JOINING OF THIN PLATES USING VARIOUS ARC WELDING HEAT SOURCES – A REVIEW

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ABSTRACT: Advancements and improvements in welding processes are mostly to expand profitability without losing the nature of the weldment. In order to protect the quality and the cost, using light material has become an interest among industries. One of the purpose of the developments in thin plate welding technology is to minimize the cost and the weight. The main objective of the current study to investigates the current status of thin plates joining using arc welding as the heat sources for common method variance in research and assists researchers in taking appropriate actions. Welding distortion resulted from residual stress and it can cause problems in terms of dimensional tolerance and manufacturing integrity in the assembled structure. In this paper, methods for thin plate welding process were reviewed and it was evident that numerical modeling and experimental has been employed on evaluation of welding parameters and its effect to the weld performance and characteristic. This paper also aims at outlining the recent findings from similar and dissimilar material, laser welding, TIG and MIG welding in regards to the thin plate welding. The most significant findings emerged from this study is that output responses related to heat source, deformation of welded joint, thermal and physical properties. Some recommendations and future research methods are also proposed.

KEYWORDS: *Thin Plate; Arc Welding; Steel; Aluminum; Automotive*

1.0 INTRODUCTION

In car ventures, thin plate parts are normally utilized. Amid gathering process, welding innovation is normally utilized due to high profitability without losing the nature of the joined. This has been a focus of competitive market worldwide. However, for current technology, one of the challenges is joining thin plate materials especially in the automotive industries. Relatively, welding distortion frequently happens in thin plate welded structures because of its low firmness. The bending causes issues in the gathering procedure as well as in the nature of the final product.

Finite element method (FEM) is one of used to simulate welding distortion in structure. They utilized the flexible FEM with those anticipated by the thermo-elastic– plastic FEM, it is checked that the intrinsic strain strategy can viably foresee the welding distortion in thin plate. [1]. A few analysts talked about the joint-hole vulnerability of thin sheets with differing holes, the FEM model can likewise be utilized to foresee required parameters continuously and refreshing them to the welding power supply to car bodies and to expand their strength while diminishing their weight [2-3].

In term of FEM modeling, welding heat source is expected as a point and a line in the beginning periods of welding demonstrating. Amid this underlying stage warm exchange depended on conduction models and later convection models are produced which observed to be more exact particularly in and around the weld pool [4]. There is a need to develop prediction on the unwanted welding distortion of thin material. The reasons are that residual distortion can cause issues as far as dimensional tolerance producing uprightness in the collected structure, and increment the cost. Several factors that influence distortion can be categorized into design-related and process related. In term of the processes involved, the variables are heat input, travel speed and welding sequence. Depending on application of welding thin materials, different distortion control methods are used to provide more solutions that are adequate. For instance, to approach stringent clamping, tacking and riveting. Understanding their capability and limitation of all these distortion control methods is critical in order to achieve a successful welding fabrication project.

2.0 MATERIAL AND APPLICATION

In automotive industries, the element of thickness in welding is rarely exceeding 2.5 mm. In the case of thinner parts (up to 1.5 mm) an overheat delivered into the joint may cause undercuts of the edges of welded sheets [5]. Be that as it may, there were extremely restricted writing depicting the expectation and the estimation of welding distortion in the thin plate welded structures particularly for this welded structure including under 3.0 mm of thickness of plate or wall. The basic plate is structural element dimensions might be classified thin and thick based on theory of elasticity [6-7].

2.1 Similar Material

Recently, for the past 10 years, researcher's attention has focused on the provision of similar material in welding process and method. Mainly, aluminum is used as a material for lightweight structures, which is progressively being utilized particularly in transport, sustenance and aviation industries [8]. Generally, the researcher's concern is on the developing interest for new joining advancements with low distortion and high creation productivity. Some researchers focused on two processes of aluminum with different thickness and process [9]. These two processes were chosen to maximize tensile force that sustained by the joints during tensile testing. Welding aluminum alloy high strength aluminum (Al-2024) thickness 3.2 mm with cold metal transfer (CMT) process have been examined for characteristics of the synergic [9-10]. By experimental thin mild steel (low carbon steel) sheet joint to quantify welding distortion in the thin plate butt-welded joint by GMAW [11]. Overall, many researchers prefer to use the same material approach in conducting experiments in their research.

