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Research Article

MODERN METHODS OF THE METAL WELDING PROCESS: REVIEW AND PROPOSALS

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ABSTRACT

Welding is a very versatile process, which is used in many industries to join metals of one type (brand) and different types (brand). This allows parts and structures to be joined permanently and firmly. Advances in welding technology have led to more precise and automated methods such as laser beam and electron beam welding. This, in turn, made it possible to create high-quality seams.

KEYWORDS

Welding, electric arc welding, welding, electrode, CO2, contact welding, welding speed, spot welding, continuous welding, disc electrode, gas welding, exothermic chemical reaction, laser welding, electron beam welding, vacuum chamber, friction welding, flywheel, anvil, filler, ultrasonic welding, ultrasound, interatomic friction, intermolecular bonding.

INTRODUCTION

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Welding is a manufacturing process that joins together materials, usually metals as well as thermoplastics. During welding, high heat is applied to the materials to be joined, melting and sometimes liquefying them, which allows them to flow and mix together when solidified by a certain environment or process. Welding is commonly used in automotive, shipbuilding, piping, and structural projects.

There are several types of material welding technology widely used in various industries. Below are types of welding, welding concepts and information:

1. Electric arc welding

Electric arc welding is a widely used welding method that uses an electric arc between an electrode and a metal to create a weld. Welding uses a power source to create an electric arc between the electrode and the metal to melt the metals at the welding point.

Factors such as welding current, voltage, electrode type, filler material, welding direction and shielding gas affect the quality and properties of the weld. In the welding process, the electrode can be consumable or non-consumable to form the weld. Consumable electrodes become part of the weld. An inert shielding gas such as CO2 or argon is often used to protect the weld area from oxidation and contamination during welding. Electric arc welding allows you to weld a variety of metals, including steel, aluminium and alloys, in all positions.

Advantages: Electric arc welding provides good penetration and welding speed. Produces strong, durable welds suitable for structural and pressure processes.

Disadvantages: Common weld defects include porosity, lack of fusion, and cracking, which can affect weld strength.

For safety reasons, due to the UV rays and heat involved in the welding process, proper safety equipment such as welding helmets and gloves should be considered.

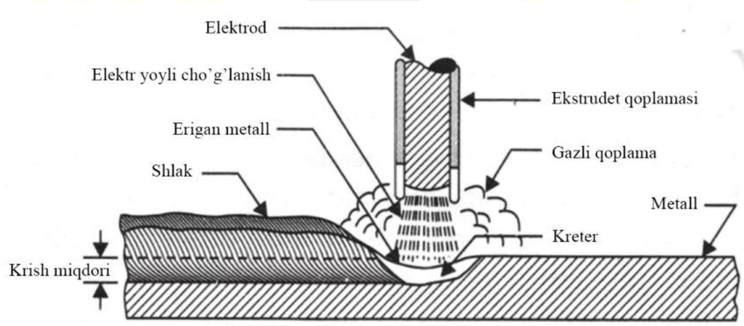

Figure 1. Electric arc welding.

2. Contact welding

Contact welding involves the process of joining metals together by passing an electric current through the metal parts to be welded, and heat is generated on the metal surface unit. Heat causes the metal to soften and fuse. Contact welding is commonly used to join thin metal parts in the automotive, household, and construction industries. Proper electrode design, current, time, and pressure are critical to obtaining quality welds without defects.

Advantages, high welding speed, reproducibility and low heat application prevent heat deformation on the metal surface. It is an alternative welding rod as a robust and inexpensive weld suitable for mass production. It can weld a variety of metals including steel, aluminium and stainless steel, typically less than 3mm thick.

Subtypes of contact welding are divided into the following types:

a) spot welding

b) welding continuous seams

c) projection welding

Spot welding is the most common type. In spot welding, two metal plates are fastened together and a contact is made by passing a large electric current through electrodes touching the top and bottom of the weld. As a result of the thermal energy generated as a result of the contact, a weld is formed.

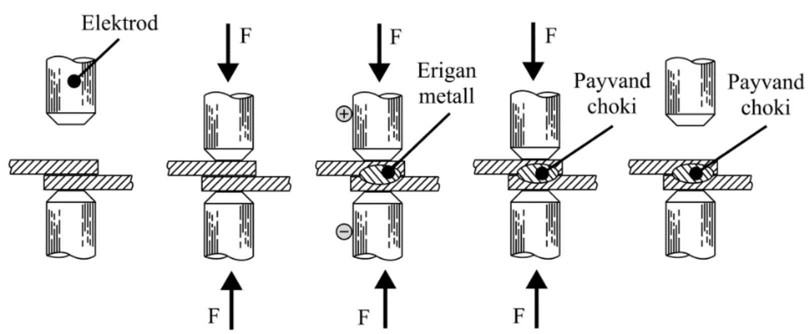

Figure 2. Spot welding.

