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3,508,978

PROCESS FOR MANUFACTURING SKI EDGES WITH L-SHAPED CROSS SECTION

Filed March 23, 1967



FIG. 1

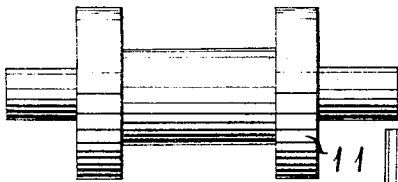


FIG. 2

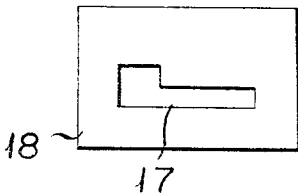
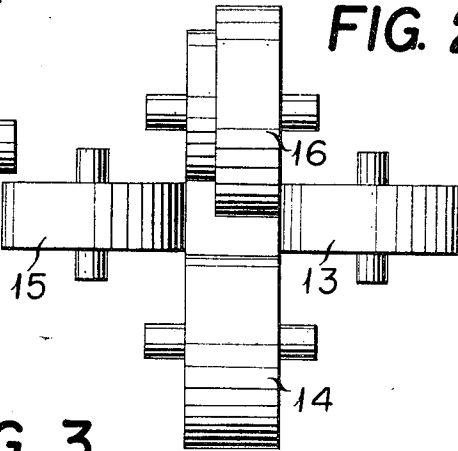


FIG. 3

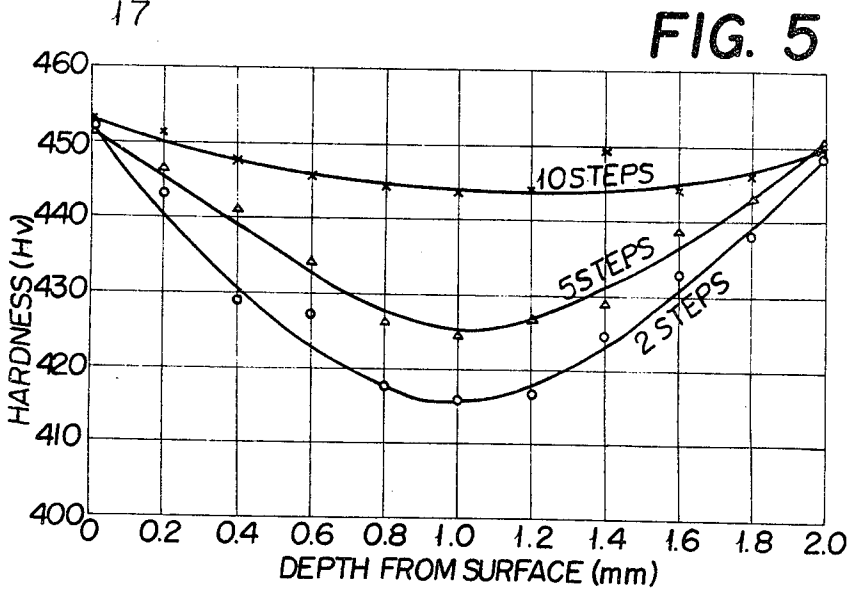


FIG. 5

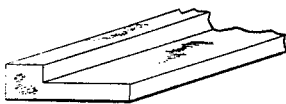


FIG. 4

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8 Claims

ABSTRACT OF THE DISCLOSURE

A method for manufacturing a ski edge of an L-shaped cross-section comprises a first stage for making a soft intermediate product having an L-shaped cross-section and a second stage for making a hard final product of a ski edge having an L-shaped cross section, the thicker portion being thinned by a greater rate of thickness reduction than the rate of thickness reduction at thinner portion from the intermediate product. The first stage consists of several steps of cold drawing and annealing, and the second stage consists of few steps of cold drawing and heat-hardening, the cold drawing being carried out with a tension greater than the yield stress applied lengthwise to the material. The surface of the thicker portion is hardest of the product.

