

# Welding, MIG, TIG

Nov 2018

5. With reference to oxy-acetylene welding:
- (a) describe the process; (2)
  - (b) explain why it is important to get the gas mixture correct; (3)
  - (c) list the design safety features and inspections to be carried out on the welding torch and cylinders before commencing welding. (5)

## (a) Oxy-Acetylene Welding Process:

Oxy-acetylene welding is a gas welding technique that uses controlled combustion of oxygen and acetylene gas to generate a high-temperature flame (around 3,300°C) for melting and joining metals. The key steps involved are:

1. Preparation: Clean the weld area thoroughly to remove dirt, grease, and any other contaminants that could affect the weld quality.
2. Setting Up: Connect the oxygen and acetylene cylinders to the torch using appropriate regulators and hoses. Adjust the gas flow rates to get the desired flame type (neutral, oxidising, or carburizing).
3. Preheating: Apply the flame to the surrounding area of the weld joint to preheat the metal. This prevents cracking and allows for smoother melting.
4. Melting and Joining: Direct the hottest part of the flame at the joint edge, melting the metal. Simultaneously, add filler metal (a rod or wire of similar composition) to bridge the gap and create a continuous weld pool.
5. Post-heating: Maintain the flame on the weld area for a short time after joining to allow slow cooling and prevent cracking.
6. Cleaning: Allow the weld to cool completely, then remove any slag (impurities) with a chipping hammer or wire brush.

## (b) Importance of Correct Gas Mixture:

Getting the gas mixture right is crucial for several reasons:

- Neutral Flame: A neutral flame with equal parts oxygen and acetylene provides the ideal temperature for most welding applications. It melts the metal effectively without excessive oxidation or carbonization, leading to strong and clean welds.
- Oxidising Flame: An oxidising flame has excess oxygen, resulting in a higher temperature but greater oxidation of the metal. This can weaken the weld joint and make it brittle. It's used for specific applications like cleaning or brazing.
- Carburizing Flame: A carburizing flame has excess acetylene, creating a lower temperature but introducing more carbon into the weld. This can weaken the joint and make it brittle. It's rarely used and can lead to weld defects.

Therefore, maintaining the correct gas ratio ensures optimal working temperature, prevents defects, and guarantees strong and reliable welds.

(c) Safety Features and Inspections:

Oxy-acetylene welding involves flammable gases and high temperatures, so safety is paramount. Before starting any welding operation, it's essential to perform the following checks:

- Torch:
  - Check for leaks in hoses and connections using soapy water.
  - Ensure all valves are closed before connecting cylinders.
  - Verify proper seating of flashback arrestors on both torch inlets.
  - Test the igniter and ensure it functions properly.
- Cylinders:
  - Check visual indicators for any signs of damage or corrosion.
  - Verify pressure gauges are in proper working order.
  - Ensure valve caps are firmly in place before transporting or connecting.
- Personal Protective Equipment (PPE):
  - Wear appropriate welding gloves, safety glasses, and a welding helmet to protect from flames, sparks, and radiation.
  - Use adequate fire-resistant clothing to prevent burns.

June 2022

5. With reference to gas metal arc welding (MIG) of mild steel:
- (a) describe the process; (3)
  - (b) explain, with reasons, the surface preparation required; (3)
  - (c) list THREE advantages and ONE limitation. (4)

(a) MIG Welding Process:

MIG welding, also known as Metal Inert Gas welding, is a semi-automatic welding process that joins metals using a continuously fed consumable solid wire electrode and an inert shielding gas. Here's a breakdown of the steps:

1. Preparation: Clean the weld area thoroughly to remove dirt, grease, rust, paint, and any other contaminants that can weaken the weld and introduce impurities.
2. Setup: Choose the appropriate wire and inert gas (e.g., argon, argon-CO<sub>2</sub> mix) based on the material and desired weld characteristics. Install the wire and gas cylinder, set the wire feed speed and welding current according to the material thickness.
3. Welding: Hold the welding torch at the appropriate angle and distance from the joint. As you trigger the welding gun, the wire feeds continuously and an arc forms between the wire tip and the metal, melting both materials. The shielding gas protects the molten metal from atmospheric contamination.

4. **Travel Speed:** Move the torch steadily along the joint seam at a controlled speed, melting and joining the metal while leaving a continuous weld bead.
5. **Cleaning:** Allow the weld to cool completely, then remove any slag (residue) with a chipping hammer or wire brush.

(b) Surface Preparation and its Importance:

Proper surface preparation is crucial for achieving strong and high-quality MIG welds in mild steel for several reasons:

- **Contaminants:** Dirt, grease, rust, and paint can all prevent the molten metal from properly bonding with the base metal, leading to weak welds and potential porosity (gas bubbles) within the weld.
- **Oxidation:** Rust and oxidation layers create impurities that can affect the weld strength and introduce slag inclusions.
- **Smooth Melting:** Clean surfaces offer a better contact surface for the molten metal, allowing for smoother melting and a more consistent weld bead profile.

