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[54] **PROCESSES FOR PRODUCING NOVEL STEELS**

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[52] **U.S. Cl.** **148/12.3,** 148/31

[51] **Int. Cl.**..... **C21d 1/78,** C22c 39/30, C22c 39/32

[58] **Field of Search**...... 75/123 N, 126 B; 148/12.3, 148/31

[56] **References Cited**

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[57] **ABSTRACT**

This application is concerned with processes for producing novel steel which, in its finished form, is at least 80 percent austenitic and in preferred embodiments is substantially fully austenitic, but yet has at least the hardness and strength of high carbon martensitic steels. The hardness of the steel plus its temper-resistance (due to the fact that it is austenitic) makes it especially useful for making cutting edges, e.g., knives and especially razor blades having improved temper-resistance. The steel is made by (*a*) heating a steel comprising from about 7 to about 30 percent manganese and about 0.6 to about 1.4 percent carbon to at least the austenizing temperature to make it fully austenitic and to dissolve sufficient carbides so as to depress the Ms temperature sufficiently below room temperature that the steel will remain mainly in the austenitic form, e.g., at least 80 percent austenitic, when it is both cooled, preferably by quenching, to room temperature and subsequently coldworked; (*b*) cold-working the steel and (*c*) thereafter age-hardening the steel. In a preferred process for making razor blades from such steels, the cutting edge is formed between the cold-working step and the ageing step.

11 Claims, No Drawings

PROCESSES FOR PRODUCING NOVEL STEELS

The present application is a continuation-in-part of U.S. application Ser. No. 194,166, filed Nov. 1, 1971, which is now U.S. Pat. No. 3,756,865.

SUMMARY OF THE INVENTION

In recent years, the shaving properties of razor blades have been substantially enhanced by the application to the cutting edge of polymeric coatings such as the fluorocarbons disclosed in U.S. Pat. No. 3,071,856 to Irwin W. Fischbein. In applying such fluorocarbon coatings and especially the higher molecular weight polymers and telomers to blade edges, it is necessary to sinter the coatings at elevated temperatures, e.g., 288° to 427°C. Such temperatures have a softening effect on both carbon and stainless steels which adversely affect their shaving properties. The stainless steels, although softer, were better able to withstand the sintering temperatures than the carbon steels and most of the first commercial applications of such coatings were on the former. Despite the softening of the steels, the fluorocarbon coatings will provide a substantial improvement in shaving comfort and ease. As can be appreciated, the benefit of such coatings would be even more fully realized if they could be applied to blades which initially had at least the hardness of carbon steels and which had substantially better temper-resistance.

One object of the present invention is to provide processes for making novel steel, which in its finished form, is mainly, austenitic, e.g., at least 80 percent (with the accompanying good temper-resistance) but which has hardnesses and strength which are at least comparable of those of high carbon martensitic steel.

Another object is to provide new and improved cutting edges such as knives and scalpels and especially razor blades comprising said steel.

Other objects should be obvious from the following description and claims.

In general, the above objects are achieved by (*a*) heating a steel comprising carbon and manganese in the ranges specified below to at least the austenizing temperature for a sufficient time to make it fully austenitic and to dissolve sufficient carbides so as to depress the Ms temperature sufficiently below room temperature that the steel will remain mainly in the austenitic form when it is both cooled to room temperature, preferably by quenching, and subsequently cold-worked; (*b*) cold-working the steel and (*c*) thereafter age-hardening the steel. In a preferred mode of making razor blades, the cutting edge is formed, e.g., by grinding between the cold-working step and the age hardening step.

Generally, the blades of the present invention are made from steels which comprise by weight about 0.6 to about 1.4 percent carbon, about 7 to 30 percent manganese and the balance iron or iron and other alloying elements which will enhance the properties of the steel but not interfere with the processes. In preferred embodiments, the steels may contain one or more alloying elements which are known to decrease the stacking fault energy of the steel. As examples of such elements (and the range in which they may usually be present), mention may be made of the following:

	Chromium	0 to 16%
	Cobalt	0 to 10%
	Silicon	0 to 2%
	Aluminum	0 to 6%
and	Copper	0 to 2%

When desired, the steel may include other alloying elements which will increase the hardenability of the steel and thus enable one to cool the steel gradually rather than by quenching and still retain the desired austenitic structure. As examples of such alloying elements, mention may be made of chromium and copper set forth above, and the following:

	Molybdenum	0 to 2%
	Nickel	0 to 5%
and	Tungsten	0 to 1%

In preferred embodiments, the steel will contain sufficient chromium so as to render it stainless. Usually this can be accomplished by incorporating at least 10 percent chromium into the composition. In the embodiments which will be the most commercially feasible, usually the steel will contain between about 10 to 20 percent chromium. When appreciable amounts of chromium are added such as set forth above to enhance the corrosion-resistance of the steel, larger amounts of manganese should be present in order to offset the carbide-forming propensity of the chromium. In steels containing, for example, 10 to 20 percent chromium, it will usually be advisable to have about 15 to 30 percent manganese present. In steels containing 10 to 16 percent chromium, it will be generally advisable to have about 15 to 25 percent. In steels which include less than 2 percent chromium, the manganese will preferably be present in amounts ranging between about 7 to 14 percent. As an example of a steel which has been found especially useful in the processes of this invention, mention may be made of one containing 1.0 percent carbon, 14 percent chromium, 21 percent manganese and the balance iron with the small amounts of impurities normally found therein. Another steel which was found useful in the processes of the invention contained 1.01 percent carbon, 12.3 percent manganese and the balance iron with the small amounts of impurities normally found therein.

