ABSTRACT
A process is disclosed for forming relatively moving metal parts with matching surfaces by preparing at least one part from porous sintered iron, impregnating the pores of the sintered iron part with oleic acid containing an inhibitor selected from Tenemene, BHA, BHT, or MTBHQ in an amount effective to inhibit the reaction between the iron and oleic acid at room temperature and subsequently bringing the parts into sliding contact until the heat developed at points of local high friction is sufficient to effect the reaction between iron and oleic acid. There is also disclosed a formed, porous sintered iron article with inhibited oleic acid in its pores.

9 Claims, No Drawings
SINTERED POROUS IRON ARTICLE IMPREGNATED WITH OLEIC ACID AND AN INHIBITOR FOR FORMING MATCHING SURFACES BY FRICTION

BACKGROUND OF THE INVENTION

Known powder metallurgy techniques permit difficult metal shapes to be formed relatively easily. For example, iron can be formed into shapes difficult to machine by pressing very small iron particles into the desired shape and then heating the formed shape to a temperature at which points of contact between adjacent particles fuse. The resultant material is called sintered iron. It is dimensionally stable and very strong even though its structure is porous.

Sintered iron parts are frequently used in sliding contact with other metal pieces in uses where it is necessary for the relatively moving surfaces to be matched very closely. Even though powder metallurgy techniques can form pieces to very close tolerances, perfectly matching surfaces are difficult to obtain by the technique.

The porous nature of sintered iron has been taken advantage of to relieve this situation. When the pores of a sintered iron piece are impregnated with oleic acid, a reaction between the iron and the acid occurs and a soft reaction product results. When this reaction takes place during sliding contact, matching surfaces can be obtained readily. However, oleic acid and powder metal iron react rapidly at room temperature so the process to achieve matched surfaces that employ the reaction between iron and oleic acid must be accomplished quickly, i.e., the parts must be brought into sliding contact with each other before significant quantities of the oleic acid in the pores have reacted with the iron. As a consequence, the technique is difficult to use because oleic acid-impregnated sintered iron parts cannot be stored and because it is necessary to have impregnating equipment and machining equipment in close proximity to one another. It is also difficult to incorporate such close timing into an ordinary industrial process.

THE INVENTION

This invention provides a process that avoids the problems set forth above. This invention is a process for forming matching surfaces between metal parts to be in sliding contact by making at least one of the parts of sintered iron, impregnating the pores of that part with oleic acid which contains Tenemene, BHA, BHT, or MTBHQ in an amount effective to inhibit the reaction between iron and oleic acid at room temperature, and then bringing the parts into sliding contact until the heat generated by friction raises the temperature of local high friction points to one at which iron and oleic acid will react.

The invention also is a formed sintered iron article that has its pores impregnated with oleic acid containing an inhibitor selected from Tenemene, BHA, BHT, and MTBHQ in an amount effective to inhibit the reaction between iron and oleic acid.

Amounts of inhibitor in excess of 0.05%w are effective to inhibit the reaction and amounts in excess of 5.0%w have small incremental effect. Accordingly, it is preferred that the inhibitor be present in very small amounts, in excess of about 0.05%w and preferably in excess of about 0.1%w, but that amounts in excess of 5%w be avoided as wasteful.

Through the present invention oleic acid-impregnated sintered iron articles can be stored at least several weeks without significant reaction between oleic acid and iron taking place. Through use of this invention, impregnation of the sintered iron parts may take place geographically remote from where the surface matching operations are effected, and in fact the surface matching operations may even be effected through normal use of the sliding surfaces as will be discussed in greater detail below.

It is presently thought that the sintered iron part impregnated with inhibited oleic acid is stable chemically as long as the temperature is room temperature. Chemically stable means that oleic acid and iron do not react at a significant rate. When the impregnated part is brought into sliding contact, those portions of the contacting surface that do not match the other surface are subjected to intense friction over a very local area. The heat from this friction raises the temperature above that at which the inhibitor is effective to retard or prevent the reaction between iron and oleic acid, and as a result the iron in the area of local high friction reacts rapidly with the oleic acid impregnated in the pores to form soft, amorphous iron oleate which is washed away with lubricant or worn away but, in any event, is disposed of benignly. When the surface aberration that caused the local high friction has been removed, the local high temperature will diminish and there will be no further reaction because the inhibitor again will be effective to prevent iron from reacting with oleic acid. Since local conditions during sliding contact are not available for analysis or observation, the foregoing hypothesis is merely suggested as the mechanism by which the process of the present invention functions, but it is not intended to limit the claims to the accuracy of this hypothesis.

For the sake of brevity, certain trademarks and trade designations are used in this specification and the following claims. Each of these has the following meaning:

Tenemene is N,N'bis (1,4-dimethyl pentyl)-p-phenylene diamine;
BHA is t-butyl hydroxy anisol;
BHT is t-butyl hydroxy toluene;
MTBHQ is mono-t-butyl hydroquinone.

DETAILED DESCRIPTION

The present invention was employed in the manufacture of rocker arm balls for use in internal combustion engines. The rocker arm balls function in sliding contact with a socket-like metal receptacle. In use it is essential that the surface of the rocker arm ball be well matched to the surface of the receptacle.

The rocker arm balls were made from a material that was 98.7%w iron, 0.18%w carbon, and the remainder miscellaneous materials including silicon, phosphorus, sulfur and oxygen. The material was in the form of a fine powder having a particle size distribution on a weight basis as follows:

| Mesh Size | % of Total | trace | 2 | 33 | 3 | 4 | 24 | 16 | +80 | +100 | +140 | +200 | +230 | +235 | +325 |
|-----------|------------|-------|---|----|---|---|----|----|-----|------|------|------|------|------|------|------|
This material was uniformly blended with 0.75%w graphite and 0.75%w of a wax lubricant, the percentages being based on the weight of powdered metal. The blended powder was then pressed into the form of rocker arm balls until it had a nominal density of 6.0 g/cc, at which density it had sufficient green strength to be handled. The parts were then heated to about 2,000°F in an inert gas atmosphere at which temperature a sintered metal structure was formed. The sintered metal structure was cooled in the oven to about 1,550°F after which it was quenched in a conventional quench oil. At this point the sintered iron piece had approximately the same dimensions and same density as the green form.

