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A REVIEW ON EFFECT OF FLUX POWDER SiO_2 FOR THE WELDING OF 304-AUSTENITIC STAINLESS STEEL

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Abstract – *In today's manufacturing market Productivity and quality plays a vital role due to vast competitive market conditions in manufacturing industries. The objectives of manufacturing Industries are related to quality product at minimum cost, safety, vendor selection, efficiency of cost. The aim of this research study is to identify the effect of activating flux which is inorganic material mixed with volatile medium in weld morphology and microstructure of the material of the welding process namely Gas Tungsten Arc Welding (GTAW) For this three input parameter i.e. current, voltage, and flux are considered in order to find out influence on responsive output parameter such as depth of penetration and weld bed width. The effort is taken to investigate optimal machining parameter and their contribution on producing better weld quality and higher productivity.*

***Key Words*: 304- Austenitic stainless steel, SiO2, flux, GTAW, Weld geometry**

1. INTRODUCTION

Welding is the most common method used for joining the two metals. Among various types of welding processes, Gas Tungsten Arc Welding (GTAW) is widely used for industrial application. It is also known as Tungsten Inert Gas (TIG) welding. Gas Tungsten Arc Welding is effective for good quality & stable arc with different types of metals. As there are benefits of using GTA welding in terms of efficiency and quality, there are certain limitations as well, like, there is a limited thickness of metal up to which single pass GTA welding method can be used, speed of weld is low in GTA welding and the deposition rate is less [1]. A simple process of applying a thin coating of the flux to the surface of the base metal before arching produces a dramatic increase in the penetration depth by between 1.5 and 2.5 times, compare with the depth produce using the conventional GTA [2]. In Autogenous TIG welding weld joint produced by melting the contact edge surfaces and subsequently solidifying it at room temperature (without addition of any filler metal) is called "Autogenous weld". Thus, the composition of the Autogenous weld metal corresponds to the base metal only. However, Autogenous weld is crack sensitive when solidification temperature range of the base metal to be welded is significantly high. TIG welding process performed without application of filler material is known as Autogenous TIG welding process. Autogenous TIG welding is preferred especially for less than 5 mm thick plate. The advantages of this process is economical process as compare to heterogeneous or homogenous welding process as no edge preparation and filler material are required.

1.1 Principle of TIG welding

In TIG welding process, the electrode is non-consumable and purpose of it only to create an arc. The heat-affected zone, molten metal and tungsten electrode are all shielded room atmospheric contamination by a blanket of inert gas fed through the GTAW torch. According to the working principle of TIG welding process, Welding torch consist of light weight handle, with provision for holding a stationary tungsten electrode. In the welding torch, the shielding gas flows by or along the electrode through a nozzle into arc region. An electric arc is created between electrode and the work piece material using a constant current welding power source to produce energy and conducted across the arc through a column of highly ionized gas and metal vapors. The electric arc produce high temperature and heat can be focused to malt and join two different parts of work piece.

1.2 Advantages of TIG welding process

- Concentrated arc produced for control heat input to the work piece. It resulting in a narrow heat-affected zone.
- This process is done without use of flux, therefore no slag formation during welding process.
- No Sparks or Spatter because of no transfer of metal across the arc during TIG welding.
- Compared to other arc welding processes like flux cored welding, fewer amounts of fumes or smokes are produced.
- Welding of thin material is possible.
- Welding dissimilar type material is possible.
- Welding of different types of metal and metal alloys are possible by proper control
- Welding of different types of metal and metal alloys is possible.

