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The high quality of the papers that appear in this publication is a tribute not only to the obvious efforts of the authors represented but to the unheralded, though essential, efforts of their reviewers. It is to the reviewers' dedication to upholding the high standards of their profession that this note pays tribute. On behalf of ASTM International and the authors as well, we acknowledge with appreciation their important contribution to the success of this journal.

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Overview

Welding is a production process used for jointed materials—most often metals and their alloys, but also thermoplastic polymeric materials—using thermal energy for simultaneous melting to join both elements (usually from the same materials or from materials of similar compositions and melting points), which after fusion are cooled, thus creating the joint. The heat-affected zone is created in the parent material due to the high-temperature phase transitions. In combination with heat or independently, pressure may be used to weld the joint. In the case of welding, in addition to melting the metal of the jointed elements, a filler material is usually used to create a weld pool of molten material, which forms a joint after cooling. A protective atmosphere is used to protect the weld pool of molten material against oxidation or contamination. The joint depends on the weld configuration, e.g., butt, full penetration, or fillet, which has strength properties comparable with those of the parent material or even better. Different energy sources are used during welding, such as gas flame, electric arc, friction, ultrasound, laser, or electron beam. Welding can be realized in the open air, underwater, or in space. Although it is mainly an industrial process because it is often carried out in the field, it is also seen in civil and building engineering, such as welding of pipelines, bridges, and other infrastructure objects. Welding requires the provision of appropriate security measures due to various risks, depending on the technology used and/or the different heat sources, e.g., inhaling poisonous fumes, burns, electric shocks, eye damage, and exposure to ultraviolet radiation. Welding differs from brazing and soldering, in which the process temperature is lower than the melting temperature of each of the jointed elements, and only the solder material is melted.

The history of joining metals spans several thousand years in Europe and the Middle East, and even in the Bronze and Iron Age. Herodotus in "The Histories" of the fifth century BC describes Glaucus of Chios, who single-handedly invented iron welding. Welding was used in the production of the iron pillar in Delhi, India, around the year 310. In 1540, Vannoccio Biringuccio published "De la Pirotechnia," which contains descriptions of welding through forging. Thermite welding was invented in 1893. Acetylene was discovered in 1836 by Edmund Davy, but oxy-fuel welding became popular at the beginning of the twentieth century. However, this process was replaced almost simultaneously with arc welding, with the use of fluxes covering the electrode, protecting against impurities, stabilizing the arc, and allowing the introduction of alloying components into the weld. The short pulse and continuous electric arc were subsequently discovered in the years 1800 and 1802 by Sir Humphry Davy and Vasily Petrov, and in 1881–1882, Nikolai Benardos and Stanisław Olszewski developed a method of electric arc welding using carbon electrodes. Important advances in arc welding were the invention of metal electrodes by Nikolai Slavyanov (1888) and C. L. Coffin (1890), the production of a coated metal electrode circa 1900 by A. P. Strohmenger, the use of a three-phase electric arc in 1905 by Vladimir Mitkevich, and finally the use of alternating current by C. J. Holslag in 1919. Resistance welding was developed by Elihu Thomson in 1885. During World War I, there was significant dissemination and development of some welding methods (e.g., arc welding for the construction of a fully welded "Fullagar" ship hull in the United Kingdom or welding of aircraft fuselages in Germany), although in the United States, acetylene was welded to the cylinder water jacket at the same time. In 1920, automatic welding was introduced, and the use of hydrogen, argon, and helium was promoted to protect the atmosphere. The first welded road bridge in the world was designed by Stefan Bryła (Lviv Polytechnic) and built in 1928 on the Słudwia river near Łowicz in Poland, and in 1930, the first fully welded merchant ship, the M/S Carolinian, was launched. In the 1930s, welding was used for reactive metals, including aluminum and magnesium alloys. In 1930, arc welding was invented, still popular, while Kyle Taylor developed a stud welding soon to be popularized in shipbuilding and construction. In 1932, Konstantin Khrenov implemented the first underwater electric arc welding.

Metal-gas arc welding was developed in 1948, and arc welding in a metal sheath using a flux-coated consumable electrode was developed in the 1950s, becoming one of the most common welding technologies. In 1953, N. F. Kazakov developed diffusion welding. In 1957, arc welding was introduced, as well as plasma arc welding, followed by electroslag welding a year later and electrogas welding in 1961. Electron beam welding has been used since 1958, and despite the invention of the laser in 1960, laser beam welding was developed only several dozen years later. Magnetic pulse welding has been used since 1967. In 1991, Wayne Thomas developed friction stir welding.

Nowadays, the most common welding methods are arc welding with metal inert gas and metal active gas, wire welding with tungsten inert gas, electric welding, coated electrodes, and covered arc, although gas welding is still used in workshop conditions. In special conditions, almost all advanced welding technologies are used, including lasers, electron beams, and plasma welding. Many welding processes are fully robotic, and the requirements of the evolving idea of Industry 4.0 pose further development requirements for welding technologies, including the widespread use of information technologies and augmented reality with the use of cloud computing, especially in such avant-garde industries as automotive, aviation, and shipbuilding, as well as the electronics and computer industries.