2.2 Dissimilar Material

There are also researchers combining different materials in their studies. Studied on cold rolled plain carbon steel sheet (SPCC) and pure aluminum sheet for a thin plate with the thickness of 2 mm [12]. Two sample sheets in which each thickness of 1 mm with different base materials AA 6082 and AA 5083 and made a comparison with respect to the gap bridging ability [13]. Research on joining of aluminum (AA6061-T6) of 2 mm thickness and high strength grade galvanize healed IF (HIF-GA) steel sheet of 1mm thickness by traditional combination welding strategies is troublesome because of the substantial contrasts in thermo-physical properties, for example, softening point, warm conductivity and thermal extension which prompt high distortion and stress residual [14]. The investigation was related on both joint comparative and disparate 5083-H111 and 6082-T651 aluminum were especially utilized as a part of ship building enterprises particularly for their high erosion protection and direct quality, and it was welded utilizing Pulsed Robotic Cold Metal Transfer (CMT) and Metal Inert Gas (MIG) innovation [15].

3.0 WELDING PROCESS

3.1 Laser Welding

Laser welding has been utilized by the car, food and aerospace industries for a long time. Several attempts have been made to industry in seeking weight reductions for large steel structures. This laser based welding process as heat source is used to high quality steels and thin plate structures together. The analysts' discoveries on exhaustion quality of welds structures beneath 5 mm is seen to have substantial variety, which gets difficulties to weakness quality appraisal thin plate [16]. The researcher’s worry on for the impact of weld geometry that is disregarded in like manner weariness quality evaluation on thin plate 3 mm and watched that pivotal misalignment in limit laser half and half welds may cause a huge indent worry in which it might expand the root side lessening the weakness quality significantly in the basic and ostensible anxiety framework [17]. A high bar quality is especially worthwhile for laser welding of aluminum composites because of its high reflectivity for thin plate [18]. Laser welding is a high energy welding process that offers quick welding speed, small heat input, and deep penetration [19]. However, laser welding is progressively used in different mechanical fields and is developing as a basic creation procedure in the vehicle business however these techniques are generally confined to welding of specific materials with exceptional plan necessity, for example, microelectronic and aviation parts.

3.2 TIG/ GTAW

Gas tungsten arc welding (GTAW), otherwise called tungsten inert gas (TIG) welding is arc welding process that uses a non-consumable tungsten electrode to create the weld. GTAW is normally used to weld thin areas of stainless steel and non-ferrous metals, for example, aluminum, magnesium, and copper composites [20-21]. In the TIG found local melting and solidification for the parts to be installed during welding is one of the difficulties encountered during the welding process, resulting in large defects that often require straightening operations in thin plates [22]. TIG process is the most famous process to increase the production time for the assembly of thin plate parts. The impact of the angle on residual stress was investigated to guarantee execution TIG welding process [23]. TIG welding, associated usually with high quality but low productivity process, can increase its potential if the productivity can be increased. For thinner sheets ≤ 3mm manual TIG is normally performed in the manual variant where welding currents are lower. However, it is also one of the slower methods of arc welding.

3.3 MIG/GMAW

As of late, as the ventures have endeavored to end up noticeably more productive, there has been recharged enthusiasm to enhance quality and to beat the restrictions of customary Gas Metal Arc welding (GMAW) which prompted the improvement of pulsed arc technologies. The process metal inert gas brazing (MIGB) is similar to MIG/GMAW welding. Some researchers investigated on conventional MIG on for thin plate. MIG welding also gives high joint effectiveness in volume generation and light-weight outlines by welding thin plates of high quality steels with different thicknesses to make complex gatherings. The low energy welding processes seems to be one of the most perspective methods of joining thin elements in automotive industry.

