## STEEL

The great part that steel plays in the industrial world to-day, its rapid substitution for other materials of construction, the perfections, and the discovery of new uses, that have recently been made concerning it, would lead one to think that this metal is a discovery of recent date rather than one of antiquity.

One will be surprised, then, to find that steel was known very early in the history of the world. The slaves of Damascus produced a steel which is famous for its hardness, flexibility, and tenacity known as Damascus steel. In the time of Pliny, (about 50 B. C.)the existence of large masses of iron ore in Spain, Elba, and elsewhere was well known and described by him as used for the manufacture of iron and steel. Both Homer and Hesoid refer to the forgoing of iron whilst the hardening and tempering of steel also appear to have been operations in common use among the ancient Greeks. The employment of a rough bellows for the forging of tools is figured in Egyptian sculpture of 1500 B. C. and even earlier dates. And thus we may recede, until, since we cannot draw a definite line between fact and mythology, we eventually arrive at the door of Vulcan's workshop.

We see references in ancient epics and poetry of the middle ages to "the good steel brand and trusty armour" and, indeed, without these, chivalry would have lost half its beauty by losing its chief adornments.

Steel is defined as a variety of iron intermediate in composition and properties between wrought and cast iron containing from .75 to 1.5 per cent of carbon.It differs from malleable iron in containing a varying proportion of carbon and when rich in carbon it resembles cast iron in composition but is freer from impurities.

We may say, then, that steel is iron which has been subjected to further treatment, so that we must necessarily speak of the extraction of iron from its ore. Iron ore is found in nearly all parts of Europe and America. In Canada it is mined particularly in Nova Scotia, along the St. Lawrence and around Lake Superior.

Iron is extracted from its ore, which consists mainly of the oxides of the metal, by the process of smelting. This process consists in removing the oxygen in combination by the interaction of carbon. The mass of metal thus formed

is known as pig iron. This metal still contains a variety of impurities. Coke and coal were first used as the source of carbon by Abraham Darby of Colebrookedale, England, in 1735. Since then many improvements have been made. Before this date charcoal was used.

A detailed account of the different processes of converting pig iron into malleable iron and steel is impossible here because of their number, so that we can only sketch briefly those which are most commonly used and to which the others, with some improvements along certain lines, are somewhat similar.

In former times steel was sometimes made directly from the ore without passing through the stage of cast iron. The Catalan forge is used for this process. In principle these forges may be considered as enlarged blacksmith or rivetting forges, in the bed of which are placed together the ore to be reduced and the reducing fuel, generally wood and charcoal. According to the way in which the draft is regulated and the materials manipulated, the resulting iron is more or less steely in character. A slow draft produces a well-carbonized hard metal and a rapid blast produces a metal softer and far less carbonized. Even after working under the hammer, until fibrous in texture, the bars produced are apt to be non-homogeneous, the steely portion being irregular.

The Siemens precipitation process is about the most successful of the methods for producing steel directly from the ore. The principle of this process is essentially fusion of the ore to be reduced with a suitable flux (lime, aluminous ore) to assist in the fusion, made by means of an intensely heated regenerative furnace, (in which hot gases are thrown upon the bed by means of direction plates) and the reaction upon the fused substance of heated anthracite or hard coke forming the covering of a lower bed in the furnace on which the fused ore is allowed to flow from the upper bed. Under these circumstances the solid carbon precipitates iron from the fluid. The iron then adheres as a pasty ball in a fluid bath of cinders.

The conversion of pig iron into malleable iron and steel is the usual method of obtaining steel in modern times. Pig iron is first converted into malleable iron by different processes, especially Bessemer's pneumatic process, by forcing air through the molten mass so as to burn out the carbon, and other impurities and also by Heaton's

process which is closely allied to that of Bessemer's, the oxidizing gases used to decarbonize the pig iron being blown through the fused mass so as to produce either semi-steel or something approaching malleable iron according to the amount of carbon oxidation effected. By another plan (Uchatius process) pig iron is granulated and heated in a crucible with manganese fire clay and the oxides of iron, the result being cast steel.

The process known as Siemen's regenerative gas furnace is rapidly coming into use because of economy of fuel. The process of puddling, because of its simplicity as compared with other processes, merits a short description.

Puddling in a general way is conducted as follows: a charge from four and a half to five hundred weight of metal, including some hammer slag and iron scale, is placed on the bed of the furnace while still hot from previous workings. In about an hour, when the furnace is in working order, the charge is melted and is then stirred or rabbled for a considerable time. Then it begins to boil by the generation and escape of carbon dioxide which forms jets of blue flame all over the surface. Gradually, as the carbon of the pig iron becomes more oxidized, pasty masses of malleable iron separate, and these are removed in balls commonly weighing about eighty pounds and sometimes larger. About an hour and a half is required to work off a charge and from twenty-two to twenty six hundred-weights of pig iron is required to produce a ton of malleable iron.

This malleable iron is converted into steel by the cementation or blister process, by depriving the malleable iron of its carbon, and then adding carbon again by heating the iron with charcoal. In making any kind of steel, the removal of silicon, phosphorous, and sulphur is most important. This is effected by large and powerful hammers, rollers or squeezers.

The tempering of steel is then effected by heating it until it becomes red hot and plunging it into cold water, oil or mercury, so that it becomes more or less hardened. When the steel thus hardened is again heated red hot and cooled slowly it loses this acquired hardness and becomes soft and malleable again. This inverse process is called "annealing." If the steel has been hardened sufficiently in the first tempering, this process produces a steel with a combination of hardness, toughness and elasticity. By gently reheating the steel, it will acquire a gradation of tints,

which indicates various degrees of hardness, beginning with pale straw color and passing successively to full yellow, brown, purple, and finally to blue. The straw color is the result of a temperature of about 220 degrees Centigrade, and the blue of about 315 degrees Centigrade, the former being the hardest, the latter the softest tempering.

Steel possesses several valuable properties which do not belong to either wrought or cast iron. It is harder, denser, and whiter in color, It is also more elastic, takes a higher polish, and rusts less easily. It is weldable and can be tempered to any degree of hardness.

Steel has numberless alloys so we will name only the most familiar. Manganese steel which contains from seven to twenty per cent manganese is exceedingly hard even when cooled slowly, and does not lose its temper readily when heated by friction. It is used for the jaws of rock-crushing machinery and machines of similar nature. Chromium-Vanadium steel (1 per cent chromium, 15 per cent vanadium) has great tensile strength and offers great resistance to change of stress and torsion. Tungsten steel (containing 8-20 per cent tungsten, and 3-5 per cent of chromium) is used for tools in high speed metal turning, as it can become red hot without loss of temper. Nickel steel, (containing 2-4 per cent of nickel) has a very high limit of elasticity, great hardness and resists corrosion. It is used for armour plate, wire cables and propeller shafts. The alloy with 36 per cent of nickel, called Invar, is practically non-expansive when heated and is valuable for meter-scales, pendulum rods and other contrivances in which an expansion is detrimental to proper working.

Steel is prepared for use by casting, rolling, or when absence of flaws is required, by forging, which is facilitated by pressure and impact made for the purpose.

The manufacture of steel, like many other industries, has made rapid advancement during the last decade and an increased scientific knowledge of it has enabled engineers to surmount such difficulties as the bridging of the St. Lawrence and perform other admirable feats of engineering. It has enabled scientists to make the aeroplane a reality instead of a theory. Man is using it in many ways to help him surmount the obstacles of nature so that we may say, with a slight change in that old adage, "the march of civilization is accompanied by the music of the steel anvil."

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