Many research works are carried out in scientific and research centers around the world in the field of developing and improving welding technologies. These works concern not only the technological aspects and selection of welding materials and the mechanical and functional properties of welded materials, but also the structure of welded materials both in the weld zone and in the heat-affected zone. In this special issue on *Advanced Welding Technologies*, a dozen articles on the subject matter are presented.

The first few articles are about welding aluminum alloys. The first paper, entitled "Improving Centerline Solidification Crack Resistivity of AA 2024 Using Tandem Side-by-Side GTAW Technique," is prepared by the team of Abdulaziz I. Albannai from Kuwait. In this paper, four gas tungsten arc welding (GTAW) techniques were employed by varying the travel speed and arc motion to analyze a centerline solidification crack. Aluminum alloy 2024 (AA 2024), a high-strength welding material, was used because of its high susceptibility to centerline solidification cracking and its application mainly in the aerospace industry. The resistance of centerline solidification cracking was improved by using the tandem technique due to the resulting disordered grains orientation, which reduces the crack energy by deflecting the crack path and preventing crack propagation through-thickness. In addition, a reduction in the average grain size of 40–60 % was achieved by implementing the tandem technique because of the fast cooling rate. The tandem technique also showed better improvement in microhardness in the weld zone compared with the other applied techniques.

The next paper on "Effect of Welding on Pitting and Intergranular Corrosion Behavior of Marine Grade Aluminium Alloy" is prepared by Shanavas Shamsudeen and Edwin Raja Dhas John from Noorul Islam University in India. This paper investigates the pitting and intergranular corrosion behavior of tungsten inert gas (TIG), normal friction stir welding (FSW), and underwater friction stir welding (UFSW) joints of AA 5052 H32 and the parent alloy. The result shows that corrosion resistance of welded joints is inferior to that of parent metals. The corrosion resistance of the FSW joint and UFSW joint are nearly equal and found higher compared with the TIG joint. The results also show that the samples welded by FSW and UFSW processes are immune to intergranular corrosion attack.

The group of authors led by Dimitrios A. Dragatogiannis from Greece prepared the paper "Friction Stir Welding between 6082 and 7075 Aluminium Alloys Thermal Treated for Automotive Applications." The paper contains an experimental investigation of the weldability between AA 6082 and AA 7075 by FSW considering thermal treatments used during Hot Forming and in-die Quenching (HFQ®) for automotive applications. The defect-free welded joints are characterized by good mechanical mixing between the joined materials as well as by grain refinement. The mechanical behavior of the produced welded joints was studied and compared with the parent materials, whereas the measured mechanical properties are correlated with the microstructure.

The second, more extensive, group of papers concerns steel. Michael Joachim Andreassen and co-authors developed a paper titled "Experimental Study of Residual Stresses in Hybrid Laser Arc and Submerged Arc-Welded 10-mm-Thick Low-Carbon Steel Plates." This paper discusses the influence of welding method on the welding-induced residual stresses in 10-mm-thick low-carbon structural steel plates, which were welded using hybrid laser-arc welding and submerged arc butt-welded. The goal of the analysis is to gain a comprehensive understanding of the distribution and development of residual stresses in relation to the welding method for better control of the residual stresses and distortion. The repeatability of the neutron diffraction measurements is also investigated and reported in this paper.

Marcin Żuk, Jacek Górka, and Wojciech Jamrozik from Gliwice, Poland, present a paper on "Simulated Heat-Affected Zone of Steel 4330V." Steel 4330V is a material containing an addition of vanadium (approximately 0.06 wt. %) and is widely used in the mining and petroleum industries. The steel microstructure contains tempered martensite. The high carbon equivalent of the steel makes it difficult to weld. The simulation of the heat-affected zone makes it possible to determine the effect of an increase in temperature on the properties and structure of the steel. The simulation of heating was performed using a resistive heating device. The tests revealed that up to a temperature of approximately 600°C, the material did not undergo structural changes. Above a temperature of 600°C, the hardness of the specimen increased to 500 HV.

The paper on "Hybrid Laser-GMA Welding of High-Strength Steel Grades" was prepared by Agnieszka Kurc-Lisiecka and Aleksander Lisiecki from Gliwice, Poland. The article presents the results of investigations on hybrid laser + GMA welding of butt joints of different fine-grained and thermomechanically rolled steel plates 5.0 mm thick produced on steel grade Domex 700MC, 960, and 1100. The results show that hybrid welding can provide a proper shape of weld, even by altering the gap between the butt surfaces of the groove and at the distinct shift of the electric arc to the laser beam spot. The results of tensile tests show that the hybrid welded joints of Domex 960 and 1100 have strength at a similar level of approximately 1,140 MPa, which is significantly higher compared with the joints of Domex 700MC at approximately 820 MPa. In turn, the weld metal of the Domex 700MC steel exhibited the highest impact toughness at the mean value of 139 J/cm^2, while the test joints of Domex 960 showed lower impact toughness at approximately 122 J/cm^2. Surprisingly, the lowest impact toughness was determined for the joints of Domex 1100, despite the same wire being applied as for the Domex 960.

