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METHOD FOR PRODUCING LACQUERED THIN SHEETS OF ALUMINUM

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It is well known to use sheets of aluminum or aluminum alloy in lacquered or unlacquered state as a substitute material for tin plate. If it is the question for example of the fabrication of cans or boxes or bottle caps of the crown cork type, sheets of a thickness of at most 0.8 mm. and at least 0.1 mm., preferably between 0.25 and 0.35 mm., are required. The aluminum sheets which have been furnished till now for such purposes and which are produced in the form of a rolled strip have a mechanical strength below that of the tin plate, especially if they were used lacquered. If a hard rolled sheet of aluminum or an aluminum alloy with only a little amount of alloying constituents is used lacquered, whereby the varnish serves as protection against corrosion or as a priming coat for a plastic coating, the metal looses its mechanical strength during heating for drying or baking the varnish, so that its strength is not sufficient for cans and crown corks. Sheets of highly alloyed aluminum, for example with 5% magnesium, which have also in the annealed state considerable tensile strength, yield strength, elongation and hardness, are not suitable as a substitute material for tin plate in the making of mass produced articles such as cans and crown corks because of their higher price. The material of the sheet should not cost sensibly more than pure aluminum.

Our present invention relates to a method for producing lacquered thin sheets of aluminum, the mechanical properties of which correspond to those of tin plate of the same thickness and which may also compete in price with tin plate.

According to our invention an aluminum alloy containing at most 1.5% of one or more of the alloying constituents Mg, Si, Zn, Cr, Mn and Ti is solution annealed and quenched at least at the double end thickness, preferably at the 3- to 5-fold end thickness, is aged at room temperature or slightly increased temperature, for example at 40 to 60° C., in order to attain a natural aging effect, then rolled to end thickness, thereafter coated with the solution of a varnish giving a coating suitable for deep-drawing and finally heated for drying or baking the varnish, whereby in comparison to the cold rolled state not only the malleability but also the mechanical strength of the sheet is increased.

If the solution annealing is carried out at the double end thickness, the sheet becomes then cold rolled with a deformation degree of 50%; if the solution treatment is carried out at the fivefold end thickness, the cold rolling degree will be 80%. This value may be exceeded if the desired mechanical strength is still reached.

The aging for attaining a natural aging effect is preferably carried out until practically the state of full age-hardening is reached. For example with an aluminum alloy with 0.4% Mg and 0.6% Si it is recommendable to choose an aging period of at least two days at room temperature, respectively somewhat shorter at a slightly increased temperature. Preferably this alloy is aged at room temperature during 3 to 4 days. Of course a longer aging period is not detrimental as the material remains unchanged after aging.

There may be considered many aluminum alloys with

a low content of alloying constituents, but for the practice of the present invention they must be hardenable by a heat treatment. Very good results are obtained with sheets of an aluminum alloy containing about 0.3 to 0.7% Mg and 0.3 to 0.7% Si. The aluminum with a low content of alloying constituents may of course contain beside Mg, Si, Zn, Cr, Mn and Ti some other elements in a low amount, provided that these other elements do not impair the result of the method according to the invention.

The sheet of aluminum alloy is preferably rolled and worked subsequently as a strip. After drying or stoving the varnish the sheet is cut, punched, divided in several small strips or furnished to the customer as a coiled strip.

For coatings which are suitable for deep drawing one uses preferably varnishes on the base of epicoate resins and vinyl chloride copolymers.

The quenching after the solution annealing may be carried out in cold or lukewarm water or in an air stream. During the following aging the tensile strength, the yield strength and the hardness become increased. A further increase results during cold rolling, but simultaneously the elongation is decreased. With an aluminum alloy containing 0.4% Mg and 0.6% Si the elongation drops to 6 to 3%. In this state the malleability is not sufficient for example for the deep drawing of cans or for the making of crown corks. But when the cold rolled sheet has been lacquered and is heated during 10 minutes to 30 seconds at a temperature of 120 to 240° C. for drying or stoving the varnish it is subjected at the same time to a relaxation of the crystalline structure resulting in an increase of the elongation for example up to 10–15% and a subsequent increase of the tensile strength, the yield strength and the hardness. The improvement of the mechanical properties of the cold rolled sheet is combined with the drying or stoving of the lacquer coating.