Therefore, thorough cleaning with grinding, wire brushing, or other appropriate methods ensures optimal weld quality and performance.

(c) Advantages and Limitation of MIG Welding:

Advantages:

1. **Versatility:** Handles a wide range of materials and thicknesses with ease.
2. **High Deposition Rate:** Creates thick and strong welds quickly due to the continuous wire feed.
3. **Cleanliness:** Inert gas shielding minimizes spatter and fumes compared to other welding processes.

Limitation:

1. **Wind Sensitivity:** The shielding gas can be easily affected by wind, requiring shielding devices in outdoor environments for consistent weld quality.

MIG welding offers a balance of ease, speed, and quality for mild steel welding, making it a popular choice for various applications. However, its wind sensitivity needs to be considered for outdoor work.

July 2021

5. With reference to TIG welding:

- (a) describe the process; (3)
- (b) explain why an ac current is preferred when welding aluminium; (2)
- (c) explain the advantages compared to other methods. (5)

(a) TIG Welding Process:

Tungsten Inert Gas (TIG) welding, also known as GTAW (Gas Tungsten Arc Welding), is a meticulously controlled arc welding process that uses a non-consumable tungsten electrode and an inert shielding gas. Here's how it works:

1. Preparation: Clean the weld area thoroughly to remove any contaminants that could compromise the weld quality.
2. Setup: Choose the appropriate tungsten electrode and shielding gas (e.g., argon) based on the material being welded. Set the welding current and flow rate.
3. Initiation: Create an arc between the tungsten electrode and the workpiece using a high-frequency start or by touching the tip momentarily and retracting.
4. Welding: Hold the torch at the desired angle and distance from the joint. Add filler metal (a separate rod or wire) manually to the molten pool created by the arc, building the weld bead layer by layer.
5. Travel Speed: Move the torch along the joint seam at a controlled pace, maintaining the arc and adding filler metal as needed.
6. Finishing: Allow the weld to cool completely, then remove any slag (residue) with a wire brush or other cleaning tools.

TIG welding offers exceptional control and precision because the filler metal is not continuously fed, allowing the welder to manipulate the molten pool directly.

(b) AC Current for Aluminum:

When welding aluminum, AC current is often preferred over DC current for several reasons:

- Penetration: The alternating polarity of AC creates a cleaning action during the positive cycle, breaking up the tenacious oxide layer (aluminum oxide) that forms on the surface. This allows for deeper weld penetration compared to DC.
- Cathode Cleaning: During the negative cycle, the aluminum melts and cleans the tungsten electrode, preventing contamination and maintaining a stable arc.
- Weld Quality: The combined cleaning and penetration effects of AC lead to cleaner welds with reduced porosity and improved visual appearance.

Though DC can be used for specific aluminum applications, AC generally offers better overall performance and ease of welding.

## (c) Advantages of TIG Welding:

TIG welding offers several advantages over other welding methods, particularly for critical applications or materials like aluminum:

- **High Precision and Control:** The ability to manually add filler metal and control the arc allows for precise weld profiles and minimal distortion.
- **Excellent Weld Quality:** TIG produces strong, clean welds with minimal spatter and high weld integrity due to the shielding gas and controlled conditions.
- **Versatility:** Works with a wide range of materials, including thin sheets, delicate parts, and even dissimilar metals.
- **Minimal Heat Input:** Less heat-affected zone minimizes warping and distortion, particularly beneficial for thin materials.

However, TIG welding requires more skill and practice compared to other methods, and its slower deposition rate might not be suitable for high-production applications.

In conclusion, TIG welding stands out for its precision, control, and excellent weld quality, making it a preferred choice for critical applications, aluminum welding, and scenarios where meticulous technique is paramount.

March 2021

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Nov 2023

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May 2023

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Nov 2021

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Covered electrode welding is a versatile and widely used process, but even the most skilled welder can encounter imperfections. Here are five common defects you might find on a weld, along with simple sketches to visualize them:

#### 1. Slag Inclusion:



- Sketch: Imagine a dark, irregular line embedded within the weld bead.
- Description: Small pieces of molten slag (residue from the electrode coating) become trapped within the weld metal as it solidifies.
- Causes: Improper cleaning of the joint, incorrect welding angle, excessive current.
- Effects: Weakened weld strength, potential cracking, corrosion risk.

## 2. Undercut:

- Sketch: Picture a groove at the toe of the weld, where the base metal dips below the level of the weld bead.
- Description: Excessive melting of the base metal at the edge of the weld, creating a groove or undercut.
- Causes: High welding current, excessive travel speed, incorrect electrode angle.
- Effects: Reduced weld cross-sectional area, weakened joint, increased stress concentration.

