extensively. This permits transformer to be placed a much closer towards welding device in a few instances therefore providing further advantages. It appears that MFDC does no longer reason line disturbances, because the case with traditional AC welder. In fact, there are benefits for electrical power supply to install MFDC transformers for resistance welding [19]. It is a favored approach for higher currents related to welding aluminium. Even with smaller transformer, cost of power supply however is notably more costly than traditional energy components.

Downsized welder energy components are utilized for small-scale RSW systems. Most SSRSW applications utilizes ”closed loop” controlled power supplies which includes regular current, voltage and energy manipulate modes and presenting quicker velocity and smaller time durations, along with linear DC power supply. A linear DC power supply is also known as a “transistor direct power deliver”. A linear DC energy supply consists of a transformer, an AC-DC rectifier, a capacitor bank and energy transistors. Transformer steps down excessive voltage from power strains to a lower level welding voltage. Then by rectifier, te ac current is converted to dc current, and capacitor bank is utilized to filter signal and minimize ripple. Finally, controlled transistors act as a direct current supply to deliver pure DC current to weld tips and work pieces. This approach has great manipulated repeatability, however restriction to low strength restricts it to thin foils and great wires and really low duty cycles [14], [16].

Some SSRSW applications utilize CD power supplies, which utilizes “open loop” control. It is also referred to as a “Stored Energy” energy supply [22]. When a CD power supply is utilized, a charged capacitor bank provides gives the energy and the quantity brought is decided through the preliminary charge, i.e., preliminary voltage throughout capacitance. This type of energy supply reveals excellent repeatability of quantity of saved energy, and it is rugged and less expensive. However since shape of heart pulse is affected by weld resistance, instantaneous weld powers are out of control. Variability of weld conductor impedance modifications energy delivered to weld. Variability of weld resistance extensively influences impact duration of weld and amount of heat dissipated at stage during weld, resulting in variability of final temperature and weld properties. Furthermore, because of limits at capacitor size, it limits this approach to most effective SSRSW.

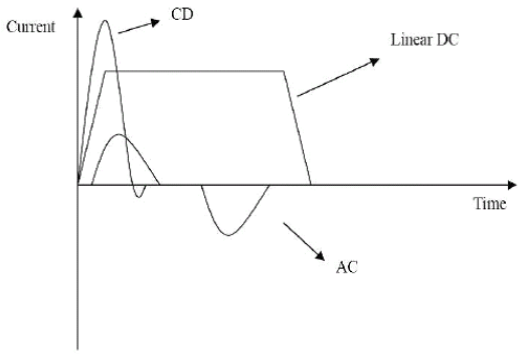

Figure 1.6: Sketch of current waveforms of CD, DC and AC power supplies

V. CONCLUSION

Austenitic stainless steels are widely utilized in industrial applications due to their strength, corrosion resistance, mechanical workability, and excellent electrical and thermal conductivities. Among them, ASS 316 stainless steel is of great practical interest because it is employed in pharmaceutical, petrochemical, offshore drilling marine shipping, water desalination, etc.Weld current is major governing factor affecting the tensile shear strength of the resistance spot welded specimens. As the weld current increases, size of weld nugget also increases. This results into increased values of tensile-shearing strength.

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