Patented Feb. 2, 1937 2,069,205

UNITED STATES PATENT OFFICE

2,069,205

METHOD OF PRODUCING IRON CHROMIUM ALLOYS OF APPRECIABLE NITROGEN CONTENT

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No Drawing. Original application December 3, 1932, Serial No. 645,637. Divided and this application January 4, 1934, Serial No. 705,282

7 Claims. (Cl. 75—127)

This invention is a division of my co-pending application, Serial Number 645,637, filed December 3, 1932, entitled Non-corrosive alloy and relates to iron-chromium alloys, and more particularly to corrosion-resisting or rustless alloy irons and steels of the class indicated, and to an art of producing the same.

Among the objects of my invention are the production in a simple, direct and economical manner of rustless ferrous alloy iron and steel of a fine even grain which is strong, durable, heat-resistant and corrosion-resistant; one that possesses high tensile strength, and high impact value; that lends itself to hot and cold working, hardening, polishing, and the like; and that is highly resistant to decarburization and grain growth under the many conditions of fabrication and use.

The invention, accordingly consists in the combination of elements, composition of ingredients, and mixture of materials, and in the several steps and the relation of each of the same to one or more of the others as described herein, and the scope of the application of which is indicated in the following claims.

As conducive to a clearer understanding of certain features of my invention it may at this point be noted that in heretofore known and/or used corrosion-resisting alloy irons and steels (iron-chromium alloys containing as essential ingredients approximately 10% to 30% chromium, .06% to 1% carbon and the balance substantially iron) many highly desirable characteristics are achieved. These alloys are durable, strong, and tough; they may be worked either cold or hot from strip, sheet or bar stock to give products or articles of desired size and shape; they are resistant to the corrosive effects of atmospheric conditions as well as to many acids, alkalies and salts, and, finally, are resistant to the effects of high temperatures, resisting discoloration and scaling while retaining their physical characteristics, strength, toughness and durability.

In heretofore known and/or used alloys of the class indicated no one alloy, however, is equally possessed of all of the beneficial characteristics outlined above. Thus, for example, an iron-chromium alloy having a chromium content near the lower limits for commercial rust resisting alloys (about 12%) lends itself to both hot and cold working, may be heat-treated to give a fair range of hardness, strength, and impact resistance, and is not particularly susceptible to decarburization and grain growth. The alloy, however, is not qualified for resistance to severely corrosive conditions, for extreme high temperature duty, and especially for high temperatures in corrosive media; which characterizes the iron-chromium alloys of high chromium contents.

Similarly, an iron-chromium alloy having a chromium content near the upper commercial limit for rustless ferrous alloys (about 27 to 30%) although highly resistant to corrosion, and resistant to discoloration and scaling at high temperatures, suffers in workability and ductility. It does not lend itself to hardening by heat-treatment, and such physical characteristics as tensile strength and impact resistance are limited. It is difficult to machine and must be carefully handled in both hot and cold forming operations to ensure a satisfactory product. It possesses a somewhat coarse grain tending toward growth, under continued use at high temperature thus causing brittleness, low impact, and low fatigue resistance.

One of the objects of my invention is the production, in an inexpensive and efficient manner, of a corrosion resistant alloy iron or steel of an inherently uniform fine grained texture; one that is less subject to decarburization and grain growth, brittleness and fatigue; one that is of improved workability over a wider range of hot and cold working conditions, and over a wider range of chromium contents of the class of alloys described above; and one that, for the ferritic alloys, lends itself to increased maximum hardening by heat-treatment and hardening by heat-treatment throughout a wider range of chromium content giving an article or product of greater strength which is more durable and of a higher impact value than in heretofore known and/or used alloys of the class indicated.

Referring now more particularly to the practice of my invention, to iron of desired carbon content there is added chromium, with or without supplementary amounts of molybdenum, tungsten, vanadium, copper and the like, together with small amounts of nitrogen giving a corrosion-resisting alloy iron or steel of an inherently fine grain structure which is especially resistant to decarburization and grain growth.