2. LITERATURE REVIEW

Welding is the process of joining together two pieces of metal so that bonding takes place at their original boundary surfaces. When two parts to be joined are melted together, heat or pressure or both is applied and with or without added metal for formation of metallic bond. Deekshant Varshney [1] studied to identify and review the literature in activating flux, and different type of welding techniques. For that purpose, a structured review method is adopted and the Scopus database is used as a primary source for the selection of papers. He finds the study provide a comprehensive understanding of the different type of welding techniques focusing on TIG welding, and the different combination of flux used and their impact was summarized by him. Harikrishna Rana[2] provided the influences of single component fluxes on the depth to-width ratio (DWR) of oxygen free copper was carried out with novel variants of tungsten inert gas (TIG) welding. For this investigation he uses thirteen distinct fluxes were used by the trials with FBTIG and FZ-TIG employing those identified DWR fluxes .He concluded that TIG welding in the pursuit of enhancing weld penetration. The depth of penetration was increased by 353% for the flux combination of MoO_3 , he also finds Superior outcomes like higher arc voltage and peak temperatures evidenced in A-TIG welding with fluxes MoO3, MgO, NiO, HgO, CaF2 and Whereas MoO3, MgO and CaF2 fluxes raised DOP in FB-TIG owing to the strong arc constriction mechanism, in the majority of the FZ-TIG welding specimens both reverse Marangoni and arc constriction played a vital role for the purpose. S.Kou[3] Studied Stationary welds of sodium nitrate and gallium were made with a defocused CO2 laser beam to simulate the effect of Marangoni convection on the shape of arc weld pools without a surface-active agent, he concluded that Increasing the beam power, increases Marangoni convection and the pool size, increases Voltage. The heat carried outward to the pool edge by the strong outward surface flow makes a concave pool bottom wide and flat. Reducing the beam diameter, this further increases Marangoni convection as well as Voltage. Both the flat and convex pool bottoms indicate Marangoni convection dominates over gravity-induced buoyancy convection in the pools. Paul kah [4] analyze how welding arc current, voltage, speed, and the effect of the water environment affect the weld bead geometry such as bead width, penetration, and reinforcement height. He concluded that the effects of welding input parameters for air and wet welding as it affects the welding output quality parameter. He found a better understanding of applying control mechanism in predicting the quality of a weld during underwater welding. A clearer insight of the weld ability of structural steels for offshore applications as it relates to underwater welding, having a full knowledge of the nonlinear multivariable parameters is indicative of better control methods. S. A. Afolalu [5] Provide an attention how 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 .He concluded, Activated-flux TIG welding process 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. Akash B Patel [6] made an attempt to understand the effect of TIG welding parameters such as welding current , gas flow rate ,electrode angle ,that are influences on responsive output parameters such as weld penetration, depth to width ratio, strength of weld joint by using optimization philosophy. He took an effort to investigate optimal machining parameters and their contribution on producing better weld quality and higher Productivity, for achieving the prosperous result of experimental work and from the literature study of various research paper the austenitic type stainless steel with grade E321 is selected and fluxes are SIO2&TIO2. Prof. A. B. Sambherao [7] focus on depth to width ratio, which determines the number of passes that are required to weld a particular thickness of metal. He made an attempt in is research work for investigating the effect of multi component fluxes of specific oxide on surface appearance, weld morphology and t retain delta ferrite structure to welding 6 mm thick AISI 316L. He used various oxide fluxes in a pack powder form. He concluded that a significant increase in penetration nearly 300% was obtained in weld done with a TiO_2 , and this is mainly due to marangoni convection. He recommended that the combination of flux such as TiO_2 and Fe_2O_3 should be used to achieve desirable properties of weld. Yanhai Lin [8] investigate the problem of radiation effects on the flow heat and mass transfer of magneto hydrodynamic steady laminar Marangoni convection in the boundary layer over a disk in the presence of a linear heat source and first-order chemical reactions. The Marangoni number related to temperature and concentration and the effort was made to find the effects of the magnetic Hartmann number, Marangoni number, radiation number, heat source number and chemical reaction number related to velocity, temperature, and concentration profiles were analyzed. The results demonstrate that the Hartmann number and Marangoni number have significant impacts on the heat and mass transfer of the Marangoni boundary layer flow. The temperature tends to increase with heat generation and decrease with heat absorption, and it exhibits a delay phenomenon for significant heat generation cases. Vijander Kumar [9] was studied Three input machine parameters namely current, welding speed and gas flow rate at three different levels have been considered in order to find out the influence of parameters on weld bead geometry, i.e. weld bead width, penetration and angular distortion. He uses Taguchi method in order to analyses the effect of various parameters on the weld geometry. Orthogonal array L9 has been applied for conduct in the experimentation. Based on the experimental data, the mathematical model has been developed using analysis of variance (ANOVA). He found that

