Effects of the Hybrid TIG-MIG Arc Welding in Terms of Appearance and Mechanical Strength

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Abstract— A TIG-MIG arc welding is a type of hybrid arc welding process meant for high speeds. The studies were carried on a mild steel plate with the help of conventional MIG welding process and a hybrid TIG-MIG welding process and the comparisons were done on the basis of weld appearance, welding appearance and mechanical properties. This hybrid welding process has got the properties of both TIG and MIG welding when studied separately. The speed achieved by this process is high as compared to conventional arc welding discussed above. This method proves beneficial for mass production welding joints. The mechanical properties of the conventional and the hybrid type welding processes were approximately same. The current and voltage of the MAG welding were stabilized by the TIG associated with it. The distance between the wire-electrode is also a very important factor to be considered for good and strong welding.

Key words: TIG Welding, MIG Welding, Hybrid Welding, Weld Appearance, Mechanical Properties

I. INTRODUCTION

TIG stands for Tungsten Inert Gas and the technical or industrial name is Gas Tungsten Arc Welding or GTAW. There is a non-consumable tungsten (W). Its work is to deliver the current to the arc. The puddle of tungsten and molten weld are cooled by an inert gas. The inert gas also protects the weld from chemical reactions with the surroundings. Generally argon(Ar) gas is used as an inert gas[1]. On the other hand metal inert gas(MIG) also known as metal active gas(MAG) welding uses a consumable wire electrodes for welding purpose. The electric arc forms between a consumable electrode and the metal workpieces [2]. This heats the metal as a result of which they melt and eventually join. a shielding gas is fed through the welding gun, which protects the process from contamination [2],[3]. The benefits of working with the TIG welding is that the inert gas used creates much less smoke and fumes. The visibility of the working area is more for the welders to work in the proper condition and this will lead to a nearly perfect weld. Another advantage of TIG process is that welding can be done with or without filler material. However, filler material is required if welding is to be done for thicker metals [1]. Though this method gives accurate weld it is a slow process and hence MAG/MIG process is widely used for mass production. However, the weld quality achieved is not as superior as TIG welding process. Also as per the study carried out by Bradstreet in the year 1968 suggested that the MIG/MAG high speed cannot be achieved by just increasing the welding speed and current in direct proportion. Another study states that there are appearance defects which includes undercut which limited improvement productivity. Hence there is a need of a special type of welding which includes the properties of both the type of welding process. So the hybrid TIG-MIG welding combination was proposed so as to eliminate the demerits of MIG welding and to add the advantages of TIG welding. The experiments were conducted to check the mechanical properties and were compared with the conventional MIG welding process. The effects of wire-electrode distance were also studied in order to obtain a better surface appearance [4].

II. EXPERIMENTAL SETUP

A. Materials and Equipment

The rated welding current of 310A for a TIG and 340A for MIG along with the matched wire feeding system were used to establish the high speed TIG-MIG hybrid arc welding system in experiments. The MAG and the TIG torch were set as push angle and drag angle respectively, which was required for the stable hybridization of TIG-MIG, as shown in Fig. 1.

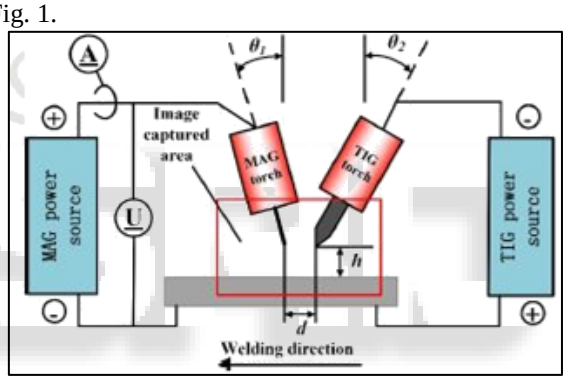

Fig. 1: Experimental setup for TIG-MIG hybrid welding

Mild steel plates of dimensions 300×50×2.0mm and 300×50×2.5mm were used as the base metals for butt welding and bead-on-plate welding respectively. The welding wire used was ER50-6 of 1.2mm diameter. The shielding gas used was pure argon gas (Ar) [4], [5].

