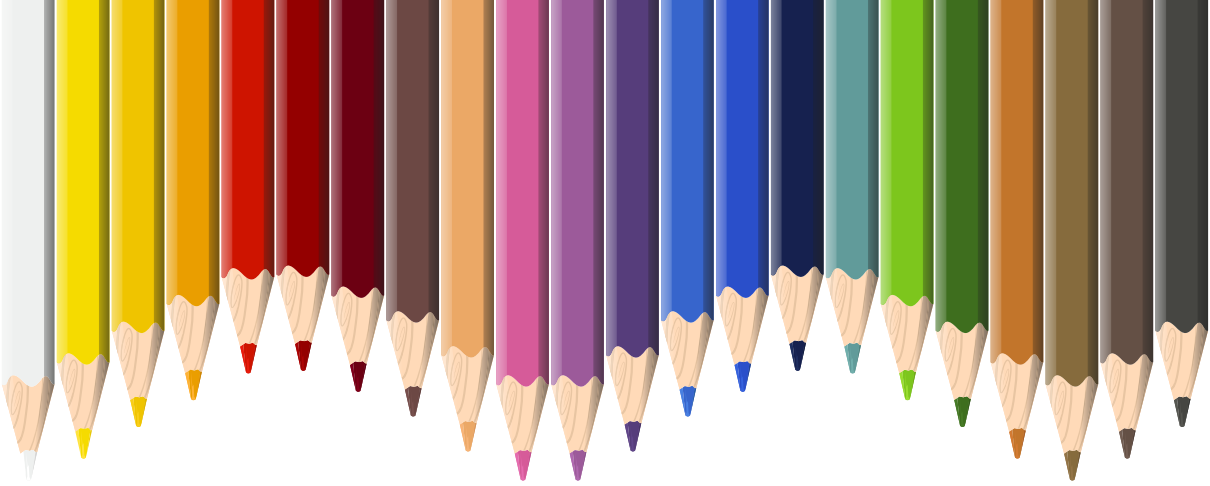


Chapter 5

GALVANIZED STEEL OF WELDING TECHNIQUE AND INDUSTRIAL APPLICATIONS

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Introduction

An essential natural tendency is suddenly reversed when iron is taken out of its ore. In most conditions, steel as well as iron will rust if left unprotected and eventually revert to their original state.

One of the most important aspects of using steel economically is preventing corrosion. The application of the proper protective coating can postpone the need for structural and equipment replacement, reduce or eliminate maintenance costs and interrupted service time, and result in significant economies of scale in the long run.

With much more advantages over painted or another coating technology, galvanizing is the finest option for preventing corrosion. In actuality, there is no comparison in terms of handling, robustness, coating thickness, application, and protection.

Galvanizing is a highly effective corrosion solution with a long, free of maintenance lifespan, which is why engineers and architects require it. Simply put, galvanized steel is regular steel that has been heavily zinc-coated. Not only does this barrier prevent corrosion, but it also effectively shields the steel from welding damage.

There are several reasons why you might wonder if it's possible to weld galvanized steel. The question is not whether you can do it or not. Large parts may require welding before galvanizing. Galvanized steel may be welded by us. On the other hand, welding may be more challenging with zinc-coated steel then it would ordinarily be with uncoated steel. Additionally, if any portions are left exposed or broken during welding, it may make the components susceptible. When welding galvanized steel, hazardous substances may be emitted during the heating process.

Although galvanized steel is still one of the most widely used constructing and manufacturing materials today, sustainable galvanized steel products are being made with ever-evolving technologies.

Galvanized Steel

Galvanised steel is a popular choice in industrial, agricultural, and construction projects. The main purpose of galvanisation is to protect the steel from corrosion, and this is achieved by applying a thin layer of zinc, either through a process of 'hot dip' galvanising, electro-galvanising, or metal spraying.

TFM - or Time to First Maintenance - is calculated according to the appearance of rust on five percent of the galvanised steel sheet surface. What this means is that five percent of the zinc coating has now eroded, exposing the steel to corrosion. It is at this stage that maintenance needs to be implemented

to protect the integrity of the steel and prolong its durability. TFM varies according to the atmospheric conditions of the structure. For example, in a dry, rural area with little rainfall and pollution, a TFM could be over 100 years, while in a more humid tropical environment, that TFM might reduce to about 70 years. By hot-dip galvanising a thin 6mm steel sheet, you are creating a zinc coating of 85 microns, which more than meets the corrosion performance required for many applications across the world.