Illustratively, the proportions of ingredients added are such as to give a ferrous alloy analyzing approximately 10% to 30% chromium .06% to .30% carbon, and .07% to .20% nitrogen. The particular quantity of the alloying metals together with the precise amount of carbon and nitrogen present are largely determinant of the

physical characteristics of the alloy as will appear more fully hereinafter.

Thus, illustratively, 195 pounds of rustless iron scrap analyzing approximately 17% chromium and .12% carbon, together with 77 pounds of ordinary low carbon scrap iron and 28 pounds of low-carbon ferrochrome analyzing approximately 70% chromium and .10% carbon is charged into the crucible of a 300-pound high-frequency induction furnace. A suitable refractory lid, preferably having associated therewith a conduit by means of which gases may be either introduced or removed from the furnace melting chamber, is then placed on the crucible. Next, the furnace is started by energizing the furnace windings from a suitable source of electrical energy.

The charge of scrap melts down giving a ferrous metal bath containing chromium and a small percentage of carbon. When this melt has been brought to a suitable temperature and a desired condition of refinement, nascent or atomic nitrogen (provided in any convenient manner as by passing a stream of bottled nitrogen through one or more electric arcs) is introduced into the melting chamber, and in intimate contact with the bath of metal, thus displacing the normal furnace atmosphere in contact with the surface of the bath of metal and providing a nascent nitrogen atmosphere for the further treatment of the metal bath.

Preferably, the nascent nitrogen is introduced by way of the conduit in the lid of the furnace crucible and is permitted to flow through the melting chamber at atmospheric pressure, although under certain conditions the nitrogen atmosphere may be maintained either above or below this pressure. The nascent nitrogen is supplied for a period of from fifteen minutes to one hour or more, depending upon the amount of nitrogen desired in the final product, the percentage of chromium content of the bath (which affects its affinity for nitrogen), the bath temperature, pressure of the gas, the chemical activity of the gas and the like.

After final adjustment of bath temperature and alloy content (as by adding a small amount of low-carbon ferrochrome with or without supplementary additions of molybdenum, tungsten, vanadium and copper, together with small amounts of manganese and silicon) the heat is poured into suitable molds.

The tapped metal analyzes about 17.3% chromium, about .10% carbon, about .09% nitrogen, with the usual small amounts of manganese and silicon.

The properties conveyed by the nitrogen content are in some respects similar to the well known properties resulting from the use of a small increased amount of carbon without, however, the attendant undesirable effects of carbon on corrosion resistance.

As indicated above, the alloy is of an inherently fine, even grain structure and especially resistant to decarburization, this latter feature becoming increasingly important in alloys of the higher chromium contents and especially those of a chromium content between 16% and 20%.

Flowing from these inherent structural characteristics are many practical advantages. Objectionable grain growth and decarburization of the rustless irons and steels of the higher chromium contents are appreciably decreased. The metal is more ductile, more workable and lends itself to hardening by heat-treatment over a wider range of chromium content than in heretofore known rustless irons and steels. Cold forming operations, especially deep-drawing, are considerably improved while hot forming operations may be successfully carried out over a wider range of temperatures. Likewise, the tensile strength of the alloy may be appreciably increased throughout a broader chromium range. So, also, may the impact resistance of the lower chromium alloys be increased.

Furthermore, as a result of the fine grain structure and increased resistance to grain growth mentioned above, the alloy more readily lends itself to welding and, in addition, gives a weld of finer grain and hence one that is more reliable than in heretofore known alloys of the class indicated.

The hot working characteristics of the metal are not adversely affected by the presence of nitrogen, the alloy lending itself to forging, upsetting, swaging and like hot operations, while the cold working characteristics such as beading, spinning and deep-drawing are somewhat improved for all chromium analyses; the improvement in deep-drawing characteristics being particularly improved for a chromium content of 16% to 20%.

