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ALUMINUM TREATING METHOD

Werner Helling, Grevenbroich, Heinrich Neunzig, Gindorf, and Wolfgang Nies, Grevenbroich, Germany, assignors to Vereinigte Aluminium-Werke, Aktiengesellschaft, Bonn, Germany

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The present invention relates to an aluminum treating method, and more particularly it relates to a method of forming a stable, glossy surface on an aluminum or aluminum alloy body.

One of the important qualities of aluminum and of aluminum alloys, especially of those of high purity, is the ability to form when suitably treated a highly light-reflecting surface, comparable to the surface of a silver body. By applying a transparent cover layer, it is possible to permanently protect the glossy light-reflecting surface against mechanical and chemical influences. Thus treated aluminum is an outstandingly suitable material for decorative objects and consequently it is being utilized more and more for such articles of manufacture which should possess a mirror-like reflecting surface. Thus, aluminum and aluminum alloys are used for light reflectors, for fittings in the automobile industry, for architectural purposes, kitchen utensils, custom jewelry and the like. Up to now such aluminum products were produced nearly exclusively from hot or cold deformed aluminum or aluminum alloys, i. e. from material which had been rolled, extruded or forged, not withstanding the fact that in many cases it would have been much more economical and practical to employ shaped casings of aluminum or aluminum alloys. The reason why up to now shaped castings of aluminum or aluminum alloys have not been successfully used for purposes where mirror-like, highly glossy surfaces are required, can be found in the unsatisfactory results of experiments for achieving mirror-like glossy surfaces on castings of aluminum or aluminum alloy. The surface areas of such castings, especially after application of the required protective layer, for instance by anodic oxidation, show cloudy, dull areas and spots which impair the appearance of the product. The causes for the lack of success in producing mirror-like gloss on aluminum and aluminum alloy castings are to be found in the particularities of the structure of cast aluminum which, as is well known, distinguishes from the structure of hot or cold deformed aluminum or aluminum alloys.

It has already been tried to homogenize aluminum alloy bodies in order to overcome the impairment of the surface characteristics due to the structure of the cast or deformed material. In order to obtain a mirror-like gloss, the aluminum body has been homogenized prior to surface treatment thereof. However, the reflection values obtained in this manner with respect to cast aluminum or aluminum alloy bodies are unsatisfactory and considerably below the corresponding values obtained by similarly treating deformed, i. e. rolled, extruded, or forged aluminum or aluminum alloy bodies. Furthermore, it was so far not possible to obtain a desired degree of gloss even on hot or cold deformed aluminum bodies, unless the aluminum or the aluminum alloy was of high purity.

It is therefore an object of the present invention to overcome the aforementioned difficulties in achieving

highly glossy surfaces on aluminum and aluminum alloy bodies.

It is a further object of the present invention to provide a method for obtaining a high gloss, mirror-like surface on cast aluminum bodies.

It is yet another object of the present invention to provide a method of obtaining on deformed aluminum or aluminum alloy bodies a higher degree of gloss than was previously possible.

It is still another object of the present invention to provide a method for obtaining a high degree of gloss on the surface of bodies made of aluminum or aluminum alloys of low purity.

Other objects and advantages of the present invention will become apparent from a further reading of the desscription and the appended claims.

With the above and other objects in view, the present invention mainly comprises in a method of forming a stable, glossy surface on a body of a substance belonging to the group consisting of aluminum and aluminum alloys, the steps of heating the body at a temperature between the homogenization temperature and the solidus temperature thereof until recrystallization of the body, whereby the surface properties of the body are changed so that the surface is better adapted for polishing, and polishing the surface of the body, thereby forming a stable, glossy surface thereon.

According to a preferred embodiment, the present invention also contemplates in a method of forming a stable, glossy surface on a cast body of a substance belonging to the group consisting of aluminum and aluminum alloys essentially consisting of aluminum and up to 3% magnesium, up to 1% silicon and up to 0.06% iron, the steps of permanently deforming the cast body, heating the body at a temperature of about 600° C. until recrystallization of the body, whereby the surface properties of the body are changed so that the surface is better adapted for polishing, the steps of permanently deforming and heating being carried out in any desired sequence, dry polishing the surface of the body, treating the dry polished body with a pickling solution, and subsequently wet polishing the surface of the body, thereby forming a stable, glossy surface thereon.