B. Experimental Procedure

Levels	Factors				
	θ_1 (deg)	I_T (A)	θ_2 (deg)	d (mm)	h (mm)
1	5	255	5	10	2
2	10	275	10	12	4
3	15	295	15	14	6
4	20	315	20	16	8

Table 1: Angles, currents and the wire electrode distances used for TIG and MIG arcs

At different MAG welding current *I*M (70A, 140A, 210A, 280A, 350A) the maximum bead-on-plate welding speed of TIG-MIG hybrid arc welding was primarily tested by adjusting the welding current for TIG welding *I*T to obtain better weld appearance. Based on the maximum welding speed and the corresponding MIG welding current determined by experiments carried out, the influences of MAG welding torch angle (θ1), TIG welding current (*I*T), TIG welding torch angle (θ2), wire-electrode distance (*d*) and

tungsten electrode height (*h*) on weld appearance were studied. The values of welding parameters are shown in Table 2. To study the mechanical properties of welded joints the butt welding experiments were conducted from the above parameters.

III. RESULTS

A. Maximum Welding Speed

In conventional MIG welding process, a critical welding speed exists at a corresponding current. Above this current defects such as undercut or discontinuous bead may be formed. By the introduction of TIG arc in hybrid arc welding, this critical welding speed was significantly increased as indicated in Fig. 2.

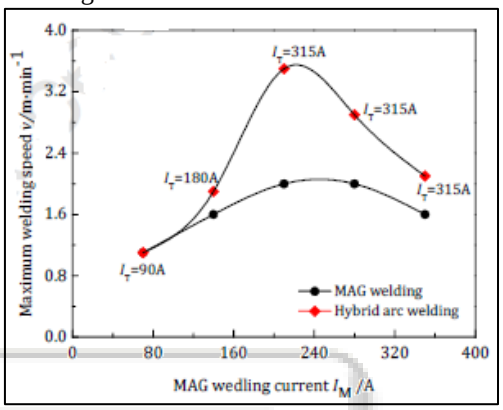

Fig. 2: Comparison between conventional and hybrid welding speed at different MIG currents.

The critical welding speed at MIG welding current of 190A ranges from 1.8m/min to 3.3m/min, and the process was stable without any defect in weld appearance. When the MIG welding current dropped below 190A the maximum weld speed decreased. The MIG arc was easily interfered by the TIG arc due to its poor stiffness at low current. Stable hybridization could not be generated. Moreover, if the TIG welding current was too high, discontinuous beads were formed, as shown in Fig. 3. Therefore, it is not possible to achieve increased welding speed at low MIG current.

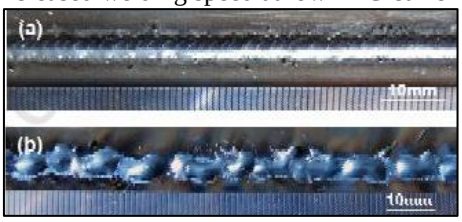

Fig. 3: Weld appearance at 70A MIG welding current (a) conventional MIG weld, (b) TIG-MIG

The welding speed also decreased when the MIG welding current was increased beyond 190A. It increased the arc pressure resulting in undercut and humping. This clearly indicates that in order to achieve a stable welding process the TIG welding current should be always higher than MIG welding current. Hence, according to the experiment performed in this paper the maximum welding speed achieved was 3.3m/min on bead-on-plate welding.

