



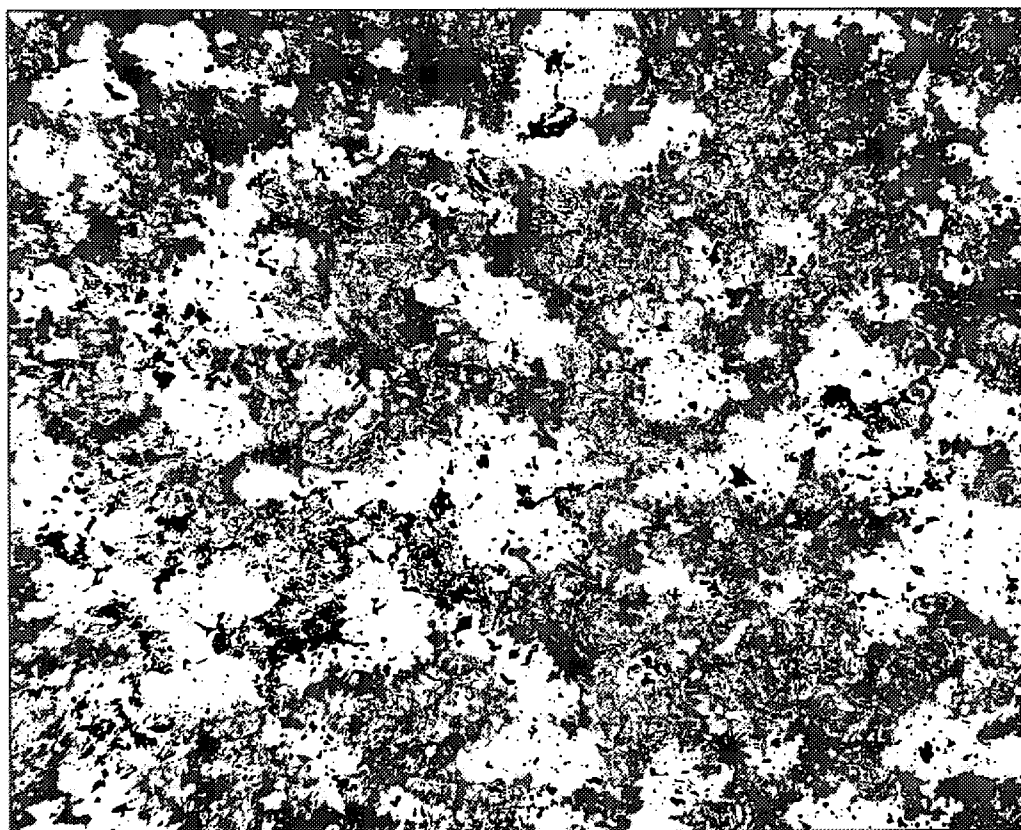
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SCOTT et al.(10) **Pub. No.: US 2011/0002805 A1**(43) **Pub. Date: Jan. 6, 2011**(54) **FORMABLE SINTERED ALLOY WITH
DISPERSED HARD PHASE**(75) Inventors: **RICHARD SCOTT**, Cumberland,
ME (US); **Stephanie Renaud**,
Lewiston, ME (US); **John Fulmer**,
Old Orchard Beach, ME (US)

Correspondence Address:

PARKER-HANNIFIN CORPORATION
HUNTER MOLNAR BAKER MORGAN
6035 PARKLAND BOULEVARD
CLEVELAND, OH 44124-4141 (US)(73) Assignee: **PARKER HANNIFIN**
CORPORATION, Cleveland, OH
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Dec. 19, 2008, now abandoned.(60) Provisional application No. 61/015,024, filed on Dec.
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B22F 3/12 (2006.01)(52) **U.S. Cl.** **419/25**(57) **ABSTRACT**

A method of forming an iron based sintered body which comprises in % by mass: 0.4 to 1.0% of C; 0.5 to 3.5% of Cr; 0.1 to 1.7% of Mo; 0.3 to 3.0% of Cu and microstructure of about 20-50% dispersed martensite in a matrix of fine pearlite is provided. The method utilizes a step of cooling a sintered article at a rate not exceeding 0.5~C/sec. Ni and/or Mn may also be included in the method.