Continuous welding is used to continuously move the work metals between a pair of disk electrodes and press them together to form a long weld.

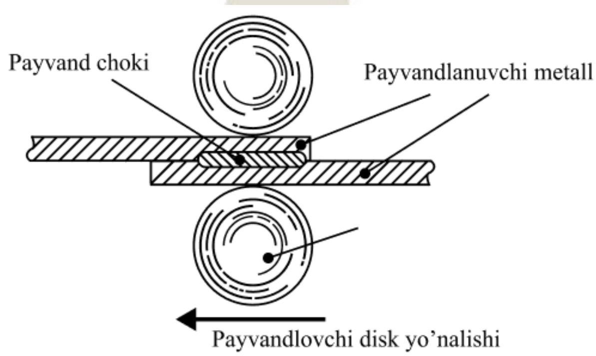

Figure 3. Welding continuous seams

3. Gas welding

Gas welding uses a fuel gas such as acetylene combined with oxygen to create a flame that melts metal surfaces. In this method, molten metal is combined. Types of gas welding include oxy-acetylene welding and oxy-fuel welding. It uses a fuel gas (such as acetylene, propane, or hydrogen) and oxygen to create a hot flame stream for welding. This fire is used to heat and melt the metal. Fuel gas and oxygen are supplied from pressure cylinders through hoses to the mixing chamber and nozzle. Gas valves are used to control the welding pattern. During the welding process, an exothermic chemical reaction occurs between fuel gas and oxygen, which reaches a temperature higher than 3000°C. Filler rods are used to create a weld. These rods are usually selected depending on the type of metal to be welded. The weld metal must have a thickness of more than 25 mm. Commonly used in construction, manufacturing, plumbing and automotive repair, this method of welding provides economical portability and low cost. Disadvantages of gas welding include limited control, the need to use a filler, and the risk of slag inclusions compared to other welding methods.

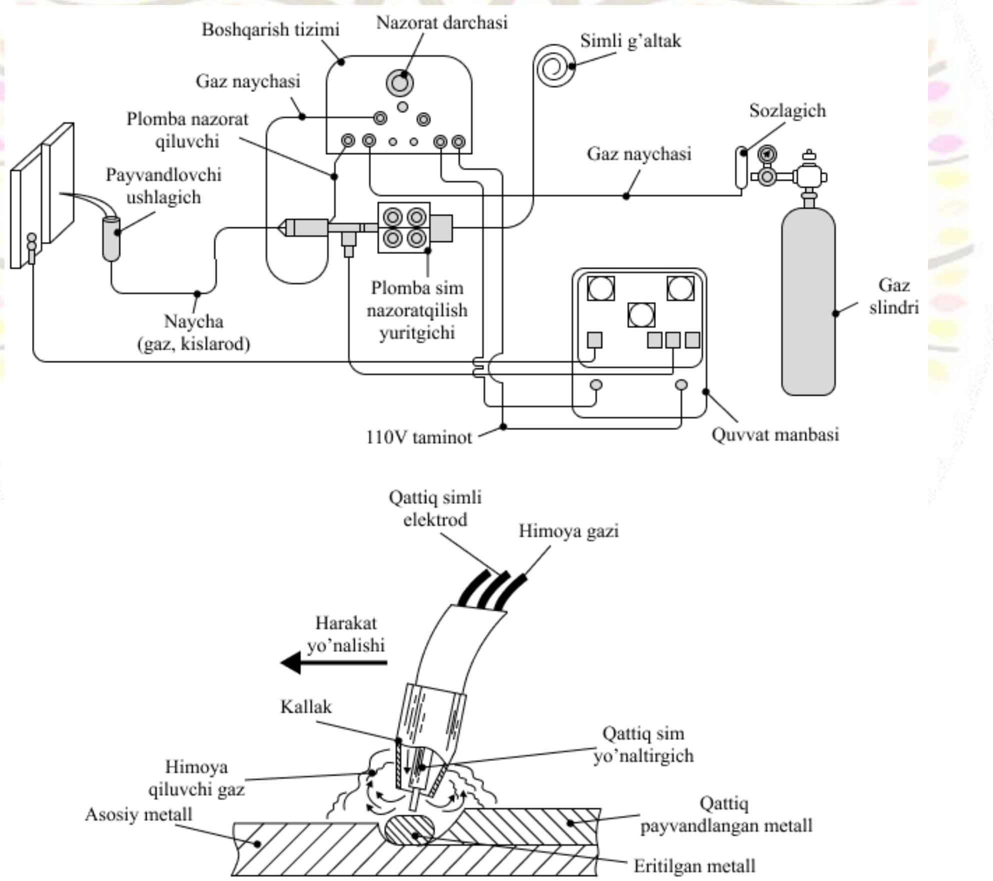

Figure 4. Gas welding.

