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CORROSION RESISTANT EDGE TOOL AND METHOD OF MAKING THE SAME

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This application is a continuation of our application Serial No. 260,841 filed Feb. 25, 1963 and now abandoned.

This invention relates to thin corrosion resistant edge tools having excellent cutting properties, high hardness and good flexibility and pertains more specifically to a method of making such edge tools from unstable austenitic steel alloys.

It has previously been proposed to provide corrosion resistant edge tools including razor blades by hardening a thin strip of a hardenable high carbon, corrosion resistant steel alloy from a temperature exceeding 1000° C. As an example of such steel alloys can be mentioned the well-known alloys containing 0.8% to 1.4% carbon, 11% to 16% chromium and a balance substantially all iron. Minor amounts of one or more further elements such as manganese, molybdenum, copper and cobalt are sometimes also included in said alloys. Edge tools of the said kind have in some respects been found unsatisfactory. Thus they are comparatively brittle and can therefore safely be bent only slightly without the danger of breaking. Moreover, their edge sharpness and wear resistance is often not of the desired high degree. In these respects they are inferior to similar edge tools made of carbon steels. In addition thereto the hardening of the tools from a high temperature implies, from the manufacturing point of view, several disadvantages.

An object of the invention is to provide corrosion resistant edge tools such as razor blades and similar thin blade or strip shaped edge tools without the above mentioned disadvantages.

A further object of the invention is to provide in a comparatively simple way and on a large scale thin flexible corrosion resistant edge tools with excellent cutting properties, including high edge sharpness and wear resistance and high hardness and without the brittleness encountered in the previous edge tools mentioned.

Still another object is to provide corrosion resistant edge tools with a Vickers hardness (500 grams load) from 700 to 880 from an unstable austenitic alloy and thus to entirely eliminate a final hardening from a high temperature.

Other and further objects will be apparent from the description which follows.

We have found through extensive investigations that thin corrosion resistant edge tools with very superior cutting properties including hardness, sharpness and edge retaining properties and also with excellent spring properties advantageously can be manufactured from unstable austenitic steel alloys, that is, steel alloys having the essential elements thereof in a predetermined balanced relation so that the alloys after quench-annealing from within the range 950° to 1200° C. are fully austenitic but when subjected to a subsequent cold working operation, e.g. cold rolling, partially transform into martensite.

According to the present invention we employ a nickel-chromium steel containing up to 0.50% carbon. The carbon content which may be as low as 0.07% is usually chosen within the range from 0.10% to 0.36%. The

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alloy conveniently in the form of a fairly thin strip or band is subjected to a quench-annealing from a temperature within the range 950° C. to 1200° C. The quench-annealing is followed by a cold working, preferably a cold rolling in a plurality of steps without intermediate annealings with a cross-sectional area reduction of the order 75% to 96% to a martensite content of at least 40%, preferably 45% to 95%, the rest being austenite. The cold worked material is finally tempered within the temperature range 350° C. to 550° C. The said tempering may be done before or after a final finishing such as an edge grinding of the tools. As no further heat treatment normally is required in the manufacture of the tools according to the invention it has thus been possible entirely to eliminate the hardening from a high temperature which was a characteristic disadvantage in connection with the corrosion resistant edge tools hitherto made. The method according to the invention has also made it possible further to reduce the thicknesses of corrosion resistant edge tools such as razor blades and still maintain the superior properties mentioned above. The thicknesses may for instance be as low as 0.02 millimeter. However, as a rule the thicknesses used lie within the range from 0.03 to 0.3 millimeter or sometimes to 0.5 millimeter.

In order to achieve the desired properties the austenitic nickel-chromium alloy steels, e.g. in the form of a strip or a band, are, subsequent to the quench-annealing cold worked, preferably by cold rolling to such an extent that a considerable or major part thereof is transformed into martensite. It has thus been found necessary to effect a cross-sectional area reduction by cold working exceeding 75% and preferably of the order 80% to 95%. The martensite content of the cold worked material must exceed 40% and normally also 45%. Preferably the martensite content shall be of the order 55% to 95%, while the rest consists of austenite. For certain very thin edge tools such as razor blades with a thickness, e.g. between 0.035 to 0.2 millimeter we have found a martensite content between 70% to 90% exceptionally advantageous.

