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METHOD OF MAKING PISTON RINGS

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ABSTRACT OF THE DISCLOSURE

A method of making piston rings for internal-combustion engines, external-combustion engines such as steam engines, air compressors and the like in which the rings are individually cluster cast from an alloy-cast iron containing 4.0 to 5.0% silicon, 0.6 to 1.2% by weight manganese and 0.2 to 0.7% by weight phosphorus. The cast iron is treated in the liquid state with bismuth to yield a raw metallurgical structure, upon casting, of cementite, pearlite, ledeburite and a phosphoric eutectic.

(1) FIELD OF THE INVENTION

My present invention relates to a method of making piston rings and, more particularly, to a method of making iron piston rings for internal-combustion engines, external-combustion engines such as steam engines, and air compressors.

(2) BACKGROUND OF THE INVENTION

Numerous methods have been proposed heretofore for the production of piston rings for high-temperature operations and considerable effort has been expended in efforts at the economical production of piston rings capable of increasing the usual life of the ring and the improvement of the motors, engines or compressors in which the rings are used.

In general, such rings are split and are received in grooves in the piston and slidably engage a cylinder wall. Especially in internal-combustion engines, the rings must withstand high temperatures, and frequently prior-art rings for this purpose have been composed of cast iron.

In conventional processes, the piston rings may be machined from individual cast rings having dimensions close to the finish dimensions of the final ring, machined from cylinders which are centrifugally or gravity cast, or by forming the piston rings from rod, bar or wire stocks. More specifically, it has been proposed to form piston rings of grey pearlitic iron, of alloyed malleable iron with pearlitic and globular carbide structures, and of nodular cast iron alloyed with silicon and of a ferritic structure. When gravity or centrifugal casting is employed, the iron is usually grey pearlitic iron, alloyed pearlitic iron, nodular cast iron with alloys of a pearlitic structure, or nodular cast iron with or without silicon alloys and of a ferritic structure.

Individual casting of rings of alloyed malleable iron with a pearlite or globular structure has the disadvantage that special charges are required to obtain low carbon and silicon contents, in that the annealing treatment requires relatively long periods of 20 to 25 hours, and in that the annealing necessitates high temperatures of 950° to 1000° C. In addition, the rings must be packed during annealing to avoid decarbonization, or furnaces must be used during the annealing which have controlled atmosphere. The individual casting of piston rings of nodular cast iron, alloyed with silicon, of a ferritic structure has the disadvantage that a large proportion of the cast rings are found to have casting defects, such as blowholes, black spots and microscopic shrinkholes which appear to

be inherent in the nature of the solidification process of the nodular cast iron and the reaction of the magnesium thereof with the moisture of the forms in which the casting is effected.

(3) OBJECTS OF THE INVENTION

It is, therefore, the principal object of the present invention to provide an improved method of making piston rings, especially for internal-combustion engines, steam engines and compressors, which have improved temperature resistance and corrosion resistance and are less wearable than prior-art piston rings with an iron base.

Another object of the invention is to provide a piston ring of the character described which improves the operating characteristics of an internal-combustion engine, an external-combustion engine, or a compressor in which the piston ring is used.

Yet a further object of the invention is to provide a method of making piston rings wherein the solidification defects and the disadvantages of the presence of magnesium are eliminated.

(4) SUMMARY OF THE INVENTION

These objects and others which will become apparent hereinafter are attained, in accordance with the present invention, in a method of making piston rings for the purposes described, which involves the casting (individual cluster casting) of piston-ring bodies from a cast iron alloyed with silicon and treated, in the liquid state, with bismuth. Surprisingly, the use of bismuth, as will be elaborated below, completely eliminates the solidification defects characteristic of earlier methods of piston-ring production and, moreover, excludes reaction between moisture and the casting forms and the metal from which the piston ring is made. Furthermore, and of equal importance, the present method eliminates the need for packing of the ring during annealing to avoid decarbonization and nevertheless eliminates disadvantages associated with prolonged heat treatments.