BACKGROUND OF THE INVENTION

This invention relates to a process for manufacturing a metal edge to be fitted lengthwise on the running surface of a ski at the both side ends. More particularly it relates to an edge with an L-shaped cross section, in which the portion constituting a part of the running surface of the ski has higher surface hardness and the portion to be worked particularly for fitting to the ski body has lower hardness.

It is known that there are two methods for obtaining an edge member with an L-shaped cross section. One consists in cutting rod or board materials of suitable metal to the desired cross sectional configuration. However, it is difficult to cut to the desired configuration any metal material which is sufficiently hard to maintain the high performance of a ski and which has been subjected to proper heat treatment in advance so as to provide such high fatigue limits as are demanded of a one piece edge for high grade skis, which undergoes in use alternating tensile and compression stresses resulting from bending. The hardness of metal material permitting efficient cutting with the present techniques and cutting machine is limited to 350 in Vickers hardness number (H_v). The edge having lower hardness value than this level does not meet the aforesaid requirements. And moreover, materials such, for example, an austenitic stainless steel are excluded from use owing to poor machinability in spite of their excellent corrosion resistance which is one of the important properties required of the ski edge.

Materials capable of increasing hardness by heat treatment after cutting to the desired cross section would provide edges having sufficient hardness for use in skis. Where heat treatment to increase hardness such as quenching and tempering is carried out to elongated materials with an L-shaped cross section, the material may have warps or twists due to strains being produced in the interior structure. Decarburization would also occur with the resultant reduction in fatigue strength.

Further major disadvantages occasioned by the aforesaid cutting are that the cut edge surface will be marred

with fine scars, which will in turn exert a notch effect on the vibrations of a ski while it is running, and thereby quicken the time of breakage due to fatigue of the edge.

The other method for obtaining a ski edge with an L-shaped cross section comprises welding two pieces of metal material together, each of which has previously been formed into a board having a rectangular cross section of the desired size, in such a manner that the assembly has an L-shaped cross section. This method permits the use of high hardness material for that portion of said assembly which has a surface exposed to the running surface of the ski and lower hardness material for that portion fitted to the ski body, for example, a member provided with bolt holes. Therefore this method eliminates the problems encountered in the first mentioned method. However, heat released in welding will cause the softening of high hardness material, and the resultant nonuniformity of local hardnesses will reduce fatigue strength. Furthermore, since weldable materials are similarly subject to certain limitations, it is impossible to select the desired type of material merely from the standpoint of hardness. For example, austenitic stainless steel can not be used in the manufacture of a ski edge due to difficulty of welding, although it has appreciable hardness and excellent corrosion resistance.

SUMMARY OF THE INVENTION

This invention provides a process for manufacturing a ski edge bearing an L-shaped cross section with the thicker section possessed of higher hardness and the thinner section of lower hardness, which comprises the steps of working an elongated metal material for plastic deformation under tension applied lengthwise in such a manner that the product has an L-shaped cross section, in which one side crosswise is thicker than the other, and the steps of further cold plastic deforming the material thus prepared similarly under tension applied lengthwise and at a higher rate of deformation for the thicker section and at a lower rate thereof for the thinner section.

The novel method enables edge material to be formed into the desired shape by stretching or drawing. Consequently it is free from the question of whether the material to be used is ready for cutting or welding. Since the material is worked at a greater amount of reduction in thickness for the thicker section and at a less reduction in thickness for the thinner section, it is possible to obtain a ski edge in which the thicker section, namely, one exposed to the running surface of the ski, is of higher hardness and the thinner section to be worked particularly for fitting to the ski body is of lower hardness.

An object of this invention is to provide a process for manufacturing a ski edge with an L-shaped cross section, in which the face of one portion exposed to the running surface of a ski is of sufficient hardness as a ski edge and the other portion has only such degree of hardness as will facilitate work required in fitting the edge to the ski body.

Another object of this invention is to provide a process for manufacturing a ski edge which has a level and smooth surface and is thereby given a sufficiently high fatigue strength to withstand the alternating bending stress and the alternating tensile and compression stresses transmitted to the edge by vibrations of the ski.

A further object of this invention is to provide a manufacturing method which permits the use of all available materials of suitable properties as a ski edge.

