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ALLOY STEEL ARTICLES

Henry S. Schaufus, Baltimore, Md., assignor, by mesne assignments, to The American Rolling Mill Company, Middletown, Ohio, a corporation of Ohio

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This invention relates to hard, corrosion-resisting and wear-resisting articles and to a method of producing the same.

Among the objects of my invention is the production, in an economical and reliable manner, of high-grade steel valves, valve-seats, pump parts, shafts, and like articles, which are particularly suited for handling acid solutions, brines and the like, especially as encountered in the oil industry; which possess high resistance to impact and deformation, so as to withstand the shock and pounding in operation; which also resist the pitting attack of various acids and salts, such as the sour oil well brines and corrosive action of other metal-deteriorating agents, as well as grit, dirt and other erosive agents, encountered in handling oil in oil wells, oil dispensaries, oil feed lines, and the like.

Other objects, in part, will be obvious and, in part, pointed out hereinafter.

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

As conducive to a clearer understanding of my invention, it should be noted at this point, that in many chemical, metallurgical and mining industries, equipment is subject to severe corrosive and abrasive attack. For example, in the oil fields, there are agents in oil, such as metal-corrosive acids or brines which directly, or with electrolytic action, attack the metal. Moreover, there is a quantity of dirt and grit which act as an abrasive. These corrosive and abrasive agents, upon attacking the equipment, make necessary frequent and costly replacement of parts.

Valves, for example, used in crude oil pumps, crude oil lines, and the like, naturally are subjected to the corrosive and erosive action of the metal-deteriorating matter which crude oil customarily contains. In operation, the valves soon wear or pit to become leaky and their replacement becomes necessary. In an oil well, for instance, check valves are included in the line through which the oil flows. The action of a pump brings oil upward past the valves, during which time the valves open by a lift of the balls, to accommodate the flow of oil. On the return stroke of the pump, any return of the oil is prevented by a closure of the valves, the balls seating themselves in the valve-seats provided. The action is repeated over and over, and subjects the ball and seat of each valve to considerable pounding or impact, tending to flake, crack and deform the valve parts.

Acids, gases, or brines contained in oil, rapidly corrode ordinary steels, and attack stainless steels at a rate varying with the type of steel. Where ordinary carbon steels become pitted and corroded on all surfaces from electrolytic attack of sour oil brines and the like, pitting of corrosion-resistant steels often is confined to small areas on the surface, while the remaining areas remain bright and shiny. These pitted areas cause a leak in the valve and a loss of efficiency of the line. Replacement of the defective part then becomes necessary.

It must be recognized that most heretofore known valves, pump parts, and like articles, clearly are not capable of adequately resisting the corrosive and abrasive attack of agents characteristically found in the oil industries. In some instances the articles are difficult and costly in working, machining and hardening. In others, they are too soft or too brittle in the hardened condition, to resist repeated deformation and impact. In short, the articles of the prior art are not wholly satisfactory where there is encountered a combination of electrolytic pitting attack, impact and abrasive.

An object of my invention is the production, in an economical and practical manner, of forged or machined and cold- or heat-treated articles, such as valves, pump parts, pipe fittings, and the like, as employed in the chemical, metallurgical and mining industries; which articles are strong and tough and possess the ability to endure continued pounding without deforming, cracking or flaking; and which articles are unusually resistant to electrolytic pitting attack by various acids and salts, such as dilute sulphuric acid, dilute hydrochloric acid and various salt solutions, giving long and efficient service without requiring replacement or repair.

Considering now more particularly the practice of my invention, I have discovered that by a proper selection of alloy ingredients and combining them in proper amounts, valves, valve-balls, valve-seats, pump shafts, pump parts and like articles of exceptional quality are produced. Thus, according to my invention, I employ a chromium-nickel-molybdenum steel comprising approximately 16% to 19% chromium; 4% to 6% nickel; 1.5% to 3% molybdenum; up to 0.5% carbon; and the balance substantially all iron. This steel, in the form of bars, rods and the like, is forged and machined into valves, valve-balls, valve-seats, pump parts and the like, which then

are precipitation-hardened and polished where necessary, to give the finished product.

I find that machined and hardened articles fashioned according to my invention withstand over a surprisingly long period of time, the corrosive action of acids, brines and gases frequently encountered in crude oils, and various chemicals. The articles are hard and tough and are thoroughly capable of resisting repeated pounding and impact. Moreover, they are characterized by high resistance to wear, such as by abrasion, and thus are affected little by the scouring action of grit, silt or the like, contained in crude oil.

As illustrative of the practice of my invention, in the production of chemical equipment parts, I fashion my pump parts, fittings, valves, and similar parts from steel bars, rods, or the like. In accordance with my invention, the steel comprises 16% to 19% chromium, 4% to 6% nickel, 1.5% to 3% molybdenum, up to 0.5% carbon, and the balance substantially all iron. I hot-work the steel into unfinished articles conveniently by forging, rolling, pressing or extruding. These unfinished articles then are quenched to soften them, then machined to size, and finally hardened. In some cases, for example, the production of valve-balls, the machining operation is dispensed with and the articles are ground to size, following the hardening operation.

The roughly-formed articles are machined and hardened in one of two ways. In some instances, I quench the articles to soften them, as by heating them to a temperature of 1800° F. to 2000° F., for about one-half an hour, and then quench in air. These articles then are machined. Following the machining operation, the articles are given a precipitation-hardening treatment by cooling them for about one hour at a temperature below 0° F., as for example, (—) 110° F. This precipitation-hardening method advantageously is used where possible, since it in no way detracts from the surface condition of the machined article.