Figure 1. Industrial Applications of Galvanized Steel for Pipelines (freepik.com, 2023).

Galvanized steel which has smooth finish, rust-free, and lowered maintenance costs a sheet of galvanised steel is smooth to the touch, making it easy to inspect. Being tough and durable, it is resistant to scratches and everyday damage. Any damage tends to occur through mishandling and untreated long-term wear and tear. Due to its smooth surface, should the galvanised steel sheet incur any damage, the integrity of the protection is compromised, making it prone to rusting. Fortunately, this makes it easily noticeable on regular inspection and therefore can be treated quickly and effectively. When it is damaged, it is the zinc that is in the first line of fire. That means that the steel underneath is protected and will only be affected if the blemish is left untreated. Protection from contamination the galvanisation process acts as a protective buffer against oxygen and moisture, resulting in a smooth, rust-free layer. As a result, the steel sheets are perfect for use in projects which require a clean, clinical environment, such as operating rooms and food preparation areas.

However, for long-term structural projects, the additional costs will more than pay for themselves in terms of longevity and reduction in maintenance over the years. Cheaper is never normally better.

White Rust for Galvanized Steel

The galvanisation process ensures that the steel sheet remains resistant to rust. However, you need to be aware of the presence of white rust, which can develop over time if the steel is exposed to moisture and not maintained.

White rust is a white chalky substance that can form on the surface of zinc due to moisture. It can cause significant damage to the galvanised coating and can ultimately compromise the durability of the zinc coating.

Otherwise known as zinc hydroxide, this white rust must be treated immediately to prevent it from spreading and reversing the effect of the galvanisation process as a whole. But prevention is better than cure, so ensure the following steps are taken to minimise the risk of white rust in the first place. Make sure the galvanised steel sheets are packed in a dry, moisture-free environment. Ensure that there is good air circulation between sheets. Store the sheets at a slight angle to ensure that any water or moisture can be drained away and not sit stagnant on the surface of the steel sheets. Make sure the surface of the zinc coating is treated with a barrier or water repellent coating to minimise any contact between water and the galvanised surface of the steel sheet. If your galvanised steel sheet has developed a white rust coating, then it can be treated. The treatment depends on the severity of the damage to date. If there is a light powdery residue, then it can usually be brushed off with no residual treatment required. However, the more established and severe the zinc oxidisation process, the more remedial treatment is required to ensure it does not compromise the long-term integrity of the galvanised coating.

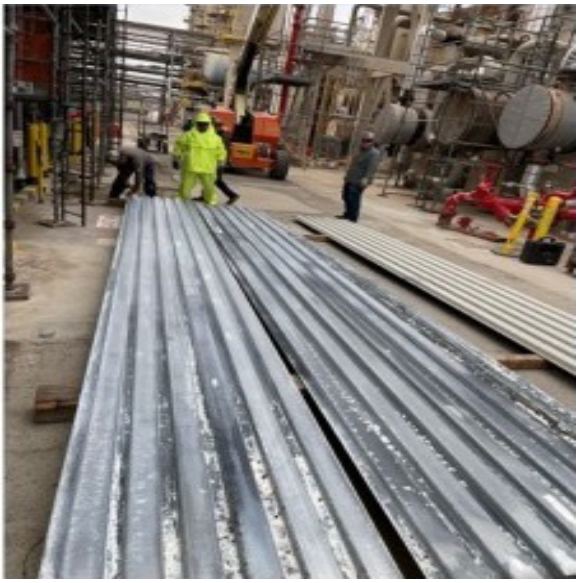


Figure 2. Example of White Rust on Galvanized Steel in industry (metaldecking.com, 2023).

One of the commonly encountered problems with galvanized steel building products is the presence of wet storage stain – also known as white rust. This condition causes a significant, powdery deposit on the galvanized material's surface which can result in damage to the coating and is detrimental to the product's appearance. Galvanizing is a metallic layer of zinc which is specified in the weight of zinc per square foot. Zinc is durable and provides an excellent anti-corrosion performance for steel (rapidmetals.co.uk, 2023). The stable form of zinc oxide that provides galvanized coatings with their longer corrosion protection cannot develop without unrestricted ventilation and carbon dioxide. Simply put, white rust is the chemical combination zinc hydroxide that occurs when zinc comes into contact with moisture. Because the substance is not freely exposed to air that contains carbon dioxide, it does not transform into the zinc carbonate passive coating.