TIG welding with flux powder SiO2 increases the penetration and decreases the bead width, and tends to reduce angular distortion of the welds. [10] Presented the effects of flux assisted tungsten inert gas (A-TIG) welding of 4 (10) mm thick austenitic stainless steel EN X5CrNi1810 (AISI 304) in the butt joint. In his planned study the influence of welding position and weld groove shape was analyzed based on the penetration depth. A comparison of microstructure formation, grain size and ferrite number between TIG welding and A-TIG welding was done. The A-TIG welds were subjected to bending test. A comparative study of TIG and A-TIG welding shows that A-TIG welding increases the weld penetration depth. M Azadi Moghaddam[11] come across SiO_2 Nano particles taken as an activatd flux for modeling and optimization he employed Tauchi method, he finds welding current is the most significant factor which affects the depth of penetration and weld bed width 68% and 88% respectively. A.G. Bogdanov [12] considered new method which is based on the phenomenology of the local muon density. He measured muon-density spectra at various zenith angles to obtained information regarding energy spectrum, mass composition and interaction of cosmic rays. He come upon the measured intensity of muon bundles produces in extensive air at large zenith angles. G Chandrasekar[13] gave a brief review on recent advancement in TIG welding which is activated flux. He concluded that the fusion welding techniques are most suitable for industrial production. The ATIG welding process can produce less width and high depth weld beads with the use of low welding heat input. He also come across that the selection of proper activating flux for the individual metal is required in order to enjoy the full benefits of ATIG process. M. Dramicanin [14] works on the TiO_2 nanoparticle-based activated flux combined with orbital welding of seamless thick-walled pipes of stainless steel and low�cycle pulse current representing a novel combination of welding processes parameters. Control specimens were welded without flux and consumable material, and without flux with the consumable material. Experimental welding with different welding parameters was done by him. He gave Special attention to characterize the flux by zetasizer method, representing a new approach, versus the conventional approach where the nominal oxide particle size is reported. The obtained welds were visually tested, macroanal the results show that the flux influences a significant increase in penetration depth, up to full penetration, which has a positive effect on the increase in the tensile and bending properties of the weld metal. Material behavior model was developed, based on microstructural features of the near weld-line. Without the flux, grain enlargement occurred near the surface, while with flux, it occurred under the weld, which can be attributed to recrystallization and a reversed Marangoni convection.

