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(54) **Method for producing an aluminium sheet**

(57) Method for producing an aluminium sheet with a decorative surface structure on at least one side, comprising the successive process steps of:

(a) providing a cold-rolled aluminium sheet of a de-

sired thickness;

(b) using cold-rolling to apply a surface roughness Ra to at least one side of the aluminium sheet, in a range from 1.2 to 3.0 microns measured in accordance with DIN 4768.

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Description

[0001] The invention relates to a method for producing an aluminium sheet with a decorative surface structure.

[0002] The values which are given in this patent application for surface roughness Ra are all measured in accordance with DIN 4768.

[0003] Sheet material, such as for example of aluminium, aluminium alloys and stainless steel, with a decorative surface structure is used, inter alia, for domestic appliances, such as for example the outside of refrigerators and freezers, and for the front panels of audiovisual equipment. Sheet material of this type has a shiny metallic or if desired a matt metallic appearance and, if desired, can be provided with an organic covering layer for further decoration or protection. A typical shiny metallic surface structure is generally obtained by blasting the sheet material with, for example, glass beads or stainless steel shot. One drawback of a surface structure obtained by blasting with beads is that the sheet material is handled in batches and sometimes even by hand, and consequently is rather expensive. Furthermore, it is often the case that an end product, such as for example a refrigerator door, is produced, and then this product is manually or semi-automatically provided with the desired shiny or matt peened surface structure. Moreover, the existing thicknesses for outer sides of domestic materials do not allow, for example, manual blasting with glass beads, on account of the risk of deformation caused by the blasting pressure, and furthermore there is a risk of non-uniformity caused by the manual blasting.

[0004] There is a market demand for aluminium sheet material with a surface structure which approximates the surface structure of a glass bead finish as closely as possible. A desired aluminium sheet material of this type must be less expensive than the cost of sheet material with a surface structure obtained by treatment by means of blasting, in particular with glass beads.

[0005] It is an object of the invention to provide a method for producing an aluminium sheet with a desired decorative surface structure as described above applied to at least one side of the aluminium sheet.

[0006] For this purpose, the method according to the invention is characterized in that the following successive process steps are carried out:

- (a) providing a cold-rolled aluminium sheet of a desired thickness;
- (b) using cold-rolling to apply a surface roughness Ra to at least one side of the aluminium sheet, in a range from 1.2 to 3.0 microns measured in accordance with DIN 4768, and more preferably in a range from 1.3 to 3.0 microns, even more preferably in a range from 1.5 to 3.0 microns.

[0007] The result is a method which can be operated

continuously and on an industrial scale to produce aluminium sheet with the desired decorative surface structure described above on at least one side of the aluminium sheet, which decorative surface structure closely to very closely approximates to that of the known finish obtained using glass beads, while the cost price of the finished product is considerably lower than that of aluminium sheet material which is blasted in batches or by hand. A cold-rolled aluminium sheet which is provided typically has a surface roughness Ra in a range from 0.2 to 0.6 microns, measured in accordance with DIN 4768. Furthermore, the method according to the invention ensures that the original mill finish has completely or almost completely disappeared. Mill finish is a term which is known to the person skilled in the art and refers to microscopically visible thin lines oriented substantially in the rolling direction. Furthermore, the method obtained results in a relatively inexpensive semi-finished product on a coil with a desired decorative surface structure, which semi-finished product can then be used to produce end products, such as for example doors for domestic appliances, which then require no further manual treatment.

[0008] Although the decorative surface structure of the known finish obtained using glass beads is closely approximated to with a surface roughness of up to Ra 3.0 microns, the roughness Ra which is applied in process step (b) is preferably at most 2.5 microns. Below this value, the decorative surface structure very closely approximates to that of the known finish obtained using glass beads.

[0009] It has been found that the appearance of the finish obtained using glass beads is still very closely approximated to in particular with surface roughness values of over Ra 1.8 microns.

[0010] In one embodiment of the method according to the invention, the surface roughness is applied to the aluminium sheet by means of rollers with a non-deterministic structure, more preferably by means of electro-discharge texturing rollers, or EDT rollers for short. This allows a desired surface structure to be applied, for example, to a coil of aluminium sheet material continuously and on an industrial scale. Furthermore, the application of the desired surface roughness by means of EDT rollers is achieved, inter alia, through the fact that the original mill finish on the cold-rolled aluminium sheet of the desired final thickness has completely or almost completely disappeared. During the application of the surface structure by means of EDT rollers, the desired result is obtained in one or more light cold-rolling passes. This changes the thickness of the final aluminium sheet by less than 15%, and typically about up to 6%, with respect to the cold-rolled aluminium starting material.

[0011] In another embodiment of the method according to the invention, the surface roughness is applied to the aluminium sheet by means of rollers with a non-deterministic structure which are produced with the aid of

the precision texturing process. In this process, a small quantity of chromium is applied to the roller in the form of circular or spherical spots.

