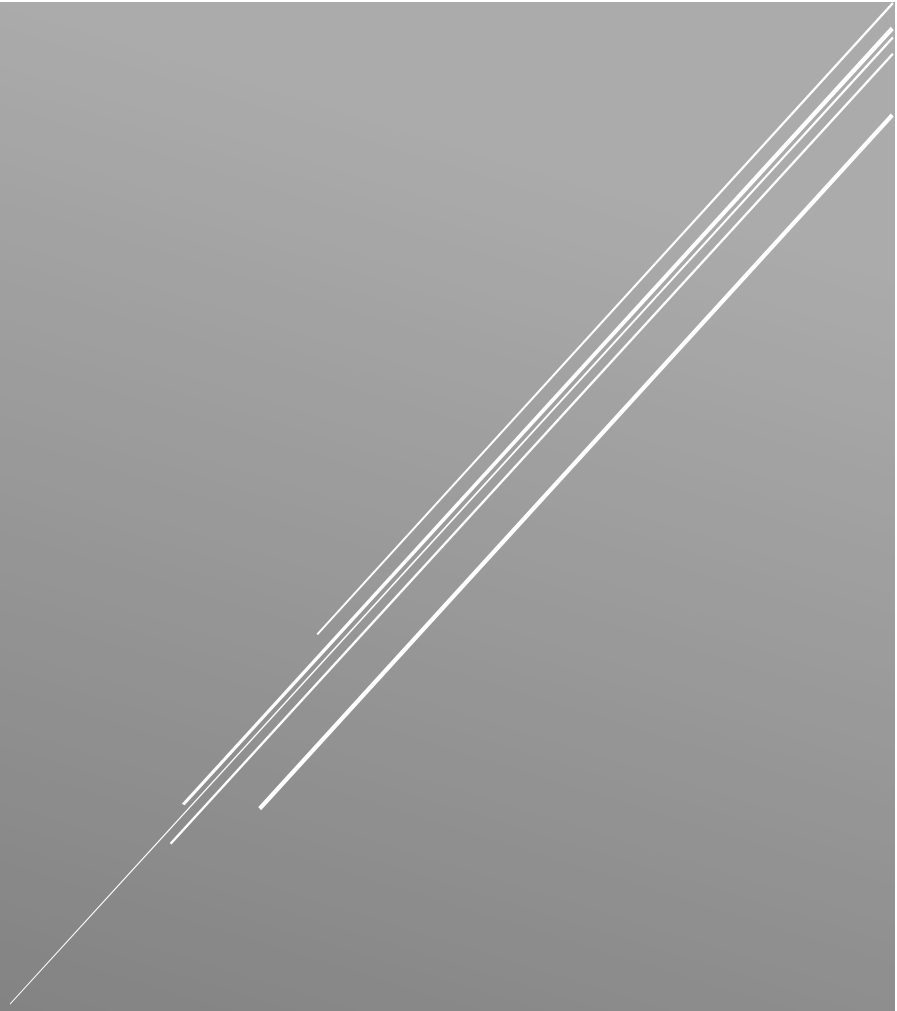


2024



ALUMINUM WELDING

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A.

Introduction:

Welding is a fabrication process that involves joining two or more materials, typically metals or thermoplastics, by causing fusion between them. This fusion is achieved by heating the materials to their melting point, or by using pressure and heat, or a combination of both. The joined materials cool and form a strong, durable bond known as a weld.

There are various welding techniques, each with its own specific application and method. Some common welding methods include:

1. Arc Welding:

Is a welding process that uses an electric arc to join metals. It is one of the most common and widely used welding methods. The process involves creating an electric arc between the welding electrode (which can be consumable or non-consumable) and the workpiece. The intense heat generated by the electric arc melts the edges of the metals, and as the molten material cools, a strong bond is formed.

