Modern American Journal of Engineering, Technology, and Innovation
ISSN(E): 3067-7939
Volume 01, Issue 03, June, 2025
Website: usajournals.org

WELDING OF CONSTRUCTIONS FROM NON-FERROUS METALS AND ALLOYS

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Abstract:
This work is devoted to considering the technological features of welding structures made of non-ferrous metals and alloys. It analyzes the main welding methods used in the manufacture of structures made of aluminum, magnesium, titanium, copper, and their alloys (TIG/MIG), electron-beam welding, laser welding, diffusion welding, and friction welding). Physicochemical processes occurring during welding, the influence of various parameters on the quality of the welded joint, and problems related to the formation of defects are considered. Recommendations for choosing optimal welding materials, welding modes, and methods for quality control of welded joints are presented. The work is intended for engineers, technologists, and specialists in the field of welding, and can also be useful for students of relevant specialties.

Keywords: Welding, Non-ferrous metals, Aluminum, Magnesium, Titanium, Copper, Alloys, Welding TIG (GTAW), Welding MIG (GMAW), Electron-beam welding, Laser welding,, Welding materials, Welding modes, Welding quality control, Welding defects,

Introduction

Non-ferrous metals and alloys used in the manufacture of welded structures or their elements are *copper alloys* (bronzes and brass), aluminum, titanium, nickel, and magnesium alloys.

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Welding of Copper Alloys

Due to copper's high thermal conductivity, it requires powerful heat sources with a high degree of thermal energy concentration for welding, sometimes preliminary and concurrent heating is used.The high linear expansion coefficient of copper (1.5 times greater than that of steel) necessitates the application of additional measures against structure warping.

When welding structures from copper and copper alloys, manual arc welding, welding under flux, in protective gases, and electroslag welding are used. Manual welding of copper with carbon or graphite electrodes is advisable to use when manufacturing structures from sheet copper of small thickness (1-10 mm). Manual welding with coated electrodes is used when welding sheets thicker than 2 mm. Automatic welding of copper under flux with a melting electrode should be carried out under fluxes that do not contain manganese oxide (melted or ceramic).

Arc welding in argon is recommended when the thickness of copper is up to 3 mm for joints requiring high seam plasticity at normal and low temperatures.Sometimes welding is carried out in nitrogen, since nitrogen is an inert gas in relation to copper and protects the molten copper from the harmful effects of oxygen and water vapor in the air.For welding bronzes, manual arc welding, automatic flux welding, and argon arc welding with a tungsten electrode are used.Manual arc welding of bronze is performed with cast welding sticks or electrodes of the same composition as the base metal. All types of bronzes are welded with a metal electrode. Aluminum bronzes are welded automatically under flux. For welding silicon bronzes, it is preferable to use argon-arc welding with a tungsten electrode with the same additive composition as the base metal.

The main difficulty in welding *latun* is that during the welding process, zinc significantly evaporates and burns, resulting in a decrease in zinc content in the weld metal, deterioration of the weld quality, pore formation, and reduced plasticity. Welding of brass with a small thickness (1-10 mm) is carried out with a graphite electrode, immersing the end of the electrode in the molten metal. This welding method reduces carbon monoxide and zinc evaporation.

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Manual arc welding with coated electrodes is mainly used for welding casting defects. Automatic welding of brass with a metal electrode under flux can be performed.

Welding of Aluminum and Magnesium Alloys.

The presence of an oxide film on the aluminum surface prevents the welded edges from fusing with each other, as well as the base and additive metals. To prevent the oxide film from entering the weld, it is necessary to remove the oxide film from the surface of the base and additive metals with chemical solvents before welding.

Due to the high thermal conductivity and heat capacity of the metal, powerful heat sources with a high degree of thermal energy concentration should be used for welding aluminum-magnesium alloys. A high linear expansion coefficient of alloys contributes to the bending of products when heated. Welding of structures made of aluminum-magnesium alloys should be carried out in rigid clamping devices - conductors.

Structures are welded with coated electrodes, along the flux layer, in protective gases with non-melting or melting electrodes, and electroslag welding can also be used. Welding with coated electrodes is performed when the metal thickness is less than 4 mm. When welding with a non-melting electrode, the quality level of the welded joint is higher than when welding with a melting electrode, but the productivity of the welding process is lower.

Welding of titanium alloys. Due to the low thermal conductivity of titanium alloys, less heat is required to form a welded joint compared to welding low-carbon steel. The welding mode parameters of titanium alloys are close to the welding mode parameters of austenitic steels. Titanium alloys are non-magnetic, therefore there is no danger of magnetic blowing, but at the same time, magnetic stands cannot be used for welding. In the molten state, titanium alloys have high fluidity and a high surface tension coefficient, therefore welded joints are prone to burns. Strict requirements are imposed on assembling joints from titanium alloys compared to welding other structural materials.

Due to the high chemical activity of titanium at elevated temperatures and especially in its molten state, the main difficulty in melt welding is to ensure

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reliable protection from the atmosphere not only of the weld pool and the weld root, but also of the cooling areas of the welded joint, heated to a temperature above 350 °C. Welded structures are usually manufactured by arc welding in protective inert gases.

Depending on the configuration and dimensions of the welded units, three types of protection of the welding zone with inert gas are used:

- general protection in a controlled atmosphere chamber;
- protecting only the welded connection using local chambers;
- jet protection of the welding zone, carried out by continuous blowing of the welding bath and cooling sections of the welded joint by moving the welding torch.

Chambers with a controlled atmosphere provide the most reliable protection of the welded joint. The use of such chambers is especially expedient in serial production in cases where the structure has a complex configuration, and the seams are located in hard-to-reach places. Welding in chambers is performed manually and automatically, while the welder can be both outside the chamber and inside it in a special suit. The chambers containing the parts to be welded are first vacuumed, and then filled with inert gas.

Local protective chambers are used with or without preliminary vacuuming. In the latter case, the displacement of air is ensured by blowing out such a chamber with 5-10 times the volume of inert gas. A variation of local protection chambers is the overhead small-scale chamber. Such chambers are mainly intended for automatic welding of non-rotating joints of tubular structures.

Welding with a non-melting electrode in air is the most common. To ensure reliable protection of the welding zone, special burners with nozzles with an elongated nozzle, substrates, and other devices have been developed. Argon arc welding is performed with a direct polarity DC current.

For welding titanium alloys of small thickness (less than 1.5-2 mm), pulsed arc welding with a non-melting electrode finds application. At the same time, the overheating of the metal decreases, welding deformations are reduced, and the plasticity of the joints increases somewhat. For welding titanium alloys with a thickness of more than 3 mm, welding under a flux layer can be used. Welding is carried out on the remaining metal lining, on the copper technological lining, or

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on a flux cushion. The high quality of welding titanium and its alloys ensures the use of electron-beam welding and arc welding in a vacuum.

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