The cold working is normally performed at room temperature or at a temperature somewhat below room temperature. Thus the cold working temperature which here is defined as the easily measured temperature of the material immediately before entering, e.g. the rolling mill may vary somewhat depending on the variations of the room temperature and does not as a rule exceed 35° C. and lies preferably within the range 15° C. to 30° C. Sometimes it may be convenient to choose a cold working temperature somewhat below room temperature, e.g. between 15° C. and -10° C. By the cold working an exceptional increase in hardness and other properties are obtained.

Subsequent to the cold working the material is tempered within the temperature range 350° C. to 550° C., preferably 400° C. to 500° C. for a time, which due to several factors such as the tempering temperature chosen and the shape and thickness of the tool to be tempered may suitably be chosen within the range from several hours up to 100 or more hours. By the tempering the hardness and other favorable properties further increase. Thus a Vickers hardness (Tukon tester with a load of 500 grams) from about 700 to 880 preferably 720 to 860 is obtained, while the maximum tensile strength for the edge tools according to the invention as a rule considerably exceeds 200 kg./mm.² and may be as high as 220-260 kg./mm.².

The rate of transformation from austenite to martensite during the cold working is dependent partly on the stability of the austenite, i.e. its greater or less tendency to transform and partly on the degree of deformation. For a certain amount of cold working the quantity of martensite formed increases with decreasing stability of the aus-

tenite. Inversely, it can be said that for a certain stability of the austenite the quantity of martensite formed is increased with the degree of cold working. Thus depending on the austenite stability and the rate of cross-sectional area reduction by cold working any desired quantity of martensite may be obtained in an unstable austenitic steel alloy. The resulting properties will depend upon the said martensite transformation.

According to the invention we use an unstable austenitic nickel-chromium steel alloy having a carbon content not exceeding 0.50% and preferably above 0.07%. The carbon content usually is chosen within the range 0.10–0.36%, e.g. about 0.15–0.30%. The carbon content should thus be comparatively low and substantially lower than that used in the corrosion resistant high chromium steel edge tools and razor blades hitherto manufactured. The nickel content in the alloy used by us for the edge tools according to the present invention may be of the order 6–10%, preferably 6–8% and the chromium content of the order 15–20%, preferably 16–18%. Besides the elements mentioned one or more further alloying elements may be added. Thus it has been found advantageous to add one or more of the elements molybdenum, manganese and silicon each preferably in amounts within the limits 0.45–1.7%. Conveniently all these elements should be present in the alloy, preferably within the following limits: 0.45–1.2% molybdenum, 0.7–1.7% manganese and 0.7–1.7% silicon. Also other elements such as tungsten, columbium, tantalum, titanium, vanadium, aluminum, copper and cobalt may be present in relatively small amounts all together preferably not exceeding 2%, the balance being iron with the usual impurities.

Particularly suitable for the purpose of the invention are alloys within the following limits: 0.10–0.36% carbon, 6–8%, preferably 6–7%, nickel, 16–18% chromium, 0–1.2% molybdenum, 0–1.7% manganese, 0–1.7% silicon, 0–1% of one or more of the elements cobalt, copper, aluminum, tungsten, titanium, vanadium, columbium and tantalum the balance being iron with usual impurities. A preferred range of analysis for steels of this type is: 0.10–0.30% carbon, 5.1–6.9% nickel, 16–18% chromium, 0.45–1.2% molybdenum, 0.7–1.7% manganese, 0.7–1.7% silicon and the balance substantially all iron with usual impurities.