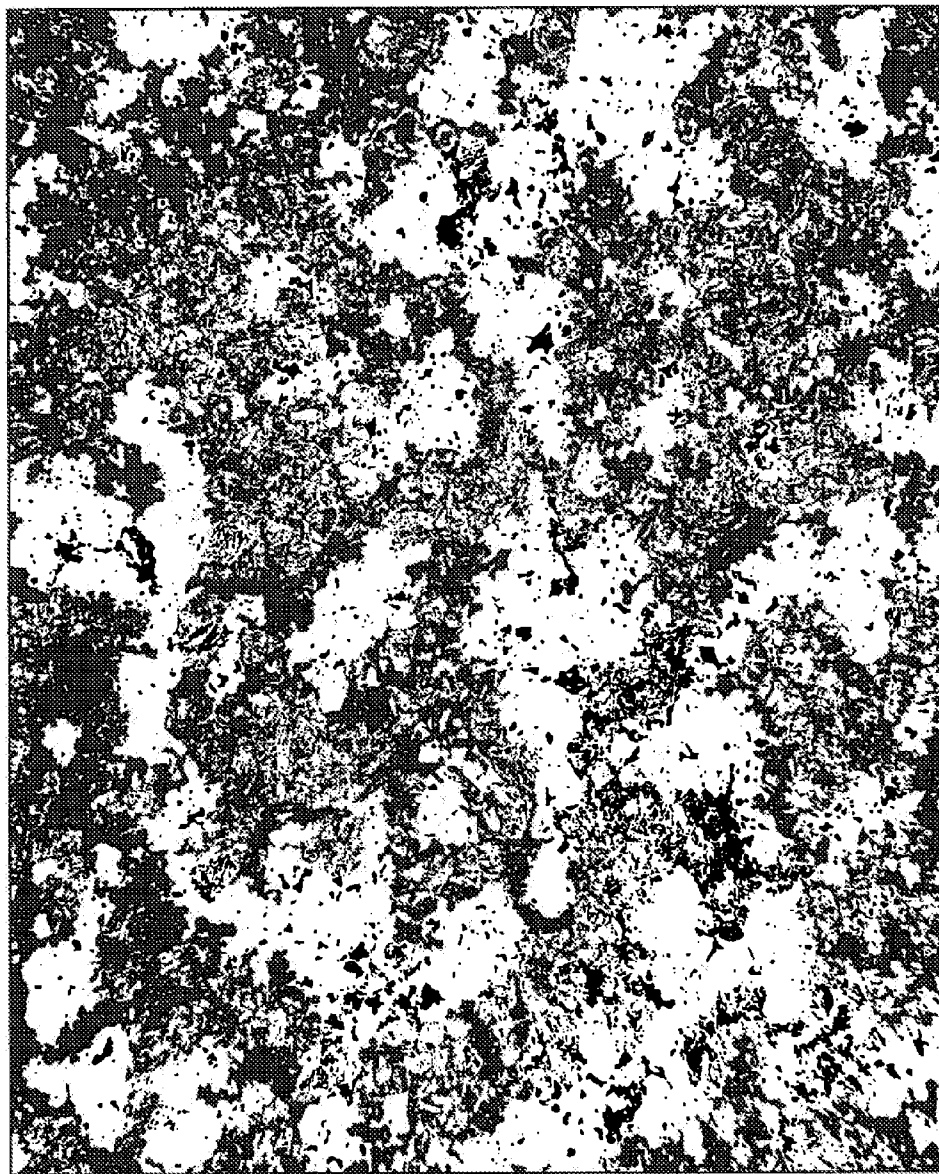


FIG. 1

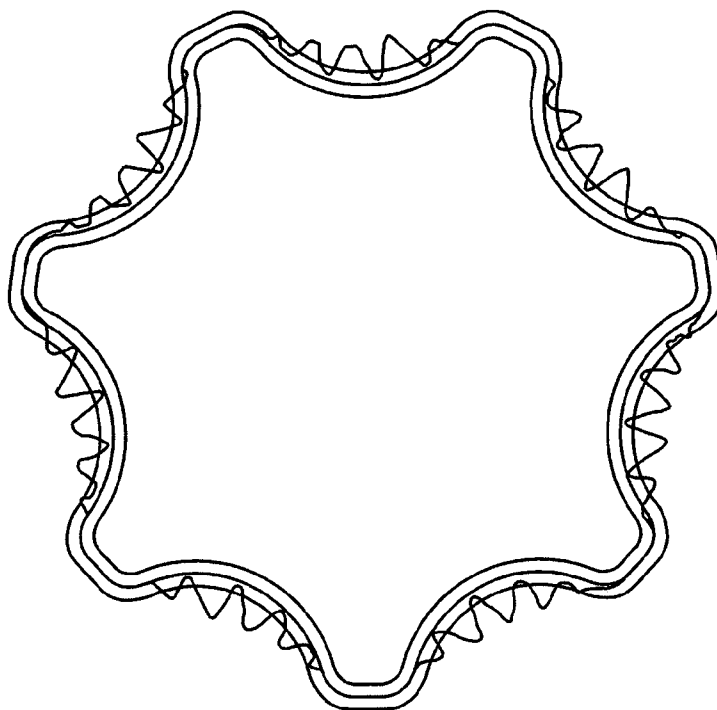


FIG. 2

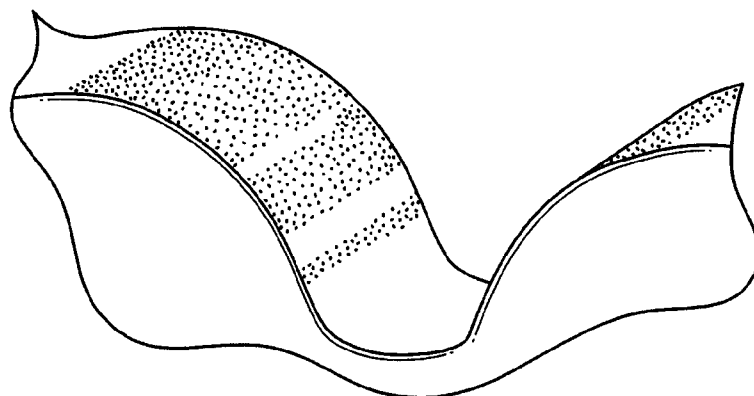


FIG. 3

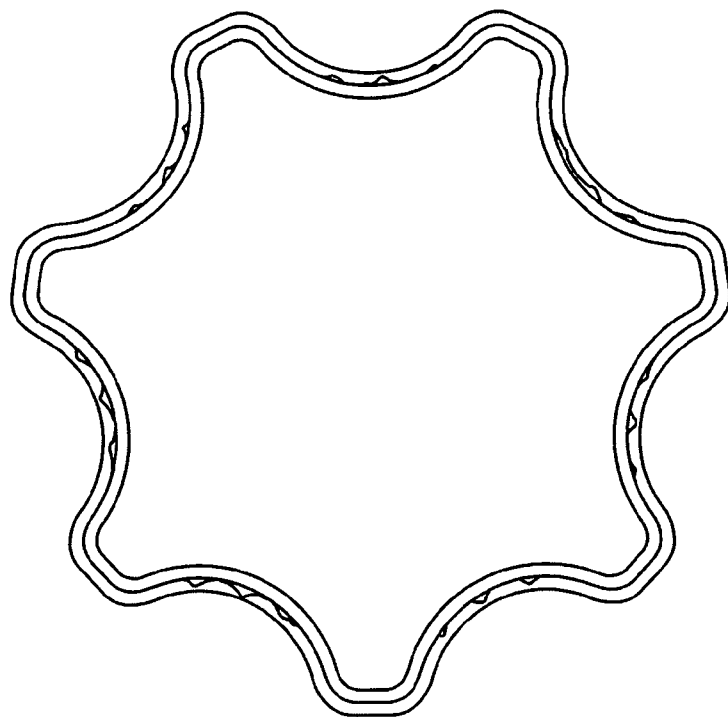


FIG. 4

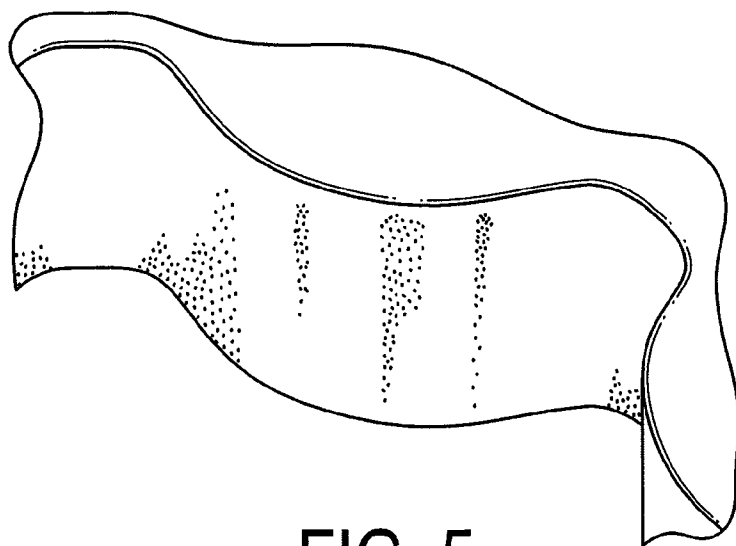


FIG. 5

FORMABLE SINTERED ALLOY WITH DISPERSED HARD PHASE

RELATED APPLICATIONS

[0001] This application is a continuation of U.S. Non-Provisional application Ser. No. 12/339,565 filed Dec. 19, 2008, which claims the benefit of U.S. Provisional Application No. 61/015,024 filed Dec. 19, 2007, both of which are hereby incorporated by reference.

BACKGROUND

[0002] This invention relates to a formable sintered alloy with dispersed hard phase.

SUMMARY

[0003] At least one advantage of the present invention is provided by a method of forming an iron based sintered body having a microstructure of about 20-50% dispersed martensite in a matrix of fine pearlite, the method comprising the steps of: providing a mixture comprising a composition in % by mass: 0.4 to 1.0% of C; 0.5 to 3.5% of Cr; 0.1 to 1.7% of Mo; 0.3 to 3.0% of Cu, the balance being primarily Fe and unavoidable impurities and lubricant; placing the mixture in a first mold possessing the approximate shape of a