Chapter VIII*

THE CHARACTERISTICS OF WROUGHT IRON

A clear understanding of the characteristics of wrought iron will enable specifiers to employ the metal more effectively in the solution of their problems involving the selection of materials to meet specific service conditions. From the standpoint of practical application and installation problems, the important characteristics of wrought iron include—resistance to corrosion, resistance to fatigue failure, the ability to take on and hold protective metallic and paint coatings, good machining and threading qualities and good forming and welding qualities. All of these, excepting the last two, are discussed in this chapter. Forming and Welding are discussed in the two following chapters.

RESISTANCE TO CORROSION

The principal virtues of wrought iron are its ability to resist corrosion and fatigue failure. Its corrosion-resistance is attributed to the purity of the iron base metal, freedom from segregated impurities, and the presence of the glass—like slag fibres embedded in the metal.

Corrosion is no respecter of metals. It is known that some metals are less susceptible to its effect than others, but there is no metal—precious, semi-precious or commercial—that is absolutely immune to all types of corrosion. Recognition of these facts will assist in the solution of corrosion problems.

The term “corrosion-resistance” as commonly applied is strictly relative and comparative. The only difference between any two metals from the standpoint of durability, when exposed to a given set of corrosive conditions, is that one will corrode more slowly and/or more uniformly, and, therefore, will last longer than the other.

Today most recognized authorities on corrosion agree that the film of corrosion products developed on a metal surface exposed to corroding media of various types has a pronounced influence on durability. The surface films developed on the commonly used ferrous metals can serve either to decrease or increase the rate of corrosion, and therefore may be classified into two groups according to the effect they produce. The first class includes films that are clearly visible and insoluble. Water will permeate them ordinarily, but they are sufficiently dense and adherent to blanket the underlying metal and thereby cause the corrosion rate to be retarded. Obviously, such films are desirable, and if broken will be replaced through natural processes.

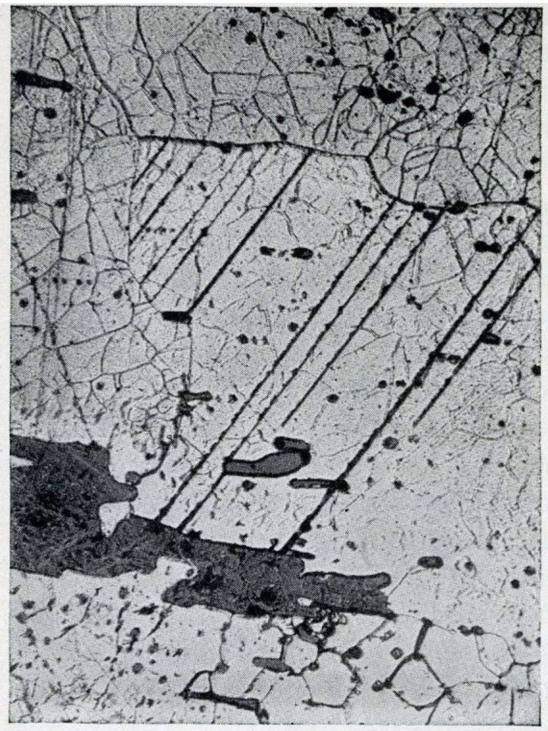
The second class includes porous, non-adherent and non-uniform films which may accelerate corrosion. One of the most commonly observed effects of corrosion is the loose, porous scale which flakes off the surface of the metal at the slightest touch. Such films retain moisture. Where they are not uniform, the corroding solution is permitted to come in direct contact with the metal surface in certain areas, which, coupled with variations in oxygen concentration, creates concentration cells. The metal underlying the deposit and not freely supplied with oxygen becomes anodic to the metal lying on the fringe of the deposit where a plentiful supply of oxygen exits. Usually this results in pitting of the anodic metal beneath the rust film.

There are, of course, certain conditions to which metals must be subjected that are not conductive to the formation of films of either class. Probably the best example of this is found in handling solutions of some of the strong acids which develop no definite protective film or do not possess the power of pacifying the metal. Under this condition the surface is dissolved continuously, leaving bare metal exposed to further attack. Incidentally, it should be mentioned that accelerated laboratory corrosion tests of the acid type subject the metal to this condition.

