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METHOD OF TREATING PISTONS

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Light metal pistons are usually made of aluminum base alloys which are either cast or forged or otherwise worked into a piston blank or shape. This piston blank is then cut or machined into the final piston form of the shape and dimensions required. Also, since high hardness is a quality much desired in pistons, the piston is treated by such thermal methods as will induce in the aluminum base alloy from which the piston is made, a substantial increase in hardness. The aluminum alloys of which pistons are usually made are those which are capable, in thermal treatment, of producing a high hardness. Such alloys should also have a coefficient of thermal expansion as nearly equal as possible to that of the usual ferrous metal cylinder in which the piston reciprocates, and it is likewise desirable that the aluminum alloy be one which machines with relative ease. Certain specific aluminum base alloys are used for such purposes but nearly all are characterized by their capability of responding on thermal treatment in increase of hardness. Some alloys are better than others with respect to the maximum hardness obtained by such treatment, the coefficient of thermal expansion and machining qualities. Consequently some alloys are preferable to others and while this invention will be described with reference to certain of the preferred alloys it relates broadly to the treatment of pistons made of aluminum base alloys which develop increased hardness on thermal treatment, such as those alloys containing magnesium or silicon or mixtures of these and other alloying elements which impart to the alloy the capacity of increasing hardness by thermal treatment.

It has been the practice in the preparation of aluminum alloy pistons for use in a motor to apply the thermal treatments by which the desired final hardness is developed in the piston prior to the machining operation. The piston is then machined and, afterwards, placed in the motor. This method of procedure has been followed as usual practice despite the fact that the thermal treatments, preceding as they do the machining, develop maximum hardness in the piston before it is machined, thus making machining difficult particularly in the case of certain alloys as hereinafter described.

The general object of this invention is to provide methods by which the disadvantages of the older processes of preparing pistons may be eliminated.

In accordance with the present invention the aluminum alloy piston blanks after being cast, forged, or otherwise fabricated, are first subjected to a thermal treatment designed to place the metal in such condition that its hardness may be improved. This treatment consists in heating the piston for from about 15 minutes to about 6 hours at a temperature of between 900° F. and 1020° F., followed by rapid cooling. If the piston is fabricated by a working process such as by forging, extrusion, etc., it may even be "die quenched"; that is to say, if the piston is fabricated at an elevated temperature, it may be removed from the dies after working, and, while still at such a temperature that the alloying constituents are in solid solution in amount in excess of the amount soluble at room temperature, it may be rapidly cooled, thereby placing it in such physical condition that it is amenable to the further steps hereinafter described. In this condition the piston may be readily machined to final dimension without surface scuffing, tool wear, or any of the other disadvantages encountered heretofore in the machining of hard pistons of certain alloys. The piston is now in condition to develop its maximum hardness and I have found that this hardness may be developed by installing the piston in the motor and operating the motor for a few hours.

The advantages of this series of steps are many. Heretofore all thermal treatments were completed and the piston brought to maximum hardness before machining. The high temperatures and rapid quenches involved in the solution treatment sometimes caused casting warpage. The surface of the piston was occasionally scored or otherwise disfigured in handling. At the lower temperatures incident to bringing the piston up to hardness, most alloys are subject to growth, some more so than others. It was therefore thought necessary to complete the thermal treatments before machining and installing the piston in the motor. Machining the hard pistons induced excessive tool wear and it was frequently necessary to use expensive tools and special technique to maintain a production schedule.

Aluminum base alloys of the type disclosed in U. S. Patent 1,799,837 have been found to be particularly amenable to the series of steps disclosed above. These alloys contain from about 7 to about 15 per cent of silicon, from about 0.2 to about 3 per cent of magnesium, from about 0.3 per cent to about 4 per cent of copper, and from about 0.5 per cent to about 7 per cent of nickel, with the usual impurities. The silicon, copper and magnesium are the constituents which are mainly instrumental in illustrating the advan-