2. Resistance Welding:

Is a welding process that joins metals by applying pressure and passing electric current through the workpieces. The heat generated due to the resistance to the electric current melts and fuses the materials at the joint. This process is widely used for joining metals in manufacturing and construction applications.

3. Gas Welding: This technique involves using a flame produced by burning a mixture of fuel gas and oxygen to melt the edges of the materials being joined. Oxyacetylene welding is a classic example of gas welding.

4. Submerged Arc Welding (SAW):

is a welding process that involves the formation of an arc between a continuously fed electrode and the work piece. The arc is submerged beneath a layer of granular flux, which shields the arc and the molten weld pool from the surrounding atmosphere. This process is particularly suitable for welding thick sections of steel in a single pass.

5. TIG Welding (GTAW):

Tungsten Inert Gas (TIG) welding, also known as Gas Tungsten Arc Welding (GTAW), is a welding process that uses a non-consumable tungsten electrode to produce the weld. TIG welding is known for its precision and versatility, making it suitable for a wide range of applications, particularly those requiring high-quality welds.

6. MIG Welding (GMAW):

Metal Inert Gas (MIG) welding, also known as Gas Metal Arc Welding (GMAW), is a welding process that utilizes a continuous consumable wire electrode and a shielding gas to create a weld. MIG welding is known for its speed, efficiency, and versatility, making it widely used in various industries.

B. Most popular welding:

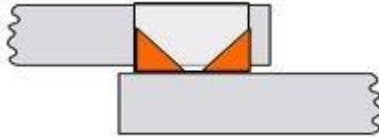
As of my last knowledge update in January 2022, MIG (Metal Inert Gas) welding is one of the most popular and widely used welding processes, particularly in industrial and manufacturing settings. MIG welding is known for its versatility, ease of use, and efficiency. It is often preferred for its ability to produce high-quality welds at a relatively fast pace. Here are some reasons why MIG welding is popular:

1. Ease of Use: MIG welding is considered more user-friendly, making it suitable for both beginners and experienced welders. The process involves a continuous wire electrode, which simplifies the operation compared to other welding methods.
2. High Productivity: MIG welding allows for high welding speeds, contributing to increased productivity in various manufacturing applications.
3. Versatility: MIG welding can be used to weld a wide range of materials, including carbon steel, stainless steel, aluminum, and other alloys. This versatility makes it applicable to diverse industries.
4. Automatic and Semi-Automatic Options: MIG welding can be easily adapted to automated or semi-automated systems, enhancing efficiency and consistency in large-scale production.

C. Types of Welding Joints

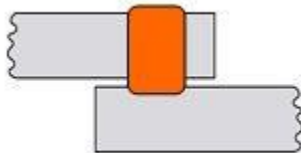
Welds Based on Configuration

A. Slot weld



Joint between two overlapping components made by depositing a fillet weld around the periphery of a hole in one component so as to join it to the surface of the other component exposed through the hole.

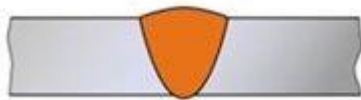
B. Plug weld



Weld made by filling a hole in one component of a workpiece with filler metal so as to join it to the surface of an overlapping component exposed through the hole (the hole can be circular or oval).

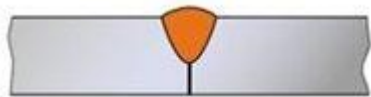
Based on Penetration

A. Full penetration weld



Welded joint where the weld metal fully penetrates the joint with complete root fusion.

B. Partial penetration weld



Weld in which the fusion penetration is intentionally less than full penetration. In the US the preferred term is partial joint penetration weld (PJP).