According to a specific feature of this invention, the high-silicon cast iron, which is to be treated with bismuth, is prepared in an electric-arc or induction furnace and has the following composition:

	Percent by weight
Carbon	2.6 to 3.0
Silicon	4.0 to 5.0
Manganese	0.6 to 1.2
Phosphorus	0.2 to 0.7
Sulphur	0 to 0.1
Iron (and trace amounts of usual impurities not affecting behavior)	Balance

The starting material may be new iron (i.e. pig iron), iron from a crude-refining or a finish-refining process which must be rejected because of a high silicon content, old or scrap iron and steel, especially carbon-steel and silicon-steel scrap, and iron or steel containing material rich in silicon.

I have found, in accordance with an important feature of this invention, that the carbon contents should be adjusted with respect to the silicon content or vice versa in dependence upon the following relationship:

$$[Si]=11.5-2.5[C]$$

where [Si] represents the silicon concentration in percent by weight of the iron and [C] represents the carbon concentration in percent by weight. Thus the carbon content will decrease within the limits of 3 to 2.6% by weight of the alloy as the silicon content increases from 4 to 5% by weight of the alloy.

According to an important feature of this invention, after the formation of the casting alloy of the above com-

position and prior to its treatment with bismuth, the melt is overheated, i.e. raised to a temperature above its melting point and preferably between 1450° C. and 1550° C., for a period of 10 to 60 minutes. The liquid cast iron, at a temperature of 1400 to 1350° C. is treated in the casting ladle with metallic bismuth in a proportion of 0.01 to 0.1% by weight of the alloy, by adding the bismuth during the filling of the ladle with the melt.

The melt is then cast from the ladle at a temperature of 1350 to 1450° C. into individual forms having the configuration of a circular or oval piston ring and prepared as green-sand molds with a number of the forms being clustered with respect to a single riser or sprue (individual cluster casting). Such molds are, of course, conventional. The microstructure of the cast rings consist of cementite, pearlite, ledeburite and the phosphoric eutectic.

According to an important feature of this invention, the cast rings are subjected to a unique heat treatment designed to modify the microstructure and open the piston-ring slot as will be apparent hereinafter. Prior to the heat treatment, however, the rings may be deburred (e.g. by tumbling or grinding) to eliminate uneven portions of the surface, and are mounted in a support designed to maintain the planarity of the rings in a stacked condition. A light pressure is applied to the rings to prevent deformation during the heat treatment.

The heat treatment, according to the present invention includes an annealing of the piston rings at a temperature of 700° to 900° C. over a period of 1 to 5 hours in an electric furnace or a liquid-fuel or gas-fuel furnace in the normal furnace atmosphere and without special measures to control decarbonization. Within the furnace, the rings are cooled to 650° to 700° C. and thereafter cooled to ambient temperature in air. The piston-ring blank treated in this manner may then be machined to impart the oval or circular profile, and the slot thereafter opened by a further heat treatment. The slot-opening heat treatment consists in annealing the ring at 700 to 720° C. for one hour, followed by cooling (quenching) in oil to room temperature.

The microstructure of the resulting piston ring consists of solid solution crystals of $Fe_{\alpha}Si$, phosphoric eutectic and nodules of graphite as formed in annealing. The piston rings have a tensile strength of 45 to 65 kgf./mm.², an elongation to break of less than 1%, a hardness of 240 to 270 B.H.N. and a modulus of elasticity of 18,000 kgf./mm.². The resistance to wear is about twice that of grey pearlitic iron.

(5) EXAMPLE

Tractor piston rings are prepared in accordance with the present invention from cast iron smelted in an acid-lined induction-furnace crucible. The fresh cast iron, with the following composition:

	Percent by weight
Carbon	3.6
Silicon	2.25
Manganese	0.8
Phosphorus	0.25
Sulphur	0.03
Iron	Balance

is smelted in the furnace and slagged with quartz sand.