In fact, as a result of the inherent resistance to decarburization advantage may be taken of higher working temperatures in processing ingots to billets, sheet, strip and bars without resultant decarburization, surface grain growth, and generally coarse structure. (The absence of decarburization and surface grain growth aids materially in producing a smooth bright surface which lends itself to easier polishing, thereby effecting important economies in this costly operation.)

In addition to the many highly beneficial characteristics outlined above, the heat-resisting characteristics of the metal are considerably improved over heretofore known and/or used alloys of the class indicated since resistance to objectionable grain growth is inherently bettered as more particularly pointed out above.

Other characteristics of alloys of the class indicated, such as resistance to corrosive effects of acid, alkaline and salt solutions are fully retained and, as a result of the finer grain structure, are substantially improved over heretofore known alloys of the kind described.

While in the above illustrative embodiment of my invention the production of rustless irons and steels containing 10% to 30% chromium and .03% to .20% nitrogen is described, it will be understood that iron-chromium alloys, or other alloy irons and steels, of the same or higher nitrogen contents may be likewise produced without departing from the teachings set forth above.

Likewise, while in the embodiment illustratively set forth above nitrogen containing rustless irons and steels are produced by maintaining the molten metal in an induction furnace in the presence of nascent nitrogen, it will be understood that nitrogen containing rustless irons and steels or other iron-chromium alloys may be similarly produced by subjecting molten chromium containing iron or steel prepared in any well known manner, employing known furnacing methods, to an intimate association with nascent nitrogen; the nitrogen being passed onto or into the molten metal.

Thus it will be seen that there has been provided in this invention an alloy rustless iron or steel, together with an art of producing the same, in which the various objects hereinbefore noted

together with many thoroughly practical advantages are successfully achieved. It will be seen that the physical characteristics of rustless ferrous alloys are greatly improved; that these improved characteristics permit many savings in manufacture and use heretofore unrealized; and that the useful field of application of these alloys is appreciably broadened.

As many possible embodiments may be made of my invention and as many changes may be made in the embodiment hereinbefore set forth, it is to be understood that all matter described herein is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In the production of iron-chromium alloys of appreciable nitrogen contents, the art which includes preparing and maintaining a bath of ferrous metal containing chromium in intimate contact with nascent or atomic nitrogen gas introduced into the presence of said bath.

2. In the production of iron-chromium alloys of appreciable nitrogen contents, the art which includes preparing a bath of metal containing chromium, and passing nascent nitrogen gas into intimate contact with said bath.

3. In the production of iron-chromium alloys of appreciable nitrogen contents, the art which includes preparing a chromium containing bath of metal, and passing nascent nitrogen gas over the surface of said bath.

4. In the production of rustless irons and steels of high nitrogen contents the art which includes, maintaining a bath of ferrous metal containing chromium in intimate contact with an atmosphere including nascent nitrogen gas introduced into the presence of said bath.

5. In the production of rustless irons and steels of high nitrogen contents, the art which includes, preparing a bath of ferrous metal containing chromium and introducing and maintaining nascent nitrogen gas in intimate contact with said bath until a desired amount of nitrogen is taken up by the bath to achieve a rustless iron or steel of desired nitrogen content.

6. In the production of iron-chromium alloys of high nitrogen contents, the art which includes, preparing a bath of ferrous metal containing chromium, passing nitrogen gas through one or more electric arcs forming thereby nascent or atomic nitrogen, and introducing said nascent nitrogen into intimate contact with said bath of metal.

7. In the production of rustless irons and steels of high nitrogen contents, the art which includes, preparing a bath of ferrous metal containing chromium, preparing nascent nitrogen by passing nitrogen gas through an electric arc, and introducing said nascent nitrogen into the presence of said bath of metal whereby a desired nitrogen content is quickly achieved.

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