## 3. Porosity:

- Sketch: Imagine small, round voids or gas pockets scattered throughout the weld bead.
- Description: Gas bubbles entrapped within the molten metal during solidification.
- Causes: Moisture on the base metal or electrode, improper shielding gas flow, contamination.
- Effects: Weakened weld strength, potential leakage paths, reduced fatigue life.

## 4. Incomplete Fusion:

- Sketch: Picture a gap or lack of bonding between the weld metal and the base metal.
- Description: The weld metal doesn't fully penetrate and bond with the base metal, leaving unfilled areas.
- Causes: Low welding current, improper electrode manipulation, inadequate joint preparation.
- Effects: Weak joint, potential cracking, structural failure risk.

## 5. Spatter:

- Sketch: Imagine small, solidified droplets of metal scattered around the weld area.
- Description: Molten metal droplets ejected from the arc during welding, sticking to the surrounding surface.
- Causes: Incorrect electrode angle, excessive current, worn-out electrode.
- Effects: Aesthetically undesirable, potential surface damage, cleaning challenges.

June 2018

## 6. With reference to joining a steel hull to an aluminium superstructure:

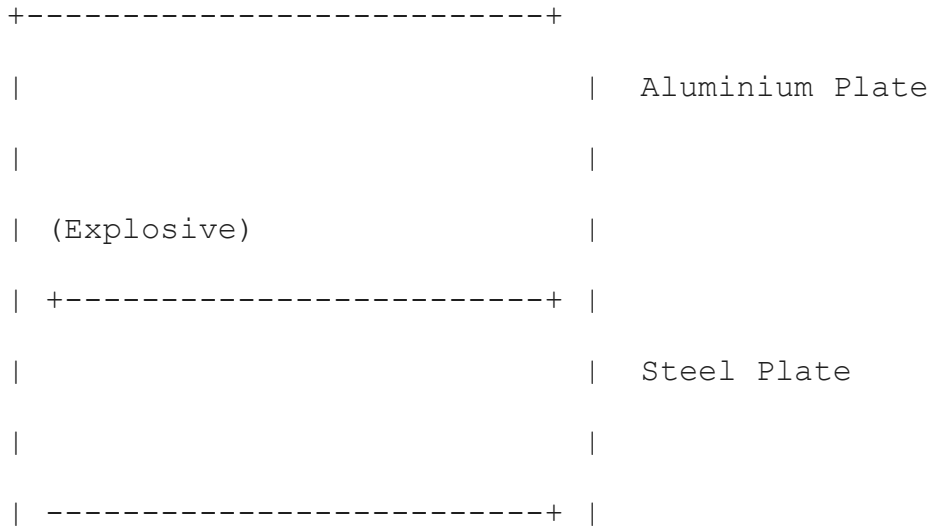
- (a) explain, with the aid of a sketch, the process of *explosion welding*; (6)
- (b) explain why this joint is superior to an insulated bolt joint. (4)

### (a) Explosion Welding Process (Sketch):



Imagine two plates, one steel and one aluminum, stacked on top of each other. A layer of high explosives is positioned between them, with a specific detonation point at one end. Detonating the explosives creates a high-pressure shockwave that travels across the plate interface.

Sketch:



Here's what happens:

1. Shockwave Impact: The shockwave strikes the aluminum plate first, liquefying its surface layer.
2. Pressure & Jetting: The high pressure forces the molten aluminum into intimate contact with the roughened steel surface.
3. Jet Cleaning: The shockwave also generates a cleaning jet that expels contaminants like oxides from the contact surfaces.
4. Solidification & Bonding: As the pressure drops, the liquefied aluminum rapidly cools and solidifies, forming a strong intermetallic bond with the steel.

(b) Advantages of Explosion Welding over Insulated Bolt Joints:

Explosion welding offers several advantages over insulated bolt joints for joining steel and aluminum:

1. Stronger Joint: The intermetallic bond created by explosion welding is stronger than the mechanical connection of bolts, providing superior joint strength and fatigue resistance.
2. Continuous Bond: Unlike bolts, which have discrete contact points, the explosion weld creates a continuous and uniform bond, distributing stress more evenly across the joint.
3. Eliminates Galvanic Corrosion: The direct, metallic bond prevents galvanic corrosion between the dissimilar metals, which can occur with bolted connections due to electrolyte penetration.
4. Reduced Weight: Explosion welding eliminates the need for heavy bolting hardware, potentially reducing the overall weight of the structure.
5. Improved Aesthetics: The seamless weld eliminates the visual clutter of bolt heads and offers a smoother finish.

However, explosion welding also has limitations, such as higher initial cost, limited geometry options, and potential safety concerns surrounding explosives. Careful consideration of material compatibility, joint design, and cost-effectiveness is crucial when choosing between explosion welding and other techniques.

By understanding the process and advantages of explosion welding, we can appreciate its unique capabilities for joining dissimilar metals like steel and aluminum in demanding applications.