

Welding Processes: Techniques, Characteristics and Applications

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ABSTRACT:

Various industries depend on welding procedures to combine materials and build sturdy, dependable structures. The various welding techniques, their traits, and their applications are described in this chapter. The topic of welding and its importance in construction and production are introduced in the chapter's opening paragraph. The classification of welding techniques into the four major categories of fusion welding, solid-state welding, brazing, and soldering follows. Brief explanations of each category are provided, outlining the underlying ideas and methods used. Arc welding, gas welding, and resistance welding are a few of the frequently utilized techniques covered under fusion welding. The chapter explains each process' fundamental workings as well as the tools employed and significant applications. Additionally, solid-state welding techniques including friction welding, ultrasonic welding, and diffusion bonding are described, with an emphasis on how well-suited they are for attaching materials without melting. brazing and soldering are discussed further as methods for combining components with a filler substance that has a lower melting point. It describes how these two processes are similar and dissimilar, as well as how they are used in diverse sectors. The chapter also briefly discusses new developments in welding, such as laser welding and electron beam welding, while emphasizing their special benefits.

KEYWORDS:

Arc, Electrode, Gas, Materials, Process, Shielding, Welding.

I. INTRODUCTION

The combining of materials to produce sturdy and dependable structures requires welding techniques. These procedures require applying heat, pressure, or both to the base materials to melt and fuse them and create a solid bond. Many industries, including construction, manufacturing, automotive, aerospace, and more, require welding. An overview of some of the most popular welding methods is provided below: A coated electrode that functions as both the filler metal and the electrode is used in stick welding, another name for SMAW. The electrode melts and a weld is formed when an electric arc forms between it and the workpiece. The molten weld pool is shielded from air contaminants by shielding gas and flux provided by the electrode's covering [1], [2]. The weld pool is shielded by a shielding gas and a continuously fed wire electrode in GMAW, commonly referred to as MIG Metal Inert Gas welding. The shielding gas and filler wire are both delivered by the welding flame at the same time. GMAW is a flexible method appropriate for a variety of materials and thicknesses.

TIG welding, commonly referred to as Gas Tungsten Arc Welding GTAW, creates the arc using an inert tungsten electrode. If needed, a separate filler wire may be employed. TIG welding is frequently utilized for thin materials, crucial junctions, and tasks needing a pleasing aesthetic due to the high-quality, exact welds it generates [3], [4]. While GMAW and FCAW are similar, the latter uses a tubular electrode loaded with flux. To shield the weld pool from air pollution, the flux creates a slag and shielding gas. FCAW is frequently used to weld thick materials and in outdoor settings where wind-affected shielding gas may be present. A constantly fed electrode and a granular flux layer are used in the automated SAW process. As a result of being submerged beneath the flux, the arc is well-protected from contaminating air elements. For welding heavy materials, such as pipes and structural parts, SAW is frequently utilized.

LBW melts and fuses the materials using a strong laser beam. A concentrated and precise heat source is produced on the workpiece as a result of the laser beams focus. For precise and quick welding, LBW is frequently employed in the automotive and aerospace sectors. To melt and connect materials, EBW uses a tightly concentrated electron beam. Deep penetration and exact control are made possible by the electrons' high energy.

For welding crucial components, EBW is frequently utilized in the aerospace and medical industries. These are but a few illustrations of welding procedures frequently used in industry. The selection of a method is influenced by elements including the type of material, joint arrangement, thickness, necessary weld quality, and production needs. Each process has its advantages and uses. Because of technological improvements and a growing need for effective and high-quality joining techniques, welding processes are always changing and getting better. Various industries depend on welding procedures to combine materials and build sturdy, dependable structures. The various welding techniques, their traits, and their applications are described in this chapter [5], [6].

The topic of welding and its importance in construction and production are introduced in the chapter's opening paragraph. The classification of welding techniques into the four major categories of fusion welding, solid-state welding, brazing, and soldering follows. Brief explanations of each category are provided, outlining the underlying ideas and methods used. Arc welding, gas welding, and resistance welding are a few of the frequently utilized techniques covered under fusion welding. The chapter explains each process' fundamental workings as well as the tools employed and significant applications. Additionally, solid-state welding techniques including friction welding, ultrasonic welding, and diffusion bonding are described, with an emphasis on how well-suited they are for attaching materials without melting brazing and soldering are discussed further as methods for combining components with a filler substance that has a lower melting point. It describes how these two processes are similar and dissimilar, as well as how they are used in diverse sectors. The chapter also briefly discusses new developments in welding, such as laser welding and electron beam welding, while emphasizing their special benefits [7], [8].