BRIEF DESCRIPTION OF THE DRAWING

FIGS. 1 and 2 are plan views of roller dies to be used in carrying out the process according to this invention;

FIG. 3 is a plan view of a die used in accordance with this invention;

FIG. 4 is a perspective view of the ski edge obtained in an example embodying this invention; and

FIG. 5 shows curves of the relations of hardness and depth from surface of the thicker section of the edge obtained in another example embodying this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the process of the present invention, elongated metal material with a circular or rectangular cross section is, at first, worked by rolling or drawing under tension applied lengthwise into a configuration with an L-shaped cross section, one side of which is thicker than the other. The tension applied to the material is of sufficient magnitude for plastic deformation, namely, in excess of the yield point of said material under stretching stress. Thus in this preliminarily working the material into a configuration with the aforesaid L-shaped cross section, the thicker part is deformed by stretching mainly arising from tension, and the thinner part is deformed by both tension and roller or die compression. In passing through the roller or die, part of the material constituting the thinner section is carried into the thicker section.

The rod material prepared by the primary fabrication is as a whole thicker than the desired ski edge. The ratio of the thicker to thinner sections should be now selected in such a manner that it exceeds that of the edge to be finally produced. For instance, when the thicker section of the final edge is desired to be 2 mm. thick and the thinner section 0.8 mm. thick (the ratio being 2.5 to 1), the thinner section (to be reduced 30 percent in thickness later) of the preliminarily fabricated edge should preferably be 1.14 mm. thick, and the thicker section (to be reduced 40 percent in thickness later) should be 3.33 mm. thick, the ratio now being 2.92 to 1. When the preliminarily worked material is finally formed into the product edge, the thicker section is reduced 10 percent more than the thinner section. This difference between the reductions in the thickness accounts for the difference in hardnesses of the thicker and thinner sections as discussed later.

The rate at which the original material can be deformed in the primary fabrication varies with its nature. Generally speaking, however, the upper limit for the deformation rate would be about 80 percent on the basis of the elongation rate of the material in the annealed state. Therefore, when the deformation rate reaches this upper limit, working should be stopped and started again after the material is annealed to reduce the hardness thereof. If work requiring a deformation rate higher than the aforesaid upper limit is continued, the deformation balance would be lost, resulting in the occurrence of wave formations on the thinner section and cracks in the sections which have changed in thickness. As a result, it is preferable to deform rod materials in several steps. This will gradually bring the circular or rectangular cross section of the material closer to the L-shape. The rod which has been preliminarily worked to have an L-shaped cross section of the desired dimensions is then annealed for softening and next cold worked by rolling or drawing under tension greater than the yield stress of the material used so as to obtain an edge of the desired size. The conditions of said cold working including size of roller or die, amount of reduction in thickness of material, magnitude of and difference between tensions applied before and after the roller or die and magnitude of friction resistance of material when passing through the roller or die should be selected with the precautions taken in general rolling or drawing, in order to prevent the occurrence of cracks or warps in the material.

The cold working should be therefore conducted in a plurality of steps, in order to prevent cracks or warps.

And on the other hand, it is necessary to carry out the

cold working under the condition in which the thicker and the thinner sections of the material are reduced at different rates in each step, namely, said rate being always greater for the former than for the latter, in order to obtain the difference in hardness, namely, the thicker section being harder than the thinner section. The hardness of the edge produced by the cold working is highest on the surface and decreases progressively toward the interior. But as the number of working steps increases the range of difference between the surface and interior hardnesses is narrowed with the hardness increasing closer to the surface. Therefore in this invention, the cold working is carried out preferably in 2 to 5 steps. When the cold working is performed in six or more steps, the hardness of all parts of the material becomes almost uniform, the interior becoming hard.

Then less prominent would become the effect of above mentioned improvement that the thinner section of the edge be less hard so as to be punched or drilled easily.