Surprisingly it has now been found that a mirror-like high gloss can be obtained on the surface of casings made of aluminum and aluminum alloys, and particularly so on the surface of castings made of aluminum or of aluminum alloys containing up to 3 percent magnesium, up to 1 percent silicon and up to 0.06 percent iron, if the castings are heated for a sufficiently long period of time at a temperature above the homogenization temperature of the material and preferably at a temperature which lies closely below the solidus temperature of the particular material. Heating of the cast aluminum body, according to the present invention has to be continued at a high temperature for a period of time which is sufficiently long to cause recrystallization within the aluminum or aluminum alloy body. Thus temperature and time conditions have to be chosen in such a manner that the structure of the aluminum or aluminum alloy body is not only homogenized but that recrystallization takes place.

Thus, according to the present invention, it is possible to obtain, preferably in combination with subsequent surface treatment such as polishing, a mirror-like reflecting surface on the cast aluminum or aluminum alloy body equal to that which can be obtained on hot or cold deformed aluminum or aluminum alloy bodies. According to the basic investigation of H. Roehrig, as reported in the Zeitschrift fuer Metallkunde, 27, (1935), 175/9, the recrystallization of the cast structure is based on a shifting of the grain boundaries which takes place after the alloying additions to the aluminum have been trans-

formed into a solid solution, and after existing differences in the concentration of these alloying materials have been equalized. Thus recrystallization takes place only by heating to a temperature above the point of homogenization of the material. This is accomplished by heating the material such as an aluminum or aluminum alloy body at temperatures above the temperature required for homogenization and by heating the material at such temperature for a prolonged period of time. The temperature at which the aluminum or aluminum alloy bodies are to be heated will be, according to the present invention, between the homogenization temperature and the solidus temperature of the aluminum or aluminum alloy body, and the period of time for which heating has to be continued in order to achieve recrystallization, will depend on the specific temperature within this range. Higher temperatures will require shorter heating periods. The specific numerical time and temperature values will depend on the specific composition of the aluminum alloy or on the specific impurities in an aluminum body. While the present invention is not to be limited to a specific numeral range of temperature, it has been found that excellent results are obtained by heating the aluminum or aluminum alloy body at a temperature which is only slightly below the solidus temperature of the material, but which is safely below the temperature at which melting or excessive softening of any portion of the aluminum or aluminum alloy body could occur and could cause deformation of the body. It has been found, according to the present invention that the temperature at which recrystallization of the structure of the aluminum or aluminum alloy body is carried out is preferably between 10° C. and 30° C. below the solidus temperature of the specific aluminum alloy. In many cases it has been found advantageous as a practical matter to heat the aluminum or aluminum alloy body at a temperature of about 600 C. The length of time for which the aluminum body is to be heated according to the present invention in order to achieve the desired recrystallization, varies depending on the specific composition of the aluminum alloy and also depending on the specific temperature at which the aluminum or aluminum alloy body is heated. It has been found that in many cases it is advantageous to heat the aluminum body for a period of time ranging between 2 and 15 hours. Thus, the improvements of the surface characteristics of aluminum and aluminum castings are primarily achieved according to the present invention due to changes in the structure of the aluminum or aluminum alloy which are caused by recrystallization. When the aluminum or aluminum alloy body is heat treated at a temperature at which recrystallization does not yet take place but only homogenization is accomplished, or when the aluminum or aluminum alloy body is heat treated at higher temperatures for a period of time insufficient to achieve recrystallization, it is not possible even by subsequent polishing or the like to achieve the very considerable increases in reflection values of the surface of the aluminum castings which are obtained according to the present invention.

The temperatures which are required for the heat treatment depend on the composition of the aluminum material, while the length of heat treatment has to be such as to assure with certainty that the recrystallized condition has been reached in consequence of the change in the structure of the aluminum or aluminum alloy. As stated above, the heat treatment temperature for achieving recrystallization is preferably chosen slightly below the solidus temperature of the respective aluminum or aluminum alloy, however sufficiently below the solidus temperature to prevent any damage, i. e., local melting of the materials. In any event, it is necessary according to the present invention that the temperature at which the heating treatment of either the aluminum or the aluminum alloy body is carried out is above the temperature at which only homogenization but not recrystallization of the material would take place.