II. DISCUSSION

Arc Welding

The widely used welding technique known as arc welding uses an electric arc to fuse the base metals being welded together. A consumable or non-consumable electrode is used to create the electric arc, which melts the metals and, upon solidification, forms a weld junction. Arc welding is a flexible procedure that has several benefits and finds use in a variety of sectors. Here are some essential arc welding elements:

Different Arc Welding Techniques

Shielded Metal Arc Welding SMAW, Gas Metal Arc Welding GMAW, Flux-Cored Arc Welding FCAW, Gas Tungsten Arc Welding GTAW, and Submerged Arc Welding SAW are a few examples of arc welding procedures. Each process has unique properties, uses, and equipment specifications.

Power Supply and Welding Gear

A power source that can maintain the electric arc while supplying the required current and voltage is required for arc welding. Depending on the exact welding process, the power source may be a transformer, generator, or inverter-based system. The welding machine, cables, electrode holder, and shielding gas if necessary are all included in the welding equipment.

Electrode for welding

Depending on the welding method, the electrode used in arc welding can be either consumable or non-consumable. The electrode is consumed during the welding process in consumable electrode techniques like SMAW and FCAW, resulting in the addition of filler material to the weld joint. The electrode does not melt when used in non-consumable electrode techniques like GTAW, where it is employed to produce the arc and act as a shield.

Shielding

Shielding is frequently needed during arc welding operations to protect the weld from ambient contaminants like oxygen and nitrogen. Inert gases such as argon or helium GTAW, flux coatings on disposable electrodes SMAW, or a mix of gas and flux FCAW can all be used to produce shielding. The shielding maintains the weld's integrity and prevents oxidation.

Welding Specifications

Arc welding requires precise control over several variables, such as welding current, voltage, travel speed, arc length, and electrode angle. The weld's heat input, penetration depth, and general quality are all determined by

these variables. To get a solid weld with good fusion and few faults, the welding parameters must be properly adjusted.

Applications

Construction, automotive, aerospace, shipbuilding, manufacturing, and repair and maintenance are just a few of the industries that use arc welding extensively. It works well for combining a variety of metals and alloys, such as titanium, carbon steel, stainless steel, and aluminum. Arc welding can be used to fabricate buildings, fix broken parts, and make strong, long-lasting welds.

Advantages

Numerous benefits come with arc weldings, such as adaptability, rapid welding depending on the procedure, compatibility for both indoor and outdoor applications, and the capacity to weld in a variety of positions. In comparison to other sophisticated welding techniques, it is a well-known and commonly used welding procedure with a comparatively cheap equipment cost. Arc welding is a basic and popular welding technique that offers a way to combine materials in a variety of applications. Because of its adaptability, adaptability, and dependability, it is a top choice for various welding applications in a variety of sectors.

General Technology of Arc Welding

An electric arc is used in the flexible welding method known as arc welding to combine metal components. It entails producing a hot arc between an electrode and the workpiece, which melts the base metals and, when they solidify, creates a weld junction. Here is a general summary of the arc welding technology:

Energy Source

A power supply that can deliver the required current and voltage for the welding process is necessary for arc welding. A transformer, generator, or inverter-based system can be used as the power supply. It offers the electrical power required to keep the arc going and melt the metals.

Electrodes

Depending on the welding procedure, arc welding uses either consumable or non-consumable electrodes. Consumable electrodes, such as those used in Flux-Cored Arc Welding FCAW and Shielded Metal Arc Welding SMAW, are employed in the process but are consumed during the welding process, adding a filler material to the weld. The arc is produced using non-melting electrodes, such as those used in Gas Tungsten Arc Welding GTAW, which prevent melting.

Generation Arc

Between the electrode and the workpiece, the electric arc is formed. An arc is started when the electrode makes contact with the workpiece and the voltage is applied. Amounts of heat produced by the arc can cause the base metals to melt. The welding area receives concentrated localized heat from the arc.

