Analysis on Impact of Differentiating Root Gap on TIG Welding Process of Mild Steel Plate

Pankaj Ahirwar
Researcher
Department of Mechanical Engineering
Shri Krishna University, Chhatarpur (M.P.)

ABSTRACT

In this investigation, autogenous TIG welding was used to weld AISI 1020 plate with a 6 mm thickness while keeping varying root gaps (0, 0.5, 0.75, and 1 mm). Analysis has been done on the tensile strength of the welded junction as well as the weld bead profile. The experimental results show that weld depth penetration rises with increasing root gap, but heat affected zone (HAZ) and weld bead width remain nearly constant. On the other hand, under filling of the weld joint rises when the root gap widens under comparable conditions. Weld joints with a 1 mm root gap show maximum tensile strength, full penetration, and increased under-filling.

KEY WORDS

Tungsten Inert Gas Welding process, Tensile Strength, Root gap, Weld Bead Geometry.

INTRODUCTION

The arc welding technique known as tungsten inert gas (TIG) welding is widely used in the manufacturing sector on a wide range of materials, including steel, titanium, magnesium, aluminum, and their alloys. By utilizing the heat created by the arc formed between the non-consumable tungsten electrode and the base metal, it allows for exact control of the amount of heat input and creates improved weld quality with no slag or splatter. The penetration or melt depth of autogenous TIG welding on thick mild steel plate is limited to a specific extent. In the material joining and fabrication sectors, proper penetration, a reduced heat affected zone, a precise weld profile, and high productivity are critical factors. The size, shape, and geometry of weld beads are greatly influenced by a number of process parameters, including current, voltage, scanning velocity, electrode dimensions, flow rate of shielding gas, etc. A well-balanced set of these parameters produces a precise, accurate, and excellent weld. Numerous study teams looked into the impact of various TIG welding process parameters.

LITERATURE REVIEW

Ibrahim *et al.* [2012] studied that impact of process parameter in the gas metal arc welding process and found that when welding current increases, penetration depth increases linearly. However, it was found that the depth of penetration or melting depth is likewise restricted to a certain value during autogenous TIG welding without the use of filler rod when plates are kept side by side with no space between them, since molten material does not flow towards the bottom side of the joint. Therefore, an appropriate space needs to be maintained for autogenous TIG welding in order for the molten material to flow properly towards the bottom of the joint. Root gap is the term for this space between two plates.[1]

Tewari *et al* (2010) reported that Depth of penetration increases up to an optimal speed with constant current and arc voltage; after that, as speed increases, depth of penetration begins to decrease.[2]

Shibahara *et al.* [2002] conclude that the impact of scanning speed utilizing the finite element analysis approach on the root gap's transient behavior during butt welding.[3]

Akella *et al.* [2013] discussed the impact of several welding parameters on the weld distortion and suggested that the weld distortion may be controlled to a certain extent by the root gap, welding current, weld speed, and gas flow rate, which contribute 43%, 37%, 14%, and 6%, respectively.[4]

EXPERIMENTAL PROCESS

The as-rolled and mill-annealed AISI 1020 steel plate was the material employed in this weld investigation. In this experiment, specimens measuring 100 × 50 mm2 were cut from mild steel plate that was 6 mm thick using a horizontal band saw machine equipped with a sufficient coolant system. Before welding, all of the plate edges that needed to be joined were properly cleaned with ethyl alcohol to get rid of any contaminants including moisture, dust, and oil. The Fronius Magic wave 2200 TIG welding equipment was used to accomplish the welding of the plates after they had been fixed on a work holding apparatus. A moving vehicle with a speed controller was linked to the welding torch. The root gap was taken into consideration as a variable welding parameter, and the welding operation was carried out at a constant welding speed of 2.33 mm/sec and current of 190 A. No filler rod was employed in this investigation, and the experiment's root gaps were set at 0, 0.5, 0.75, and 1 mm. Table 1 illustrates the specific welding parameters.

Table 1: Welding parameters for autogenous TIG welding experiments

Welding Parameter	Values
Welding current [A]	190
Welding speed [mm/sec]	2.33
Diameter of electrode [mm]	2.4
Tip angle of electrode	90°
Electrode gap [mm]	3
Shielding gas	Argon
Gas flow rate [l/mm]	15
Root varying gap [mm]	0, 0.5, 0.75, 1