Welds Based on Accessibility



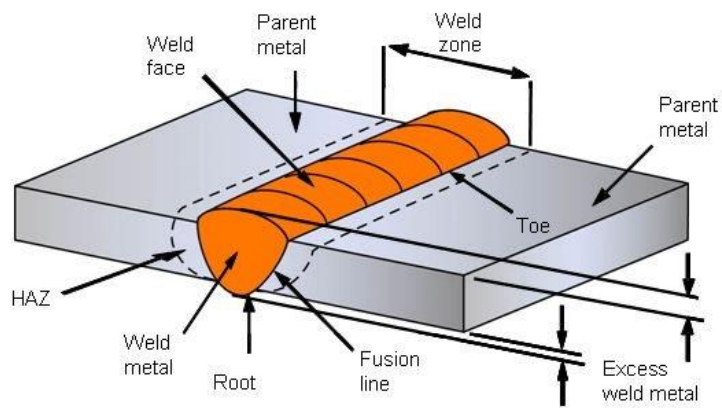
Single side weld



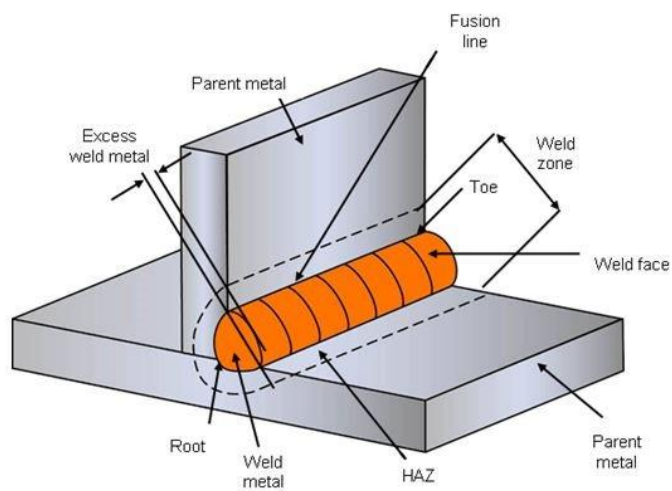
Double side weld

Features of Completed Welds

Butt weld



Fillet weld



D. Aluminum welding

1. Definition:

Aluminum welding is a fabrication process that involves joining pieces of aluminum or aluminum alloys using a variety of welding techniques. The goal of aluminum welding is to create a strong and durable bond between the aluminum components, allowing them to function as a unified structure. The welding process for aluminum is distinct from other materials due to the unique properties of aluminum, such as its high thermal conductivity, low melting point, and susceptibility to oxidation.

2. Practices when aluminum welding

For good results, you will need to pair the best welding types and filler metal for aluminum with some best practices.

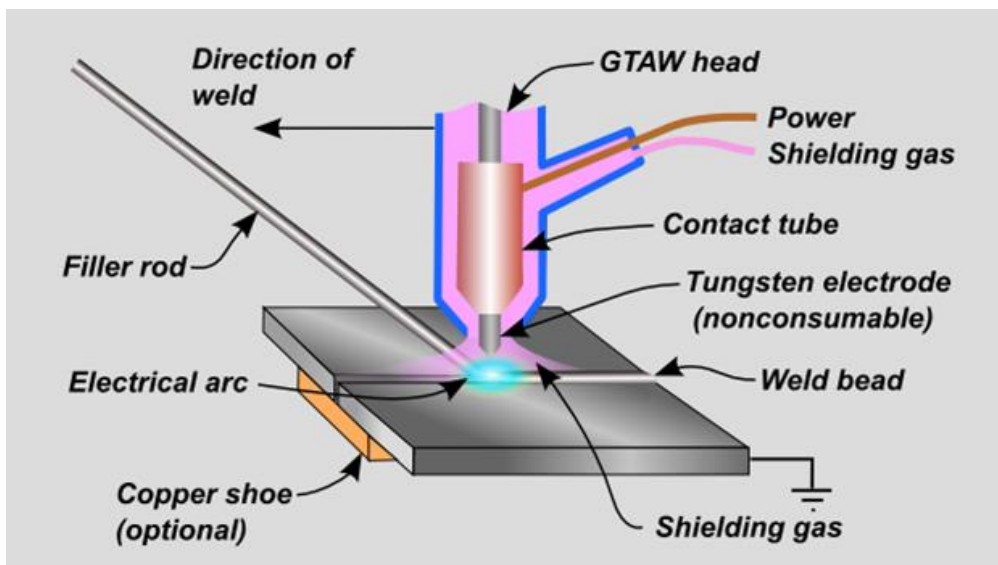
- **Clean the aluminum sheets** – Clean the base material thoroughly before welding. Removing contaminants like oil, dirt and dust reduces chances of porosity and improves the final results.
- **Remove the oxide layer** – Use a new stainless-steel brush to remove the oxide layer. Without removing the coating, you could run into problems when you start welding.
- **Proper storage** – Store the aluminum sheets properly to prevent porosity. Store the sheets indoors and preferably vertically as opposed to piling them on top of each other.