[0012] In an embodiment according to the method, the roller with the non-deterministic structure has a surface roughness Ra in a range between 2 and 6 microns, preferably between 3 and 6 microns, measured in accordance with DIN 4768. Depending on the reduction in the thickness of the aluminium sheet which is employed during the roughening in one or more cold-rolling passes, in this way a desired decorative surface structure within the desired Ra range is achieved on the aluminium sheet.

[0013] In one embodiment of the method according to the invention, in a process step (c) the roughened aluminium sheet is provided with a coating layer, for example by means of painting, in which case the coating layer is a layer of paint, or by means of nano-coating, in which case the coating layer is a nano-coating, or by means of anodization, in which case the coating layer is an anodized layer. The nano-coating may comprise a sol-gel process.

[0014] The choice of thickness and the type of layer is determined by the end use of the aluminium sheet. Depending on the thickness and the type of layer, the decorative surface structure can be attained or even adapted to the desired appearance of the peened surface structure. Alternatively, the surface can in this way be provided with a desired colour. Moreover, the surface of the roughened aluminium sheet is provided with better protection against scratches and other external influences by the coating layer.

[0015] In an embodiment of the method according to the invention, the roughened aluminium sheet is anodized in a process step (c) or is provided with an anodized layer with a thickness in a range of up to 20 microns, preferably in a range of up to 15 microns, more preferably in a range from 3 to 15 microns, by means of anodization. The anodization may be carried out in the customary continuous way on an industrial scale by passing strip material continuously through an anodization bath. Colour anodization is also possible. It has been found that the continuously produced and anodized strip material can also undergo further operations, such as for example punching, bending and light deep-drawing without excessive cracking of the anodized layer which has been applied. Despite the application of a thin anodized layer, the surface roughness applied remains within the given range, and therefore the desired decorative surface structure is also retained. Since it is no longer necessary for a product to be anodized in batches after deformation, there is a considerable reduction in cost of the end product.

[0016] Another advantage of anodization over, for example, painting is that the anodized layer obtained by anodization offers very good protection against external chemical influences, such as against spilt cooking ingredients such as tomato sauce and mustard.

[0017] In one embodiment of the method according to the invention, the aluminium sheet, after the application of the desired surface roughness and before the anodization, is pickled in a process step (b1). The aluminium sheet may be chemically or electrochemically pickled in an alkaline or acidic medium. More preferably, the aluminium sheet is pickled in an alkaline medium. The intermediate pickling prior to anodization leads to the final sheet material acquiring a surface structure which is somewhat more matt in terms of appearance. For a number of applications of the aluminium sheet obtained using the method according to the invention, this is a highly desirable property of the sheet material. A further advantage is that a pickling treatment is relatively simple to incorporate in a continuous industrial production line which is suitable for the method according to the invention.

[0018] In principle, all wrought aluminium alloys which can be treated successfully by means of anodization can be processed in the method according to the invention. However, it has been found that the aluminium alloys which cannot be heat-treated can be processed more successfully than the aluminium alloys which can be heat-treated.

[0019] Very good results are obtained with the method according to the invention if an aluminium alloy selected from the Aluminium Association (AA)1xxx series, (AA)3xxx series, (AA)5xxx series and (AA)6xxx series is used for the cold-rolled aluminium sheet. It is preferable to select a wrought aluminium alloy which cannot be heat-treated from the AA5xxx series. These are the aluminium alloys in which magnesium is the most important alloying element. Typical examples which, however, do not limit the invention are the alloys AA5005 and AA5754.

[0020] More preferably, the cold-rolled aluminium sheet is brought into a strengthened state, also known as an H temper by the person skilled in the art. This designation applies to products which have been cold-formed after annealing or after hot-forming or to a combination of strengthening and annealing or stabilizing for hardness, in order to obtain the specific mechanical properties. Typical examples which, however, do not limit the invention are an H14 and an H22 temper. It has been found that in particular wrought aluminium alloys with an H temper are very suitable for the application, efficiently and reproducibly on an industrial scale, of the desired surface roughness by cold-rolling, and in particular by EDT rolling.

[0021] The invention is also embodied by a curved aluminium sheet part, such as for example the door of a refrigerator or a freezer or the housing of a remote control for audiovisual equipment, produced from an aluminium sheet obtained using the method according to the invention.

[0022] The invention will now be explained with reference to a number of examples, which do not restrict the invention.

Example 1

[0023] Aluminium sheet made from the AA5754 alloy in an H temper with a thickness of 0.7 mm on an industrial scale is provided with a surface roughness Ra of 1.35 microns, measured in accordance with DIN 4768, using an industrial EDT roller. The EDT roller used in this example has a surface roughness Ra of approximately 2.5 microns. The roughened aluminium sheet is then pickled lightly in an alkaline solution based on sodium hydroxide, and is then provided, in a sulphuric acid solution, with an anodized layer with a thickness of 5 microns. The final surface roughness Ra of the aluminium sheet obtained was 1.31 microns. The aluminium sheet obtained is then provided with a protective plastic film and was then bent to form a door panel for a refrigerator. The final surface of the door panel provided a very good approximation to the appearance of a finish obtained using glass beads. Gloss measurements were also carried out at an angle of 60°, in accordance with ASTM D-523, on the cold-rolled aluminium sheet after the roughening with the aid of the EDT roller and after the anodization. The results were 175.4 and 25.6 gloss units, respectively.