The quenched rocker arm balls were cleaned by a technique which provided available porosity volume for the subsequent impregnation with inhibited oleic acid.

The balls thus prepared were divided and some of them were immersed in oleic acid, while others were immersed in oleic acid containing various amounts of various inhibitors. The total pore volume of the balls was such that a maximum of 0.4 grams of impregnant, consisting of quench oil and oleic acid, could be taken up per ball. In all cases of balls prepared as described above, about 44% of the maximum impregnant was taken up as oleic acid. The acid impregnated balls were exposed to open air at room temperature for three weeks after which they were analyzed to determine their free oleic acid content. The results of these analyses are set forth in Table I:

<table>
<thead>
<tr>
<th>Inhibitor</th>
<th>Concentration wt%</th>
<th>% of Maximum Impregnant, As Free Acid After 3 Weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tenemene</td>
<td>0.1</td>
<td>38</td>
</tr>
<tr>
<td>Tenemene</td>
<td>5.0</td>
<td>38</td>
</tr>
<tr>
<td>BHA</td>
<td>0.1</td>
<td>34</td>
</tr>
<tr>
<td>BHT</td>
<td>0.1</td>
<td>31</td>
</tr>
<tr>
<td>MTBNO</td>
<td>0.1</td>
<td>29</td>
</tr>
<tr>
<td>None</td>
<td>0</td>
<td>1.0 - 1.5</td>
</tr>
</tbody>
</table>

The rocker arm balls containing inhibited oleic acid were heated in the presence of an indicator and it was found that the inhibitor in all cases was temperature sensitive. At temperatures higher than 200°F the reaction between iron and oleic acid proceeded at a rapid rate even though an inhibitor was present. The impregnated iron articles of this invention may be employed directly in accordance with the process of the invention by bringing the mating surfaces together with sufficient force and in sliding contact to create friction that will raise the temperature of local surface aberrations above the effective temperature of the inhib. Surfaces such as valves and valve seats to be used in a cold environment may be so prepared. If oleic acid is not wanted in the final structure, it may be removed by conventional methods such as immersing the part in a solvent or employing the solvent with ultrasonic vibrations.

A particularly useful embodiment of the invention is to install the oleic acid-impregnated part in a final assembly and to have the mating surfaces to be in sliding contact matched during the operation of the final assembly. As an example, the rocking arm balls described above may be so employed. In the assembly of an internal combustion engine, oleic acid-impregnated sintered iron rocker arm balls may be assembled in the normal manner and the process for producing matched surfaces may be effected when the finally assembled internal combustion engine is put into operation. When the engine is operated, preferably slowly under break-in conditions, the sliding contact between the rocker arm balls and their sockets will produce virtually perfectly matching surfaces. Additionally, the normal circulation of lubricant will cause any iron oleate formed to wash way, eventually being captured in the oil filter, while the impregnated oleic acid is soluble in oil and will be removed from the rocker arm balls when its effect is no longer desirable.

What is claimed is:

1. An article of manufacture comprising a porous, sintered iron article having in the pores thereof oleic acid containing an inhibitor selected from the group consisting of N,N'-bis (1, 4-dimethyl penty1)-p-phenylene diamine, t-butyl hydroxy anisol, t-butyl hydroxy toluene, and mono-t-butyl hydroquinone in an amount effective to inhibit the reaction between iron and oleic acid at room temperature.

2. The article of claim 1 wherein the oleic acid contains at least 0.05%w of inhibitor.

3. The article of claim 1 wherein the inhibitor is N,N'-bis (1, 4-dimethyl penty1)-p-phenylene diamine.

4. The method for producing relatively moving parts with matching surfaces comprising:
   A. manufacturing one of said parts of porous, sintered iron,
   B. impregnating the pores of the sintered iron part with oleic acid containing an inhibitor selected from the group consisting of N,N'-bis (1, 4-dimethyl penty1)-p-phenylene diamine, t-butyl hydroxy anisol, t-butyl hydroxy toluene, and mono-t-butyl hydroquinone in an amount effective to inhibit the reaction between iron and oleic acid at room temperature, and
   C. placing the relatively moving parts in contact and effecting relative motion for a time and under conditions such that product of high friction will be at a temperature at which the reaction between iron and oleic acid is effected.

5. The method of claim 4 wherein the oleic acid contains at least 0.05%w of inhibitor.

6. The method of claim 4 wherein the inhibitor is N,N'-bis (1, 4-dimethyl penty1)-p-phenylene diamine.

7. The method for producing a sintered iron article suitable for moving engagement with another metal part comprising:
   A. preparing a porous sintered iron article,
   B. cleaning the article to provide open pore volume, and
   C. impregnating the pores in the article with oleic acid containing an inhibitor selected from the group consisting of N,N'-bis (1, 4-dimethyl penty1)-p-phenylene diamine, t-butyl hydroxy anisol, t-butyl hydroxy toluene, and mono-t-butyl hydroquinone in an amount effective to inhibit the reaction between iron and oleic acid at room temperature.

8. The method of claim 7 wherein the oleic acid contains at least 0.05%w of inhibitor.

9. The method of claim 7 wherein the inhibitor is N,N'-bis (1, 4-dimethyl penty1)-p-phenylene diamine.

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