When such recrystallized cast material is then subjected to a mechanical deformation by rolling, forging, extruding or the like, it is surprisingly found that the result of the preceding recrystallization, namely the possibility to improve the gloss of the surface of the aluminum or aluminum alloy body is not lost by the subsequent deformation thereof. Objects which are made by deformation of such semi-finished material show, after suitable surface treatment such as polishing, considerably higher reflection values than those that can be obtained on similarly produced objects which however have not been recrystallized.

Furthermore, it has been found that after the cast material has been recrystallized according to the present invention any further intermediary heating during subsequent deformation steps can be carried out without loss of the improved surface characteristics. When carrying out such intermediary heating it has to be taken into consideration that the recrystallized structure which has been shattered by deformation will during prolonged subsequent heating suffer a coarsening of the grains. Such coarsening of the grains might cause, upon further working of the metal body such as bending, pressing, or deep-drawing, formation of an undesirable pitted surface. It is therefore advantageous, to limit any intermediary heating which takes place after recrystallization has been accomplished, to as short a period of time as possible, particularly if further deformation after such intermediary heating is intended. Such intermediary heating can for instance be carried out in a flow type furnace or in a salt bath because in such devices it is possible to reach the desired elevated temperature in a very short period of time.

Cast aluminum or aluminum alloy bodies also show a coarsening of the grain during recrystallization according to the present invention however in this case such coarsening does not harm the reflection characteristics of the surface because no further deformation of the cast bodies takes place.

Preferably, the method of the present invention is carried out in the treatment of aluminum and aluminum alloys which contain between 0 and 3% magnesium, between 0 and 1% silicon and between 0 and 0.06% iron, since it has been found that the greatest improvement in surface characteristics is obtained with materials of the above composition.

It is preferred to heat a body consisting of aluminum or an aluminum alloy containing between 0 and 3% magnesium, between 0 and 1% silicon and between 0 and 0.06% iron at a temperature between 570° C. and 640° C. for a period of between 2 hours and 15 hours in order to achieve the desired recrystallization of the structure of the aluminum or aluminum alloy body.

Surprisingly it has been found, that for obtaining a high degree of glossiness according to the present invention, it is frequently immaterial whether the heating of the aluminum or aluminum alloy for recrystallization of the same takes place when the material is still in the form of a casting or during subsequent deformation of the cast aluminum or aluminum alloy body. For instance, when it is intended to produce bumpers for automobiles from extruded shapes of hardenable aluminum alloys, the recrystallization treatment according to the present invention is preferably carried out after the forming has been completed and it then is carried out simultaneously with the solution heating which is required for the hardening of the alloy. In this case, according to the present invention, the temperature at the heat treatment is increased beyond the temperature required for the solution heating for the purpose of hardening the material, up to a point which is just below the solidus temperature of the material in order to recrystallize the same. The thus treated finished bumpers show after subsequent gloss treatment such as polishing, a considerably increased gloss as compared with bumpers which were similarly produced but were heated in the solution

heat treatment only to the temperature required for hardening of the alloy.

The recrystallization of rolled material in preformed condition may, for instance, be carried out as follows:

In the forming of sheets it is possible and very frequently advisable, to first reduce the thickness of the material by reduction rolling by between about 10 and 90 percent. The thus prerolled blocks or strips are recrystallized by heating as described above in this semi-rolled state, and then are further rolled to finished sheets in the same manner in which the rolling is carried out with prerolled materials which have not be recrystallized.

The following may serve as an example for the recrystallization of finished products made of sheets of aluminum or aluminum alloys: It has been found that hub caps for motor vehicles which are made of aluminum-magnesium-silicon alloys are preferably recrystallized by heat treatment according to the present invention, after the same have been completely shaped and before they are to undergo the final gloss treatment. Thereby a mirror gloss is obtained on the finished hub cap which is by far superior to the mirror gloss which can be obtained without the heat treatment according to the present invention. The absolute degree of reflection or glossiness which can be obtained on the finished product is always to some extent dependent on the final gloss or polishing treatment which is applied to the surface of the article. However irrespective of the specific gloss treatment, it has been found that a higher gloss is obtained under otherwise equal conditions by heat treating the material according to the present invention so as to achieve recrystallization thereof.