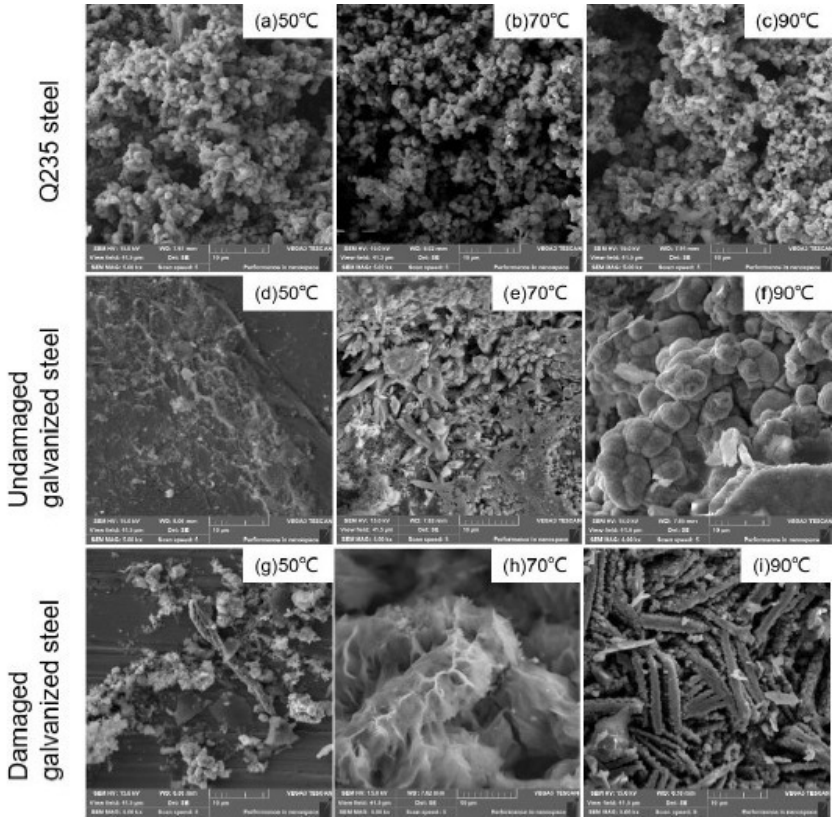


Figure 3. SEM photos of Q235 steel and undamaged-damaged galvanized steel (Yusong L., et al., 2023).

Zinc hydroxide (white rust) will continue to form as long as the surfaces are wet and starved of carbon dioxide. Once the wet material has been separated and allowed to dry the staining will remain, however, no further staining will occur.

Advantages of Galvanized Steel

Steel that has been coated with a coating of zinc to stop rust and corrosion is known as galvanized steel. This process makes steel significantly more durable and versatile, offering a variety of advantages over uncoated steel.

Durability, the zinc coating acts as a physical barrier between the steel and the elements, protecting it from rust, corrosion, and wear and tear. This can significantly extend the lifespan of steel structures and components, often lasting for decades with minimal maintenance. Low maintenance, unlike uncoated steel, which requires regular painting or other protective measures to prevent rust, galvanized steel is virtually maintenance-free. This can save

time and money in the long run, making it a cost-effective choice for many applications. Versatility, galvanized steel can be used in a wide variety of applications, both indoors and outdoors. It is commonly used in construction, infrastructure, agriculture, automotive, and other industries.

Conductivity: Galvanized steel is a good conductor of electricity, making it suitable for use in electrical applications. Aesthetics: Galvanized steel has a distinctive silver-gray appearance that can be left as-is or painted for a more customized look. Sustainability, galvanized steel is a recyclable material, making it an environmentally friendly choice. Fire resistance: Galvanized steel is fire-resistant, making it a safe choice for use in buildings and other structures.

Galvanized steel is simple to work with, easy to install, and can be shaped into a variety of forms and sizes by cutting and welding. Overall, galvanized steel is a versatile and durable material that offers a wide range of advantages over uncoated steel. It is a cost-effective choice for many applications and can help to extend the lifespan of steel structures and components.

Galvanized Steel in Welding Techniques

Closer control of welding conditions than for uncoated steel is usually necessary but procedures are simple and well established. This section details procedures for all suitable welding techniques for galvanized steel including GMA (gas metal arc), carbon arc, GTA (gas tungsten arc), manual arc, and oxyacetylene welding.

