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RE: What is Hot Dipped Galvanization?

An In-Depth Look at Ways to Protect Steel from Corrosion

Low cost, high strength, and easy workability make mild steel the material of choice for most structural applications such as buildings, bridges, the reinforcement members (rebar) in concrete, pipes, tanks, and much more. While steel possesses a multitude of desirable properties, it also has a weakness that threatens its structural integrity and longevity: rust. Most people are aware of rust because it causes disruptions in many of the machines we depend on daily – automobiles and bicycles for example – not to mention critical fixed infrastructure such as bridges, pipes, dams, utility poles, and much more. Estimates of the annual world-wide cost of corrosion exceed $2.5 trillion dollars which was 3.4% of the global GDP in 2013 when the estimate was made!

What is Rust?

Most people are aware that water has something to do with rust: when you leave your bicycle outside and it gets rained on, you notice more rust on it. Corrosion is a process of coupled chemical reactions: a reduction reaction and an oxidation reaction that are referred to as a "redox" reaction to remind us that they always occur together. In the case of rust, the steel provides both the anode and cathode at different locations on the surface, while the water is the electrolyte for the ions and the steel conducts the electrons between the anode and cathode areas.

Since the final products of these reactions – water and hydrated iron oxide – have a lower energy state than pure iron, rust is inevitable.

Ways to Combat Rust

Galvanization, plating, painting, and powder coating are common methods to slow the corrosion process of mild steel and have enabled bridges, tall buildings, and other infrastructure to serve our needs for well over 100 years.

Galvanization

Galvanization is a process that chemically bonds zinc to the surface of a steel part. This zinc, in both ionic and electrical contact with the steel, is more "eager" to give up electrons and thus it is the zinc that corrodes, leaving the steel substantially unaffected. The zinc serves as the anode for the redox reaction and therefore makes the steel the cathode – hence the name "cathodic protection".

It turns out that zinc is an excellent choice for cathodic protection of steel due to its low cost, wide availability, and the fact that it is convenient to use in several processes that bond a layer of zinc to the steel. Hot-dip galvanizing is one of several processes to adhere a layer of zinc to the surface of a steel part. In the hot-dip galvanizing process, the steel part is submerged into a vat of molten zinc. The molten zinc is hot enough (450 C) to melt the surface of the steel part. In the vat of molten zinc, various zinc-iron alloys are formed at the new surface of the steel part. These metallurgically bonded layers provide a strong mechanical barrier between the environment and the steel that is highly abrasion resistant.

The main point to understand is that galvanizing provides a chemically active bonded coating that provides more protection than a coating like paint, which simply provides a barrier between the steel and the environment.

Plating

Steel can be plated with a variety of more noble metals (nickel is a common choice) through an electrochemical reaction that is driven by the application of a voltage. Zinc can also be plated to steel as an alternative to dipping a steel part in a vat of molten zinc.

Painting

Painting the surface of steel is another way to provide corrosion resistance. The paint slows corrosion by creating a barrier between the steel and the environment. Paint and epoxy coating technology has advanced substantially, and these techniques positively impact the lifespan of automobiles, for example. From purely a corrosion standpoint, paint does not provide any cathodic protection, so any crack, chip, or scratch in the paint coating allows corrosion of the steel to start.

Powder Coating

Somewhat like painting, powder coating is a finish that can be applied to many substrates including steel that forms a hard decorative finish tougher than paint. Applied to the substrate as a dry powder and then cured on the surface using heat or ultraviolet light, powder coating seals the substrate from the environment thus protecting it from corrosion. However, as with paint, powder coating does not provide any cathodic protection.

Different Kinds of Galvanizing

Galvanizing as a corrosion protection for steel is such an excellent way to mitigate corrosion that several methods of depositing the zinc on the steel have been developed. Selecting a particular galvanization process involves factors such as ability to coat interior cavities; desired thickness of the coating; the temperature that the substrate can withstand; follow-on processes like welding, cutting, and forming; and the size of the part being galvanized.

In-line Galvanizing

Inline Galvanizing is a continuous process that entails feeding straight lengths of material through a bath of molten zinc, and then applying a conversion coating to prevent the formation of naturally occurring zinc oxide and hydroxide. Sometimes a clear polymer topcoat is added to the outside surfaces. Since this is a continuous process done on straight sections of material, it can be more cost effective than hot dip galvanizing. However, the tradeoff is that any post-galvanizing operations done to the pipe such as welding or cutting can compromise the galvanized layer and be a weak link in the corrosion protection of the final assembly.

Hot-Dip Galvanizing

The process of dipping a part – in some cases very large, finished assemblies such as open-web trusses, light poles, and guard rails – in molten zinc is the crux of the hot-dip galvanizing process. The part to be dipped is cleaned, degreased, pickled, and fluxed before being dipped. Hot-dip galvanizing is known for the quality of the finished part and can be used on exterior surfaces as well as interior cavities when vent and drain holes have been carefully planned. Hot dip galvanizing typically deposits a 3x thicker zinc layer than In-line galvanizing. When a welded assembly is hot-dip galvanized, the entire structure is well protected.

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