Furthermore it has been found according to the present invention that an especially high degree of mirror gloss can be achieved on articles made of aluminum or aluminum alloys when a number of processing steps are carried out in a predetermined sequence, and specifically in such a manner that the recrystallization of the material as described further above is combined with at least two subsequently carried out mechanical polishing treatments of the surface of the finished article. Most preferably chemical pickling is interposed between the two mechanical polishing treatments. The mechanical polishing treatments consist in working the surface with dry or paste-like polishing materials for instance with commercial fat-containing pastes, and subsequently polishing the surface with a suspension of polishing materials in liquid such as for instance a suspension of polishing red in alcohol or water. Depending on the condition of the surface which is to be treated, the dry polishing may be further subdivided into a pre-grinding with coarser materials and pre-polishing with finer materials.

A further considerable increase in the degree of glossiness and a shortening of the period of time required for wet polishing of the surface, can be achieved by subjecting the articles to a pickling process which is interposed between the pre-polishing and the finishing polishing. As pickling solution for instance an aqueous solution of sodium hydroxide containing about 10 percent sodium hydroxide may be used.

The above described mechanical polishing in combination with the pre-treatment of the aluminum or aluminum alloy body according to the present invention by heat recrystallization of the same, will result in a very considerable increase of the degree of mirror gloss on articles made of deformed aluminum material. A particularly marked increase in the mirror gloss of the final surface is however accomplished by heat treating cast aluminum bodies and subsequently polishing the same as has been described above.

The method of the present invention can be employed in the treatment of all aluminum alloys which can be recrystallized in cast condition. Furthermore the method is well suitable for aluminum materials which due to their lower purity can not be recrystallized in cast condition, which however can be recrystallized in hot or cold deformed condition. Consequently, the method of the present invention is not only applicable to very pure aluminum but also to aluminum and aluminum alloys of lesser purity, especially to those which so far due to their iron content could not be provided with a glossy surface. Thus the method of the present invention makes it possible to use a great variety of cast aluminum alloys for decorative purposes.

The degrees of surface reflection which can be obtained with various aluminum alloys by treating the same according to the present invention is shown in the following table. The table also shows the results which are obtained with the same alloys but without recrystallization of the structure thereof according to the present invention.

In order to obtain comparable results, the mirror gloss which was obtained in all of the examples has been measured as specular reflection which has been expressed in percent with reference to the reflection of a silver mirror as a 100 percent standard.

The individual steps in the treatment of aluminum alloys which were recrystallized according to the present invention are indicated in Table 1 as follows:

A—indicates the step of dry polishing.

B—indicates the step of pickling or treating with a pickling solution.

C—indicates wet polishing.

D—indicates chemically improving the gloss of the surface.

E—indicates anodic oxidation.

F—indicates the application of a protective transparent lacquer layer.

In some of the examples such as Nos. 17 and 18 it is indicated that the material has been recrystallized while in deformed condition. According to these examples the original ingot was hot rolled to a thickness of 10 millimeters and subsequently cold rolled from 10 millimeters to a thickness of 4 millimeters. The thus obtained metal sheet was then recrystallized for 8 hours at 600° C. and subsequently cold rolled to a final thickness of 1.5 millimeters.

The surface treatments A–F were carried out as follows:

A. DRY POLISHING

A polishing paste consisting of 66 parts of finely subdivided alumina, 26 parts of stearin, 6 parts of montan wax, and 2 parts of petroleum jelly was used to dry polish the metal surface with a flexible polishing wheel made of nettle cloth, having a diameter of 300 millimeters and a width of 40 millimeters. The dry polishing was carried out at a circumferential speed of 50 meters per second for a period of two minutes. In Examples 1, 2, 3, 15, 19, 20, 21, 25, and 26, the surface was pre-polished with a fat-containing polishing paste.

B. PICKLING

The metal bodies were treated with a sodium hydroxide containing pickling solution by immersion for 30 seconds in 10 percent aqueous sodium hydroxide solution at a temperature of 55° C., subsequent rinsing with water, neutralizing by immersion for a short period of time in 20% aqueous nitric acid at room temperature, and final rinsing with water.

C. WET POLISHING

The polishing fluid for the wet polishing of the metal surface was prepared by diluting 300 cubic centimeters of a commercial suspension of polish alumina (No. 3 of Jean Wirtz, Dusseldorf) with one liter water and adding thereto 1.3 grams of an oxyethylmethyl cellulose of medium viscosity (Tylose SL400 made by Kalle & Co., Wiesbaden-Biebrich).

A flexible polishing wheel was used consisting of several layers of absorbent cotton which were sewn together. The diameter of the polishing wheel was 300 millimeters and the width 40 millimeters. The circumferential speed of the rotating polishing wheel was 20 meters per second. The above described polishing fluid was continuously douched onto the polishing wheel. Wet polishing was carried out for a period of 10 minutes.