Nowadays, the thickness of the panel in vehicle construction are becoming increasingly thin as low as 0.3 mm, and 0.2 mm for composite. Base on a review, low energy transfer of arc welding innovation utilizing gas protecting which is known as surface tension transfer (STT), cold metal transfer (CMT) and ColdArc are next variations of MIG/MAG welding to take care of issue happening when joining thin plates, high protection steel sheets, covered and non-covered, stainless steel metal sheets and those made of aluminum combination [24]. A few MIG welding systems with controlled heat input on board circuiting were presented such as STT delivered by Lincoln, CMT by fronius innovation influences welds to require low heat input is substantially simpler without overheating or consuming through, it limited the distortion and reduced the welding current short circuiting for a thin plate [25-26]. Hence, the reigniting happens with low power and decreases spatter formation, heat input and weakening. The coldArc by EWM manipulation of the wire feeding system is outfitted with an advanced digital signal processing unit, which permits identifying the short. This offers the possibility to join unique materials or thin sheets without enormous weak intermetallic stages and to maintain a strategic distance from or limit scatter [27].

4.0 METHOD OF STUDY

4.1 Modeling

Finite element (FE) techniques utilizing strong mechanics to displaying the welding procedure, the exact recreation of the welding heat source delivered by the welding light has a critical impact in creating dependable warmth contributions to the FE model. This would permit a precise reenactment of temperature circulations and varieties, which thus decide material properties, welding distortion and residual stress of the welded structure. There are many types of FE analysis and mathematically model for welding such as ABAQUS, Ansys, Solidworks, Matlab, Taguchi ANOVA, etc. Previous researchers proposed that elastic FE technique in view of inherent strain hypothesis and simulate welding deformation is a compelling way to deal with anticipating welding distortion in production of thin plate structures [28-30]. Other hand approached FEM on welding induced angular distortions in steel plates and it was predicted using artificial neural networks using Matlab [31]. Some researchers using a modified Taguchi method proposed to determine the optimal process parameters [32] and few used a combination of a neural network with a fuzzy clustering technique [33].

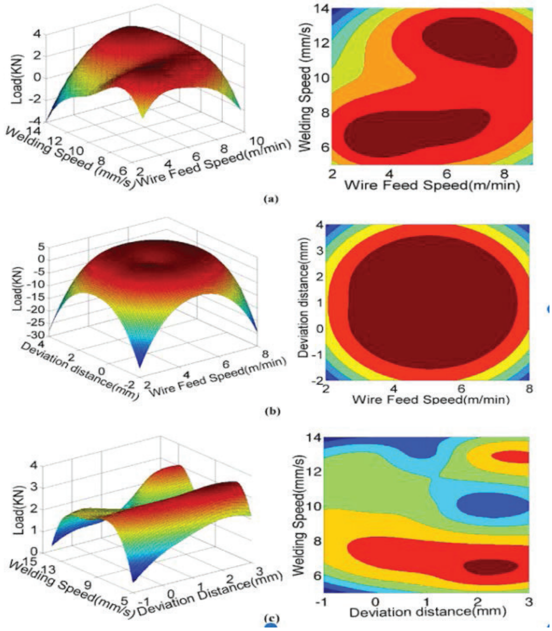

Figure 1: The combined main effects of various process variables on the joint strengths pertaining by ANOVA analyses: (a) wire-feed speed × welding speed, (b) wire-feed speed × deviation distance, and (c) welding speed × deviation distance on the strength of CMT weld-brazed aluminum-to galvanized mild steel [35]

ANOVA analyses also can prediction of major distortion such as angular distortion, transverse shrinkage and longitudinal shrinkage by empirical formula on joint process welding [34]. To determine the statistical significance of the process the statistical analysis of variance ANOVA had also been performed. ANOVA analyses are shown in figure 1 the merged main effects of various process variables on the joint strengths pertaining on thin plate aluminum. Develop by combining the results optimum welding window with welding voltages of 12–14 (welding speeds of 6–8 mm/s, deviation distances of 2–3.5 mm, and wire-feed speeds of 4–6 m/min) [35]. These results shown the significant of study dissimilar material thin plate aluminum to mild steel. Other hand, these gives a harsh diagram of the techniques utilized as a part of the thin plate welding procedure to show the viability of each procedure. The determination of each demonstrating technique is expected to give sensible information dissects on the materials contemplated.

4.2 Experimental Procedures

One technique is to decide the ability of a procedure is successful or not is through experimentation. In this procedure, any undertaking or example is tried with real parameters in view of industry circumstance. Numerous researchers utilize this strategy to get information or data identifying with the real situation. There are researchers discussing the analytical and experimental results of transverse shrinkage in butt welding to find the appropriate parameters [36]. Various researchers, hypothetically or tentatively have attempted to anticipate the heat and mechanical reactions of welding structure to discover approaches to predict welding remaining distortion and residual stress [37]. Generally producing system streamlining is to maintain a strategic distance from impeding welding distortion, and this can be refined by an iterative test methodology in current assembling. However, it was unpractical due to its huge amount of cost. To determine the effect of thin plate, the researcher made a comparison between method numerical and experiment to identified welding distortion. The fatigue quality of 3 mm using laser welding to tests welded butt joints was considered utilizing the genuine weld geometry and the notch stretch approach [38]. The use of experiment in double-electrode gas metal arc welding (DE-GMAW) by welding process recently has been developed to increase welding productivity while maintaining the base metal heat input at a desired low level [39]. Some conducted an experiment using different types of wires to validate the predicted results and the range of the joint gap that can be bridged effectively MIG short-circuiting metal exchange and AlSi5 compound wire in 1.2mm distance across was chosen as the filler metal amid the welding procedure [40]. It was led on the thin plate of unadulterated aluminum sheets and an unadulterated argon protecting condition is utilized [41-43].

5.0 OUTPUT RESPONSE

Thin plates on welded structures are generally involved complicated geometrical shapes and are subjected to severe thermal loads during fabrication. In most of the investigations, only a few specific conditions are studied. For a better understanding of the thin plate using arc welding as heat sources such as material, process welding and method of study. A legitimate investigation to decide the quality and the stiffness of such structures depends to a great extent on the exact expectations of the heat flow and a realistic stress that is fit for including the thermal effects and their effect on the mechanical properties of the material structures. Numerous specialists examined the thermo-mechanical conduct of thin plates amid the welding operation and cooling down the welded parts, the parameters of the heat source will be upgraded with the reaction surface of a DOE technique using such as Taguchi or Respond surface method. This strategy is extremely well fitting for various welding speeds and permits recreating an exact width and thickness of the weld without losing quality. The heat source on thin plate demonstrate displayed ends up being adaptable and can be utilized to various sorts of the model weld. It creates the impression that the impacts of the liquid zone are unimportant on the heat flow examination and the pinnacle temperature after in correlation with the test comes about. The expectation for the transient focal redirection and the transient heat strains are in great concurrence with the accessible exploratory information. The dispersion of the distortion and residual stress seems, by all accounts, to be exceptionally sensible and it is like those detailed in the writing for various curve properties of a similar weld type. In this review, residual stresses and distortions induced in MIG welding of thin plates are implementing a moving distributed heat source model FE software ABAQUS in thin plates. Welding distortion happening from thin plate joint or structure is unavoidable and regularly brings about loss of dimensional control, basic honesty and expensive in assembling because of its extra rectifying.

6.0 CONCLUSION

Generally, recent researches on the development of inherent deformation for welding distortion prediction in the fabrication of thin plates. The following conclusions have been drawn:

i. Recently, the focus of the researchers and industry is to study the comparison of thick (≥ 3mm) material and thin (≤ 3mm) material because of its welding technologies process is quite established.

ii. MIG process Surface Tension Transfer (STT), (Cold Metal Transfer (CMT), and Cold Arc) are new variant technologies indicated for thin plates and penetration welds, thus it is quite popular for the productivities achieved, yet the quality (shape) of the welds is very good. MIG has proved to be a very high potential technology to increase the production at lower cost guaranteeing however incomparable welding quality standards when compared with traditional welding processes.
iii. Two types of the basic method were research approach numerical (FE) and (DOE) Design of experiment method to investigate the distortion and residual stress on welding process.
iv. Commonly, researchers' parameter and concern in their study on MIG process is heat input, voltage, current, welding sequence, a gap of the plate, wire feed, welding speed, and gas.

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