Welding aluminum is an easy task if you take the time to prepare and follow these tips.

3. Types of welding used for Aluminum

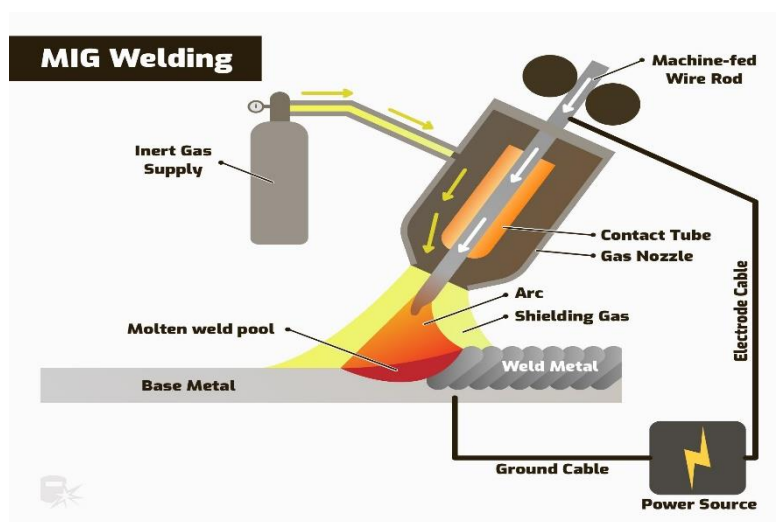
Gas Tungsten Arc Welding (GTAW)/ TIG

This is the most common method of welding aluminium. It is also known as Tungsten Inert Gas welding. This method doesn't require mechanical wire feeding, which saves you the problems that come with feedability issues. Using this method, you will feed the filler material into the puddle by your hand. One of the reasons this method is highly preferred is because of the new and clean weld it produces. It also prevents contamination of the work area by the atmosphere.



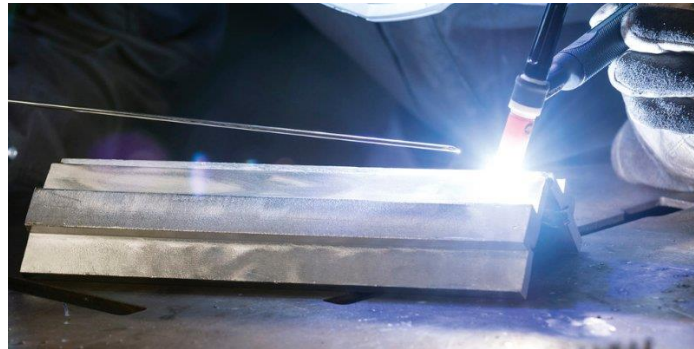
Gas Metal Arc Welding/ MIG

MIG welding uses an electrode for the wire that is continually fed at the base of the weld. The wire is shielded by inert gas and in some instances, a gas mixture to prevent the absorption of hydrogen. The method is often messy because of the trace of tiny metal beads that are left behind as a result of using the spray transfer method.



