INDUSTRIAL SECTION

Stainless Steels*

IN the courtyard of a mosque near Delhi, there stands an iron pillar nearly 24 feet high, 15¼ in. in diameter and weighing about six tons, which was erected about A.D. 300. It is very interesting to know that the Indian craftsmen of that day were able to fashion so large a piece of iron at a time when all other peoples then, and for centuries later, could only forge iron in the form of small pieces for use as weapons, tools and household appliances. *Still more remarkable is the fact that that pillar has withstood the ravages of time and atmospheric corrosion up to the present day.*

Since the days when that pillar was set up, the metallurgy of iron has made enormous strides. The invention of blast furnaces and the art of steel making, the development of rolling mills, steam hammers and hydraulic forging presses, aided by scientific investigation of the physical and chemical properties of iron and steel have, so to speak, changed the face of the earth. But for all that the problem of protecting iron and its alloys from the weather, and from attack by chemical agents was not solved until about thirty years ago, at a time when the iron and steel industry had already attained a remarkably high state of efficiency.

In the year 1909, the metallurgical engineers of the Krupp Works were conducting experiments in search of a heat-resisting steel suitable for Pyrometer sheaths. The experimental melts made by them contained chromium in varying amounts. These alloy steels proved satisfactory in respect to scale resistance at elevated temperatures, but at the same time it was perceived that some of the alloys tested remained perfectly bright for months in the highly corrosive atmosphere of the laboratory. That was indeed a turning point! There in the metallurgists' hands was the very first iron alloy capable of resisting intense chemical attack!!

Systematic scientific investigation of these alloys was forthwith organised, one of the main objects being to develop methods of heat-treatment that would render these then extremely hard metals amenable to shaping and machining processes.

When these problems were successfully solved, the Company's Metallurgists devoted themselves to the task of improving the methods of fabricating these valuable metals so as to enlarge their sphere of usefulness. The technique of welding, in particular, was brought to a high state of perfection, so that to-day rustless steel plant up to the largest sizes can be built up by welding at site.

The great variety of working conditions which rustless steel is required to meet, led to the evolution of a number of different types of this metal, and in addition to two corrosion-resisting alloys, the most important of these being the VA and VM groups. The various groups differ from each other in chemical composition and physical properties. Their chief characteristics are:—

The 'VA' Group

Composition: (*a*) About 18 per cent. chromium and 8 per cent nickel, with a low carbon content. (*b*) Other ratios of chromium to nickel, to which are sometimes added other alloying elements.

They possess an austenitic structure and are non-magnetic. They are not hardenable by quenching, and are available with tensile strengths varying from 35 to 48 tons per square inch.

For this group, generally speaking, the differences in tensile strength existing between the various types is of less importance than other considerations such as corrosion resistance and easy workability. These steels are the most important as far as the chemical industry is concerned. In addition to possessing the highest corrosion and acid-resisting properties of all steels, they are comparatively easily workable, as they possess good deep drawing qualities and are easily welded. Up to a comparatively short time ago, it was necessary to heat-treat all

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stainless steels after welding in order to restore their corrosion-resisting properties, which were affected by the welding process. In the case of larger parts, which could not be easily treated, this was a serious disadvantage. Now this disadvantage has been overcome and types are available that do not require any heat-treatment after welding.

Of all corrosion-resisting steels and alloys, the "VA" Group offers the widest field of application. Even at higher temperatures they are absolutely resistant to corrosion by numerous organic and inorganic acids, bases and salts. They are indispensable in up-to-date plants for the production of nitric acid, artificial fertilisers, explosives, artificial silk, photographic films, dyestuffs, oils, soap, paper and textile goods. They are widely used in breweries and distilleries, and in the dairy and foodstuffs industries.

The 'VM' Group

The next group to be considered is known by the designation "VM". The steels in this group have a composition of from 12 to about 18 per cent. chromium, with varying carbon contents. They possess a Troostito-martensitic structure, and are magnetic. That they are hardenable by heat-treatment gives them a special value for certain applications, where this property is essential. The tensile properties can be varied by heat-treatment to meet specific requirements. In the heat-treated state, owing chiefly to a difference in carbon content, their tensile strengths range from 41 up to 102 tons per square inch.

The development of the "VM" steels is a triumph of the Metallurgists' endeavours to make stainless steels with greatly varying tensile strengths to meet the needs of an immense number of different types of industrial plant. They are primarily intended for use as constructional steels for general engineering purposes and similar applications, but not for welded work. There are special types suitable for parts subject to heavy mechanical stresses, as, for instance, shafts, piston rods, valve stems and seats, turbine blading, ships' propellers, etc.

Another type has been developed to meet those cases where a high degree of hardness up to 530 Brinell is essential, *e.g.*, machine knives, plungers, measuring instruments, ball and rollers for bearings, etc.

The "VM" Group of steels depends to a considerable extent on heat-treatment and surface finish for its corrosion-resisting properties. Provided these are given the necessary attention, excellent results are obtained.