The phenomenon where such different hardnesses arise is generally observed when metals are rolled at a great amount of reduction per working step. This may be ascribed to the fact that when pressure is applied in the direction of thickness, metal materials present different aspects of deformation between the surface and the core due to different fluidities of the interior structure. Increase in the number of working steps represents decrease in the amount of reduction per step. This will probably cause the difference of deformation fluidities between the surface and center of metal materials to be lessened, with the resultant decrease of difference in hardness between these two sections. Consequently, if the total amount of reduction is the same, a single step fabrication of edge material to the desired shape and size would result in a maximum difference of hardness between the surface and core, so as to enable the thinner section of the material to have better punching characteristics. In this case, however, the material is often worked at the amount of reduction beyond it work limits, so that the edge thus produced will present cracks or wave formations.

The amount of reduction achieved by cold working should be limited in a range between 30 and 60 percent for the thicker section and between 10 and 35 percent for the thinner section, and in any case, the thicker section should be reduced, for example, 10 or more percent more than for the thinner section. With almost all materials to be used in ski edges, reduction within the aforesaid ranges will enable the thicker and thinner sections to be worked into the desired configuration by both stretching and compression for the former and mainly by stretching for the latter. In the edge thus obtained, the surface of the thicker section, namely, one exposed to the running surface of a ski, is sufficiently hard, while the thinner section, i.e., one which is worked particularly for fitting to the ski body, is only hard enough to permit secondary work, such as punching, drilling or counter sinking. With this type of edge, it is also easy to bend part or the whole of it in the longitudinal direction so as to match the ski curvature.

The amount of reduction by cold working may be selected suitably according to the nature of the material being used. For instance, with metal materials capable of being hardened by low temperature annealing such as austenitic stainless steel, heat treatment after primary fabrication does not bring about appreciable increase in hardness. Consequently it is necessary to select such size of the material after primary work as will assure a great amount of reduction and to carry out further work in such a manner that after cold working, the material is already possessed of sufficient or approximately sufficient hardness as a ski edge. In the case of precipitation hardenable materials such as some types of semi-austenitic stainless steel, heat treatment after cold working results in considerably increased hardness, so that cold working may be performed at a relatively small amount of reduction.

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Cold working is carried out by rolling or drawing. The rolling device suitable for rolling may comprise, as illustrated in FIG. 1, a combination of a female roller 11 having a flat-bottom depression in the center and a male roll 12 which is provided with a stepped section so as to assure fitting into said depression. A roller die is shown in FIG. 2 which comprises a combination of three flat rollers 13, 14 and 15 arranged in such a manner that the axes are at right angles to each other and a stepped roller 16 installed in parallel to the roller 14.

Where a mold die 18 as illustrated in FIG. 3 is used which has the desired shape, size and L-shaped cross sectional opening 17 and the material to be cold worked is forced through said opening 17, the material can also be worked to have the desired L-shaped cross section. Furthermore, the size of the opening of aforementioned rolling device or roller die or mold die may be selected so as to assure the thickness reduction as previously described.

After cold working and secondary working required for fitting the edges to the ski body, the material may be subjected to heat treatment for further hardening. While the conditions for heat treatment should be selected suitably according to the thermal properties of the material being used, details of said heat treatment techniques are probably clear to one skilled in the art.

Even where heat treatment is not required for hardening, it is advisable to carry out such treatment as to eliminate warps or strains caused in the interior of materials by cold working or secondary working.

The process of this invention enables a ski edge with an L-shaped cross section to be manufactured without cutting or welding in the course of changing the cross section to the desired form. This means that the process of the present invention is not disturbed in the selection of materials by such factors as machinability or weldability. Therefore the present invention has made possible the employment of such materials as have previously been excluded from use due to poor machinability or weldability, although they had good properties as ski edge material. Furthermore, elimination of cutting is useful in improving the smoothness of an edge particularly in the longitudinal direction. Thus the one piece edge fitted to a high grade ski is saved from possible causes of breakage resulting from vibrations of the ski.

The process of this invention will be understood more clearly with reference to the examples which follow. It should be noted, however, that these examples are given only for illustrative purposes and that this invention is not limited by them in any way. It will also be noted that the term AISI and the number attached thereto to indicate the type of stainless steel used in the examples herein contained are given as provided in the specifications of the American Iron and Steel Institute.