Shielding

Shielding is used to protect the weld from air pollution. By shielding, molten metal is kept from reacting with oxygen and nitrogen, which could result in weld flaws. Inert gases like argon or helium GTAW, flux coatings on disposable electrodes SMAW, FCAW, or a mix of gas and flux FCAW are used to produce shielding.

Welding Specifications

To regulate the welding process and obtain the desired weld quality, many parameters are changed. These variables include the electrode angle, welding current, voltage, and travel speed. The particular welding procedure, material thickness, joint design, and desired weld qualities all have a role in the selection and adjustment of these parameters.

Welding Methods

Different methods, including weaving, straight-line welding, circular welding, and combinations of these methods, can be used to execute arc welding. The joint configuration, welding position, desired weld form and desired weld penetration all influence the procedure choice.

Safety Measures

High temperatures, bright light, and potentially harmful fumes and gases are all involved in arc welding. Because of this, it is necessary to take the correct safety precautions, such as donning protective clothes, utilizing welding helmets with auto-darkening filters, ensuring adequate ventilation, and adhering to electrical safety regulations. The welding process known as arc welding is well-known, reliable, and capable of joining a wide range of metals and alloys. It can be used for everything from little maintenance to extensive industrial fabrication. Arc welding can result in high-quality welds and help build sturdy, long-lasting structures with the right instruction, practice, and adherence to safety procedures.

Aw Processes Consumable Electrodes

For connecting metals, arc welding techniques using disposable electrodes are frequently employed in a variety of sectors. In these procedures, electrodes are used, which serve as both a heat source and a filler material during the welding process. Some of the frequently used arc welding procedures using consumable electrodes are listed below:

SMAW, or shielded metal arc welding

SMAW, also referred to as stick welding uses a coated electrode made up of a core wire encased in a flux coating. During welding, the flux covering melts, creating a shielding gas and slag to shield the weld pool from contaminating air particles. SMAW is adaptable and works with a variety of metals and alloys.

FCAW, or flux-cored arc welding

A tubular electrode used in FCAW is filled with flux, which has components to produce shielding gas and slag. Compared to SMAW, the flux-cored electrode enables faster deposition rates, and depending on the process variation gas-shielded or self-shielded, it can be utilized with or without external shielding gas. In the building, shipbuilding, and industrial sectors, FCAW is frequently employed.

Gas Metal Arc Welding

The electrode for GMAW, often referred to as MIG/MAG welding, is continuously supplied with solid or flux-cored wire. During welding, the wire electrode is consumed, and an external shielding gas such as argon or a combination of gases is utilized to keep the weld zone free from contaminating air. Because of GMAW's high productivity, adaptability, and simplicity of automation, it can be used for a variety of applications.

SAW: Submerged Arc Welding

A constantly fed consumable electrode, either in the form of a solid wire or a strip, is used in SAW. Granular flux is used as a protective covering throughout the welding process and to help maintain arc stability. For welding thick sections, such as those used in shipbuilding, pressure vessel manufacturing, and structural steel applications, SAW is frequently utilized. Each of these consumable electrode arc welding methods has unique benefits and is appropriate for various applications. When carried out correctly, they offer flexibility, high deposition rates, and good weld quality. The choice of the best welding procedure is influenced by several variables, including the material being welded, the joint configuration, the required weld qualities, and productivity standards.

Aw Processes Nonconsumable Electrodes

For precise and high-quality welding applications, non-consumable electrode arc welding methods are frequently used. These procedures use electrodes that don't melt while welding, acting as a source of electric arc and a conduit for heat transfer to the base metal. The following are some of the popular arc welding procedures that use non-consumable electrodes:

Using a Gas Tungsten Arc Welder (GTAW)

The arc is produced by a non-consumable tungsten electrode in GTAW, also referred to as TIG Tungsten Inert Gas welding. The welding process can be precisely controlled since the tungsten electrode can sustain high temperatures without melting. The weld zone is shielded from atmospheric pollution using shielding gas, usually argon or helium. Thin sections, important junctions, and reactive metals like titanium and stainless steel are all good candidates for GTAW welding.