4. Laser welding

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Laser welding uses a high-powered laser as a heat source to fuse metal materials together. Laser beams concentrate a large amount of energy into a very small area to melt metal. This type of welding provides precise control and usually involves a high precision process. Mainly widely used in electronics, medical devices, automobile and aerospace industries. Unlike some types of welding, filler metal is not required because the laser can melt the metal so precisely that the materials adhere well to each other. Therefore, there are no sparks or cinders. It is possible to perform the welding process even on complex surfaces.

As a welding object, thin metal sheets (0.1-3 mm), pipes, wires and thin parts of steel, aluminum, titanium and other alloys can be welded.

Advantages: includes high welding speed; consistency; ease of automation; and the ability to create small, precise stitches.

Disadvantages: the high cost of the equipment and the need for laser protection glasses.

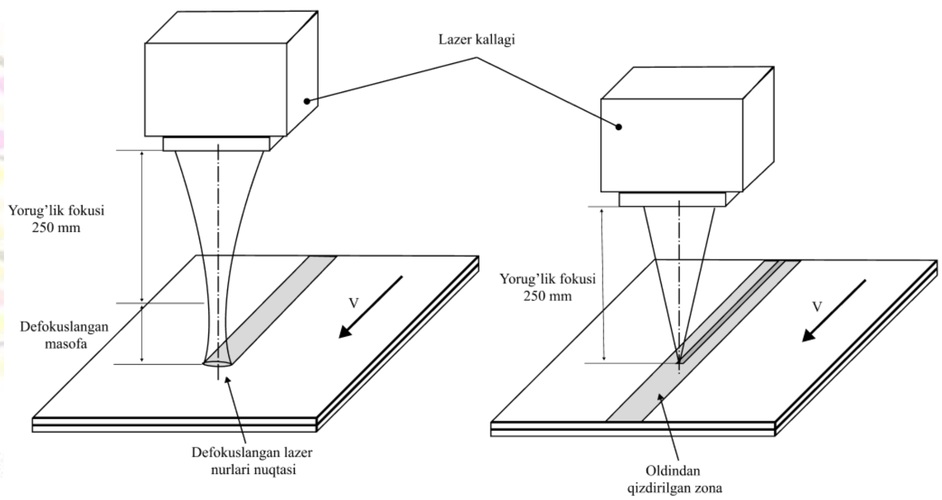

Figure 5. Laser welding process

5. Electron beam welding

Electron beam welding is a process that uses a beam of high-speed electrons generated in a vacuum by heating the tungsten filament cathode and accelerating it with a high voltage. The electron beam in the welding process is capable of deep melting even thick metals. As a safety measure in this type of welding, the welding process is carried out under a vacuum, usually around 0.001 torr (0.133322368 pascal), to prevent the spread of electron beams. This is done using a vacuum chamber. No filler metal (filler) is needed when welding in this environment because the beam precisely melts and joins the materials. Thin parts and complex shapes can be welded. Ideal welding type for welding dissimilar and reactive metals such as stainless steel, titanium, Inconel, etc. due to the inert vacuum environment. Welding of metals with a thickness from 0.5 mm to 150 mm is carried out depending on the power of the welding equipment.

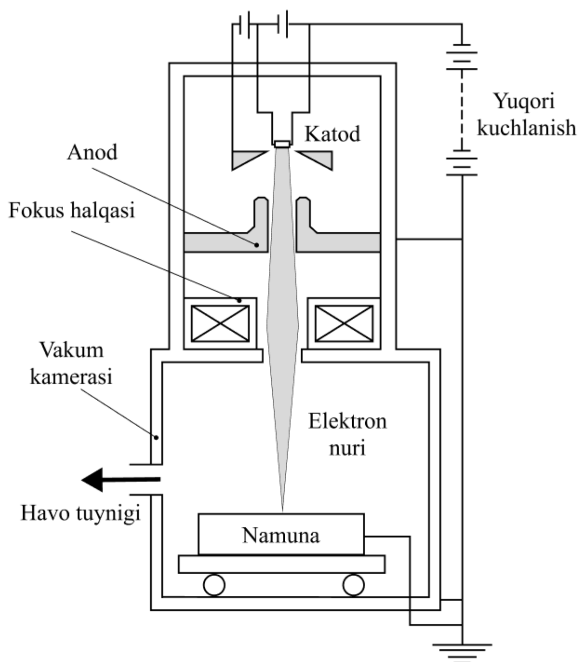

Figure 6. Electron beam welding.