Example 1

The material used was a round rod 6 mm. in diameter and subjected to solution treatment which consisted of AISI 304 austenitic stainless steel, one of the low temperature annealing hardenable alloys. The rod was initially worked into a configuration with a rectangular cross section by being passed through a roller die having an opening size of 4.5 mm. x 7.0 mm. under lengthwise tension applied by setting the roller front tension at 1200 kg. and the back tension at 500 kg. Then the material was further worked in three steps under the conditions indicated in Table I below.

TABLE I.—WORKING CONDITIONS

	Width (mm.)	Height of thicker section (mm.)	Width of thicker section (mm.)	Height of thinner section (mm.)	Front tension (kg.)	Back tension (kg.)
1st step-----	7.0	4.5	2.4	3.0	1,100	500
2nd step-----	7.0	4.2	2.3	2.0	1,000	450
3rd step-----	7.0	4.0	2.2	1.23	1,000	450

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The material which had been worked in the three steps was maintained at a temperature of 1060° C. for 5 minutes and then subjected to solution treatment by water cooling. It was pickled with an aqueous solution containing 20 percent nitric acid and 2 percent hydrofluoric acid. It was cold worked in three steps under the conditions shown in Table II below until it was formed into the desired edge size.

TABLE II.—COLD WORKING CONDITIONS

	Width (mm.)	Height of thicker section (mm.)	Width of thicker section (mm.)	Height of thinner section (mm.)	Front tension (kg.)	Back tension (kg.)
1st step-----	7.0	3.0	2.1	1.0	550	200
2nd step-----	7.0	2.5	2.0	0.9	700	300
3rd step-----	7.0	2.0	2.0	0.8	800	300

The cold worked edge material had an L-shaped cross section as illustrated in FIG. 4, and indicated a hardness of 450 (Vickers hardness number H_V) at the surface and 420 at the core of the thicker section, and 350 at the surface and 330 at the core of the thinner section.

The thinner section of said edge material was provided with bolt holes for fitting to the ski body, and was entirely bent to match the ski body curvature. It was maintained at a temperature of 415° C. for 2 hours and hardened by low temperature annealing. Hardness (H_V) after hardening treatment was 500 at the surface of the thicker section.

Since AISI 301 stainless steel, the same type as AISI 304, presents a high degree of hardening by cold working, it is desirable to work the former in the same manner as described above. On the other hand, materials such as carbon steel, alloy steel, and AISI 410 stainless steel develop a low degree of hardening by cold working, better results will be obtained if after primary working, they are subjected to patenting treatment without annealing for softening and then to cold working with a relatively high hardness maintained. After cold working, these materials also undergo secondary working and low temperature annealing.

Example 2

The material used was a round rod 6 mm. in diameter and subjected to solution treatment which consisted of AISI 631 stainless steel, one of the precipitation hardenable alloys. The material thus treated was worked into a form with a substantially rectangular cross section 7.0 mm. wide and 4.3 mm. thick, and further worked in three steps under the conditions shown in Table III below. Between the first and second working steps, it was maintained at a temperature of 1040° C. for 6 minutes and subjected to solution treatment by water cooling. It was pickled with an aqueous solution containing 20 percent nitric acid and 2 percent hydrofluoric acid.

TABLE III.—WORKING CONDITIONS

	Width (mm.)	Height of thicker section (mm.)	Width of thicker section (mm.)	Width of thinner section (mm.)	Front tension (kg.)	Back tension (kg.)
1st step-----	7.0	3.8	2.6	3.0	1,100	500
2nd step-----	7.0	3.5	2.4	1.8	750	300
3rd step-----	7.0	3.2	2.2	1.1	900	400

After the above mentioned three steps of deformation working, the material was again maintained at 1040° C. for 3 minutes and subjected to solution treatment by water cooling. It was pickled with an aqueous solution containing 20 percent nitric acid and 20 percent hydrofluoric acid. It was cold worked in the steps under the conditions given in Table IV below.