tages of my invention by reason of their susceptibility to change of condition under thermal treatments. It had heretofore been found that from the standpoint of economic commercial production, it was practically impossible to machine these pistons after the maximum hardness had been developed by a solution treatment followed by an aging treatment prior to machining. A compromise theatment was frequently resorted to, that is to say, the piston was given a low temperature aging treatment without prior solution treatment, thereby achieving an intermediate degree of hardness which rendered the machining operation commercially feasible but which was never capable of developing maximum hardness. By my process it is now possible to put this or any other heat treatable alloy in a condition to develop its maximum hardness in the motor by first giving it the high temperature solution theatment, machining it while it is relatively soft, say between 80 and 100 Brinell, and finally, without further thermal treatment, installing it in the motor. Several additional specific advantages may be mentioned. The artificial aging step, heretofore deemed necessary before installation of the piston in the motor, has now been eliminated thereby effecting a substantial saving in furnaces, other materials, labor, and time. The period when the piston is coming up to maximum hardness in the motor is the period when the motor is undergoing its "breaking-in", or in other words, when it is being operated with greatest care. If the alloy happens to be such that low temperature thermal treatments subsequent to fabrication or solution treatment cause it to exhibit growth, the phenomenon will be compensated for by preliminary wearing in of piston and cylinder, thereby rendering unnecessary calculated tolerances which allow for piston growth in the cylinder. Pistons which are at maximum hardness when installed do not wear in as readily as those which are softer.

The article on which I have been able to exhibit the advantageous properties of the invention to a superior extent is a piston cast in permanent mold from an aluminum base alloy containing about 14 per cent of silicon, 0.8 per cent of copper, 1.0 per cent of magnesium, and 2.5 per cent of nickel, with possible additions of other constituents. Prior to the date of the present invention it had been the practice to merely age this alloy at a relatively low temperature before machining, thereby attaining an intermediate degree of hardness, because if subjected to the combination solution and aging treatment, the hardness increased to such an extent that machining was accomplished only with difficulty. It is now possible to develop the maximum hardness in the piston by first heating it at a temperature between about 900° F. and 1020° F. for from 15 minutes to 6 hours, thereafter machining it while its Brinell hardness is between about 85 and 110, and finally installing it in the motor where its hardness increases to between about 120 and 150 Brinell in the first few hours of motor operation.

When pistons are not subject to an unusual amount of growth, it is possible to age them artificially after machining in the soft condition, and before installing them in the motor, but in the preferred embodiment of my invention I avoid the expense involved and time lost in this extra step.

The steps outlined hereinabove are applicable to alloys not specifically disclosed herein but which exhibit similar characteristics, namely, susceptibility to solution treatment and development of high hardness by artificial aging attended by machining difficulties. Alloys containing in addition to other metals substantial amounts of silicon with magnesium and/or copper are representatives of this type.

I claim:

1. In the process of treating a motor piston whereby the piston develops its maximum hardness under the influence of the heat of the motor in which it operates, the steps comprising fabricating said piston from an alloy amenable to the development of increased hardness by thermal treatment, heating the piston at an elevated temperature, rapidly cooling the piston, machining the piston to the desired dimensions, and, without further thermal treatment, installing said piston in said motor.

2. In the process of treating a motor piston whereby the piston develops its maximum hardness under the influence of the heat of the motor in which it operates, the steps comprising fabricating the piston from an alloy amenable to softening by heating to a temperature in excess of 900° F. and to hardening by heat treating at a relatively low temperature, heating said piston at a temperature in excess of 900° F., rapidly cooling said piston, machining said piston to final dimensions, and, without further thermal treatment, installing said piston in said motor.

3. In the process of treating a motor piston whereby the piston develops its maximum hardness under the influence of the heat of the motor in which it operates, the steps comprising casting the piston in a chill mold, removing said piston from said mold at an elevated temperature, rapidly cooling said piston, machining said piston to final dimensions, and, without further thermal treatment, installing said piston in said motor.

4. In the process of treating a motor piston whereby the piston develops its maximum hardness under the influence of the heat of the motor in which it operates, the steps comprising fabricating the piston, causing the said piston to attain a Brinell hardness of between about 80 and 110 by quenching it from an elevated temperature, machining the piston to final dimensions while within said hardness range, and, without further thermal treatment installing said piston in said motor.