By the cold working which as previously mentioned conveniently is performed as a cold rolling operation in several steps without any intermediate annealing blanks or strips with the desired thickness, e.g. 0.05–0.15 millimeter are obtained. These blanks or strips may prior or subsequent to the tempering following the cold working be cut and/or stamped to the shape intended for the edge tools or razor blades and may finally be provided with the cutting edge or cutting edges desired. The shaping of the cutting edges along one or more of the edges of the thin tool blank or strip may be done in any suitable way such as mechanical grinding, electrolytic grinding or electroerosive or spark cutting.

According to an embodiment of the present invention the cold working, e.g. cold rolling is performed in such a way that the cross-sectional area reduction along at least one of the edges of the material to be reduced will be considerably larger than along the main body of the said material. This may be achieved by shaping in a convenient way the rolls of the cold rolling mill to be used. Thus the rolls may at their circumferential surfaces be shaped with elevated wedge shaped portions which provide the larger reduction along the edge or edges of the material. In such a mill the higher reduction along the edge or edges of the material will result in an edge tool or edge tool blank having a larger amount of martensite within the edge portion or portions than in the main body. This means that the edge tool will have a higher hardness and a higher ultimate strength along the said edge or edges and that the hardness increases in the direction of the thinnest part of the more or less wedge-formed edge or edges,

which often may be very important in this kind of thin edge tools such as razor blades. Also in edge tools of the above type it is usually necessary to shape the cutting edge or edges by a final finishing operation.

The following specific example is intended as an illustration of the invention, but not as a limitation upon the scope thereof:

A steel strip of an alloy comprising 0.15–0.25% carbon, 6.1–6.9% nickel, 16.2–17.8% chromium, 0.50–1.2% molybdenum, 0.8–1.6% manganese, 0.7–1.6% silicon and the balance substantially all iron with usual impurities was heated to a temperature within the interval 1000–1200° C. with subsequent rapid cooling in air, water or oil. The strip was then cold-rolled at room temperature in a plurality of steps without any intermediate annealing with a cross-sectional area reduction within the range 85–95% to a martensite content of 75–90%. The strip thus cold rolled was tempered at a temperature within the range 375° C.–500° C. for at least 3 hours. Finally the strip was cut and/or stamped to the desired form and the cutting edge or edges shaped by grinding or any other conventional method. The edge tool obtained which was cold rolled to a thickness of between 0.05–0.15 millimeter had a Vickers hardness number (500 grams load) above 720 and about 800.

We claim:

1. The method of making a thin flexible corrosion resistant edge tool having excellent cutting properties and a Vickers hardness (500 grams load) from 700 to 880, comprising quench-annealing an unstable austenitic nickel-chromium steel alloy containing up to 0.50% carbon from a temperature within the range 950° C. to 1200° C., said alloy remaining fully austenitic after said quench-annealing, cold working said quench-annealed alloy in a plurality of steps without intermediate annealing with a cross-sectional area reduction within the range 75% to 96% to a thickness of from 0.05 to 0.15 mm. and a martensite content of at least 70% the rest being austenite, and tempering the resulting cold worked alloy within the temperature range 350° C. to 550° C. said alloy containing 0.10–0.36% carbon, 6–8% nickel, 16–18% chromium, 0–1.2% molybdenum, 0–1.7% manganese, 0–1.7% silicon, 0–1% of at least one element selected from the group consisting of cobalt, copper, aluminum, tungsten, titanium, vanadium, columbium and tantalum, the balance being iron with the usual impurities.

2. The method of making edge tools as claimed in claim 1 in which the alloy is cold worked to a reduction in cross-sectional area within 80% to 95%.

3. The method of making edge tools as claimed in claim 1 in which the alloy is cold worked to a martensite content of 70% to 95%.

4. The method of making edge tools as claimed in claim 1 in which the said austenitic alloy contains 0.07–0.50% carbon.

5. The method of making steel tools as claimed in claim 1 in which the said austenitic alloy contains 6.0–10% nickel, 15–20% chromium and at least one of the elements molybdenum, manganese and silicon each within the range 0.45–1.7%.