Table 1 summarizes 27 examples of treating aluminum alloy bodies. Examples 1–10 were carried out in conventional manner, while Examples 11–27 illustrate various manners of carrying out the method of the present invention. It must be understood that the examples are given as illustrative only of the method of the present invention and that the present invention is not limited to the specific details of the examples.

Table I

Example No.	Alloy Composition	Final State	Heat Treatment			Surface Treatment [1]	Specular Reflection, percent
			Temp., ° C.	Time, h.	State		
1	2.01% Mg, 0.12% Si, 0.035% Fe, Balance Al.	Casting	(2)	(2)	(2)	A+D+E	46
2	Same as 1	do	550	8	Casting Homogenized	A+D+E	57
3	do	do	600	1	do	A+D+E	62
4	2.0% Mg, 0.01% Cu, 0.012% Zn, 0.066% Si, 0.033% Fe, 0.025% Mn, Balance Al.	do	500	8	do	D+E	70
5	0.57% Mg, 0.029% Fe, 0.048% Si, Balance Al.	Sheet	500	8	do	A+D+E	76
6	1.92% Mg, 0.033% Fe, 0.066% Si, Balance Al.	do	500	8	do	A+D+E	70
7	2.94% Mg, 0.033% Fe, 0.066% Si, Balance Al.	do	500	8	do	A+D+E	32
8	0.6% Mg, 0.003% Fe, Balance Al.	do	(2)	(2)	(2)	A+D+E	85.2
9	0.6% Mg, 0.024% Fe, Balance Al.	do	(2)	(2)	(2)	A+D+E	77.1
10	0.6% Mg, 0.056% Fe, Balance Al.	do	(2)	(2)	(2)	A+D+E	60.2
11	0.7% Mg, 0.051% Fe, Balance Al.	do	600	8	Casting Recrystallized	A+D+E	68
12	Same as 11	do	600	8	do	A+C+E	72.4
13	do	do	600	8	do	A+B+C+E	80.2
14	2.30% Mg, 0.031% Fe, 0.112% Si, Balance Al.	do	600	8	do	A+C+E	68
15	Same as 1	Casting	600	15	do	A+B+C+E	83
16	Same as 4	Sheet	600	15	do	A+B+C+E	83
17	Same as 14	do	600	8	Deformed Recrystallized	A+C+E	67
18	do	do	600	8	do	A+B+C+E	84
19	Same as 1	Casting	600	8	Casting Recrystallized	A+D+E	74
20	do	do	600	15	do	A+D+E	75
21	do	do	600	20	do	A+D+E	76
22	Same as 5	Sheet	600	8	do	A+D+E	82
23	Same as 6	do	600	8	do	A+D+E	76
24	Same as 7	do	600	8	do	A+D+E	70
25	Same as 1	Casting	600	15	do	A+E	43
26	do	do	600	15	do	A+B+C+F	85
27	0.8% Mg, 0.4% Si, 0.029% Fe, Balance Al.	Bumper	600	4	Finished Product Recrystallized.	A+B+C+E	84

[1] A=dry polishing, B=pickling, C=wet polishing, D=chemical gloss treatment, E=anodic oxidation, F=lacquering.
[2] No treatment.

Thereafter the metal bodies were rinsed with flowing water.

D. CHEMICAL GLOSS TREATMENT

The metal bodies were immersed for 30 seconds in a bath containing 125 grams ammonium hydrogen fluoride, 170 cubic centimeters pure concentrated nitric acid (53%), 0.05 grams lead nitrate and 5 grams gum arabic per liter of solution. The bath temperature was kept at 55° C. Thereafter the metal bodies were rinsed in flowing water, immersed for a short moment in nitric acid of 36% concentration, and finally again rinsed with flowing water.

E. ANODIC OXIDATION

The aluminum or aluminum alloy metal bodies were anodically oxidized for 10 minutes in 20 percent aqueous sulfuric acid at 18° C. The current density was kept at 1.5 amperes per 100 square centimeters. The thus obtained oxide layer had a thickness of about 5 microns.

F. LACQUER COATING

The wet polished metal bodies were rinsed in distilled water, then dipped in ethanol and dried in an air stream having a temperature of 50° C. Thereafter the metal bodies were immersed in zapone lacquer, and suspended in air for drying.