The 'VF' Group

The next type of steels to be considered lie within what is known as the "VF" Group. These contain over 12 per cent. chromium with a very low carbon content. They have a ferritic structure and are magnetic. They are not hardenable by heat-treatment. As they have a ferritic structure, heat-treatment produces no change in the structure of the steels, or at the best a partial change only. It follows, therefore, that heat-treatment cannot modify the mechanical properties of these steels to any appreciable degree. The most widely used types have a tensile strength of from 35 to 41 tons per square inch. They are used for constructional purposes in cases where the parts are not subject to severe mechanical stresses. Corrosion resistance is about equal to that of the steels in the "VM" Group. As they are somewhat cheaper than the steels of the latter group, they are used instead of that material wherever possible. They have not found extensive employment in the fabrication of chemical plant because the weldability is rather limited. Nevertheless, when selected for suitable purposes, they give excellent results and immunity from corrosion.

Nirostaguss Alloy

Under Group IV, is included the "Nirostaguss" alloy. This contains over 24 per cent. chromium, from 1 to 2 per cent. carbon and dependent on the use to which it is to be put, with or without an addition of nickel and/or molybdenum. The alloy is a ferrito-ledeburitic or austenitic structure according to the nickel content. The magnetic properties are also dependent on the composition as stated before.

"Nirostaguss" resembles cast iron inasmuch as it shows no elongation to speak of, and is also rather sensitive to shock. The tensile strength of "Nirostaguss" is about twice that of ordinary gray iron. The alloys are immune from attack by numerous chemicals. They are useful substitutes for casting purposes in such cases where steels of the "VA" Group are not absolutely indispensable, or where such steels cannot be employed on the grounds of founding technique. They are used especially in the nitric acid industry and pulp industry; furthermore, for drying cylinders for the paper industry, etc.

Thermisilid Group

The last group of stainless alloys to be dealt with is known as "Thermisilid". This is actually a high silicon cast iron, which is remarkable for its excellent resistance to many kinds of corrosive attack. The material is produced by a special founding process. These alloys resist attack by a number of corrosive agents against which alloy steels proper are not proof. Unfortunately, their sphere of usefulness is limited by a certain lack of ductility, owing to which their employment is restricted to such parts of chemical plant as are not subject to severe mechanical stresses. For all that, and particularly if suitable protection against shock is provided, the "Thermisilid" alloys may be employed to great advantage in the form of apparatus, piping and fittings in acid manufacturing plants, explosive factories, dye works, pickling plants and many other kinds of chemical works.

Heat-resisting Alloys

Heat-resisting alloys which are in many ways related to the stainless alloys and which also serve many useful purposes in the chemical and allied industries have been developed to meet a number of requirements. The most essential of these being:—

(1) Corrosion resistance particularly at elevated temperatures. Under this head comes scale-resistance, by which term is understood immunity to oxidation at high temperatures, and also resistance to attack by sulphurous gases and similar corrosive media. (2) Retention of mechanical strength and shape at elevated temperatures. (3) Retention of mechanical properties in repeated heating and cooling operations. (4) Special physical properties. A further important requirement is good ductility.

As regards the economic aspect of the use of heat-resisting alloys, it can be stated as a general rule that a saving in production cost is effected not only through increased length of service of plant, but also owing to certain incidental factors such as reduction in weight and resultant fuel economy, less idle time of plant due to repairs, replacements, etc.

In comparison with ceramic refractory materials, the better thermal conductivity of the heat-resisting alloys, their greater toughness and resistance to blows and shocks, as well as the possibility they offer of repairing fractured parts, are distinct advantages.

The advent of heat-resisting alloys has solved many baffling problems of metallurgical and chemical equipment design.

Two essentially different types are produced. The first of these have an austenitic structure and the second have a semi-ferritic or entirely ferritic structure. The service temperatures at which they can be safely employed vary from 800° C. up to 1300° C. Generally speaking, their most important features are the corrosion resistance at elevated temperatures and tensile properties and retention of strength at elevated temperatures.

For many years, the heat-resisting steels have been put to numberless uses in the chemical industry, for example for annealing tubes and muffles, protective sheaths, crucibles, retorts, rabbles for roasting furnaces in various industries, *e.g.*, sulphuric acid manufacture, apparatus and conduits for hydrogenation processes, etc. They have also been extensively used in the enamelling trade, engine construction, furnace construction, porcelain and ceramic industries, and so on.

The discovery of rustless steels and alloys, and heat-resisting alloys, is one of the outstanding achievements of the human mind. Numerous chemical processes are indebted to these materials for their practical application on a manufacturing scale, while a still greater number of others have been placed on a far sounder economic basis than formerly by the use of a plant made of them. For a great variety of other purposes, the application of stainless steels ensures spotless cleanliness and the acme of sanitary perfection. It will certainly not be long before this excellent metal is used to the exclusion of all others for hospital, hotel, restaurant, and even private household utensils, fittings and appliances, with the result that this really epoch-making invention, which has already had such a far-reaching influence on industry, will eventually confer its benefits upon human society at large.