A Literature Review on Gas Metal Arc Welding (GMAW)

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***Abstract*- In a significant industrial process called welding, two or more pieces of material are joined together by being heated or mixed together under pressure while they cool and solidify. Welding production aims to put materials together to satisfy service needs while paying the least amount of money possible. To do this, advanced welding manufacture (AWM) will employ scientific techniques. There are three steps to it: (1) pre-design that chooses process and joint design based on available processes (properties, capabilities, and costs); (2) design that utilises models to forecast the outcome from a given set of welding parameters and minimises a cost function for optimising the welding parameters; Manufacturers must attend to step (3) of the production process. The most popular robotic welding technique is gas metal arc welding, and this study analyses and analyses the state-of-the-art in real-time sensing of this process, including seam tracking, machine vision, weld pool monitoring, machine learning, etc. The intent of this paper is to compile and review the previous work done on improvements of MIG Welding.**

Keywords: MIG welding, metal transfer, numerical analysis, Seam tracking, Weld pool

I. INTRODUCTION

Since its invention in the 1940s, gas metal arc welding (GMAW), which has a number of benefits over other welding techniques, has grown to be a very popular welding technology for the automobile body manufacturing industry. It is especially well adapted to a variety of light and heavy applications, including road trains, semi-tippers, and one-tonne tray bodies for tradesmen vans. This procedure may be utilised on a variety of materials because to its adaptability, simplicity, and fairly low distortion rate. In the gas metal arc welding (GMAW) method, an electric arc is maintained between a constantly supplied wire electrode and the component to be welded, producing the heat required for fusion. A gas shroud that is provided to the weld pool by the welding torch protects the hot weld zone, the molten weld metal, and the consumable electrode from the environment. According to its definition, gas metal arc welding (GMAW) is an arc welding technique that causes metals to coalesce by heating them in an arc between a constantly fed filler metal electrode and the work. The molten weld pool is shielded using a gas that is supplied outside throughout the operation. The electrode must typically have DC+ (reverse) polarity when using GMAW. GMAW is also referred to as MIG (Metal Inert Gas) welding and MAG (Metal Active Gas) welding in non-standard terms. In either case, the GMAW technique makes it easy to weld a variety of materials, including tubular metal-cored electrodes and solid carbon steel. The spectrum of alloy materials for GMAW includes silicon bronze, tubular metal-cored surface alloys, carbon steel, stainless steel, aluminium, magnesium, copper, and nickel. Applications for robotic automation, hard automation, and semiautomatic welding can all benefit from the GMAW process.

II. WORKING PRINCIPLE

MIG/MAG welding is a versatile technique suitable for both thin sheet and thick section components. An arc is struck between the end of a wire electrode and the workpiece, melting both of them to form a weld pool. The wire serves as both heat source (via the arc at the wire tip) and filler metal for the welding_joint. The wire is fed through a copper contact tube (contact tip) which conducts welding current into the wire. The weld pool is protected from the surrounding atmosphere by a shielding gas fed through a nozzle surrounding the wire. Shielding gas selection depends on the material being welded and the application. The wire is fed from a reel by a motor drive, and the welder moves the welding torch along the joint line. Wires may be solid (simple drawn wires), or cored (composites formed from a metal sheath with a powdered flux or metal filling). Consumables are generally competitively priced compared with those for other processes. The process offers high productivity, as the wire is continuously fed.

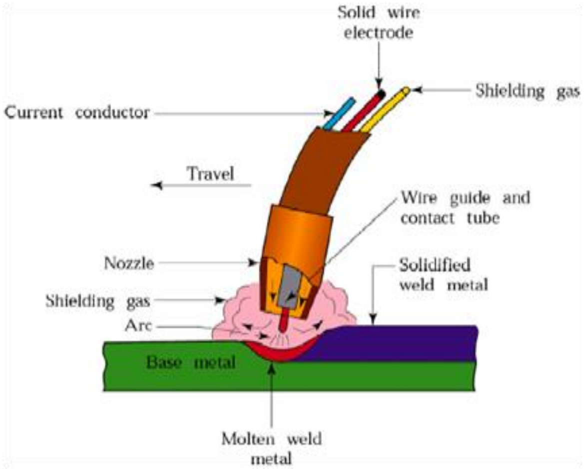

Fig 2.1 Schematic diagram of GMAW Welding

Manual MIG/MAG welding is often referred as a semi-automatic process, as the wire feed rate and arc length are controlled by the power source, but the travel speed and wire position are under manual control. The process can also be mechanised when all the process parameters are not directly controlled by a welder, but might still require manual adjustment during welding. When no manual intervention is needed during welding, the process can be referred to as automatic. The process usually operates with the wire positively charged and connected to a power source delivering a constant voltage. Selection of wire diameter (usually between 0.6 and 1.6mm) and wire feed speed determine the welding current, as the burn-off rate of the wire will form an equilibrium with the feed speed.