In order to protect the glossy surfaces against mechanical and chemical attack, all of the glossy metal surfaces produced according to the following examples were covered with protective layers such as are conventionally provided according to E or F.

Examples 1–3 shows the results obtained by conventionally treating cast aluminum magnesium alloys. According to Example 1 heat treatment was completely omitted, in Example 2 the casting was heated for 8 hours at 550° C., and in Example 3 for one hour at 600° C. Thereafter all three samples were similarly surface treated by dry polishing, chemical gloss treatment and anodic oxidation. Specular reflection values of 46%, 57%, and 62% were obtained.

Comparison of Examples 15, 19, 20, and 21 with Examples 1–3: According to Examples 15, 19, 20, and 21, the same alloy which was used in Examples 1–3 was recrystallized in cast condition according to the present invention. In Examples 15 and 20 recrystallization was carried out at 600° C. for 15 hours, while Examples 19, 20, and 21 show the effect of recrystallizing at 600° C. for varying lengths of time, namely 8, 15 and 20 hours.

Subsequent surface treatment was carried out in Examples 19, 20 and 21 in a conventional manner similarly to the surface treatment according to Examples 1–3. However, according to Examples 19, 20 and 21, specular reflection values of 74%, 75% and 76% were obtained as compared with specular reflection values of only 46%, 57% and 62% according to Examples 1–3. In Example 15, the surface treatment of the recrystallized body was carried out according to the present invention in such a manner as to obtain optimum gloss. This was done by dry grinding and polishing, pickling, wet polishing and anodic oxidizing. In this manner a specular reflection of 83% was obtained, as compared with the specular reflection of 75% according to Example 20.

The superiority of the gloss obtained according to

Examples 15, 19, 20 and 21 which were treated according to the present invention, as compared to the gloss obtained according to Examples 1–3 is apparent. Furthermore it can be seen that the reflection values which are obtained according to Examples 19–21 do not vary considerably. However, a slight increase in the reflection value is shown by lengthening the heating period from 8 to 15 and 20 hours. This seems to be due to further progressing change of the structure during extended heating periods.

The reflection values obtained in Examples 15, 19, 20 and 21 as compared with the values obtained in Examples 1–3 represent a significant advance over the conventional methods, particularly when recrystallization according to the present invention is combined with the additional inventive combination of surface treating steps such as has been illustrated in Example 15. A comparison between Examples 3 and 21 shows the increase in reflection values which are obtained by recrystallization alone, over the best results could be obtained in the past. The improvement of the specular reflection value from 62% to 76%, or by 22.6% is of great practical significance.

Comparison of Examples 4 and 16: Example 4 illustrates the conventional treatment of a cast body made of a different aluminum magnesium alloy. The sample was homogenized for 8 hours at 500° C., subjected to chemical gloss treatment and anodically oxidized. A mirror gloss equivalent to 70% specular reflection was achieved. According to Example 16, a body made of the same alloy was recrystallized according to the present invention for 15 hours at 600° C., subsequently dry polished, pickled, wet polished and anodically oxidized. In this manner, a specular reflection as high as 83% was obtained.

Comparison of Examples 25 and 26 with Example 15: According to Examples 25 and 26, a cast alloy body similar to the one used in Example 15 was recrystallized in the same manner as indicated in Example 15, namely at 600° C. for 15 hours. However, according to Example 26 the anodic oxidation of Example 15 was replaced by a transparent lacquer layer, and according to Example 25 pickling and wet polishing was omitted and the surface treatment was limited to dry polishing and anodic oxidation. Thereby it was found that specular reflection in Example 26 was further increased to 85%, while in Example 25 only a specular reflection of 43% was obtained. It can be seen that the inventive combination of surface treatment steps subsequent to recrystallization according to the present invention gives greatly improved results.

Comparison of Examples 5 and 22: According to these two examples, aluminum-magnesium-silicon alloy ingots were pretreated in cast condition prior to being rolled into sheets. According to Example 5, the ingot was homogenized for 8 hours at 500° C., while according to Example 22 recrystallization of the alloy structure was achieved according to the present invention by heat treating the ingot for 8 hours at 600° C. Subsequent surface treatment was carried out in identical manner in both examples and consisted of prepolishing, chemical gloss treatment and subsequent anodic oxidation. The conventionally homogenized sheet according to Example 5 was found to have a specular reflection of 76%, while the recrystallized sheet according to Example 22 showed an increase in the specular reflection value to 82%.