GMA (gas metal arc) welding, also known as CO_2 or MIG welding, is a versatile semi-automatic welding process which is convenient and easy to use. It is particularly suited to the welding of thinner materials. Welding galvanized steel vaporizes the zinc near the arc (zinc boils before steel melts). The zinc oxidises in the air to a fine white powder. In the GMA welding of galvanized steel, the presence of the zinc coating has no effect on weld properties although some weld spatter is produced. Arc stability is excellent and is not affected by the galvanized coating, although some reduction in welding speed is required.

The weld takes place in a protective gas shield. A small diameter consumable wire electrode of 0.8 mm to 1.6 mm is fed automatically to the weld torch. The high current density resulting from the small diameter of the wire is in the region of 200 A/mm^2. Gas metal arc welding, also known as Metal-Inert Gas (MIG) welding, is a versatile semi-automatic welding technique particularly suited for the welding of thinner materials (<1/2 [13 mm] thick.

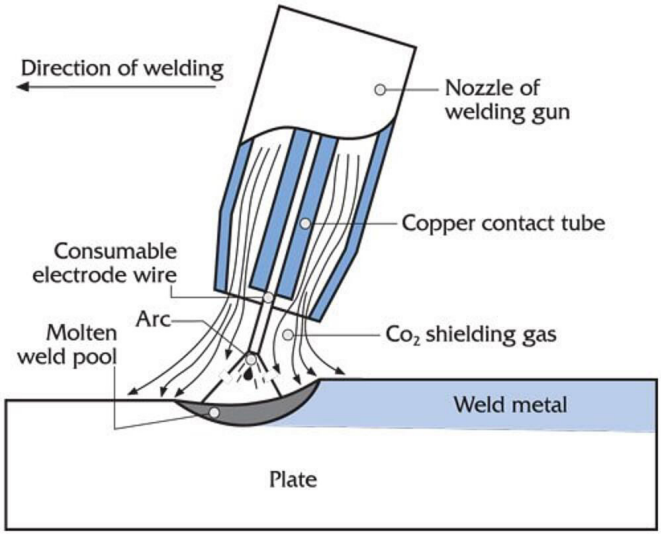


Figure 4. Gas Metal Arc Welding (GMAW) parts in ilustrated (galvanizeit.org, 2023).

Gas metal arc welding, also known as Metal-Inert Gas (MIG) welding, is a versatile semi-automatic welding technique particularly suited for the welding of thinner materials (<1/2 [13 mm] thick.

Welding speeds for GMAW are typically slower for galvanized surfaces. These reduced speeds allow longer time for the zinc to burn off at the front of the weld pool. Increasing the current supplied to the welding electrode may provide sufficient means to burn off zinc coatings of greater thickness.

Weld penetration depth is decreased when welding galvanized steel. When performing butt-welds, larger gaps must be provided. Consistent penetration is achieved by employing a side-to-side motion of the welding torch when butt-welding in the flat position. Spatter increases when welding galvanized steel using CO_2 shielding gas.

The formation of spatter particles is directly proportional to the thickness of the zinc coating. Therefore, spatter formation is greater for hot-dip galvanized steel than continuously galvanized (sheet) steel.

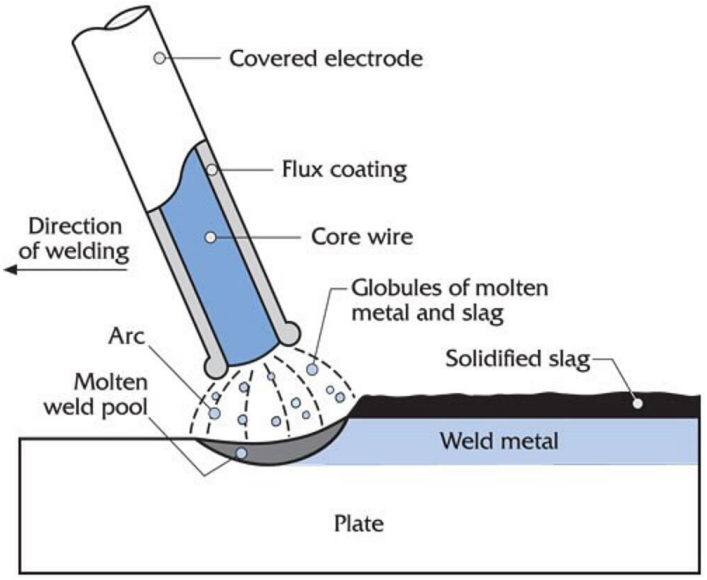


Figure 5. Shielded Metal Arc Welding (SMAW) parts in ilustrated (galvanizeit.org, 2023).