III. PARAMETERS

Parameters is a quantity whose value is selected for the particular circumstances and in relation to which other variable quantities may be expressed, these are the one which influence the result. There are 6 parameters Involved in MIG welding.

1. Welding current
2. Arc voltage
3. Welding Speed
4. Electrode
5. Gas flow rate
6. Shielding gas composition

1. Welding Current - The value of welding current used in MIG has the greatest effect on deposition rate, the weld bead size, shape and penetration. In MIG welding metals are generally welded with direct current polarity electrode positive, because it provides the maximum heat input to work and therefore a relatively deep penetration can be obtained.

2. Arc voltage: - An arc voltage discharges an electrical breakdown of a gas that produces an ongoing electrical discharge the current through a normally non-conductive medium, such as air produces a plasma, the plasma may produce visible light. The Arc voltage to be used depends metal thickness type of joints electrode composition and size, shielding gas composition and welding position types of welds.

3. Welding Speed-travel speed is a function of time and distance travelled represent the actual length for which weld metal is deposited from initiation of arc to the termination of arc. This is quite is quite simple to calculate for a given welding process.

4. Electrode - Gas metal arc welding, sometimes referred to by its sub types metal inert gas welding or metal active gas welding, is a welding process in which an electric arc forms between a consumable wire electrode and the work piece metal which heats e work piece metals causing them to meet and join.

IV. MODES OF METAL TRANSFER

With most of the commonly used welding processes the operator has little control over the way metal is transferred across the arc. With GMAW the operator can select and control the type of metal transfer. This is done primarily by selection of arc voltage, although wire diameter and shielding gas also influence metal transfer.

The metal transfer mode determines the characteristics of the GMAW process. The Operator must select the most appropriate mode of transfer and set the machine accordingly before starting the weld. Apart from the pulsed transfer mode, which requires sophisticated power sources, the welding operator can select from three transfer modes:

- Short circuit transfer
- Globular transfer
- spray transfer
- Pulse transfer

1. Short Circuit

The coldest form of MIG welding is short circuit, which uses low voltage. The welding wire touches the metal, electricity goes through the gun and a short circuit is created. The effect is a wet metal puddle that quickly solidifies and fuses the materials together.

2. Spray

In a spray transfer mode, wire gets melted into fine droplets that get sprayed or misted into the weld joint. This is a constant voltage process that uses a high heat input and sends a constant stream of weld metal from the arc to the base material.

3. Globular

The globular transfer method is similar to the short circuit method. An electrode wire arcs and touches the base material. However, there is a higher heat input and the wire is heated for a longer period. This creates a larger weld puddle, which collects at the tip of the gun and drips into the joint.

4. Pulse

The pulsed spray transfer is similar to the spray arc method but modified to remove potential disadvantages. The welder will pulse the voltage many times per second, allowing a droplet to form at the end of the wire that gets pushed across the arc into the puddle. It is the most functional and flexible transfer time but can be the most expensive as it requires a high-end MIG welding machine.

Fig 4.1 Schematic diagram of modes of metal transfer

V. LITERATURE SURVEY

[1] W. Provost (1982) explored the impacts of a pressure alleviation warm behavior on the strength of weight container quality steels. The aftereffects of this work depict the impact of post weld warm medicines on the strength of welded joints in weight vessels quality steels. Uncommon consideration is paid to the base plate thickness for which a post weld warm treatment ought to be prescribed. The acquired outcomes demonstrate that, in spite of the fact that the present code prerequisites are tasteful for C-Mn steel. They were totally modified for Nb-micro alloyed steel, welded through high warmth input.

[2] T.A Lechtenber and J.R. Foulds (1984) explored the impact of pre-warm on the microstructure, hardness and strength of HT-9 weldments. A diminished preheat, affecting a quicker weld metal cooling rate, results in an expanded upper rack vitality and lower pliable weak progress temperature with no charge in weld metal. SEM examinations show a diminished dendrite separating and bring down interdendritic isolation with a quicker cooling rate. It is obvious that the shifting interdendritic ferrite substance and morphology and the dendrite dividing, both constrained by the cooling rate, assume a critical job on the weld metal unique crack conduct. The outcomes propose the most reduced preheat perfect with great welding practice causes in to accomplish the greatest advantages to the weld metal crack mechanics.