In carrying out the processes of the present invention, the steel is heated to at least the austenizing temperature, for a sufficient time, to make it fully austenitic and to dissolve sufficient carbides so as to depress the Ms temperature sufficiently below room temperature that the steel will remain mainly austenitic, e.g., at least 80 percent, when it is both cooled, preferably by quenching, and subsequently cold-worked. In preferred embodiments, the steel is so heat treated that the Ms temperature will be at least below −150°C and preferably below −200°C. Generally, for most steels within the scope of this disclosure, the Ms temperature can be sufficiently depressed by heating the steel to a temperature between about 1,000° and 1,250°C and holding it there for periods from at least 1 minute to 1 hour; with the longer times being used for the lower temperatures. In preferred embodiments, the steel is heated to a temperature between 1,050° to 1,250°C. Particularly useful results were obtained by heating the steel to a temperature of 1,050°C and holding it there for about ½ hour.

The cold-working step, which imparts a substantial increase in hardness to the steel, may be carried out by any of the well-known methods, e.g., rolling, stamping, pressing, drawing, etc. Further when the processes disclosed herein are used in making cutting edges such as razor blades at least a portion of the cold-working may be accomplished in the grinding operation which is used in forming the cutting edge. In preferred embodiments, the cold-working is carried out by cold-rolling. Generally the extent to which the steel can be cold-worked without being converted to martensite will depend upon the Ms temperature. Usually the lower the Ms temperature, the more the steel can be cold-worked without being appreciably converted to the martensitic form. It is generally desirable that the steel subsequent to cold-working contain less than 20 percent martensite and preferably less than 10 percent. In especially preferred embodiments, the steel is substantially fully austenitic subsequent to the cold-working step. Generally with a steel whose Ms temperature has been sufficiently depressed, e.g., to at least below −200°C substantial increases in the hardness can be achieved by cold-working the steel until there has been a reduction in thickness of at least 50 percent. Usually the maximum hardness which can be obtained in the cold-working step will generally be achieved by cold-working the steel until there has been a reduction in thickness of at least between about 70 and 96 percent. It is to be understood that reductions beyond this extent may be made, but generally they will not result in additional hardening. Preferably the cold working will be carried out under ambient conditions. However if desired it may be performed at temperatures below ambient temperature, e.g., down to that of liquid nitrogen or at elevated temperatures, e.g., up to 375°C.

In using the processes of the present invention for producing cutting edges such as razor blades, the cold-working which is necessary to provide the maximum hardness which is obtainable in this step may be provided at least in part by the grinding step which is normally employed in forming the cutting edge. Thus, if desired, one may, for example, partially harden the strip by, for example, cold-rolling; carry out any desired stamping or perforation steps and then complete the cold-working step at least in the edge area by the grinding operation. Of course, it will be understood that when desired, substantially all the cold-working may be carried out, for example, by cold-rolling and the grinding step would contribute little additional hardening. In such event, if desired electrosharpening methods could be employed in forming the cutting edge. In preferred modes of making razor blades, the edge is formed prior to the age-hardening step when the steel is not as hard. It should be understood, however, that, when desired, the cutting edge may be

formed subsequent to the age-hardening step but the steel will be appreciably harder. Generally, the methods which may be employed for forming the cutting edge are well-known to the art and the specifics thereof form no part of this invention.

The age-hardening step, which is carried out subsequent to the cold-working step is a time, temperature dependent reaction in which a further substantial increase in hardness is achieved. Generally, the optimum hardnesses will be achieved by heating the steel at a temperature between about 200° and 500°C for periods, for example, of at least from about 10 seconds to 10 days. As will be appreciated, the shorter times will be applicable to the higher temperatures and the longer times to the lower temperatures. Further with steels that are essentially iron, manganese and carbon alloys, the age-hardening step should be preferably carried out at temperatures below 425°C. In carrying out the age-hardening step, excessively high temperatures for extended periods should be avoided in order to prevent over-ageing. With the steel containing 1.01 percent carbon, 12.3 percent manganese and the balance iron, optimum hardness was achieved by heating it for about 3½ hours at 350°C. With the steel containing 1 percent carbon, 14 percent chromium and 21 percent manganese, optimum hardness was achieved by heating it at 350°C for 3 hours.

The following non-limiting examples illustrate the processes of the present invention as it relates to the preparation of a razor blade.