Some metals have greater ability than others to develop natural protective films of corrosion products. That fact is primarily responsible for the difference in the corrosion resisting characteristics of various metals.

It was about a decade or more ago that the corrosion-resistance of wrought iron was first attributed film formation. Of course it had been recognized for quite some time that the slag fibres in wrought iron are present in such great numbers that they serve in one capacity as an effective mechanical barrier against the progress of corrosion, and, under most conditions, force it to spread over the surface of the metal rather than to pit or penetrate. Also, it was known that wrought iron had the ability to develop a dense, uniform and adherent skin or film of scale when exposed to the great majority of corrosive conditions, but this fact had never been taken into account in explaining its durability. Subsequent investigations revealed that the characteristics of this film, particularly its density and adherence, are influenced primarily by the siliceous slag fibres embedded in the iron base metal.

In some cases, the beneficial effect of the slag component is accentuated by the presence of compounds in the corroding medium that become occluded in the film and add to its effectiveness in protecting the underlying metal.



Photomicrograph of wrought iron which was in service for fifty years subjected to shock and vibration as well as corrosion. The parallel black lines represent the paths of slip planes which were intercepted by the slag fibres.

The record for durability that wrought iron has established over a long period of years, subjected to a wide variety of actual operating conditions, provides a sound engineering basis for its use in the many services for which it is specified today. Lacking imperishability in a metal, it is obviously safe and economical to employ one that has definitely proved its durability.