It was already known to lacquer after solution annealing and quenching articles made of an aluminum alloy containing 0.6 to 1.4% Mg, 0.8 to 1.2% Si, 0.6 to 1.0% Mn and up to 0.3% Cr (known in Europe as AlMgSi) and to heat them thereafter in order to stove the varnish and to age the alloy at the same time. But it was the question neither of an aluminum alloy with a low content of alloying constituents nor of the lacquering and artificially aging of a naturally aged aluminum alloy, nor of a material suitable to a great deformation after the last heating and which may be used therefore as a substitute material for tin plate, nor of a material which can compete in price with tin plate in the manufacture of mass produced articles. Thanks to the new combination of the several working steps: solution annealing, quenching, natural aging, cold rolling, artificial aging together with drying and stoving the lacquer, it was possible to increase the tensile strength, the yield strength, the hardness and the elongation and also to dry the varnish. Without the natural aging after the solution annealing and quenching it is not possible to obtain a sufficient mechanical strength by artificially aging a sheet of an end thickness of for example 0.25 to 0.45 mm. if the sheet should be used for the fabrication of cans or crown corks.

The method according to our invention presents besides the already mentioned advantages (steady improvement of the mechanical strength during the last working steps, combination of the artificial aging with the drying and stoving of the varnish) further advantages:

(1) The solution annealing and the quenching have not to be carried out at the end thickness of the sheet, but can be done at a considerable higher thickness. A hardening by solution annealing and quenching at an end thickness of for example 0.25 to 0.45 mm. is uneconomical, technically difficult to be carried out and does not give the maximal values for the mechanical strength.

(2) Generally the surface of the hardenable aluminum alloys, even of the alloys with a low content of alloying constituents, shows a grey colour after solution annealing and quenching, which colour does not disappear during aging. But during the cold rolling of the aged material according to our invention the surface becomes bright again, what is very advantageous for the use of the material.

Example.—A strip of aluminum containing 0.4% Mg and 0.6% Si is solution annealed at an intermediate thickness of 1 to 1.5 mm. quenched in cold water and naturally aged, whereby the yield strength is increased from 4–6 kg./mm.^{2} up to 8–15 kg./mm.^{2}, the tensile strength from about 10 up to about 20 kg./mm.^{2} and the Brinell hardness from 20–30 up to 55–60 kg./mm.^{2}. During the following cold rolling to the end thickness of 0.3 mm. (deformation degree of 70 to 80%) the yield strength rises to 28–34 kg./mm.^{2}, the tensile strength to 30–35 kg./mm.^{2} and the Brinell hardness to 90–100 kg./mm.^{2}. In this state the elongation is only 3 to 4%, that means the malleability is insufficient for example for the manufacture of crown corks. If now such a cold rolled sheet is then lacquered according to any known method and the varnish is dried by heating at a temperature between 120 and 240° C., the elongation becomes considerably increased; its value may rise up to 15%, whereas yield strength and tensile strength do not decrease, but increase further by about 6 to 8% respectively 8 to 10%. The mechanical strength of the material obtained in this way corresponds to the strength of the usual tin plate of the same thickness.

What we claim is:

1. The method for producing lacquered thin, deformable sheets of aluminum with high mechanical strength

comprising the steps of solution annealing and quenching to room temperature a rolled sheet of an aluminum alloy containing at least one of the constituents selected from a group consisting of Mg, Si, Zn, Cr, Mn and Ti, in an amount not to exceed 1.5% by weight, the said constituents being in such combination and amount that the alloy is hardenable by heat treatment, these annealing and quenching steps taking place at a thickness at least twice the desired ultimate thickness of the sheet; aging the sheet for attaining a natural aging effect; cold rolling the sheet to end thickness; covering the sheet with the solution of a varnish giving a coating suitable for deep-drawing and heating the lacquered sheet to 120 to 240° C. for drying or stoving the varnish, whereby not only the malleability but also the mechanical strength of the sheet become increased in comparison to the mechanical strength of the sheet in the cold-rolled state.

2. The method according to claim 1, in which the sheet is worked in strip form.

3. The method according to claim 1, in which the sheet is made from an alloy consisting of aluminum, 0.3 to 0.7% Mg and 0.3 to 0.7% Si.

4. The method according to claim 1, in which the sheet is cold rolled to a thickness of 0.8 to 0.1 mm.

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