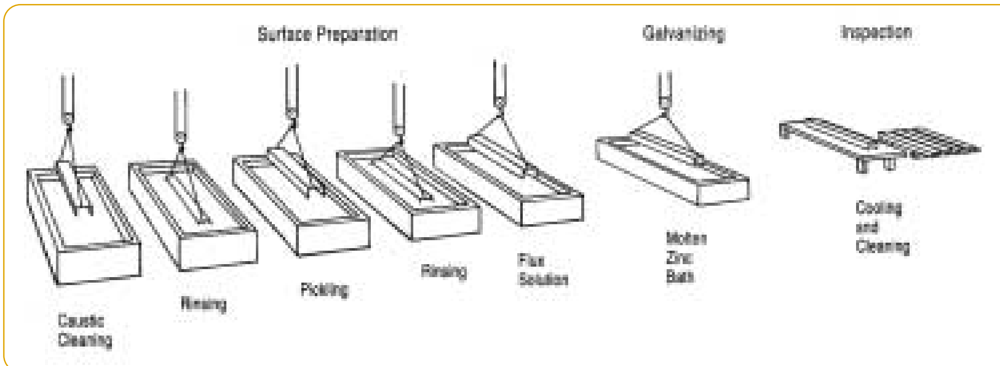
by Thomas J. Kinstler

Hot-dip galvanizing is a "dip and drain" thermal-reaction process that has significant requirements for optimum results. Guidelines, published standards, and consultation/ assistance about design and fabrication for galvanizing are available from various sources. The American Galvanizers Association (AGA) has booklets, CDs, design aids, and seminars about hot-dip galvanizing, available at no cost from the web site, www.galvanizeit.org. Local galvanizers usually are available for consultation, and can be important resources for practical knowledge as designs and fabrications evolve. ASTM Standards, particularly ASTM Standard A-385, and A-143, are "tried-and-true" design and fabrication aids. Most of the requirements for optimum galvanizing have other non-galvanizing-related benefits, such as ease of fabrication, aesthetics, corrosion prevention, or fatigue resistance.

Some limitations on galvanizing relate to kettle size and weight-lifting capacity. Over the past five years, significant kettle length and width, number and location, and lifting capacity have been added to the industry in North America. A general guideline is that if a structural element can be transported by truck without special permits, and one dimension is less than the width of the galvanizing kettle, it probably can be galvanized, depending on dimensions and geometric complexity. "Double-dip," or progressive galvanizing methods, can extend the range of galvanizing capacity beyond the physical dimensions of a given galvanizing kettle. If a structural member being designed is to have a depth or length more than 30% greater than a potential galvanizing kettle, detailed consultation with the galvanizing plant should be made before design is finalized.

The factors which contribute to the lowest cost and highest performance for galvanized steel, and which form the basis of the design aids and fabrication guidelines, can be found in five concepts: symmetry, uniformity, cleanliness, access, and reactivity.



Symmetry

Symmetry refers to the geometric cross-section of components to be galvanized, and the balance of forces, such as residual stress from cold forming and welding. Symmetrical sections, such as "H" and "I" sections, respond to the thermal transient of galvanizing more uniformly than non-symmetrical sections such as "C" and "T." But beyond "mass" symmetry, residual stresses from welding or forming, offset from the neutral axis and unbalanced, could induce distortion potentials not found in balanced or unstressed sections.

Uniformity

Uniformity, for purposes of this discussion, refers to uniformity of section thickness, as well as the composition and surface character of steel surfaces. For example, a fabrication having "thick" and "thin" sections welded together will undergo induced thermal stresses (or stress reduction) as the article transits the galvanizing thermal profile from ambient temperature, to ~850°F (~440°C), and back to ambient. For plate girders, the lowest ratio of flange-to web thicknesses possible would be optimum, but in any case, not more than 4:1 if web "oilcanning" is a critical design consideration.

Uniformity also refers to the surface condition of the article to be galvanized. New steel and older pitted steel welded together, or steels of differing grade or chemical composition welded together will have a different surface appearance after galvanizing. This is due to differences in surface profile or zinc reactivity. The "age" and smoothness of steel surfaces should be matched to the extent possible.

Weld metal can be different from the parent steel, and can result in aesthetic variation after galvanizing. Guidelines on galvanizing weld-metal compatibility are available from the AGA, and should be factored into selection for structural welding.

Cleanliness

Cleanliness refers to the degree of contamination or "foreign" residues present on the steel surface. The galvanizing process includes chemical surface preparation removing scale, rust, and many organic contaminants. But since galvanizing is a metallurgical reaction and requires intimate contact with molten zinc, the process can be inhibited by surviving surface residues. While seemingly a "negative" aspect of galvanizing, it is actually "positive" in that contamination not removed by the chemical-cleaning process cannot be "coated over" by zinc, and thus such incomplete surface preparation results in an easily identified defect in the galvanized coating. Such contamination generally is limited to pipe lacquer, tars, and certain marking paints. Compatibility can be checked with the local galvanizing firm.

In addition, weld slag, anti-spatter compounds, and pipe lacquer "burned in" during welding can cause similar problems. Galvanizing standards and conditions for other coating applications require such material to be removed.

Access

Access refers to the venting of vapors and the free flow of liquids through and from a fabrication, particularly those having relatively closed sections, such as pipe and HSS. This requirement is related to the aesthetics and integrity of the galvanized article, and also to safety in the galvanizing plant. The liquid immersion and flow, and the thermal transient of galvanizing, can result in loads, pressures, and forces that are controllable in the design and fabrication process. Overlapped plates or surfaces should be vented against pressure buildup from residual aqueous solutions entrapped in crevice areas. All vent and drain provisions, including internal gussets and stiffeners, should be tangential with the highest and lowest points while in the galvanizing orientation.

Tubular assemblies of any type should allow for the full and rapid venting and expulsion of air, steam, and vapors, the free release and complete flow of cleaning solutions and zinc into and out of the fabrication, and inhibit buoyancy. The completeness of that flow pattern should be externally verifiable. AGA guidelines and ASTM standards clearly identify the venting and draining requirements for tubular sections. Adherence to these guidelines will result in safe galvanizing and adequate coverage of all internal spaces, which cannot be achieved by non-immersion processes.

In addition, the access required can allow the rapid cooling of articles after galvanizing, aiding in retention of galvanized surface appearance, and in critical cases, the cohesive integrity of the coating. Another factor is the provision for suspending articles in the galvanizing process, such as by bolt holes, or lifting lugs. These should be oriented to allow and assist the draining and venting of the article while in the galvanizing process spacial orientation.

To ensure the best results from the galvanizing process, refer to the AGA guidelines and the ASTM standards. And don't forget to consult with prospective galvanizers when working on a project. ★

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