HUANG Yong [15] uses A-TIG Welding with alternating current for multi-component flux AF305 aluminum alloy, he found that flux AF 305 dramatically improves weld penetration. The relationship between slag distribution and weld penetration was studied by adding aluminum powder into flux AF305 to change the distribution of slag. During welding, the separate distribution of slag on the weld pool results in the great constriction of arc spots, an increase in arc spot force, and an increase in Lorentz force within the arc and weld pool. Finally he concluded that the weld penetration is increased. Her-Yuh Huang[16] researched the effects of activating flux in the weld morphology, arc profile, angular distortion and microstructure of two different arc welding processes namely, Gas Tungsten Arc Welding (GTAW) and Plasma Arc Welding (PAW), was carried out. The results showed that the activating fluxes affected the penetration capability of arc welding on stainless steel. He comes across an increase in energy density resulting from the arc constriction and anode spot reduction enhanced the penetration capability. He also finds that the Depth/Width (D/W) ratio of the weld played a major role in causing angular distortion of the weldment. Also, changes in the cooling rate, due to different heat source characteristics, influenced the microstructure from the fusion line to the Centre of the weld. A.Hunter [17] Presented The solidification behavior of AISI 304 stainless steel strip was studied using a melt/substrate contact apparatus, whereby a copper substrate embedded in a moving paddle is rapidly immersed into a steel melt to produce thin (1-mm gage) as-cast coupons. For cases where other casting conditions were kept constant, the effect of substrate topography and melt superheat on the development of microstructure and texture during solidification was studied using electron backscatter diffraction (EBSD) and optical microscopy. He mentioned that nucleation and growth of grains during solidification were influenced both by substrate topography and melt superheat. By the manipulation of casting parameters, it is possible to produce strip-cast austenitic stainless steel with a particular microstructure and texture. S. P. Tewari [18] studied the effect of various welding parameters on the weldability of Mild Steel specimens having dimensions 50mm× 40mm× 6 mm welded by metal arc welding, for this purpose he choose welding current, arc voltage, welding speed, heat input rate as welding parameters. The depth of penetrations were measured for each specimen after the welding operation on closed butt joint and the effects of welding speed and heat input rate parameters on depth of penetration were concluded by him. Kuang-Hung Tseng [19] Presented a study on five kinds of oxide fluxes, MnO_2, TiO_2, MoO_3, SiO_2, and Al_2O_3, for the effect of activated tungsten inert gas (activated TIG) process on weld morphology, angular distortion, delta-ferrite content, and hardness of Type 316L stainless steels. He applied an autogenous TIG welding to 6 mm thick stainless steel plates through a thin layer of flux to produce a bead-on-plate welded joint. The oxide fluxes used were packed in powdered form. His results indicated that the SiO2 flux facilitated root pass joint penetration, but Al2O3 flux led to the deterioration in the weld depth and bead width compared with conventional TIG process. Activated TIG welding can increase the joint penetration and weld depth�to-width ratio, thereby reducing angular distortion of the weldment. On the basis of the present results, he considered that the centripetal Marangoni convection and constricted arc plasma as a mechanism used in increasing the penetration of activated TIG joint. Hsuan-Liang Lin [20] researched work to investigate the effects of activating fluxes and welding parameter to the penetration and depth-to-width ratio (DWR) of weld bead. For this experimentation he took Inconel 718 alloy welds in the tungsten inert gas (TIG) welding process. In the activating flux with TIG (A-TIG) welding process, the single-component fluxes used in the initial experiment were SiO_2, NiO, MoO_3, TiO_2, MnO_2, ZnO, and MoS_2. Based on the higher DWR of weld bead, four fluxes were selected to create six new mixtures using 50% of each original flux. The A-TIG weldment coated 50% SiO2 + 50% MoO3 flux and 75^0 of electrode tip angle were provided with better welding performance. Finally he mentioned that the weld bead geometry of Inconel 718 welds via the FB-TIG with 1.2 mm gap are slender than that applying A-TIG process. The FB-TIG process produced full penetration in 6.35 mm-thickness of Inconel 718 alloy plate with single pass weld.A. Rodrigues [21] investigate the influence of three shielding gases argon and argon– hydrogen and argon–helium mixtures and two activating fluxes a commercial flux and a TiO2 based flux on the geometry of welds produced by the tungsten inert gas (TIG) welding process on several casts of austenitic stainless steel AISI 316, using currents ranging from 100 to 300 A. He find that Argon shielded welds show higher depth to width ratio (aspect ratio) than argon–hydrogen welds for currents above 150 A, he also said that weld penetration depth increases with increasing current for argon, argon–hydrogen and argon–helium shielded welds. M.Tanaka [22] presented effect of activated flux by using stainless steel using the gas tungsten arc welding; he uses oxides and halides as an activated flux. He also focus on arc phenomena in welding and mentioned that anode roots are strongly related to the metal vapour from the weld pool which is related to the temperature distributions on the weld pol surface. Akhilesh Kumar Singh [23] provided a brief review on techniques to improve weld penetration in TIG welding. In review work he discussed the influence of various methods such as Activated flux TIG, Flux bonded TIG and Pulses current TIG by using flux or fluxes and pulse current to improve weld penetration and weld quality.

3. CONCLUSION

This paper presents an overview of crucial published experimental investigations on different Activated flux powder and their effect on various parameters. It also gives brief descriptions of inputs and methods adopted by researcher in a systematic manner. According to the literature review the method that has gained most attention is to use TiO_2 and SiO_2 as an activated flux which helps in reduce weld bed width and significantly increase weld penetration ability when assisted with GTAW welding, microstructure characteristics also taken into consideration which shows distinct grain morphology in different weld zone by distinct welding techniques Such as FZ of the specimen comprised of elongation coarse attribute on the faster heating cooling cycle and directional solidification, HAZ was occupied with fine grain morphologies owing to post weld super cooling.

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