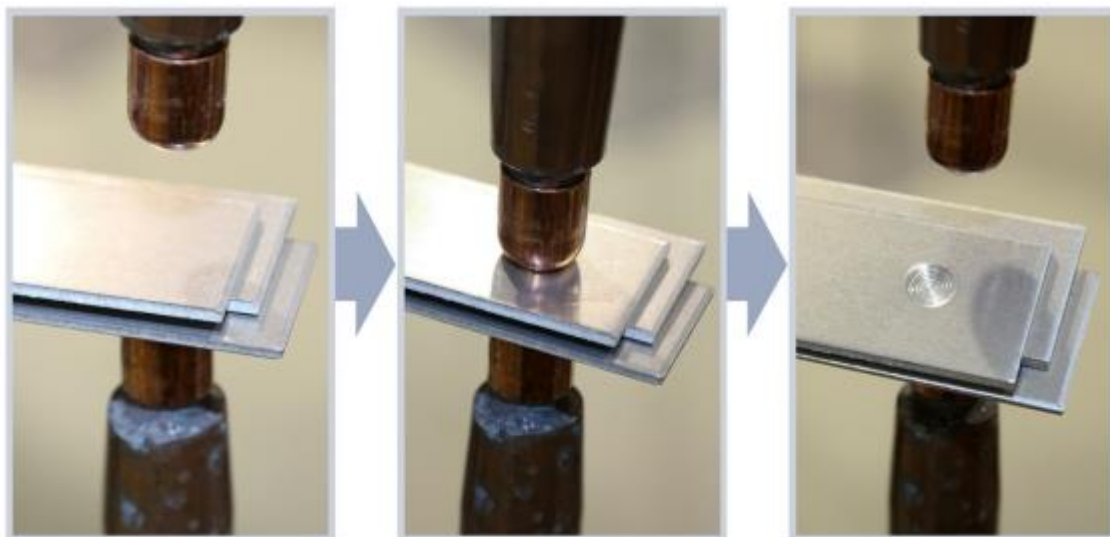
Arc Welding

Arc welding is the very first welding technique ever discovered. This technique uses a power supply to melt and join the aluminium sheet. Although it is the most cost-effective type of welding aluminium, it should only be completed by an experienced welder.