RESULT AND DISCUSSION

Weld bead geometry: Fig. 1 shows the weld joint's traverse cross section of the weld bead profile created by keeping a distinct root gap. Under an optical microscope, the fusion zone, heat-affected zone, and base metal are all clearly visible. With the use of the IMAGEJ program, the weld bead profiles (penetration depth, weld breadth, heat affected zone, and weld under-fill) were measured and plotted in Figure 2(a-d). The entire depth of penetration was reached at a root gap of 1 mm. A notable rise in penetration depth has been seen with an increase in root gap. On the other hand, weld width variation and the heat affected zone were shown to be minimal with an increase in root gap. High velocity plasma arc force, electromagnetic force, buoyancy, and surface tension at the fluid-solid contact interface are what propel the flow of the weld pool during TIG welding.[5] When the heat source is moved downward for autogenous welding without the use of filler rod, the axial electromagnetic force and the high velocity axial plasma arc force strike the weld pool at its top surface, creating a spatial gradient of surface tension that stirs the weld pool and causes the base material to melt.[6]

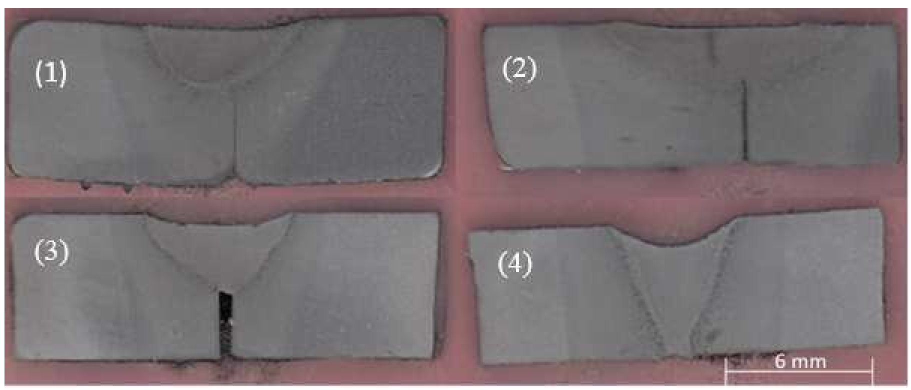

Fig.1: Weld bead profile of 6 mm thick AISI 1020 steel plate for maintain root gap of (1) 0 mm, (2) 0.5 mm, (3) 0.75 mm and (4) 1 mm.

Tensile Strength of the weld joint: Fig. 2 shows the impact of root gap on the weld joint's final tensile strength. Plotting the weld joints' ultimate tensile strength against the used root gap has been done. The graph shows that when the root gap widens, the tensile strength also grows. In the fusing zone, every tensile specimen broke. The under fill defect and incomplete penetration that cause stress concentration on the weld zone are the causes of fracture in the fusion zone. The weld joint's tensile strength rises when the root gap is increased because deeper penetration results from this increase. The weld joint's tensile strength was found to be somewhat lower (521.3 MPa) when there was no root gap or a smaller root gap used. With a root gap of 1 mm, the tensile strength of 501.173 MPa was attained, which is nearly the tensile strength of the base metal.

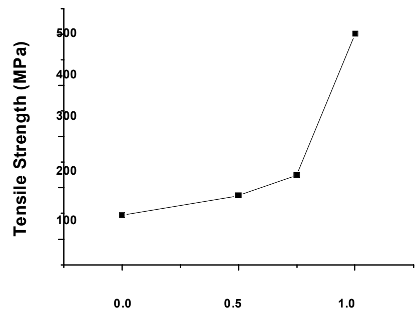

Fig. 2: Effect of root gap on tensile strength of the weld joint.

CONCLUSION

Based on the experimental findings, it can be concluded that the root gap significantly affects the quality of the weld. For autogenous TIG welding of 6 mm thick AISI 1020 steel plates, the weld under-fill depth and penetration depth both increase with the root gap. There hasn't been any discernible variation in the heat affected zone or weld width across all experiments because the heat input was the same. As the root gap widens, so does the weld joint's tensile strength. The tensile strength of a TIG welded junction with a 1 mm root gap was found to be nearly identical to that of the base material.

REFERENCE

[1] I. A. Ibrahim, S. A. Mohamat, A Amir, A Ghalib: Procedia Engineering, Vol 41(2012), p.1502-1506
[2] S. P. Tewari, A. Gupta, J. Prakash: International Journal of Engineering Science and Technology, Vol. 2(4) 2010, p. 512-516
[3] M. Shibahara, H. Serizawa, H. Murakawa: The international society of offshore and polarengineers Conference (2002), p. 325-331
[4] S. Akella, B. R. Kumar: Advanced Materials Manufacturing & Characterization, Vol 3(2013),p. 199-206
[5] S. A. David, S. S. Babu and J. M. Vitek, in: Advances in welding science and technology, OakRidge National Laboratory (1996), p. 1-6
[6] T. DebRoy, S. A. David, in: Physical processes in fusion welding, Reviews of Modern Physics,Vol. 67, (1995), p. 85-112