The advantages include excellent welding quality, speed, penetration and automation capabilities, while the disadvantages include the high cost of equipment and the need for vacuum systems.

Electron beam welding is widely used in aerospace, nuclear, medical implants, and electronics where strength and precision are critical. The quality level is also very suitable for the same areas.

6. Friction welding

Friction welding is a solid-state welding process that generates heat through mechanical friction to join materials without melting them. Friction welding involves rubbing one piece (usually called a flywheel) against another stationary part (called an anvil) under pressure. The resulting friction causes localized heating at the interface, often above the recrystallization temperature of the materials. This heating causes the materials to soften and mix at the molecular level without completely melting. The heated pieces of metal are bonded together under pressure, forming a strong bond between the working surfaces. It is commonly used for welding metals such as steel, aluminium, copper and titanium. Friction welding is often an automated process. This allows precise control of welding parameters such as rotation speed, stroke pressure and time. Given the

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complexity of welding metals of different grades together, this type of welding allows joining metals that are not of the same grade. It is widely used in industries such as automotive, aerospace, medicine and energy. The advantages of welding over other methods include the absence of the need to melt filler metal or welding metals, and the ability to join materials that are difficult to weld.

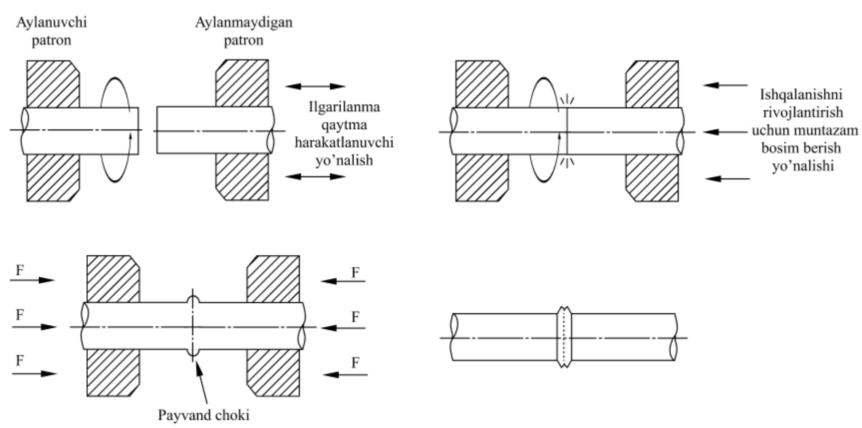

Figure 7. Friction welding

7. Ultrasonic welding

Ultrasonic welding is a welding process that uses high-frequency ultrasonic vibrations to join materials without melting them. It is mainly used in various industries for welding small electronic components, assembly of medical devices, packaging, wire and cable connection. Ultrasonic welding is usually used to join thin metal sheets or wires. Produces welds that are stronger than other welding methods. The high-frequency vibrations cause interatomic friction without creating thermally induced defects. The main process parameters include vibration amplitude and frequency, welding pressure and time. Optimum heat generation and welding process must be properly adjusted. One of the parts to be joined is held in an ultrasonic transducer horn that oscillates at ultrasonic frequencies (typically 20 kHz or higher). When the horn parts are pressed together, the vibrations generate heat through friction on the working surface. This leads to the softening of materials and intermolecular bonding.

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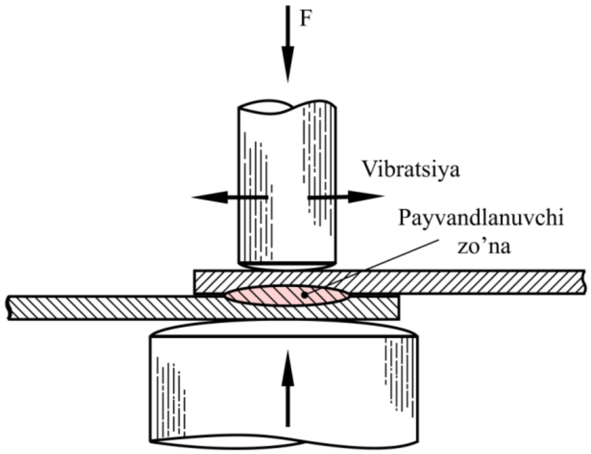

Figure 8. Ultrasonic welding.

CONCLUSION

In summary, welding is a versatile and important process used to join materials in various industries. In general, welding plays an important role in the manufacturing and construction industries. It involves the application of heat to fuse and melt the metals, creating a weld that is strong and durable.

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