6. The method of making edge tools as claimed in claim 1, in which a quench-annealed band of the said austenitic steel alloy is cold rolled to a reduction in cross-sectional area within 85% to 95%.

7. The method of making edge tools as claimed in claim 1 in which a quench-annealed strip of the said austenitic steel alloy is cold rolled to a thickness from 0.02 to 0.5 millimeter.

8. The method of making edge tools as claimed in claim 1 in which a quench-annealed strip of the said austenitic steel alloy is cold worked with a higher cross-sectional area reduction along at least one of the edges of the strip.

9. The method of making a corrosion resistant strip edge tool with a thickness from 0.03 to 0.3 millimeter and having excellent cutting properties and flexibility includ-

ing a Vickers hardness (500 grams load) from 700 to 880, comprising quench-annealing an unstable austenitic nickel-chromium steel alloy containing 0.07 to 0.50 carbon from a temperature within the range 950° C. to 1200° C. said alloy remaining fully austenitic after said quench-annealing, cold working said quench-annealed alloy in a plurality of steps without intermediate annealing with a cross-sectional area reduction within the range 80% to 95% to a thickness of from 0.05 to 0.15 mm. and a martensite content of 70% to 95% the rest being austenite, and tempering the resulting cold worked alloy within the temperature range 350° C. to 550° C. said alloy containing 0.10-0.36% carbon, 6-8% nickel, 16-18% chromium, 0-1.2% molybdenum, 0-1.7% manganese, 0-1.7% silicon, 0-1% of at least one element selected from the group consisting of cobalt, copper, aluminum, tungsten, titanium, vanadium, columbium and tantalum, the balance being iron with the usual impurities.

10. The method of making a corrosion resistant razor blade with a thickness from 0.035 to 0.2 millimeter and having excellent cutting properties and flexibility including a Vickers hardness (500 grams load) from 700 to 880 comprising quench-annealing a strip of an unstable austenitic nickel-chromium steel alloy containing 0.10-0.36% carbon from a temperature within the range 950° C. to 1200° C., said alloy remaining fully austenitic after said quench-annealing, cold rolling said quench-annealed austenitic steel alloy strip in a plurality of steps without intermediate annealing with a cross-sectional area reduction within the range 85% to 95% to a thickness of from 0.035 to 0.2 mm. and a martensite content of 70% to 90% the rest being austenite, and tempering the cold worked strip material within the temperature range 350° C. to 550° C., said alloy containing 0.10-0.36% carbon, 6-8% nickel, 16-18% chromium, 0-1.2% molybdenum, 0-1.7% manganese, 0-1.7% silicon, 0-1% of at least one

element selected from the group consisting of cobalt, copper, aluminum, tungsten, titanium, vanadium, columbium and tantalum, the balance being iron with the usual impurities.

11. The method of making corrosion resistant razor blades with a thickness from 0.03 to 0.3 millimeter and having excellent cutting properties and flexibility including a Vickers hardness (500 grams load) from 700 to 880, comprising quench-annealing from a temperature within the range from 950° C. to 1200° C. a strip of an unstable austenitic steel alloy containing 0.10-0.36% carbon, 6.0-8% nickel, 16-18% chromium, 0.45-1.2% molybdenum, 0.7-1.7% manganese, 0.7-1.7% silicon and a rest substantially all iron, said alloy remaining fully austenitic after said quench-annealing, cold rolling said quench-annealed austenitic steel alloy strip in a plurality of steps without intermediate annealing with a cross-sectional area reduction within the range 80% to 95% to a thickness of from 0.03 to 0.3 mm. and a martensite content of 70% to 95% the rest being austenite, and tempering the resulting cold worked strip material within the temperature range 350° C. to 550° C.

12. A corrosion resistant thin edge tool with excellent cutting properties and a Vickers hardness (500 grams load) from 700 to 880 made by the method defined in claim 1.

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