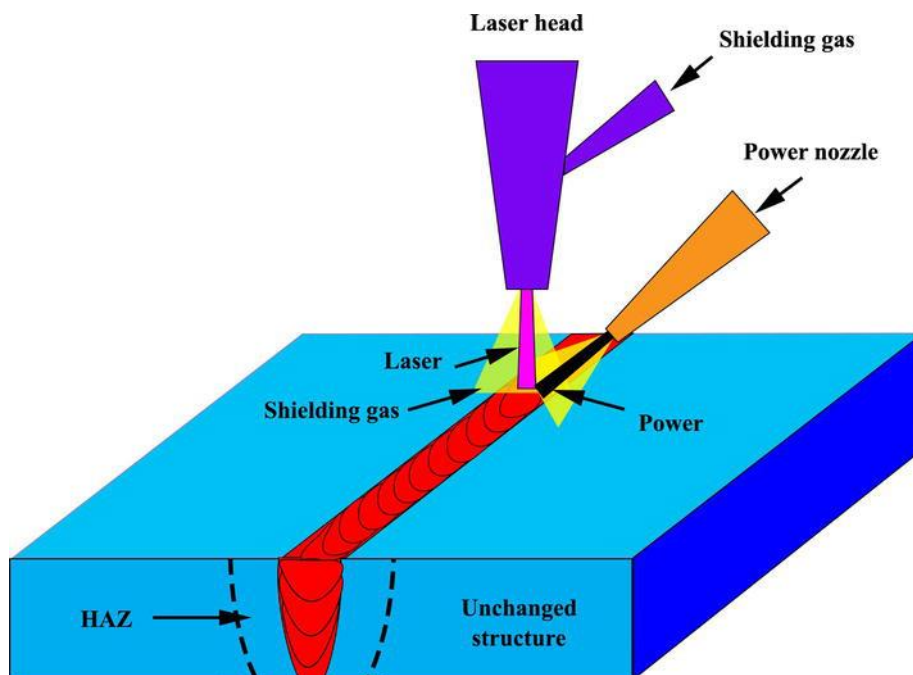
Resistance Welding

Resistance welding is also a possibility when working with aluminium. But it's not without challenges, mainly because of aluminium thermal conductivity properties. To complete the weld successfully, you will need to use special tips, welding equipment and take time developing the parameters.



Electron Beam Welding and Laser Beam Welding

Beam welding produces a high-power density, which is excellent because it prevents a cold start. But both laser and electron beam welding techniques are not without challenges. With laser welding, light reflectivity is the primary concern. Porosity is also a concern, but with proper shielding gas optimization you can prevent it.



Electron beam welding is more manageable. It's done in a vacuum, so you don't have to worry about porosity and it doesn't use light as an energy medium.

4. The Challenges in Welding Aluminum

Welding aluminum is a complex process that requires knowledge, skill, and experience. Understanding the [different welding processes](#) suitable for aluminium and the challenges and workarounds regarding those methods is paramount for achieving successful [welding joints](#).

Oxidation

Aluminium rapidly oxidises when exposed to the atmosphere, forming a thin oxide layer with a higher melting temperature (2072 C°) than aluminium (660 C°). Welding through this barrier might burn holes through the workpiece.

The oxide layer can be dissolved using solvents or acids before welding the workpiece. It can be physically removed through mechanical abrasive techniques through an exclusive stainless steel wire brush or sandblasting.

Porosity

Aluminium in its molten state, absorbs high amounts of hydrogen, resulting in tiny voids or bubbles forming in the weld metal. This weakens the structural integrity of the metal, making it vulnerable to failure from pressure and stress.

[Porosity](#) is minimised by using clean materials and equipment, removing oil and grease from the metal's surface, and using a shielding gas to limit contamination.

Impurities

Oil, dirt, air and debris can negatively impact the weld zone, affecting the strength and appearance of the workpiece. These impurities can come from multiple sources, such as the environment, equipment, preparation and storage. Discolouration, graining, [corrosion](#) and oxidation present signs of impurities in a weld joint.

Proper storage, equipment maintenance and metal preparation are the steps to take to avoid impurities.

Thickness

Working with aluminium typically involves welding materials with varying thicknesses. Welding through a combination of thin and thick material simultaneously can be tricky.

Heat applied to the workpiece might melt through the thin material or not penetrate the thick material enough to create a strong weld joint.

A thorough understanding of the aluminium grades, welding methods, and techniques is the key to success in effectively welding different aluminium sheet thicknesses. Welders can effectively weld these metals by setting the parameters such as amperage and heat input to optimal levels.

Hot Cracking

High levels of thermal stress can lead to hot cracking or solidification cracking in aluminium welds. It is one of the reasons why aluminium was once deemed unsuitable for arc welding.

Combining various alloying elements and treating aluminium alloys can drastically improve its [mechanical properties](#). (Al-Cu) 2xxx and (Al-Zn) 7xxx grade series are aluminium alloys that can heat-treated.

Thermal Conductivity

The high thermal conductivity of aluminium makes it challenging to penetrate the weld joint successfully, as it absorbs and dissipates heat quickly.

Adjusting the settings of the welding equipment to higher heat input improves penetration.

E. Sources

- https://ia800202.us.archive.org/11/items/Welding_Aluminum_Its_Alloys/Welding_Aluminum__Its_Alloys.pdf
- <https://www.thyssenkrupp-materials.co.uk/technical-knowledge-hub/types-of-welding-used-for-aluminium>
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- <https://www.millerwelds.com/resources/article-library/guide-to-industrial-aluminum-welding-beyond-the-basics>
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