finished product; subjecting the mold to compaction pressures of between generally 35 and 65 tsi to produce a green body compact; sintering the green body compact at a temperature of between 1120~C and 1180~C to form a sintered article; cooling the sintered article at a rate not exceeding 0.5~C/sec; thermally stabilizing the sintered article; placing the sintered article in a second mold possessing the desired shape of the finished product; and subjecting the second mold to pressures generally between 50 and 75 tsi.

[0004] At least one advantage of the present invention is provided by a A method of forming an iron based sintered body having a microstructure of about 20-50% dispersed martensite in a matrix of fine pearlite, the method comprising the steps of: providing a mixture comprising a composition in % by mass: 0.4 to 1.0% of C; 0.5 to 3.5% of Cr; 0.1 to 1.7% of Mo; 0.3 to 3.0% of Cu, the balance being primarily Fe and unavoidable impurities and lubricant; placing the mixture in a first mold possessing the approximate shape of a finished product; subjecting the mold to compaction pressures of between generally 35 and 65 tsi to produce a green body compact; sintering the green body compact at a temperature of between 1120~C and 1180~C in an atmosphere comprising about 90% nitrogen and 10% hydrogen for about 25 minutes to form a sintered article; cooling the sintered article at a rate not exceeding 0.5~C/sec; thermally stabilizing the sintered article; placing the sintered article in a second mold possessing the desired shape of the finished product; and subjecting the second mold to pressures generally between 50 and 75 tsi.

BRIEF DESCRIPTION OF THE DRAWING

[0005] Embodiments of this invention will now be described in further detail with reference to the accompanying drawing, in which:

[0006] FIG. 1 is a microscopic view of an embodiment of the iron based sintered material of the present invention;

[0007] FIG. 2 is a wear plot of a prior art gear after an accelerated pump durability wear test;

[0008] FIG. 3 is a perspective view of a portion of the prior art gear of FIG. 2 showing wear on the gear surface;

[0009] FIG. 4 is a wear plot of a embodiment of a gear of the present invention after the same accelerated pump durability wear test that the prior art gear of FIGS. 2-3 were subjected to; and

[0010] FIG. 5 is a perspective view of a portion of the gear of FIG. 4 showing light burnishing on the gear surface.