Thereafter, the iron is overheated for a period of 30 minutes at a temperature of 1500° C., the final composition of the cast iron being as follows:

	Percent by weight
Carbon	2.8
Silicon	4.6
Maganese	0.98
Phosphorus	0.58
Sulphur	0.025
Iron	Balance

The cast-iron melt is treated with 0.05% by weight bismuth, the latter being gradually added to the melt as it is introduced into the casting ladle. The resulting melt is cast at a temperature of 1450° C. in green-sand molds to product a cluster of piston rings. After removal of the deadheads, burrs and surface irregularities, the piston rings are mounted (stacked) upon a mandrel under light axial pressure and are introduced into an annealing furnace. In the electrically heated annealing furnace, the rings are heated at a temperature of 850° C. for three hours and are cooled in the furnace to 650° C. The rings are then cooled in air to ambient temperatures. Thereafter, the piston rings are machined to the desired configurations and, when circular-profile piston rings are desired, a slot of 11 mm. width is formed. The piston ring slot is opened by annealing the rings, while mounted upon the annealing mandrel, at 700° to 720° C. for a period of an hour, whereupon the rings are quenched in oil. Oval piston rings are produced by machining controlled by a cam in accordance with the usual techniques and receive a slot having a width of about 15 mm. After annealing, a diametral elastic force of about 10,000 g. is found.

The piston rings have a modules of elasticity of about 18,000 kgf. per mm.², a resistance to wear of about twice that of pearlitic iron, a hardness of 240 to 270 B.H.N., an elongation to break of less than 1% and a tensile strength of 45 to 65 kgf. per mm.². The micro structure of the piston rings is found to be that of annealing graphite, solid-solution crystals of Fe_{α}-Si and phosphoric eutectic.

The piston rings as produced are found to have high wear resistance, almost twice the elastic force of a conventional piston ring for the same slot width, to be practically free from internal stress and of structural and dimensional stability temperatures of 650° C. and greater, to improve functioning of internal combustion engines, steam engines and compressors by virtue of an increased sealing of the gap between the piston and the cylinder wall. In fact, oil consumption in an internal-combustion engine using the piston rings of the present invention is reduced.

I claim:

1. A method of making a piston ring for internal and external combustion engines, compressors and the like, comprising the steps of: preparing a cast iron melt of substantially the following composition:

	Percent by weight
Carbon	2.6 to 3.0
Silicon	4.0 to 5.0
Manganese	0.6 to 1.2
Phosphorus	0.2 to 0.7
Sulphur	0 to 0.1

the balance iron, and trace amounts of substance not materially affecting the properties of the cast iron; treating said melt in a liquid state with 0.01 to 0.1% by weight bismuth; and casting the bismuth-treated melt to produce a piston-ring body.

2. The method described in claim **1** wherein a plurality of such bodies are individually cluster cast from the bismuth-treated melt, said method further comprising the step of annealing said bodies at a temperature of 700° to 900° C. for a period of 1 to 5 hours in an annealing furnace, cooling said bodies to a temperature of about 650° to 700° C. in said furnace, and thereafter cooling said bodies to ambient temperature in air.

3. The method described in claim **2**, further comprising the step of machining said bodies to a circular profile and forming a slot therein, and opening said slot by heating said bodies at a temperature of 700° to 720° C. for a period of about 1 hour and thereafter quenching said bodies in oil.

4. The method described in claim **2** wherein said melt is overheated to a temperature of 1450° C. to 1550°

C. for a period of 10 to 60 minutes prior to its treatment with bismuth.

5. The method described in claim 4 wherein said bismuth-treated melt is at a temperature of 1350 to 1450° C. upon casting of said bodies.

6. The method described in claim 5 wherein said bodies are cast in a green-sand mold.

References Cited

UNITED STATES PATENTS

2,214,650	9/1940	Bancroft	148—2 X
2,214,651	9/1940	Bancroft	148—2 X
3,189,443	6/1965	Laudenslager	75—130 A X
3,282,683	11/1966	Moore	75—130 A X
2,578,794	12/1951	Gagnebin	75—130 A X
1,386,997	8/1921	Elliott	148—3
1,591,598	7/1926	Williams et al.	148—3
2,370,225	2/1945	Boegehold	148—3
3,518,128	6/1970	Takao et al.	148—3

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. **3,673,004** Dated **10 July 1972**

Inventor(s) **Traian DUMITRESCU**

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the identification of the assignee

"CERETARI" should read -- CERCETARI -- .

Signed and sealed this 9th day of January 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents