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Impact of activated–flux tungsten inert gas (a-tig) welding on weld joint of a metal – Review

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Abstract

Welding is applied in every industry and it's a major method of manufacturing and revamping metal products because its generally economical, efficient and reliable as a means of joining together metals. Various ways have been proposed to improve the process ranging from adjusting the various welding parameters like welding current, voltage, arc length, width, type of shielding gas used, to using arc pulsing. The method that has however gained the most attention is the Activated-flux TIG welding process which utilizes welding flux to help reduce the bead width and increase the weld penetration. In order to improve the TIG welding process's industrial efficiency and penetration ability, one method commonly applied is the use of activating flux with the welding process. This review provides insight to the impact of Activated - Flux Tungsten Inert Gas Welding on weld joint of a materials metal.

Keywords: Activated; Flux; Welding; Tungsten; A-TIG.

1.0 Introduction

Welding is a procedure used in fitting together materials, usually thermoplastics or metals together by means of coalescence, which occurs by the application of heat to the metals to be joined causing them to melt and form a weld pool (with or without the application of a filler metal) which is stronger than base metals that are joined. Pressure is also occasionally used either in combination with heat or on its own to form the joint. Welding is applied in every industry whether big or little, and it's a major method of manufacturing and revamping metal products because its generally economical, efficient and reliable as a means of fitting together metals [1]. The history of metal joining stretches back several millennia to the iron and bronze ages in Europe and the Middle East. Iron welding was credited by Herodotus the Ancient Greek historian as having been invented in the 5th century BC in the city of Chios by a man called Glaucous, and iron welding was used greatly in the Middle East and Asia to construct various objects and buildings like the Iron pillar of Delphi built in 310 A.D in Delhi, India with an estimated weight of about 5.4 tons. The Middle Ages saw great advancements take place in the various welding processes especially forge welding, in which metal was heated then pounded together repeatedly until bonding occurs and the metal welds together. This process formed the backbone of work that went on during the renaissance with craftsmen being very skilled in the process [2].
In the 19th century, improvements to the process of welding started in earnest with discovery of the "short pulse" electric arc and the continuous electric arc by Sir Humphry Davy and Vasily Petrov,

this resulted in the invention of the first electric arc welding process using carbon electrodes in 1880 by Nikolai Benardos and Stanisław Olszewski. Further improvements that occurred were invention of metal electrodes in 1888 by Slavyanov and Coffin (1890), the development of a coated metal electrode in Britain by A. P. Strohmenger in 1900 which gave a stable arc as an addition. In 1905, the use of a three-phase electric arc was suggested by Vladimir Mitkevich. C. J. Holslag developed alternating current welding in 1919 but for another decade the process did not gain overall usage [3]. The processes developed at first in the late 19th century included the Arc welding and Oxyfuel welding process followed soon after Following the world wars, demand for cheaper and more reliable ways of joining metals skyrocketed and this led to the development of several modern welding techniques like the Shielded Metal Arc, Gas Metal Arc, Electroslag, Submerged Arc and Flux-cored welding [4].

2.0 Types of welding

There are various types of welding methods available right now for use in joining metals together, they include; Gas Tungsten Arc Welding (GTAW), Shielded Metal Arc Welding (SMAW), Gas Metal Arc Welding (GMAW), Submerged Arc Welding (SAW), Flux Cored Arc Welding (FCAW), Electron Beam Welding (EBW), Electro Slag Welding (ESW) and laser beam welding (LBW) methods [45]. Arc welding has come to be used as an industry wide welding standard, and it has been adapted into various variants for use in industry by changing the parameters that govern it [5]. Arc welding processes use the basic principle of creating an arc electrically between the electrode and the workpiece, and the heat generated utilized in melting a filler metal as in GMAW, SMAW, GTAW, FCAW or fuse the work piece together without a filler metal as in Autogenous TIG welding [6].

The properties of these welding processes can be increased greatly through the use of welding fluxes, ranging from oxides to fluorides [7]. Welding fluxes are chemical compounds which greatly improve the weld properties of a weld joint when applied. They are used in various arc welding process which include GMAW, GTAW, plasma arc welding (PAW), laser beam welding (LBW) and EBW processes for welding several dissimilar, ferrous and non-ferrous materials [8]. A flux fundamentally is a mix of activated compounds conveyed in a carrier solvent. The most popular fluxes are fluorides, chlorides and oxides and are selected based on the welding process to be used and the base metal to be joined. An activated flux's defining characteristic is that for it to complete its function, the flux must be applied over the entire surface to be welded evenly [9]. Among these various types of welding, the one most significant in this project work is the TIG welding process.

2.1 TUNGSTEN INERT GAS WELDING

Gas tungsten arc welding (GTAW), as TIG Welding is otherwise called utilizes a non-consumable tungsten electrode for the creation of weld, this is one of the many welding processes that exist [10]. The weld pool being shielded from the oxidation and other environmental defilement such as air contaminants and impurities by a protecting inert gas such as helium or argon. The use of a filler metal is usually utilized in this arc welding process despite the fact that a few welds such as autogenous welds do not need to utilize this filler metal for their welding process. Electrical current is produced by a consistent flow of power supply for welding known as plasma which is directed exceptionally through a segment over ionized gas alongside metal vapors [11]. Gas Tungsten Arc

(GTA) welding also called Tungsten Inert Gas (TIG) Welding is a process in which metal parts are joined by using heat created by an arc electrically struck between the job to be joined and a Non expendable Tungsten electrode [12,13]. It was invented in the early 1940's by Russell Meredith in Southern California. It was developed because the Northrop aircraft corporation needed a way to join magnesium and aluminum together which existing welding processes at the time could not achieve. It was developed to enable aircraft manufacturers to join alloys of light metals together used in manufacturing air frames and it did this in an inexpensive way and created high quality welds there establishing it as a standard for welding airframes. It is commonly used in the industry for joining various metals together, both ferrous and non-ferrous. It produces a smooth, clean weld and can be carried out in any welding position [14]. It is a reliable process and it is used where high-quality welds are required due to the shielding provided for the weld pool by the shielding gas. It is used for the welding of tube, sheet, plate and castings used in a variety of industries ranging from nuclear to aerospace to ship building and various others. It can be used with filler metal to produce thick section welds or used devoid of filler metal to produce an autogenous weld [15] An electrical current provides a source for the arc used in TIG welding process, Alternating Current (AC) and Direct Current (DC) are used in TIG welding [16]. The various welding currents are different modes of the alternating and direct currents, and they include; Direct Current Reverse Polarity, Direct Current Straight Polarity (DCSP) and Alternating Current. The DCSP is most commonly used for DC type welding current connections. In this setup the tungsten is the negative terminal and receives 30% of the heat of the weld, making sure that the tungsten electrode is cool compared to the DCRP and it doesn't melt away. The use of DCSP results in a good penetration of the weld and a narrow profile. The DCRP setup has the tungsten as the positive terminal and 70% of the heat is received there which causes the tungsten to start to melt. It is seldom used and the weld produced is shallow and wide. The AC is the most stable one as the heat supplied to the electrode is leveled out as the AC wave oscillates from crest to trough (i.e. one side of the wave to the other). It is the welding current of choice for joining white meals together e.g. magnesium and aluminum. [17].

TIG welding stands out amongst the most broadly utilized metal joining forms in industry. The examination of this study was illustrated by (Graczyk *et al.*, 2015). The process of welding however creates harmful particles which poses as a health hazard for the welders. Be that as it may, current writing is yet to have a substantial characterization of particles of fumes gotten from welding. Applications of GTAW is essential where control of the metallurgical features and weld bead shape is vital. However, when outsized components are joined, low productivity occurs. The Activated flux TIG welding process uses a thin layer of activated flux on the parts to be joined, and this results in a great increase in penetration depth of the weld. Elements of high electronegativity lead to electron capture in the outer parts of the arc and this produces an effect of arc compression which is similar to what happens during plasma arc welding. [18]

Tungsten Inert Gas Welding is generally use in industry for joining metals, this expands the scope of study for this form of welding. Industries can use this process for castings and the production of weld with wide diameter and thickness. Alternating current and direct current are types of welding current which can conduct this welding process [19]. The review of mechanisms by which fluxes that are active can cause an increment of the TIG welds. Activated tungsten inert gas is assessed as well. Furthermore, due to the molten pool having a contrast to a surface tension change, the

mechanism for increased infiltration is considered to be a segment that is circular. A test program of work was done utilizing A-TIG transition in mix with various welding forms [46]. By increasing the thickness of the current, there was investigation conducted by [20] whereby compared to normal TIG welding, it resulted in the plasma procedure having an increased penetration. The electron beam processes and the CO_2 laser processes do not depend on current carry arc due to the source of the heat for welding also being carried out and additionally examined. The activated tungsten inert gas displayed effectiveness when the weld pool. Macro sections taken from the welds made by these processes showed that the activated tungsten inert gas flux process only gave the required results when the weld pool production was done by an arc or plasma, this was derived from tests carried out on Macro sections of welds carried out using these techniques. There was absence of plasma and arc and due to this the flux had little effect [21].
TIG welding also known as Gas Tungsten Arc Welding standout amongst broadly utilized metal joining forms in industry. The process of welding however creates harmful particles which poses as a health hazard for the welders [22]. Be that as it may, current writing is yet to have a substantial characterization of fume particles from welding. Indeed, not much is thought around welding exhaust created through welding disciples with minute involvement in welding. All subjects overall, the molecule tallies having a percentage of 92% at the BZ were below 100nm. Presentation appraisal was directed by [23]. For individually understudy welder at the zone of breathing within the welded head protector and within close field (NF) area, at a distance of 60centimetre from the errand to be welded within a geometric mean width of 45nm, the mean molecule number fixation at the breathing zone was 1.69E+06 particles-3. Mean ROS creation probable was essentially greater for understudies which consumed the metal amid the assignment to be welded [24]. Future introduction appraisals mull over welding execution as a probable presentation for disciplining welders which modifies them or welders who have insignificant preparing. We portrayed particulate issue (PM4), molecule number focus and molecule estimate, molecule morphology, compound structure, receptive oxygen species (ROS) generation potential, and vaporous segments [25]. We watched raised convergences of tungsten, which was in all probability because of terminal utilization. Fumes of tungsten inert gas welding was characterized in an environment that was controlled simultaneously with the maintenance of an occupationally important human factor for the generation of fumes. In an atmosphere or environment of concentrations that were high of fume particles from welding, representation showed the apprentice welders had been exposed and consist nearly wholly of particles with GMDs <100nm [26].

Moreover, production feasible for ROS was essentially greater for understudies which consumed metals at the time of their welding duties. It was suggested that future exposure evaluations think about welding execution concerning nature of the weld as a feasible presentation modifier for disciplining welders which modifies them or welders who have insignificant preparing. Expanded research should be completed to survey the wellbeing impacts of understudy welders presented to TIG welding exhaust [27].

2.2 Tig welding –limitation

However, TIG welding has some demerits which discourages its use in the industry include;

i. Low weld penetration during single pass, high cost due to requiring specialized preparation of its edges and additional filler metal necessary to fill up the welds [28], reported that due to the inability of TIG welding to produce welds with a deep penetration, the metal that can be joined reliably by TIG welding process have to be less than approximately 3mm. Workpiece greater than 3 mm required preparation of the joint edge and running the weld multiple times/ to fill up the joint [29].
ii. Low productivity is also a problem due to the need to combine lower speed of welding and multi-pass welding technique in welding thicker section materials together, and if there is an increase in the welding current or travel speed decreased, the weld pool becomes overly wide with little increase in weld penetration. Supplementary expenses incurred using this process include cost of preparation of its edges and longer time to make the various passes required to fill up the joint. [30]. Bodkhe and Dolas, 2018, reported that low productivity is also a problem due to the need to flux gap welding procedure and with change in the welding current, the weld pool widened disproportionately with little increase in weld penetration.
iii. Its inability to take into account the various different composition of materials like variations in composition of welds made due to presence of certain impurities also make TIG welding problematic [31].

3.0 Activated-flux tungsten inert gas welding

Activated-Flux Tungsten Inert Gas (A-TIG) welding is a method created to improve the TIG welding method. It is a distinctive welding process that was created by scientists at the Paton Institute of Welding in 1960, also known as Flux Zone Tungsten Inert Gas (FZTIG) welding [32]. The activated flux is applied in the A-TIG welding process to the joining surfaces, creating a thin flux layer after which the TIG welding process is applied (Vidyarthy and Dwivedi, 2016), the arc's heat melts the flux as it passes over it and thus increases the TIG weld's penetration depth by up to 3 times per heat input. [33] found that an increase in penetration depth of up to twice the penetration obtained under conventional TIG welding was achieved when different fluxes were applied [34].
It was discovered that the flux increased the penetration of the weld through the convection flow of the molten metal directed by different forces, namely Buoyancy force, Marangoni convection (surface tension) and Lorentz force (electro-magnetic). The flux applied resulted in some spectacular effects in the weld pool, such as arc restriction and a halving of the weld bead width when compared to conventional TIG welding, resulting in an increase in weld penetration. The main component of the A-TIG welding process is the welding flux, which gives the process its special characteristics [35].
Until the late 19th century, the only way metals were joined was through the forge welding process where iron and steel was joined by heating then hammering by blacksmiths. The processes developed at first in the late 19th century included the Arc welding and Oxyfuel welding process followed soon after by electric resistance welding [36]. Following the world wars, demand for cheaper and more reliable ways of joining metals skyrocketed and this led to the development of several modern welding techniques like the Gas Metal Arc Welding, Shielded Metal Arc Welding, Flux-cored, Submerged Arc Welding and Elecroslag welding[37].

Welding is a procedure used in fitting together materials, usually thermoplastics or metals together by means of coalescence, which occurs by the application of heat to the metals to be joined causing them to melt and form a weld pool (with or without the application of a filler metal) which is stronger than base metals that are joined. Pressure is also occasionally used either in combination with heat or on its own to form the joint. Welding is applied in every industry whether big or little, and it's a major method of manufacturing and revamping metal products because its generally economical, efficient and reliable as a means of fitting together metals [38,39].

3.1 Properties of activated flux tig weld

Mild steel plates were welded using A-TIG welding and the performance of the welding process was studied. They carried out tests using Cr_2O_3, $MgCO_3$, MgO, CaO, Al_2O_3 as fluxes and They found that using Cr_2O_3 flux produced the most effect on the weld penetration while the $MgCO_3$ flux gave the lowest penetration of all the fluxes tested [40]. They also found that the quality of the weld increased on application of the fluxes, this was confirmed by the Vickers hardness test.) Flux powder was developed for welding of DMR-249A Shipbuilding Steel and studied the mechanical properties of the weld produced with the fluxes [41,42]. They found that a combined concentration of oxygen and silicon in the flux determines the penetration depth, the concentration of the silicon and oxygen need to be optimized to increase the depth of the penetration. It was also found that using an air gap of 3mm, torch speed of 60 mm/min and a weld current of 270 A resulted in maximum penetration of 7.8 mm. Chai, (1981) investigated the Slag metal reactions that occur in binary welding flux CaF_2-Metal oxide and he found that most of the metal oxides when used singly decompose at high temperature thereby causing oxygen contamination of the weld [43]. He carried out tests using CaO, K_2O_3, Na_2O, $Ti0_2$, Al_2O_3, MgO, SiO_2, No, and he found that CaO is the most stable while SiO_2 and MnO are the most unstable. He also found that addition of CaF_2 helped stabilize the flux by reducing their oxidizing potential [44,46].

4.0 Conclusion

So many different ways have been introduced in improving the process ranging from adjusting the various welding parameters like welding current, voltage, arc length, width, type of shielding gas used, to using arc pulsing [47]. The method that has however gained the most attention is the Activated-flux TIG welding process which utilizes welding flux to help reduce the bead width and increase the weld penetration. In order to improve the TIG welding process's industrial efficiency and penetration ability, one method commonly applied is the use of activating flux with the welding process

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