DETAILED DESCRIPTION OF THE INVENTION

[0011] A microscopic view of an embodiment of the composition of the present invention is shown in FIG. 1. The lean composition achieves desired microstructure/properties and associated sliding wear resistance with reduced content of expensive alloying ingredients. The constituent ingredients demonstrate sufficient hardenability to achieve martensitic transformation at cooling rates attainable in conventional furnaces thereby leveraging existing installed capacity and deferring capital investment in specialized furnaces. The constituent ingredients demonstrate sufficient hardenability to achieve martensitic transformation at cooling rates attainable in conventional furnaces thereby avoiding the dimensional distortion penalty associated with rapid quenching by oil baths and/or gas pressure quenching. The volume fraction of fine pearlite matrix of generally 70% affords sufficient formability to achieve a high degree of dimensional accuracy required of net-shape sintered articles. Forming may be performed without supplemental part heating, tool heating, intermediate quenching and thereby avoids the associated operational complexity and cost of warm/hot forming processes.

[0012] An embodiment of the iron-base alloy of the present invention comprises a 20 to 50% weight fraction of prealloy steel of composition A and a 48 to 78% weight fraction of prealloy steel of composition B to which additional alloying elements (and lubricant) are added in preparation of a powdered metal blended mixture. The resulting mixture composition of the embodiment comprises in % by mass: 0.4 to 1.0% of C; 0.5 to 3.5% of Cr; 0.1 to 1.7% of Mo; 0.3 to 3.0% of Cu; and the balance being primarily Fe and unavoidable impurities. (The lubricant will volatilize during sinter and as such is not reflected in the composition %). The mixture is placed in a mold possessing the approximate shape of the finished product and subjected to compaction pressures of between generally 35 and 65 tsi to produce a green body compact. The green body compact is subsequently sintered at a temperature of between 1120~C and 1180~C for about 25 minutes in an atmosphere comprised of 90% nitrogen and 10% hydrogen. The sintered article subsequently is cooled at a rate not exceeding 0.5~C/sec producing a sinter-hardened composite wear resistant microstructure of approximately 20 to 50% dispersed martensite in a matrix of fine pearlite. The sintered article subsequently is subjected to cold treatment and tempering for thermal stabilization. Upon completion of thermal treatment, the sintered article is placed in a mold possessing the desired shape of the finished product and subsequently subjected to forming pressures generally between 50 and 75 tsi to achieve dimensional refinement enabling production of discretely toleranced net-shape features. The sintered and formed article demonstrates acceptable sliding wear properties for pumping elements employed with ultra low sulfur diesel fuels (Shell MJ04 U.S. Worst Case Diesel) while offering the costs advantages of lean composition and reduced process complexity in comparison to prior art.

[0013] In one embodiment, Nickel may be added such that the resulting mixture composition of the embodiment comprises in % by mass: 0.4 to 1.0% of C; 0.5 to 3.5% of Cr; 0.1 to 1.7% of Mo; 0.3 to 3.0% of Cu; 0.1 to 6.0% Ni; and the balance being primarily Fe and unavoidable impurities. In another embodiment, the resulting mixture composition of the embodiment comprises in % by mass: 0.4 to 1.0% of C; 0.5 to 3.5% of Cr; 0.1 to 1.7% of Mo; 0.3 to 3.0% of Cu; 0.1 to 0.5% Mn; and the balance being primarily Fe and unavoidable impurities. In still another embodiment, the resulting mixture composition of the embodiment comprises in % by mass: 0.4 to 1.0% of C; 0.5 to 3.5% of Cr; 0.1 to 1.7% of Mo; 0.3 to 3.0% of Cu; 0.1 to 6.0% Ni; 0.1 to 0.5% Mn; and the balance being primarily Fe and unavoidable impurities.