Example 2

[0024] Aluminium sheet produced from the AA5005 alloy in an H temper with a thickness of 0.5 mm on an industrial scale was provided with a surface roughness Ra of 1.53 microns, measured in accordance with DIN 4768, using an industrial EDT roller. The roughened aluminium sheet was then pickled very lightly in an alkaline solution based on sodium hydroxide and was then provided, in a sulphuric acid solution, with an anodized layer with a thickness of 5 microns. The final surface roughness Ra of the aluminium sheet obtained was 1.52 microns. The aluminium sheet obtained was then provided with a protective plastic film and was then bent to form a panel for a remote control. The final surface of the remote control provided a very close approximation to the appearance of a finish obtained using glass beads. Gloss measurements at an angle of 60° were once again carried out, in accordance with ASTM D-523, on the cold-rolled aluminium sheet after the roughening with the aid of the EDT roller and after the anodization. The results were 182.2 and 23.1 gloss units, respectively.

Example 3

[0025] Aluminium sheet which was produced from the AA5754 alloy in an H temper with a thickness of 0.7 mm on an industrial scale was provided with a surface roughness Ra of 2.1 microns, measured in accordance with DIN 4768, using an industrial EDT roller. The EDT roller used in this example has a surface roughness Ra of approximately 3.8 microns. Then, the roughened alu-

minium sheet was pickled lightly in an alkaline solution based on sodium hydroxide and was then provided, in a sulphuric acid solution, with an anodized layer with a thickness of 5 microns. The ultimate surface roughness Ra of the aluminium sheet obtained was 2.0 microns. The aluminium sheet obtained was then provided with a protective plastic film and was then bent to form a door panel of a refrigerator. The ultimate surface of the door panel provided a very close approximation to the appearance of a finish obtained using glass beads. Gloss measurements at an angle of 60° were also carried out, in accordance with ASTM D-523, on the cold-rolled aluminium sheet after the roughening with the aid of the EDT roller and after the anodization. The results were 128.3 and 22.7 gloss units, respectively.

[0026] For comparison purposes, aluminium sheets were provided with a surface roughness of Ra 0.9 micron and Ra 1.0 micron with the aid of EDT rollers. Visual inspection revealed that these sheets do not have a surface structure which approximates the desired surface structure which would be obtained by blasting with glass beads.

[0027] It should be noted that it may be advantageous, in particular for a relatively thick anodized layer and/or substantial deformation operations carried out on the decorative aluminium sheet provided with the decorative surface structure to be curved or bent before the curved aluminium sheet is anodized, despite the higher costs associated with batchwise anodization. This has the advantage that the anodized layer cannot be damaged during the deformation.

Claims

1. Method for producing an aluminium sheet with a decorative surface structure on at least one side, comprising the successive process steps of:
 - (a) providing a cold-rolled aluminium sheet of a desired thickness;
 - (b) using cold-rolling to apply a surface roughness Ra to at least one side of the aluminium sheet, in a range from 1.2 to 3.0 microns measured in accordance with DIN 4768.
2. Method according to Claim 1, **characterized in that** during process step (b) the surface roughness is applied by means of rollers with a non-deterministic texture.
3. Method according to Claim 2, **characterized in that** during process step (b) the surface roughness is applied by means of electro-discharge texturing (EDT) rollers.
4. Method according to one of Claims 1 to 3, **characterized in that** after process step (b) the roughened

aluminium sheet is provided with a coating layer in a process step (c).

5. Method according to one of Claims 1 to 4, **characterized in that** after process step (b) the roughened aluminium sheet is anodized in a process step (c). 5
6. Method according to one of Claims 1 to 4, **characterized in that** after process step (b) the roughened aluminium sheet is provided, in a process step (c), with an anodized layer with a thickness in a range of up to 20 microns, preferably in a range of up to 15 microns, by means of anodization. 10
7. Method according to Claim 5 or 6, **characterized in that** after process step (b) and before process step (c) the aluminium sheet is pickled in a process step (b1). 15
8. Method according to Claim 7, **characterized in that** during the process step (b1) the aluminium sheet is chemically or electrochemically pickled in an alkaline or acidic medium. 20
9. Method according to one of Claims 1 to 8, **characterized in that** during process step (b) a surface roughness in a range of Ra 1.3 to 3.0 microns is applied, preferably in a range of Ra 1.5 to 3.0 microns, measured in accordance with DIN 4768. 25
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10. Method according to one of Claims 1 to 9, **characterized in that** the roughness Ra which is applied in process step (b) is at most 2.5 microns, measured in accordance with DIN 4768. 35
11. Method according to one of the preceding Claims 1 to 10, **characterized in that** an aluminium alloy from the AA1xxx series, the AA3xxx series, the AA5xxx series or the AA6xxx series is selected for the composition of the aluminium sheet provided. 40
12. Curved sheet part produced from an aluminium sheet obtained using the method according to one of Claims 1 to 11. 45

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