Using a Plasma Arc Welder (PAW)

GTAW and PAW are similar, but PAW makes use of a tighter-fitting nozzle to produce a more intense and focused arc. In comparison to GTAW, the plasma arc offers a higher energy density that enables deeper penetration and faster welding rates. PAW is frequently utilized in fields including aerospace, nuclear, and automotive applications where precise control over the welding process and high-quality welds are essential.

CAW: Carbon Arc Welding

With or without shielding gas, CAW operates with a carbon electrode in place of a tungsten electrode. A welding arc is created between the carbon electrode and the workpiece, producing a lot of heat. In addition to specific specialized applications like gouge and metal removal, CAW is typically utilized for welding thick materials. These non-consumable electrode arc welding procedures provide fine control, superior weld quality, and the ability to weld a variety of metals and alloys. They are frequently used for applications that demand meticulous attention to detail, great accuracy, and crucial weld integrity. The material being welded, the joint design, the thickness, and the desired weld qualities all play a role in choosing the best welding technique.

Resistance Welding

A common welding technique is resistance welding, which involves creating heat by running an electric current through the resistance between two or more metal workpieces. The metals soften as a result of the heat produced at the contact locations and join together to form a weld. Resistance welding is frequently employed in the manufacturing sector due to its quickness, effectiveness, and capacity for producing welds of excellent quality. Here are some essential characteristics of resistance welding:

Functioning Premise

Resistance welding relies on the Joule heating phenomenon, in which heat is produced when an electric current is carried through two conductive materials because of their resistance to one another. The metal becomes molten or pliable due to the heat produced at the contact locations, which enables bonding.

Resistance Welding Techniques

Processes for resistance welding come in a variety of forms, such as spot welding, seam welding, projection welding, and flash butt welding. Each method has a particular use and is appropriate for various joint designs and materials.

Spotting Welding

Resistance welding most frequently takes the form of spot welding. It entails applying pressure and electricity to the workpieces at particular spots to form a weld nugget. In the automotive sector, spot welding is frequently used to attach sheet metal parts including body panels and frames.

Welding Seams

To make continuous welds along the length of overlapped workpieces, seam welding is utilized. It makes use of revolving wheels or electrodes to deliver pressure and current to the workpieces as they pass through. A prevalent technique in the manufacture of pipes, tubes, and containers is seam welding.

Welding in Projections

Workpieces having projections or embossments are joined using projection welding, which produces localized heating and guarantees accurate and consistent welds. It is frequently used to link components with threaded studs, nuts, or other protrusions in the automobile and appliance sectors.

Welding a Flash Butt

By bringing two workpieces together and running a strong current through them, a flash butt welding procedure joins them. The ends melt as a result of the heat produced, and extra material is released as a flash. Large-scale operations like rail welding and the production of wire and rod products frequently use flash butt welding.

Resistance Welding Benefits

High welding speeds, economical energy use, good weld quality, and flexibility for automation are only a few benefits of resistance welding. It generates welds with little to no deformation and requires little to no additional

filler material. Resistance welding is also eco-friendly because it doesn't use consumable electrodes, gases, or fluxes. Resistance welding is a flexible and popular welding technique that allows for the quick and effective joining of metal workpieces. It can be used for everything from small-scale manufacturing to massive industrial activities. Resistance welding can create sturdy and dependable welds for a range of applications with the right equipment setup, process management, and quality assurance methods.

III. CONCLUSION

The ability to unite metal components to produce structures and goods is made possible by welding procedures, which are vital in many sectors. Each welding process has its advantages and uses, whether it be fusion welding with consumable or non-consumable electrodes or resistance welding with its effective heat generation. The diversity of welding methods enables the joining of various materials, thicknesses, and joint types. They give you the option to make strong, long-lasting welds that are resistant to a variety of mechanical and environmental pressures. New procedures, tools, and materials are constantly being developed in the welding industry, enhancing weld quality, output, and safety. It is crucial to remember that welding procedures demand competent operators who are aware of the concepts, limitations, and safety issues related to each technique. High-quality welds and the integrity of the finished product depend on proper training, equipment upkeep, and adherence to industry norms and regulations. Numerous industries, including those in the automobile, building, aerospace, shipbuilding, and manufacturing, use welding methods extensively. They are necessary for the fabrication of numerous components, machines, vehicles, pipes, and buildings.

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