Example 1

A strip of steel containing 1.00 percent carbon, 21 percent manganese, 14 percent chromium and the balance iron and the usual trace impurities found therein, was made fully austenitic by heating it at 1,200°C for ½ hour and thereafter cooling it rapidly in water. The strip which had a hardness of 220 DPHN was cold-rolled to a thickness of four thousandths of an inch with a reduction of 96 percent in the thickness of the steel. The hardness was 740 DPHN and the strip was still substantially fully austenitic. The strip was then sharpened to produce an edge through conventional razor blade sharpening techniques. Subsequent to sharpening, the blade was heated to 350°C for 3 hours and the body hardness rose to 885 DPHN and was still substantially fully austenitic. A polytetrafluoroethylene telomer coating was applied to the cutting edge and it was cured thereon at 343°C for 10 minutes. The following table illustrates the temper-resistance of the blades of the present invention during the polytetrafluoroethylene sintering step as compared with typical carbon and stainless steel blades.

Blade	Body Hardness Before Sintering	Sintering Temperature & Duration of Sintering	Body Hardness After Sintering
Blades of Example 1	885 DPHN	343°C — 10 min.	885 DPHN
Carbon Steel Blades	825 to 880 DPHN	343°C — 10 min.	510–560 DPHN
Stainless Steel Blades	750 DPHN	343°C — 10 min.	580–595 DPHN

Example 2

A steel strip containing 1.01 percent carbon, 12.3

percent manganese and the balance iron and the usual trace impurities found therein, was made fully austenitic by heating it at 1,050°C for ½ hour and thereafter quenching it to room temperature in water. The strip which had a hardness of 200 DPHN was cold-rolled to a thickness of four thousandths of an inch with a reduction of 95 percent in the thickness of the steel. The hardness was 750 DPHN and the strip was still substantially fully austenitic. The strip was then sharpened to produce an edge through conventional razor blade sharpening techniques. Subsequent to sharpening, the blade was heated to 350°C for about 3½ hours and the body hardness rose to 850 DPHN and was still substantially fully austenitic. A polytetrafluoroethylene telomer coating was applied to the cutting edge and it was cured thereon at 343°C for 10 minutes. Subsequent to the cure, the blade had a body hardness of 850 DPHN which is substantially better than that of the typical carbon or stainless blades set forth in Example 1.

Example 3

Blades were prepared by a process similar to that of Example 2 except that the age-hardening step was carried out at 400°C for 15 minutes. The results were comparable to those of Example 2.

It should be understood that when desired the age-hardening and polymer sintering step can be carried out simultaneously.

The steels of this invention due to their austenitic nature are generally non-magnetic and also have good low-temperature ductility. Accordingly, in addition to being useful for making cutting edges such as razor blades, they are also useful for other purposes in which one or more of their useful properties is desired, e.g., springs, cryogenic hardware, high-strength wire and cable, and any other end uses where their good temper-resistance may be useful.

Having thus described my invention what is claimed is:

1. A process for making steel which in its finished form is mainly austenitic, has hardnesses which are at least comparable to high carbon martensitic steel, and has improved temper-resistance, said process comprising (*a*) heating a steel comprising from about 7 to 30 percent manganese and 0.6 to about 1.4 percent carbon to at least the austenitizing temperature for a sufficient time to make it fully austenitic and to dissolve sufficient carbides so as to depress the Ms temperature of said steel sufficiently below room temperature that the steel will remain mainly in the austenitic form when it is both cooled to room temperature and subsequently cold-worked; (*b*) cold-working said steel and thereafter (*c*) age-hardening said steel.

2. A process as defined in claim 1 wherein the steel is quenched to room temperature subsequent to the austenitizing step.

3. A process as defined in claim 1 wherein said steel is austenitized at a temperature of 1,000° to 1,250°C for a period of 1 minute to 1 hour.

4. A process as defined in claim 1 wherein said age-hardening step is carried out at a temperature between about 200°C to 500°C for a period of at least about 10 seconds to 10 days.

5. A process as defined in claim 1 wherein said steel in its finished form is at least 80 percent austenitic and wherein in the initial heating step said steel is heated to a temperature between 1,000° to 1,250°C for a period of at least 1 minute to 1 hour and wherein said ageing step is carried out at a temperature between about 200° to 500°C for periods of at least from about 10 seconds to 10 days.

6. A process as defined in claim 1 wherein said steel is cold-worked until there has been a reduction in thickness of at least about 50 percent.

7. A process as defined in claim 1 in which said steel includes at least one alloying element which reduces the stacking fault energy of said steel.

8. A process as defined in claim 1 wherein said steel contains less than 2 percent chromium and between 7 to 14 percent manganese.

9. A process as defined in claim 1 wherein said steel includes 10 to 20 percent chromium and from 15 to 30 percent manganese.

10. A process as defined in claim 1 wherein said steel includes 10 to 16 percent chromium and from 15 to 25 percent manganese.

11. A process as defined in claim 1 wherein said steel in its finished form is substantially fully austenitic.

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