[0014] In one embodiment, the sintered and formed article may be a gear, such as a gear for a gerotor. Testing of a sintered and formed gear in accordance with the present invention was subjected to an accelerated pump durability test with the results of the prior art control gear shown in FIGS. 2 and 3 and the results of the gear of the present invention shown in FIGS. 4 and 5. FIGS. 2 and 4 are wear plots showing the magnitude of the surface wear of the gear teeth by vector representation. While the wear in FIG. 2 is significantly more than the gear of the present invention shown in FIG. 4, it is noted that the wear shown in FIG. 4 is magnified at a scale twice that of FIG. 2 in order to see the wear. It is also noted that non-wear portions of the wear plot of FIG. 4 caused by offset have been removed from the original plot to eliminate any confusion from the wear comparison.

[0015] Although the principles, embodiments and operation of the present invention have been described in detail herein, this is not to be construed as being limited to the particular illustrative forms disclosed. They will thus become apparent to those skilled in the art that various modifications of the embodiments herein can be made without departing from the spirit or scope of the invention. Accordingly, the scope and content of the present invention are to be defined only by the terms of the appended claims.

What is claimed is:

1. A method of forming an iron based sintered body having a microstructure of about 20-50% dispersed martensite in a matrix of fine pearlite, the method comprising the steps of:

providing a mixture comprising a composition in % by mass: 0.4 to 1.0% of C; 0.5 to 3.5% of Cr; 0.1 to 1.7% of Mo; 0.3 to 3.0% of Cu, the balance being primarily Fe and unavoidable impurities and lubricant;

placing the mixture in a first mold possessing the approximate shape of a finished product;

subjecting the mold to compaction pressures of between generally 35 and 65 tsi to produce a green body compact; sintering the green body compact at a temperature of between 1120~C and 1180~C to form a sintered article; cooling the sintered article at a rate not exceeding 0.5~C/sec;

thermally stabilizing the sintered article;

placing the sintered article in a second mold possessing the desired shape of the finished product; subjecting the second mold to pressures generally between 50 and 75 tsi.

2. The method of claim 1 wherein the step of sintering the green body compact is performed in an atmosphere comprising about 90% nitrogen and 10% hydrogen.

3. The method of claim 1 wherein the step of thermally stabilizing the sintered article comprises cold treatment and tempering.

4. The method of claim 1, wherein the step of providing a mixture further includes in % by mass: 0.1 to 0.5 of Mn.

5. The method of claim 1, wherein the step of providing a mixture further includes in % by mass: 0.1 to 6.0 of Ni.

6. The method of claim 1, wherein the first mold is in the form of a gerotor gear.

7. The method of claim 1, wherein the second mold is in the form of a gerotor gear generally at net shape.

8. The method of claim 1, wherein the step of sintering the green body compact at a temperature of between 1120~C and 1180~C is performed for about 25 minutes.

9. A method of forming an iron based sintered body having a microstructure of about 20-50% dispersed martensite in a matrix of fine pearlite, the method comprising the steps of:

providing a mixture comprising a composition in % by mass: 0.4 to 1.0% of C; 0.5 to 3.5% of Cr; 0.1 to 1.7% of Mo; 0.3 to 3.0% of Cu, the balance being primarily Fe and unavoidable impurities and lubricant;

placing the mixture in a first mold possessing the approximate shape of a finished product;

subjecting the mold to compaction pressures of between generally 35 and 65 tsi to produce a green body compact;

sintering the green body compact at a temperature of between 1120~C and 1180~C in an atmosphere comprising about 90% nitrogen and 10% hydrogen for about 25 minutes to form a sintered article;

cooling the sintered article at a rate not exceeding 0.5~C/sec;

thermally stabilizing the sintered article;

placing the sintered article in a second mold possessing the desired shape of the finished product;

subjecting the second mold to pressures generally between 50 and 75 tsi.

10. The method of claim 9 wherein the step of thermally stabilizing the sintered article comprises cold treatment and tempering.

11. The method of claim 9, wherein the step of providing a mixture further includes in % by mass: 0.1 to 0.5 of Mn.

12. The method of claim 9, wherein the step of providing a mixture further includes in % by mass: 0.1 to 6.0 of Ni.

13. The method of claim 9, wherein the first mold is in the form of a gerotor gear.

14. The method of claim 9, wherein the second mold is in the form of a gerotor gear generally at net shape.

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