The team of V. Maduraimuthu from India presented the paper on "Optimization of A-TIG Welding Process Parameters for P92 (9Cr-0.5Mo-1.8W-VNb) Steel by Using Response Surface Methodology." In this work, the optimization of activated TIG (A-TIG) welding process parameters for P92 (9Cr-0.5Mo-1.8W-VNb) steel has been carried out using response surface methodology (RSM). The design matrix for conducting experiments was generated using the central composite design of RSM. Second-order response surface models were developed for predicting the response for the set of given input process parameters. Moreover, the response optimization was carried out for obtaining the maximum depth of penetration, minimum bead width, and target heat-affected zone (HAZ) width using a desirability approach. The validation experiments were carried out on the determined optimized process parameters, and it was found that there was good agreement between the predicted weld bead dimensions and actual values obtained during the experiments.

The next paper on "Residual Stresses, Microstructure and Mechanical Properties of EB-Welded 90-mm-Thick UNS S41500 Martensitic Stainless Steel after PWHT" was authored by the team led by Sheida Sarafan from Montreal, Canada. This paper evaluates the microstructural characteristics, mechanical properties, and through-thickness residual stresses of the electron beam (EB)-welded butt joints in 90-mm-thick UNS S41500 grade of 13% Cr-4% Ni martensitic stainless steel, jointed using a single pass autogenous process, after post-weld heat treatment (PWHT). The results of the longitudinal residual stresses, static tensile properties, Charpy impact energies, and bending test results of the transverse weld cross sections provide the essential data for validating a manufacturing process for the assembly of high-performance joints in an important hydroelectric turbine material.

The next few papers apply the welding of stainless steels. The first was written by Devon S. Gonzales and coauthors from the Colorado School of Mines and Los Alamos National Laboratory in the United States and is entitled "Oxygen Effects on Solidification Behavior of Gas Tungsten Arc-Welded Laser Powder Bed Fusion–Fabricated 304L Stainless Steel." This study was made to characterize the solidification behavior of gas tungsten arc welds made on the laser-powder bed fusion (L-PBF) process 304L stainless steel. It was determined that gas tungsten arc welds on L-PBF 304L stainless steel exhibited a vermicular ferrite solidification structure compared with a mix of vermicular and lathy ferrite structure in wrought 304L. Macroscopically, such partitioning affected the surface tension within the weld pool, producing asymmetric weld pool geometries. The compositional differences between wrought and L-PBF fabricated 304L stainless steels resulted in irregular solidification behaviors during welding, affecting the final weld microstructure.

The paper titled "Friction Stir Welding of AISI 316L Stainless Steel in a 3.5 NaCl Aqueous Solution: Metallurgical and Mechanical Characterization" was prepared by S. Shashi Kumar and coauthors from India. Submerged friction stir welding (SFSW) was employed for joining of AISI 316L stainless steel sheets. The results of the experimental analysis reveal that the SFSW joints exhibited overall better joint strength, and the weld made at 1,000 r/min was superior in terms of strength and microstructural features to that of the base steel. The pitting corrosion resistance of all the weld joints was marginally higher, and the weld joint made at 1,000 r/min was especially superior to that of the base steel.

The paper on the "Effect of Welding Processes on the Microstructure and Mechanical Properties of Duplex Stainless Steel Weld Joints" is by Nanda Naik Korra and coauthors from India. The objective of the investigation involves studying the microstructure and mechanical properties of duplex stainless steel (DSS) alloy 2205 and super DSS (SDSS) alloy 2507 weld joints fabricated by TIG welding and its variant A-TIG welding processes. The microstructures exhibited different forms of austenite, including grain boundary allotriomorphs, widmanstatten side plates, and intragranular precipitates in the weld metal. The hardness values and the tensile and yield strength of multipass TIG weld joints were higher compared with those of A-TIG weld joints mainly due to the balanced ferrite-to-austenite ratio in the weld microstructure opposite the changes of the toughness values obtained by Charpy impact testing.

A group from Mexico with L. Zamora Rangel and coauthors prepared the last paper, "An Investigation of Dissimilar Metal Weld Joints SB166–Alloy 82/182–SA182." The alloy 82 and 182 has been widely used as a filler metal to join the austenitic stainless steel with alloy 600 by a shielded metal arc welding process in the reactor pressure vessel and pressure vessel nozzles, both components in boiling water reactors. The chemical compositions of different materials indicate that they correspond to the joints of alloy 600 and SS304L with alloy 82 and 182. The values of microhardness are interesting results of these welding joints. They show a slight increase in the hardness value as the measurements approach the fusion line, with the exception of the SA182 alloy.

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