Comparison of Examples 6 and 23, and 7 and 24: Examples 6 and 23, and 7 and 24, respectively, show the difference in the effect of a pretreatment by homogenization or by recrystallization of the cast ingot without change in the surface treatment of the finished sheets. Aluminum-magnesium-silicon alloys with higher magnesium content were chosen for these experiments. An increase in specular reflection from 70% to 76%, and from 32% to 70% clearly shows the superiority of the recrystallization treatment according to the present invention.

Examples 8, 9 and 10 illustrate the unfavorable effect of impurities on the mirror gloss of aluminum alloy bodies. The samples were conventionally treated without preheating by dry polishing, chemical gloss treatment and anodic oxidation. The iron content of the aluminum alloy varied from 0.003% corresponding to purest aluminum, in Example 8 to 0.024% in Example 9, and 0.056% in Example 10 corresponding to aluminum of low purity. The thus obtained specular reflection values of 85.2%, 77.1% and 60.2% show how the specular reflection value depends on the purity of the material.

Comparison of Examples 11, 12 and 13 with Example 10: In Examples 11–13, ingots of a composition nearly similar to the composition of the material used in Example 10 were recrystallized according to the present invention. Subsequent surface treatment of sheets rolled from the recrystallized ingots were varied between Examples 11–13 in order to show the better results which are obtained by combining recrystallization with the specific surface treatment according to the present invention. An increase in specular reflection from 68% according to Example 11 to 80.2% according to Example 13 is shown. A comparison of the specular reflection according to Example 10 which was carried out without recrystallization according to the present invention, with the result obtained according to the Example 11, again shows the effect of the heat treatment according to the present invention on aluminum alloys of low purity. An increase in specular reflection from 60.2% to 68% was obtained. Comparing Examples 12 and 13, it can be seen that the inclusion of a pickling step in the surface treatment caused an increase in specular reflection from 72.4% to 80.2%.

Comparison of Examples 17 and 18 with Example 14: According to Examples 17 and 18, sheets were recrystallized according to the present invention after rough rolling and prior to final rolling. A comparison of the result obtained according to Example 17, with the result obtained according to Example 14 shows that similar material which is similarly surface treated will give practically identical specular reflection values (67% or 68%) regardless whether the cast ingot or the roll sheet is heat treated according to the present invention.

While the surface treatment according to Example 14 and 17 did not include a pickling step, pickling of the finished material is included in the surface treatment according to Example 18, and thereby an increase in the specular reflection value from 67% to 84%, or of 25.4% is obtained.

Example 27: In Example 27 the effect of recrystallization according to the present invention on an article of manufacture made of an aluminum-magnesium-silicon alloy is shown, whereby the finished article has been subjected to recrystallization heat treatment. In combination with subsequent surface treatment according to the present invention, very high mirror gloss, corresponding to specular reflection value of 84% is thus obtained.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. In a method of forming a stable, glossy surface on a body of a substance belonging to the group consisting of aluminum and aluminum alloys essentially consisting of aluminum and up to 3% magnesium, up to 1% silicon and up to 0.06% iron, the steps of heating said body at

a temperature as close as possible to the solidus temperature of said body but sufficiently below the same to prevent melting of any portion of said body and until recrystallization of said body, whereby the surface properties of said body are changed so that the surface is better adapted for high-gloss polishing; and polishing the surface of said body, thereby forming a stable, glossy surface thereon.

2. In a method of forming a stable, glossy surface on a body of a substance belonging to the group consisting of aluminum and aluminum alloys essentially consisting of aluminum and up to 3% magnesium, and up to 1% silicon and up to 0.06% iron, the steps of heating said body at a temperature between 10° C. and 30° C. below the solidus temperature of said body until recrystallization of said body, whereby the surface properties of said body are changed so that the surface is better adapted for high-gloss polishing; and polishing the surface of said body, thereby forming a stable, glossy surface thereon.

3. In a method of forming a stable, glossy surface on a body of a substance belonging to the group consisting of aluminum and aluminum alloys essentially consisting of aluminum and up to 3% magnesium, up to 1% silicon and up to 0.06% iron, the steps of heating said body at a temperature of about 600° C. until recrystallization of said body, whereby the surface properties of said body are changed so that the surface is better adapted for high-gloss polishing; and polishing the surface of said body, thereby forming a stable, glossy surface thereon.