[3] J.N Clark (1986) researched about the weld fix of low compound downer safe steel castings without preheat and post-weld warm treatment. Extra information on downer pliability of the weld metal were given and talked about reference to the more extended term honesty of fixes.

[4] D.G. Crawford and T.N. Dough (1991) puncher examined about microstructure and strength of low carbon steel weld metal. An investigation of the trial information was completed, in view of the preface that minor stages were the essential locales for fragile break inception, and that effective proliferation or generally of such splits was an element of the encompassing gross microstructure. The subsequent connection among's microstructure and durability given a methods for defending the impact of a scope of compositional and different factors on sturdiness, through their consequences for the microstructure.

[5] O.M. Akselsen and O. Grong (1992) explored the forecast of weld metal Charpy V score durability. A progression of exact conditions has been produced which relates the durability to the weld metal microstructure and elasticity. A correlation among expectations and analyses demonstrated that the best understanding is accomplished by the utilization of estimated qualities for a definitive elasticity and the acicular ferrite content. The charts can, thus, fill in as a reason for legitimate choice of consumables for welded steel structures.

[6] V.S.R. Murti, P.D. Srinivas, G.H.D. Banadeki and K.S. Raju (1993) researched the impact of warmth contribution on metallurgical properties of HSLA steel in multi-pass MIG welding. Here its weldability via Auto MIG welding utilizing 309L terminal wire has been examined. This outcomes in high welding rate, high statement rates and more profound infiltration.

The cooling rates are higher contrasted with SMAW, where the slag cover delivers low cooling rates of the weld dabs. Thus, the high welding paces of Auto MIG welding causes air float into the weld zone, prompting its defilement. Along these lines the warmth input rate can be differed by changing the voltage and current setting additionally, however this isn't ideal. Higher voltages modify the dab geometry and combination zone, which influences the resultant microstructure, and can likewise destabilize the circular segment and deliver scatter.

[7] Alberto Sánchez Osio, Stephen Liu and David L. Olson (1996) explored the impact of cementing on the development and development of considerations in low carbon steel welds. Since incorporations are nucleants to proeutectoid stages, the nearness of these second stage particles move the ceaseless cooling change (CCT) bends to shorter occasions. In this manner, the displaying of the arrangement and development of incorporations was alluring to foresee weld metal microstructure and properties. In their examination, they proposed another model, considering solute redistribution amid. An intriguing component of this model was that it predicts the adjustment in the state of the size dissemination bend with the solute creation and the nearby hardening time.

[8] C.Smith, P.G.H. Pistorius and J. Wannenburg (1997) researched the impact of a long post weld warm treatment on the trustworthiness of a welded joint in a weight vessel steel. Multipass submerged-curve welds were made at a warmth contribution of 1·2 and 4·3 kJ mm-1. Individual microstructural locales saw in the warmth influenced zone of the real weld were re-enacted. These locales were fragile in the as-reproduced condition. Post weld warm treatment for times of up to 40 h at 620°C brought about a critical enhancement in the Charpy affect strength. A break sturdiness of 134 kJ m2 was estimated in the warmth influenced zone of the 4·3 kJ mm-1 welds after delayed post weld warm treatment. The enhancement in weldment durability with post weld warm treatment was essentially credited to mellowing of structure.

[9] N.Orhan, M Aksoy and N Orhan (1999) researched the impact of coarse introductory grain estimate on microstructure and mechanical properties of weld metal and warmth influenced zone (HAZ) of low carbon steel. In this examination, the impacts of coarse introductory grain estimate with shifting warmth contributions on microstructure and mechanical properties of weld metal and HAZ were researched. In the welding tests, SAE 1020 steel examples in hot-rolled and in grain-coarsened conditions were utilized. Following the welding, microstructure, hardness and sturdiness of weld metals and HAZs were researched. From the outcomes, a connection between introductory grain estimate of weld metals and HAZs has been set up. Most extreme strength of HAZ of the coarse starting grain measured example was accomplished with a high info, while greatest sturdiness of unique example was acquired with a medium warmth input.

[10] S. H. Lalam, and H.K.D.H Bhadeshia et al. (2000) distributed exploratory information on the propensity for 2.25 Cr-1Mo to experience pollution instigated temper-embrittlement. Bruscato factor (X) has been determined by the (10P + 5Sb + 4Sn + As)/100 (in ppm) quantitatively. It was discovered that phosphorus, silicon and manganese all make 2.25 Cr-1Mo helpless to temper-embrittlement, with the embrittling power diminishing that arrange. Molybdenum decline inclination of polluting influence-initiated embrittlement. The investigation likewise demonstrated that there is no noticeable impact of arsenic, tin and antimony due to overpowering impact of phosphorus.