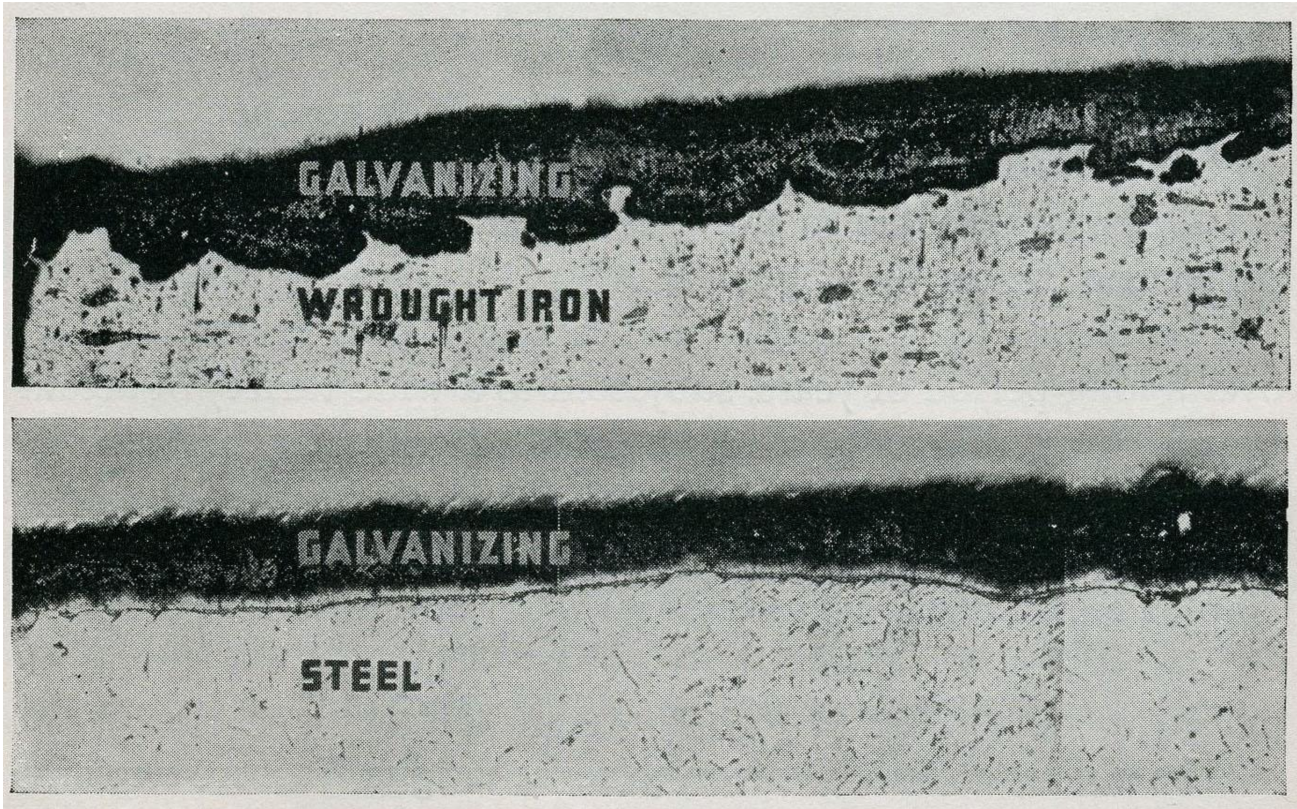
RESISTANCE TO FATIGUE FRACTURE

The ability of wrought iron to resist fatigue fracture explains the reason for the extensive use of this metal, particularly in the railroad and marine industries. Wrought iron is known to be relatively insensitive to notch effect and unusually resistant to over stress. These desirable properties are attributed primarily to high ductility and, of particular importance, to the presence of the slag fibres which confer on the metal a tough, fibrous structure somewhat analogous to that of a stranded wire cable. The slag fibres apparently serve to minimize stress concentration and deflect the path of slip planes that develop in a metal under the influence of conditions which ordinarily would result in fatigue failure.

ADHERENCE AND WEIGHT OF PROTECTIVE COATINGS

Under some conditions where corrosion is a factor, the useful life of metals can be increased to some degree by the application of a protective coating, such as paint or galvanizing. The added life due to the coating will be influenced by the adherence of the coating to the metal surface and its weight or thickness. It should be remembered that the length of service life obtained from an installation subjected to corrosion will depend primarily on the durability of the metal itself, because after the coating is destroyed, the relatively thicker metal must bear the brunt of the corrosive attack.

It has been found through experience that either paint or hot-dipped metallic coatings, such as galvanizing, will adhere better and last longer on wrought iron than on the other commonly used metals. The answer lies in the fact that the natural surface of wrought iron is microscopically rougher than that of other metals and, therefore, provides a better “tooth,” or anchorage for paints. In the case of galvanizing, the natural roughness of a wrought iron surface is accentuated by the acid pickling operation used to clean the metal before it is dipped in the molten zinc. The slag fibres are responsible for this increase in roughness. Thus, a coat of zinc is given an even better anchorage than paint on wrought iron. As a result, wrought iron will take on a natural zinc coating which is 25% to 40% heavier than that on other metals and this makes the coating itself longer lived.



The reason that wrought iron takes on a heavier and more adherent protective zinc coating is illustrated clearly by these photomicrographs of galvanized wrought iron and galvanized steel pipe.

MACHINING AND THREADING PROPERTIES

The machinability or free cutting characteristics of wrought iron, like that of most other ferrous metals, is proportionable to its hardness which in turn can be compared with its tensile strength, since the latter two properties are comparable. However, in addition to hardness and tensile strength, there are certain structural features which may also have a pronounced influence on machinability. In the case of wrought iron, a very important feature is the presence of the siliceous slag fibres which are of distinct advantage, particularly in threading operations. In threading, the fibrous structure of the metal produces chips that crumble and clear the dies rather than ones that form long spirals. This of course promotes the production of clean, sharp threads on wrought iron pipe or other products that must be threaded.

Any properly adjusted hand-threading die or threading machine in good condition, furnished by a reputable manufacturer for threading ductile ferrous materials, will thread wrought iron with complete satisfaction. The minor variations in lip angle, lead and clearance are not sufficient to affect threading results.

A bulletin containing a detailed discussion of the threading of wrought iron pipe is available and may be obtained by writing to A. M. Byers Company.

*Excerpt from:

Wrought Iron
Its Manufacture, Characteristics and Applications
by James Aston
Consulting Metallurgist, A. M. Byers Company
and Edward B. Story
Chief Metallurgist, A. M. Byers Company
Published by, A.M. Byers Company, Pittsburgh, Pennsylvania
(2nd edition, 1939)