As an alternate method, the forged, rolled, pressed or extruded articles are heated to a temperature of 1800° F. to 2000° F. for about an hour and cooled to room temperature, in order to soften them. Then they are machined, after which they are re-heated to a temperature of 1000° F. to 1600° F. (preferably 1200° F. to 1400° F.) for approximately an hour, to effect a precipitation-hardening. The hardened articles are brought to room temperature and ground or polished, to give a finished surface. This alternate method commonly is used where the cooling equipment required in the sub-zero treatment is not available. Unfortunately, it does give rise to a slight discoloration of the surface, or even a light scale, and grinding or polishing is necessary to finish the article.

In some instances, as noted above, it is practical to precipitation-harden the articles directly from the hot-worked condition, that is, the forging, hot-rolling, hot-pressing, hot-extruding. In such instances, the alternate method of precipitation-hardening is advantageously used because any scale formed in the heating operation is immaterial. This permits the use of conventional heat-treatment equipment.

My precipitation-hardened articles relatively are cheap, yet in quality are greatly superior to like articles made in accordance with known methods from heretofore employed steels. The articles are produced economically, for they are made from steels having relatively low alloy contents. Hardening of the articles to a satisfactory, serviceable degree of hardness is accomplished in a very short period of time, making production of the articles practical from a commercial standpoint. The precipitation-hardened articles can be finished with good results and without great expense. Economy and reliability in use, moreover, are achieved through the use of my novel articles, for they possess high resistance both to impact and to permanent deformation, coupled with high resistance to corrosion and abrasion in the presence of crude oil, dilute acids, salt solutions, and the like.

I find that my precipitation-hardened articles possess Rockwell hardnesses ranging from C-42 to C-50. The hardened articles possess high strength in tension and compression, together with high impact resistance. Samples of my precipitation-hardened articles, upon being subject to an accelerated test of an 0.3-volt electrolytic current in an artificial sour brine solution comprising 4.75% salt and 0.1% sulphuric acid at room temperature, showed no signs of electrolytic pitting, even after a period of about three days. Upon subjecting several conventional crude oil equipment parts of usual grade (when of higher chromium and other alloy contents than the articles of the present invention) to the same test, all of the parts showed signs of pitting or etching within five hours.

While good results are had in articles throughout the composition ranges indicated above, I find best results are achieved when the steel comprises 17% to 18% chromium, 4.5% nickel to 5.5% nickel, 1.5% to 2.5% molybdenum, 0.15% up to .50% carbon for an extra hard grade of article (or up to 0.15% maximum for articles of less hard grade) and the balance substantially all iron. Hot-worked, machined, precipitation-hardened oil valves, particularly check valves, valve-balls and valve-seats, pump shafts, pump parts, and the like, of this composition, especially are resistant to the corrosive and abrasive action of crude oil and its accompanying materials, such as sour brines, gases, grit and the like. The precipitation-hardened articles are not brittle, but are tough and impact-resistant and thus are thoroughly capable of withstanding shock or deformation instigated by pounding.

Thus it will be seen that there is provided in my invention, corrosion-resistant alloy products, together with a method for producing the same, whereby the various objects hereinbefore noted, together with many thoroughly practical advantages are successfully achieved. It will be seen further that the physical characteristics of the products are greatly improved and that these improved characteristics permit savings in manufacture and use heretofore unrealized.

As many possible embodiments may be made of my invention and as many changes may be made in the embodiment herebefore 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 impact resistant alloy steel articles of excellent surface and having particular resistance to corrosion and abrasion in the presence of dilute acids and salt solutions and under electrolytic action, the art which includes, preparing machined articles from metal softened by heating to a temperature of 1800° F. or more and cooling and comprising approxi-

mately, 16 per cent to 19 per cent chromium, 4 per cent to 6 per cent nickel, 1.5 per cent to 3 per cent molybdenum, up to 0.5 per cent carbon, and the remainder substantially all iron, and then subjecting the machined articles to a precipitation-hardening treatment consisting of cooling the same at a temperature of about —110° F.

2. In the production of impact resistant alloy steel articles having particular resistance to corrosion and abrasion in the presence of dilute acids and salt solutions and under electrolytic action, the art which includes, preparing unfinished articles from metal, comprising approximately, 16 per cent to 19 per cent chromium, 4 per cent to 6 per cent nickel, 1.5 per cent to 3 per cent molybdenum, up to 0.5 per cent carbon, and the remainder substantially all iron, annealing the same by heating to a temperature of 1800° F. to 2000° F. for about one-half hour, machining the articles, then without detracting from the machined surface subjecting the articles to a precipitation-hardening treatment consisting of cooling the same at a temperature of about —110° F.

3. In articles of manufacture of the class described, impact-resistant alloy steel machined products such as oil valves, pump parts, and the like, having particular resistance to corrosion and abrasion in the presence of crude oil and its accompanying metal-deteriorating agents and electrolytic action and comprising approximately 16 per cent to 19 per cent chromium, 4 per cent to 6 per cent nickel, 1.5 per cent to 3 per cent molybdenum, up to 0.5 per cent carbon, and the remainder substantially all iron, machined following softening by heat at about 1800° F. or more and cooling, and precipitation-hardened by cooling below 0° F.

HENRY S. SCHAUFUS.