5. In the process of treating a motor piston whereby the piston develops its maximum hardness under the influence of the heat of the motor in which it operates, the steps comprising fabricating the piston, causing the said piston to attain a Brinell hardness of between 80 and 110 by quenching it from an elevated temperature, machining the piston to final dimensions while within said hardness range, and thereafter installing said piston in said motor.

6. In the process of treating a motor piston whereby the piston develops its maximum hardness under the influence of the heat of the motor in which it operates, the steps comprising casting the piston in a chill mold, removing said piston from said mold at an elevated temperature, rapidly cooling said piston, machining said piston to final dimensions at a Brinell hardness of between 80 and 110, and, without further thermal treatment, installing said piston in a motor.

7. In the process of treating a motor piston whereby the piston develops its maximum hardness under the influence of the heat of the mo-

tor in which it operates, the steps comprising fabricating the piston between dies, removing the piston from the dies at an elevated temperature, rapidly cooling the piston, machining said piston to final dimensions, and, without further thermal treatment, installing said piston in a motor.

8. In the process of treating a motor piston whereby the piston develops its maximum hardness under the influence of the heat of the motor in which it operates, the steps comprising fabricating the piston from an aluminum base alloy containing from 7 to 15 per cent of silicon, from 0.2 to 3.0 per cent of magnesium, from 0.5 to 7.0 per cent of nickel and from 0.3 to 4.0 per cent of copper, heating the piston at a temperature of between 900° F. and 1020° F., rapidly cooling the piston, machining the piston to final dimensions, and, without further thermal treatment, installing said piston in said motor.

9. In the process of treating a motor piston whereby the piston develops its maximum hardness under the influence of the heat of the motor in which it operates, the steps comprising fabricating the piston from an aluminum base alloy containing from 7 to 15 per cent of silicon, from 0.2 to 3 per cent of magnesium, from 0.5 to 7.0 per cent of nickel, and from 0.3 to 4 per cent of copper, heating the piston at a temperature of from 900° F. to 1020° F. for from 15 minutes to 6 hours, rapidly cooling the piston, and thereafter installing said piston in said motor.

10. In the process of treating a motor piston whereby the piston develops its maximum hardness under the influence of the heat of the motor in which it operates the steps comprising casting the piston in a chill mold from an aluminum base alloy containing from 7 to 15 per cent of silicon, from 0.2 to 3.0 per cent of magnesium, from 0.5 to 7.0 per cent of nickel, and from 0.3 to 4.0 per cent of copper, removing said piston from said mold after solidification but at a temperature in excess of 900° F., rapidly cooling said piston, machining said piston to final dimensions, and, without further thermal treatment, installing said piston in said motor.

11. In the process of treating a motor piston whereby the piston develops its maximum hardness under the influence of the heat of the motor in which it operates, the steps comprising fabricating the piston from an aluminum base alloy containing about 14 per cent of silicon, about 1.0 per cent of magnesium, about 2.5 per cent of nickel and about 0.8 per cent of copper, heating the piston at a temperature of from 900° F. to 1020° F. for from 15 minutes to 6 hours, rapidly cooling said piston, machining said piston to finished dimensions, and, without further thermal treatment, installing said piston in said motor.

12. In the process of treating a motor piston whereby the piston develops its maximum hardness under the influence of the heat of the motor in which it operates the steps comprising fabricating the piston from an aluminum base alloy containing about 14 per cent of silicon, about 1.0 per cent of magnesium, about 2.5 per cent of nickel and about 0.8 per cent of copper, heating the piston at an elevated temperature and cooling therefrom so as to induce in the piston a Brinell hardness of from 80 to 110, machining the piston to final dimensions while in said hardness range, and, without further thermal treatment, installing said piston in said motor.

13. In the process of treating a motor piston whereby the piston develops its maximum hardness under the influence of the heat of the motor in which it operates, the steps comprising fabricating the piston from an aluminum base alloy containing a substantial amount of silicon, rapidly cooling the piston from an elevated temperature, machining the piston to final dimensions at a Brinell hardness not in excess of 110, and, without further thermal treatment, installing said piston in said motor.

GEORGE L. MOORE.