4. In a method of forming a stable, glossy surface on a body of a substance belonging to the group consisting of aluminum and aluminum alloys essentially consisting of aluminum and up to 3% magnesium, up to 1% silicon and up to 0.06% iron, the steps of heating said body at a temperature between the homogenization temperature and the solidus temperature thereof until recrystallization of said body, whereby the surface properties of said body are changed so that the surface is better adapted for high-gloss polishing; and polishing the surface of said body, thereby forming a stable, glossy surface thereon.

5. In a method of forming a stable, glossy surface on a cast body of a substance belonging to the group consisting of aluminum and aluminum alloys essentially consisting of aluminum and up to 3% magnesium, up to 1% silicon and up to 0.06% iron, the steps of permanently deforming said cast body; heating said body at a temperature between the homogenization temperature and the solidus temperature thereof until recrystallization of said body, whereby the surface properties of said body are changed so that the surface is better adapted for high-gloss polishing, said steps of permanently deforming and heating being carried out in any desired sequence; and polishing the surface of said body, thereby forming a stable, glossy surface thereon.

6. In a method of forming a stable, glossy surface on a cast body of a substance belonging to the group consisting of aluminum and aluminum alloys essentially consisting of aluminum and up to 3% magnesium, up to 1% silicon and up to 0.06% iron, the steps of heating said body at a temperature between the homogenization temperature and the sodidus temperature thereof until recrystallization of said body, whereby the surface properties of said body are changed so that the surface is better adapted for high-gloss polishing; permanently deforming said recrystallized body; and polishing the surface of said body, thereby forming a stable, glossy surface thereon.

7. In a method of forming a stable, glossy surface on a cast body of a substance belonging to the group consisting of aluminum and aluminum alloys essentially consisting of aluminum and up to 3% magnesium, up to 1% silicon and up to 0.06% iron, the steps of permanently deforming said cast body; heating said permanently deformed body at a temperature between the homogenization temperature and the solidus temperature thereof until recrystallization of said body, whereby the surface properties of said body are changed so that the surface is better adapted for high-gloss polishing; and polishing the surface of said body, thereby forming a stable, glossy surface thereon.

8. In a method of forming a stable, glossy surface on a body of a substance belonging to the group consisting of aluminum and aluminum alloys essentially consisting of aluminum and up to 3% magnesium, up to 1% silicon and up to 0.06% iron, the steps of heating said body at a temperature between the homogenization temperature and the solidus temperature thereof until recrystallization of said body, whereby the surface properties of said body are changed so that the surface is better adapted for high-gloss polishing; dry polishing the surface of said body; and subsequently wet polishing the same, thereby forming a stable glossy surface thereon.

9. In a method of forming a stable, glossy surface on a body of a substance belonging to the group consisting of aluminum and aluminum alloys essentially consisting of aluminum and up to 3% magnesium, up to 1% silicon and up to 0.06% iron, the steps of heating said body at a temperature between the homogenization temperature and the solidus temperature thereof until recrystallization of said body, whereby the surface properties of said body are changed so that the surface is better adapted for high-gloss polishing; dry polishing the surface of said body; treating said dry polished body with a pickling solution; and subsequently wet polishing the same, thereby forming a stable glossy surface thereon.

10. In a method of forming a stable, glossy surface on a cast body of a substance belonging to the group consisting of aluminum and aluminum alloys essentially consisting of aluminum and up to 3% magnesium, up to 1% silicon and up to 0.06% iron, the steps of permanently deforming said cast body; heating said body at a temperature of about 600° C. until recrystallization of said body, whereby the surface properties of said body are changed so that the surface is better adapted for high-gloss polishing; said steps of permanently deforming and heating being carried out in any desired sequence; dry polishing the surface of said body; treating said dry polished body with a pickling solution; and subsequently wet polishing the same, thereby forming a stable glossy surface thereon.

11. In a method of forming a stable, glossy surface on a body of a substance belonging to the group consisting of aluminum and aluminum alloys essentially consisting of aluminum and up to 3% magnesium, up to 1% silicon and up to 0.06% iron, the steps of heating said body as a temperature between 570° C. and 640° C. for a period of between 2 hours and 15 hours until recrystallization of said body, whereby the surface properties of said body are changed so that the surface is better adapted for high-gloss polishing; and polishing the surface of said body, thereby forming a stable, glossy surface thereon.

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