THE CORROSION OF IRON.

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IN writing on the "Corrosion-Resisting Qualities of Modern Mild Steel vs. Old-Time Iron" in *The Canadian Engineer* of June 4th, 1914, Mr. A. T. Enlow draws attention to a few of the erroneous ideas which prevail on this subject which have been quite generally overlooked in recent discussions. Some of these points are of such practical importance that they will bear referring to again. He emphasizes the fact that chemical analyses showing the sulphur, phosphorus, silicon and manganese (and he might have added oxides and slag) may be very misleading as to the enduring qualities of the metal. He goes on to say: "The idea that the analysis tells the whole story has its origin in the statement, so often reiterated when the idea of a modern rust-resisting metal was first conceived several years ago, that 'the purer the material as regards the absence of foreign chemical elements, the better would it withstand corrosion.' At best this statement only conveys part of the truth."

Referring to the exceptional cases where old-time iron has withstood the ravages of time to such an extent as to be, in some cases, in a state of good preservation to-day, Mr. Enlow points out that this is no proof that the old-time irons were all of this character—quite the reverse is the case—for the few samples which can now be found are merely the survival of the fittest. In speculating as to the cause of the long life shown in these exceptional cases by old-time iron the author seems to reach the conclusions that this was due to the absence of manganese in this iron and the presence of something which, perhaps for lack of a more definite term, he calls "vitality." This, it is presumed, is lacking in iron which shows more rapid corrosion. There is no question but that modern iron and steel, no matter by what process it has been made, varies to some degree in quality according to how carefully the metal has been refined and worked. This was most probably true, if not to a greater extent, in regard to the old-time iron referred to.

Regarding the effect of manganese, I believe the author is inconsistent and reaches a conclusion which is not supported by evidence. It is well known that manganese alloys with iron more uniformly than any other element and shows very little tendency to segregate. Many comparisons have been made of low-carbon steel made in the open-hearth furnace without manganese and ordinary soft steel carrying .30 to .40 per cent. manganese. On the whole, these tests show no decided difference in corrosion. The writer has had an opportunity of studying the effect of hot aerated water in pipe lines made up of modern puddled iron and soft steel. Here the conditions as to uniformity were ideal. From over one hundred of such comparisons no difference in the extent or depth of the corrosion could be seen, although the wrought iron had a mere trace of manganese, and the soft steel carried over .30 per cent.; so that the manganese is no exception to the general conclusion which Mr. Enlow has drawn that "chemical analysis of the carbon, sulphur, phosphorus, silicon and manganese may mean much or little."

As to the absence or presence of "vitality," it is true that by aiming at exceptional purity and not using such additions as ferro-manganese, properly applied, the steel may be rendered very sensitive to subsequent heating, and, as a practical welder would say, "it is dry." The metal in this state may have a very high degree of purity as in the case of so-called "ingot iron," but probably due to this extreme purity it readily absorbs gases when heated, and when fabricated may be decidedly inferior to soft steel carefully made by standard practice and carrying sufficient manganese to protect the iron from oxidation.

While in the writer's opinion the various operations of refining and working the metal have a bearing on corrosion, there is another factor of far more importance which is too often overlooked. The writer had an opportunity a few years ago to study some old iron of French manufacture on the Panama Canal which had shown remarkable resistance to corrosion under adverse conditions. This material was found to be of a variable analysis, corresponding to modern soft steel in some cases and in others the metal was evidently made by the puddling process. A close examination showed that corrosion had not penetrated through the surface of the metal, which was protected by a film of tenacious scale. Upon removing this surface skin and exposing the clean metal under the same conditions it was found to corrode as rapidly as modern soft steel. This was tried out a number of times where other instances of more or less perfectly preserved old iron have come to light, and it invariably proved that on removing the protective skin from these metals corrosion proceeds quite rapidly, the metal being destroyed apparently as fast as in the case of unprotected steel of modern manufacture.

Considering the fact that the iron and steel made up to 30 or 40 years ago was slowly fabricated, so that, especially where hand-forged, the finish was not nearly so smooth as nowadays, it seems that the film of cinder which was left on the surface of the forged article adhered tenaciously, and in most cases was responsible for preserving the metal from corrosion. In some cases these cinders are in the nature of a thin enamel and are quite impervious to moisture.

From our experience I am quite in accord with the author's conclusion that "the physical qualities unquestionably have very much to do with this question . . ." but I am inclined to question the statement that as a rule old irons are more dense than modern mild steel. It is very important, in my opinion, that the metal be uniformly finished in the final stages of refining and afterwards carefully heated and given as much work as possible in the process of fabrication. It is of advantage to apply this work in more than one direction, as in forging operations, so as to get as uniform density as possible, and in working metal in this way as far as practicable all loose scale should be removed from the metal between passes so that the finished surface may be as uniform as possible. This is the ideal to which we have been working in the manufacture of soft steel to withstand corrosion. It is obviously impracticable to make the large tonnage which is produced nowadays by the old-time methods, even though it was proved that iron so made had superior durability. Modern requirements call for a smoother finish, and protection, where required, should be applied to the carefully-prepared surface after fabrication.

After all, it seems that durability in service is more often a question of protection of the surface of the metal from moisture, either accidental or by means of protective coatings, than by virtue of any inherent quality in the metal itself. Chemical composition, *per se*, so far as the common metalloids are concerned, seems to have less influence on the corrosion of iron than any other factor.