COMPOSITION AND HEAT TREATMENT of STEEL

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COMPOSITION AND HEAT TREATMENT OF STEEL

BY
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PREFACE

In preparing the matter that enters into this book no attempt has been made to go into details on the subjects of the ores, their melting down into iron, or refining the iron in steel making. This part has merely been covered in a general way in order to lead up to and give a better understanding of the effect of the elements present in and added to steels of the various grades and kinds.

An attempt has been made to cover all the materials that have been used, either commercially or experimentally, for the purpose of making better steel and improving the standard brands so they will have greater strengths; withstand strains and stresses better; possess a longer wearing surface; have a greater electrical resistance, conductivity, or magnetism; attain a greater hardness, ductility, resiliency, or malleability; be capable of taking larger cuts on other metals or machining them faster; produce a metal that can be easier rolled, hammered, pressed, drawn, forged, welded, or machined into shape; be non-corrosive, or, in fact, make a better metal for any of the many uses to which it is put. The effect these materials or elements have had upon the carbon and alloyed steels has been told as well as the data at hand would permit, and hints have been injected, as to what might be expected from many of the elements, in order to stimulate further investigations and experiments. Results have been obtained in this way in the very recent past that are truly wonderful, yet these are liable to sink into insignificance before the discoveries that may be made in the near future.

The different chemical compositions that can be made from the elements here listed and described are so numerous that it seems hopeless to expect that all of them will ever be compounded, and tests made, and the results recorded. However, with the many individuals that are working along these lines some combinations are bound to be made that will prove to be beneficial, and doubtless some steels will be produced that will cause as great a revolution as "Mushet" or "Bessemer" steels did in their respective lines. A very few of the possible quaternary steels have been tried, *i.e.*, alloys made by combining four different elements with the ferrite, and therefore many are yet to be investigated in the many different percentages in which it is possible to combine them. And this does not take into consideration the compositions that are possible with six, eight or more elements.

Following the ingredients of and materials used in steel, comes the heat-treatment, as the two have moved along parallel lines, in the many investigations, experiments, and improvements that have been made, and seem to be inseparable. Each change in composition seems to have altered the heat-treatment, and each improvement in heat-treatment seem to have altered the percentage, that is best to use, of some one or more element. Many different methods and various kinds of materials have been experimented with and consequently a great deal of useful information has been obtained and many improvements of a radical nature made. New methods, new materials, and new apparatus have thus been brought into use for the heat-treatment of steel. These have enabled the hardener to get more definite, positive, and uniform results, and in this way the metal has been improved to a great extent.

All of the information that could be obtained on this phase of steel making and working has therefore been recorded as carefully as possible. This also suggests ideas that would indicate that there is still room for important improvements or discoveries. One of these is the attaching of a positive and negative wire of an electrical circuit to the piece of steel to be hardened and place it in a quenching bath. The current can then be turned on, the piece heated, the current turned off, and the piece quenched without moving it or allowing the air to strike the metal and oxidize it. Another instance is the possibilities suggested by carbonizing steel with gases or chemicals and thus doing away with the old laborious method of packing the steel pieces in bone and charcoal. Still another is the 30-minute annealing of high speed steel and the possibility of a similar method being applied to carbon steel.

In gathering together the data necessary to add to my own, very little credit has been given to individuals, as to make this correct is not only a laborious but a hopelessly impossible task. To illustrate this I have seen professors claim as their own discoveries, new principles, new methods, etc., that were developed and perfected by students in their classes, and shop foremen and superintendents claim as theirs, inventions made by men in the shop. Two important discoveries that developed into new kinds of steel were made through the mistakes of workmen in steel mills. Two men on the same job added the correct percentage of a material and thus this element was twice as large as it was thought would give good results. In fact, it was believed that it would injure the metal to add more than a certain percentage, but when this maximum percentage was doubled the metal was given properties that were very beneficial for certain purposes. None of us can add but a mite to the knowledge that we have obtained from others and because we are enabled to write it so it will be recorded in books and papers does not give us the privilege of claiming to be the originators of certain ideas,

principles, discoveries, or inventions. Every one who has worked in the steel mill or the laboratory is entitled to a part of the credit for any new ideas or information that may happen to be enclosed between the two covers of this book. To pick out a few individuals and give less credit than this would be working an injustice and stating an untruth, and to name all that should be given credit is a physical impossibility.

E. F. Lake.

CONTENTS

COMPOSITION AND HEAT TREATMENT OF STEEL

CHAPTER I

THE MAKING OF PIG IRON

THE iron that forms the base for all steel, as well as iron, products is first obtained from its ores, as a commercial product, from a blast furnace similar to that shown in Fig. 1. It is then in the form of an iron that contains a large amount of carbon, both in the graphitic and combined state. This makes it too weak and brittle for most engineering purposes, but about one-third of the total product is run out of the blast furnace into pigs of iron that is used only for castings that are to be subjected to compressive, transverse or very slight tensile strains, such as bed plates or supporting parts for machinery, stove plates, car wheels, etc.

The various kinds of steels are relatively increasing in proportion to the amount of pig iron used. To-day about two-thirds of this product is being turned into steel through purification by either the Bessemer, open-hearth, puddling, crucible, or electric methods. The carbon content is reduced to any desired point, the graphitic carbon being eliminated by any of these processes, and the silicon and manganese are oxidized out by the accompanying reactions, or as a condition precedent to the reduction of the carbon. The two impurities of the metal which are the greatest bane to engineers and steel makers alike are phosphorus and sulphur. These are reduced by either the basic open-hearth, puddling, or electric processes.

In making steel, the operation begins by making pig iron from the iron ore, which is a natural iron rust or a combination of iron and oxygen. The oxygen is removed by combining iron ore, coke, and limestone in a furnace, as shown in Fig. 2, and heating them to a high temperature by injecting superheated air into the bottom of the furnace. The coke is burned by the oxygen in the air; a part of it aids in maintaining this high temperature while the rest is useful in removing the oxygen.

This superheated air is usually produced by passing the blast through a hot blast stove. This has been previously heated by means of the combustible gases which have been conducted from the top of the furnace to the bottom through the pipe shown to the left of the furnace in Fig. 2.

Four of these stoves are shown grouped in pairs, to the left of the blast furnace, in Fig. 1. They are about the same height as the furnace,