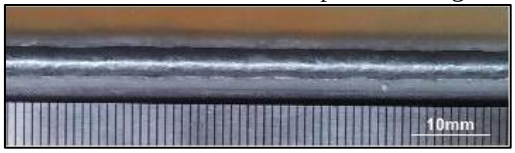

Fig. 4: Appearance of weld under optimized condition

B. Mechanical properties of the weld

The tensile test was conducted to check the strength of the weld and it concluded that the hybrid arc welding can maintain sufficient amount of tensile strength for the engineering applications besides better weld appearance at a considerable amount of speed of welding as shown in Fig 7. However, in case of the comparison in terms of the elongation with the conventional MIG weld it was found that a slight increase in elongation than that of conventional weld[6].

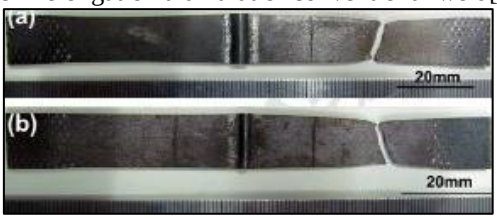

Fig. 5: Fractures of tensile specimens: (a) MIG welding specimen, (b) TIG-MAG hybrid arc welding specimen

IV. DISCUSSION

The experiment conducted above showed that the wire electrode distance and the TIG arc currents were the most important factors that affects the weld characteristics such as shape, voltage and current.

A. Effects of the wire electrode distance

The arc shape of the hybrid welding was affected due to the changes in the wire electrode distances as shown in the Table 2.

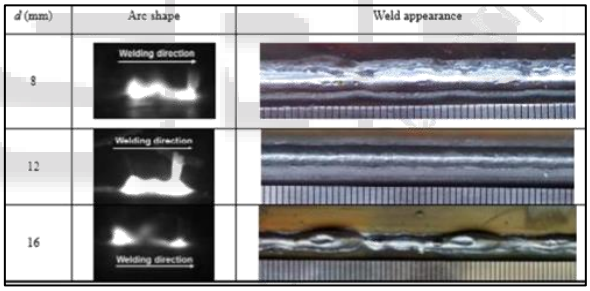

Table 2: Arc shapes and weld appearances at different wire-electrode distances (*I*M=190A, *I*T=315 A).

With the small wire electrode distance of 8mm, the arcs of the TIG and MIG interfered with one another and generated weld bead had roughness and undercut which were aperiodic in nature.

When the distance was increased to 12mm, the arc of hybrid weld was stable with a better appearance. This arc formed less arc force on the weld and the heating area was larger as compared to the 8mm arc.

Further increasing the distance to 16mm it was found that the high speed welding was difficult to achieve because of the serious undercut and humping in the weld formation. This happened due to the large wire electrode distance as a result of which hybridization was not achieved. The TIG and MIG arcs behaved almost independently.

B. Effects of TIG welding current

With the increase of TIG welding current the speed of the hybrid welding was increased as shown in Fig.9. The speed was increased significantly only when the TIG current was more than the MIG current. In this case the TIG arc had high stiffness and a stable hybridization generated that significantly increased the welding speed.

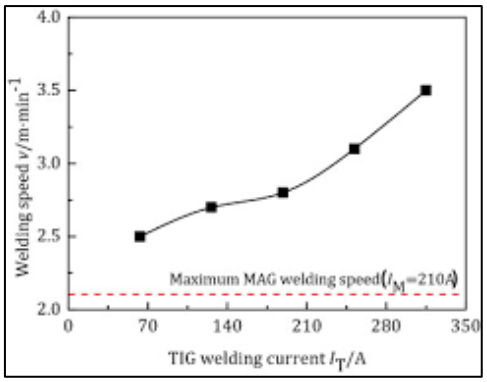

Fig. 6: Hybrid arc welding speed at different TIG welding currents

V. CONCLUSIONS

The hybrid TIG-MIG arc welding increased the welding speed for mild steel plate with high quality of weld appearance.

Welded joints obtained by this process have high tensile strength compared to that of conventional MIG welding.

Stable hybridization was obtained by balance between TIG and MIG welding current.

To stabilize the welding process and to suppress the appearance defect formation proper wire-electrode distance was the key factor.

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