TABLE IV.—COLD WORKING CONDITIONS

	Width (mm.)	Height of thicker section (mm.)	Width of thicker section (mm.)	Width of thinner section (mm.)	Front tension (kg.)	Back tension (kg.)
1st step-----	7.0	2.4	2.1	0.9	600	200
2nd step-----	7.0	2.0	2.0	0.8	800	300

The cold worked edge material indicated a hardness of 450 (Vickers hardness number H_v) at the surface and 420 at the core of the thicker section, and 350 at the surface and 320 at the core of the thinner section. After the required secondary working, the material was maintained at a temperature of 475° C. for one hour and thereby subjected to precipitation hardening. Its surface had a hardness of 560 (H_v).

Several samples of the same material were worked under the same conditions as described above. They were cold worked in varying numbers of steps. Measurement was made of the hardness of every part from the top surface to the bottom surface of the thicker section of the edge material thus worked. The results are presented in FIG. 5. As seen from this figure, with increasing numbers of working steps, namely, with decreasing thickness reduction per step by cold working, the range of difference in hardness between the surface and the core was lessened.

Precipitation hardenable alloys other than AISI 631 stainless steel, such as AISI 630, 632 and 633 stainless steel or Maraging steel can be worked by the same process as described above. However, since these materials somewhat differ in cold workability and thermal properties, it will be necessary to carry out their cold working and heat treatment under slightly varying conditions.

Ski edges of the same size were prepared from various materials by the process of the present invention as well as by the conventional cutting method. Measurement was made of resistance to breakage by repeated bending. All samples were fixed at one end and subjected to repeated bending of 9 mm. amplitude applied at a distance of 100 mm. from the fulcrum. The resistance to breakage is indicated in the number of these repeated bendings required to cause breakage, Table V below shows the results of measurement. It is seen from these results that the edge obtained by the process of this invention has very excellent fatigue strength.

TABLE V.—FATIGUE STRENGTH AND MECHANICAL PROPERTIES

	Material	Heat treatment	Hardness (H_v)		Number of repeated bendings
			Surface	Core	
Edge obtained by the process of the present invention.	AISI 631.....	Hardening by precipitation.	560	530	586,000
	AISI 304.....	Low temperature annealing.	500	470	251,000
	AISI 304.....	None.....	480	450	212,000
	AISI 410.....	Low temperature annealing.	450	420	208,000
Edge obtained by the conventional cutting process.	AISI C-1055.....	do.....	450	420	141,000
	AISI 40.....	Quenching and tempering.	400	400	89,000
	AISI C-1055.....	do.....	400	400	63,000

It should be appreciated to those skilled in the art that many changes and modifications may be made as to the particular construction of the apparatus, and these are intended to be covered by the appended claims.

What is claimed is:

1. A process of manufacturing a ski edge comprising the steps of

(a) using an elongated raw workpiece made of material selected from the group consisting of low temperature annealing hardenable steel alloys and precipitation hardenable steel alloys;

(b) forming a soft intermediate product of substan-

tially L-shaped cross section by a plurality of longitudinal drawing steps so as to effect cold working by applying tension in excess of the yield point of the workpiece cross section and annealing the workpiece after at least one of said drawing steps;

(c) forming a hard final product of the ski edge by a plurality of longitudinal drawing steps so as to effect cold working to the intermediate product by applying tension in excess of the yield point thereof, the reduction in thickness of the thicker portion of the workpiece being accomplished at a greater rate than of the thinner portion.

2. The process of claim 1 wherein annealing is carried out after each cold working step of the raw workpiece.

3. The process according to claim 1 wherein said material is deformed by said cold deforming at a thickness reduction ranging between 30 and 60 percent for the thicker section and between 10 and 35 percent for the thinner section, the thickness reduction for the thicker section being selected so as to be greater than that for the thinner section.

4. The process according to claim 3 wherein said material is deformed by cold deforming in 2 to 5 passes.

5. The process according to claim 1 wherein said material is subjected to secondary working required for fitting to a ski body after said cold deforming.

6. The process according to claim 5 wherein said secondary working consists in bending the whole of said material so as to match a curvature of the ski body.

7. The process according to claim 5 wherein said secondary working consists in drilling and counter sinking the thinner section of said material.

8. The process according to claim 5 wherein said material is subjected to heat treatment for hardening after lent fatigue strength.

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