

1

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METHOD OF PREVENTING STAINING OF ALUMINUM DURING ANNEALING

Howard M. Rue, Media, Pa., assignor to Sun Oil Company, Philadelphia, Pa., a corporation of New Jersey

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This invention relates to the processing or fabrication of aluminum. More particularly, it concerns the prevention of staining of aluminum during the operation of annealing the metal.

In fabricating aluminum into the form of plates or sheets, the metal is conventionally subjected to a rolling operation wherein it is passed one or more times through a rolling mill to press it into the desired form. In this operation lubricating oil customarily is applied continuously to the rollers to reduce friction and minimize the energy expenditure. Usually the oil used for this purpose is of relatively low viscosity, for example, within the range of 35–300 S. U. S. at 100° F., although oils of higher viscosity are used in some cases. Most of the commercial aluminum rolling operations are carried out by utilizing a petroleum oil having a viscosity between 35 and 75 S. U. S. at 100° F. The aluminum plates or sheets which leave the rolling mill retain on their surface a thin film of the oil which has been applied as lubricant.

During the rolling operation the aluminum tends to undergo what is referred to as work hardening; and it is customary thereafter to anneal the hardened aluminum by subjecting it to a temperature above 600° F. Work hardened aluminum will anneal satisfactorily at a temperature of, for example, 650° F., and it would be desirable to conduct the annealing step at about this temperature level. However, it has been found that at such temperature staining of the aluminum will occur due to the presence of the surface film of hydrocarbon oil, and that the surface generally will be left in a discolored, unsightly condition. This is apparently due to formation from the oil of a thin varnish-like deposit which adheres strongly to the metal and which cannot be removed by wiping. Hence, in order to avoid such staining in commercial practice, the aluminum is customarily annealed at a temperature sufficiently high to burn off the varnish deposit, usually 800–850° F. The use of such higher temperature substantially increases the expense of the annealing operation.

The present invention is directed toward avoiding or minimizing the above described stain formation during annealing of the aluminum, so that lower annealing temperatures or a shorter annealing time can be used than otherwise would be required to produce an annealed product of acceptable appearance.

According to the invention, lubrication during the rolling operation is effected by means of a hydrocarbon oil having elemental sulfur dissolved therein in minor amount. I have discovered that when aluminum is annealed at a relatively low annealing temperature, the presence of elemental sulfur in the oil film causes a considerable reduction in the amount of surface tarnish. Instead of the heavily discolored and unsightly condition which results when a conventional oil has been used in the rolling step, a surface of much better appearance having only a slight or moderate stain is obtained. By conducting the annealing step at a somewhat higher temperature but

2

still lower than that normally required, staining can be substantially completely eliminated and the surface will have a clean, bright appearance. If a high annealing temperature such as 800–850° F. is employed in practicing the invention, then the time that the aluminum need be maintained at such temperature to obtain a surface of acceptable appearance is substantially reduced.

Practice of the invention thus involves lubrication of the roller surfaces with hydrocarbon oil containing a minor amount of elemental sulfur dissolved therein, and thereafter subjecting the rolled aluminum carrying a film of the sulfur-containing oil to a suitable annealing temperature sufficient to remove the oil film and leave the aluminum surface in an unstained condition. Suitable annealing temperatures for practicing the invention generally lie within the range of 600–800° F. and are less than are normally required in conventional practice.

The base oil to which the sulfur is added may be any of the usual hydrocarbon oils used in lubricating roller mills. It usually will be preferable to employ an oil of viscosity within the range of 35–75 S. U. S. at 100° F., although oils having viscosities as high as, or higher than, 300 may be used if desired. It is also generally preferred to employ a distillate oil which has been derived from a naphthenic base crude oil, i. e. a crude oil having a viscosity-gravity constant above about 0.86.

Only a small amount of sulfur need be incorporated in the base oil to secure the desired anti-staining effect. The amount should be in excess of 0.05% but not in excess of that required to saturate the oil at the atmospheric temperatures to which the mixture may be exposed. Generally, less than 1.0% sulfur is sufficient although larger amounts may be used if the solubility of sulfur in the base stock is high enough. An illustrative composition for satisfactory commercial practice of the invention is composed of 0.5 part of sulfur dissolved in 99.5 parts of an unrefined distillate oil obtained from a naphthenic base crude stock.

Any suitable procedure may be used for incorporating the sulfur in the base oil. Generally the desired quantity of sulfur is added to the oil and the mixture is heated slightly, for example, to 120–130° F. to facilitate dissolution and is agitated until all of the sulfur has dissolved in the oil. No further treatment is required, and the composition may be used immediately for practicing the invention or may be stored for future use.

By way of illustration of the invention, a series of comparative tests was made employing as base stock a lubricating oil distillate derived from naphthenic base crude oil and having a viscosity of about 57 S. U. S. at 100° F. and an A. P. I. gravity of about 25. In each test 0.8 cc. of lubricant was spread over the upper surface of a circular piece of aluminum sheet having a diameter of 5½" and a thickness of 0.064" and the aluminum was then heated in an oven at 650° F. for 30 minutes. The condition of the surface to which the lubricant had been applied was observed following this treatment.

With the base stock oil alone, the aluminum surface had a vari-colored tarnish which could not be removed by wiping vigorously with a cloth. When the base oil contained 0.1% by weight of elemental sulfur, the amount of tarnishing was considerably reduced. When it contained 0.5% elemental sulfur, the degree of tarnishing was still further reduced and the aluminum surface had only a slight amount of stain of light brown color.

The exact mechanism whereby the presence of elemental sulfur in the rolling oil inhibits the tarnishing tendency of the oil is not certain. It is postulated, however, that it prevents unsaturated hydrocarbons formed by cracking at the annealing temperature from polymerizing or otherwise reacting to produce high molecular

3

weight products such as tar. It is believed that such high molecular weight product is the matter which constitutes the tarnish film. The elemental sulfur in the oil is thought to react with the cracked hydrocarbons as soon as they are formed and thereby prevent the formation of this material.

I claim:

1. In the annealing of aluminum having a surface film of hydrocarbon lubricant thereon, the method of preventing staining of the aluminum surface which comprises subjecting the aluminum to an annealing temperature in the presence of a surface film of lubricant comprising hydrocarbon oil having incorporated therein a minor amount of elemental sulfur between 0.05% by weight and the amount required to saturate the oil at atmospheric temperature.

2. Method according to claim 1 wherein the annealing temperature is within the range of 600-800° F.

3. Method according to claim 2 wherein the amount of sulfur is in the range of 0.05 to 1.0% by weight based on the sulfur-oil mixture.

4. Method according to claim 1 wherein said hydrocarbon oil has a viscosity within the range of 35-75 S. U. S. at 100° F.

5. In the annealing of aluminum having a surface film of hydrocarbon lubricant thereon, the method of prevent-

4

ing staining of the aluminum surface which comprises subjecting the aluminum to an annealing temperature in the presence of a surface film of lubricant comprising a distillate hydrocarbon oil derived from naphthenic base crude oil and having dissolved therein sulfur in amount of 0.05-1.0% by weight based on the sulfur-oil mixture.

6. Method according to claim 5 wherein said distillate hydrocarbon oil has a viscosity within the range of 35-75 S. U. S. at 100° F.

7. In the working and subsequent annealing of aluminum wherein the metal is in contact with lubricating oil at an elevated temperature such that the metal normally becomes discolored, the improvement which comprises adding to the lubricating oil elemental sulfur in an amount between 0.05% by weight and the amount required to saturate the oil at atmospheric temperature to reduce discoloration of the metal.

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