The most common arc welding process is shielded metal arc (SMAW) welding. SMAW welding is a process in which flux-covered electrodes ranging from 9 to 18 inches (23 to 46 cm) in length, and 1/16 to 5/16 inches (1.6mm to 8.0 mm) in diameter, are used.

Weld depth penetration is decreased in the SMAW welding of galvanized steel, as is the case for GMAW welding, the root opening for butt-welds must be increased from that of uncoated steel surfaces. However, it is possible to obtain full weld depth penetration by altering the normal weld techniques for uncoated steel. If the angle of the electrode is reduced from the normal 70º to 30º , and the weld speed is reduced significantly, normal weld depths can be achieved by moving the electrode back and forth in line with the joint.

Spatter formation also increases using SMAW welding. Generally, spatter formation does not increase to an extent where anti-spatter compounds are required. Slower welding speeds allow for more of the zinc coating to burn off and reduce the amount of spatter formation. As for GMAW welding, it is not usually necessary to increase the current to the electrode to increase the amount of zinc burned off.

Reducing the angle of the electrode and reducing the weld travel speed will significantly increase the quality of SMAW weld on the zinc-coated surface. Steels with thicknesses greater than 1/2 (13 mm) are recommended to be welded with SMAW.

Oxyacetylene Welding

All grades of hot-dip zinc coated steels can be welded by oxyacetylene fusion welding. Preparation for welding is similar to that for welding uncoated steel. Because low travel speed is necessary for this process, which is necessary to bring the joint edges to the fusion temperature, the extra heat causes the zinc coating to be affected over a much greater area than when using faster welding processes. Best results are obtained when the filler rod is moved back and forth, producing a ripple weld. Nozzle sizes similar to those used for welding uncoated steel of similar thickness should be used. Welds should not be remelted by a flame to improve their appearance; this will result in additional loss of the zinc coating.

Friction Welding

Flat-ended studs, whether uncoated or galvanized, cannot be welded to galvanized plate because the alloy layers in the zinc coating appear to act as a low friction-bearing surface and insufficient heat is developed for welding. Using pointed studs solves the problem with friction welding studs to galvanized surfaces. The best results are obtained on studs with a point having a 120º angle. The presence of zinc coating on the stud increases the time required for welding.

Resistance Welding of Zinc-Coated Steel

Resistance welding is generally used to join galvanized steel less than 1/4 inch thick and with a zinc coating lighter than 305 g/m^2. Coatings up to 460 g/m^2 have been successfully welded, but electrode life is much shorter than with lighter coatings. On heavier coatings, it is necessary to replace or redress worn electrodes more frequently. Sheet materials can be resistance welded without removal and with little damage to the zinc coating. Most after-fabrication galvanized coatings are thicker than recommended for resistance welding and become impractical to do so.

Conclusion

Beyond health dangers, there are additional issues that might arise from welding galvanized steel. The weld may be compromised by the zinc coating present in galvanized steels. The coating might result in impurities and porosity in a weld and makes penetration more challenging. It's also typical for there to be no fusion at the weld's tips. To reduce these dangers, welding procedures and technique must be followed correctly. Before welding, try to take off any zinc coating that may be around the weld region. If not, use a filler substance designed specifically for use on materials coated with zinc.

The variety of galvanizing procedure used to coat the steel is another aspect that will contribute to the quality of the welds.

Varying zinc layers over the steel surface are a result of different galvanizing techniques. The coatings on zinc electroplated steel are usually thinner than those on hot dipped galvanized and thermally sprayed steel. Choose zinc electroplated steel instead of thicker-coated hot-dipped or zinc thermal-sprayed steel to get a better weld. Once welding automation is taken into consideration, zinc plated and steel will also have a much more uniform coating.

Preserving corrosion resistance following welding is another challenge when welding galvanized steel. The region that is left uncoated and vulnerable following welding galvanized steel is caused by the zinc coating burning away surrounding the weld. Weld failure due to expediency may thus occur in the exposed, naked weld. A post-weld procedure, such as painting or re-galvanizing the material, must be employed if corrosion resistance is still needed after welding.

Galvanized steel may be securely and successfully welded, but there are several crucial precautions that need to be followed. Safety rules must be studied and understood in order to weld galvanized steel safely. Additionally, welders must wear the appropriate personal protective equipment to shield them from potentially harmful vapors. It's also critical to understand every detail of the application, including the kind of galvanizing technique being used, the environment in which the weldment will be placed, the welding procedure being followed, and the standards by which the weld will be judged.

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