[11] J.C.F Jorge, L.F.G Souza and J.M.A Rebello (2001) examined the impact of chromium on the microstructure/strength relationship of C– Mn weld metal stores two carbon substance were gotten by weakening utilizing diverse welding methodology [11]. The variety in the chromium content was acquired by the expansion of various measures of chromium powder to the weld groove. The connection among microstructure and durability of weld stores was concentrated by methods for hardness, Charpy-V score and metallographic tests in examples slice transversely to the weld dabs. Subjective and quantitative investigations of microstructural constituents and fine stages were made by light optical and filtering electron microscopy, individually. The outcomes demonstrated that chromium weakens affect durability, despite the fact that it advances an expansion in level of acicular ferrite (AF). What's more, it was seen that an expansion in carbon content advanced a further decline in effect durability because of the complex volume part of the M/A constituent.

[12] M.A. Islam et al. (2003) researched impact of earlier austenite grain estimate. It was discovered that

phosphorus was an exceptionally basic follow component that can isolate at earlier austenite grain. This paper examined isolation of P amid reversible temper embrittlement (96 hrs. at 520°C) of extinguished and completely tempered 2.25Cr-1Mo steel by Auger electron spectroscopy and depicts the isolation system. This paper additionally depicted the impact of P isolation on break opposition and crack method of unembrittled steels, individually, by crack sturdiness testing over a temperature scope of −196 °C to 20°C and fractography in examining electron magnifying lens. This isolation caused a decrease in break strength estimations of the extinguished and tempered steels at all test temperatures and an expansion in the progress temperature. The micromechanism of break at temperatures from the upper rack, in any case, remained practically unaltered.

[13] V. Muthupandi et al. (2003) researched the impact of weld metal science and warmth contribution on the structure and properties of duplex treated steel welds. Solid mix of solidarity and erosion obstruction in hardened steels (DSS) is because of their strict organization control and small-scale basic parity. To accomplish the ideal ferrite– austenite balance and consequently properties, either the weld metal piece or additionally the warmth input is controlled. Results broke down that (I) concoction structure has a more noteworthy effect on the ferrite– austenite proportion than the cooling rate, and (ii) even EBW which is viewed as a juvenile procedure in welding of DSS, can be utilized given methods for filler expansion could be contrived. . [14] L.F. Guimaraes de Souza et al. (2003) have done microstructural investigation of solitary pass 2.25% Cr-1.0% Mo steel weld metal with various manganese substance. Weld metals of the 2.25% Cr-1.0% Mo type with 0.84%, 1.21% and 2.3% Mn created by submerged curve welding were broke down in the as-welded (AW), post weld warm treatment (PWHT) and PWHT pursued by step-cooling (SC) warm treatment conditions. A checked carbide precipitation was watched, especially at grain limits. This could be credited to the SC warm treatment and related with the embrittlement. Notwithstanding, the use of a de-embrittlement warm treatment to this progression cooled weld metal has demonstrated proficient, in light of the fact that the effect vitality after this warmth treatment outperformed those acquired in the pressure assuaged condition. This was unmistakably shown that isolation of polluting influences to grain limits were in charge of the low effect vitality levels.

[15] Karl Million et al. (2005) explored the impacts of warmth contribution on microstructure and durability of the 8 Mn-Mo-Ni 5 shape-welded atomic steel. The weld metal well demonstrated in the German atomic industry filled in as the reason for the affirmation of a shape-welded steel to be utilized as base material for fabricate of atomic essential segments. The advanced plan for reactor vessel was viewed as especially appropriate for utilization of shape welded parts instead of forgings. Notwithstanding this the requirement for plan and advancement of new shape-welded steel grades for other new age reactor ventures was accentuated.

CONCLUSION

In this paper the discussion about GMAW process and its welding techniques & variable process, arc voltage advantages, travel speed and shielding gas. From the review paper study, it is found that when the welding current, voltage increases, the tensile strength decreases, but when welding speed increases ,the tensile strength also increases. In the case of elongation is also same to tensile strength. Welding current, arc voltage, welding speed, type of shielding gas, gas flow rate, wire feed rate, diameter of electrode etc. are the important control parameters of Metal Inert Gas Welding process. They affect the weld quality in terms of mechanical properties and weld bead geometry. The value of depth of penetration increased by increasing the value of welding current and the grain boundaries of the microstructure are varied when the welding parameters are changed. Optimization was done to find optimum welding conditions to maximize tensile strength and percentage of elongation of welded joints. The Study found that the control factors had varying effects on the response variables. Constant welding current with increasing heat input leaded to decrease in corrosion resistance of the joints.

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