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TREATMENT OF MACHINE ELEMENTS TO FACILITATE BREAKING IN

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This application is a continuation-in-part of my copending application Serial Number 132,351, filed March 22, 1937, and the invention herein disclosed and claimed is an improvement over the invention disclosed and claimed in the application of George L. Neely et al., Serial No. 235,542, filed October 17, 1938, entitled Pretreated bearing surfaces and method of producing the same.

This invention relates to the treatment of metallic frictional surfaces of machine elements and especially to a treatment of hypoid gears and other devices in which the frictional surfaces are operated under extremely high pressures. The treatment of this invention prevents scuffing, scoring or seizing of moving metal surfaces in frictional contact and accelerates the wearing in process.

Because of the increased power and increased speed of moving parts of recently designed automobiles, it has been found that previously suitable lubricants are not capable of providing safe lubrication under all conditions of operation. This is especially true during breaking in of cars provided with hypoid gears. Various lubricants have been developed in an effort to meet the extreme requirements necessary to insure absolutely safe lubrication under the high pressures and sliding friction encountered in modern machines.

The problem of lubricating hypoid gears has become particularly acute. Lubricants which have been provided for these gears may be classified into two general types, namely, corrosive extreme pressure lubricants containing for instance, free sulfur or corrosive oil-soluble sulfur compounds, and two, milder extreme pressure lubricants containing non-corrosive oil-soluble compounds of sulfur or other materials which aid lubrication and increase resistance to scuffing or seizure. Although these lubricants are highly useful they are not entirely satisfactory.

It has been found for example that corrosive extreme pressure lubricants are not always desirable for lubrication of well "run-in" gears because of detrimental effects on bearings and other parts and because of an accelerated rate of wear produced on the gears themselves. It has also been observed that less corrosive lubricants are not as desirable as the more corrosive lubricants for use during the breaking in period.

Difficulties have also been encountered during breaking in of machine elements which are operated at lower loads, but higher speeds than gears. In internal combustion engines, for example, the piston rings, cylinder walls, camshafts

and the like tend to score or scratch during the initial operating period unless speed and load on the engine are properly controlled for the first 500 to 1,000 miles of operation. It is not desirable to use extreme pressure lubricants in the crankcase of internal combustion engines because of corrosive effects resulting therefrom and various means have been proposed to overcome this difficulty in breaking in engines.

One such suggestion comprises the application of a soft metal such as tin or lead to the piston rings, etc. These coatings were applied preferably by electroplating and were of a thickness of from $\frac{3}{4}$ of one-thousandth to a few thousandths of an inch. (See U. S. Patent to Summers, Reissue 18,814, May 2, 1933.) Such coatings are to be distinguished from coatings of a thickness obtained by "flash coating" without an externally impressed E. M. F.

This invention avoids difficulties heretofore encountered during breaking in of machine elements and provides a new and advantageous method of pretreating such elements prior to breaking in which not only insures against scuffing and scoring of the frictional surfaces but also greatly facilitates and accelerates the running in process.

Accordingly it is an object of the invention to provide a process of treating gears, pistons, piston rings, cylinder walls, camshafts and frictional surfaces of other machine elements so that danger of scuffing or seizing is avoided during the breaking in process.

Another object of the invention is to provide a method of pretreating machine elements which will accelerate the wearing in process.

A still further object of the invention is to provide a method of treating machine elements prior to breaking in to produce a metal flash coating on the frictional surfaces thereof whereby breaking in will be facilitated.

An additional object of the invention is to provide a method of chemically treating ferrous machine elements prior to breaking in to produce an integral thin tenacious non-ferrous sulfide coating on the frictional surfaces thereof whereby breaking in will be facilitated.

Another object of the invention is to provide an integral thin tenacious film of a sulfide of a non-ferrous metal on pistons, piston rings and cylinder walls of an internal combustion engine by applying a metal flash coating to the frictional surfaces and chemically reacting thereon with a sulfur containing bath, whereby wearing

in is accelerated and blow-by is reduced during breaking in.

Another object of the invention is to provide a metal flash coating on the frictional surfaces of ferrous gears and to convert said flash coating to a sulfide film either prior to or during breaking in whereby scuffing or seizing is avoided and production of a smooth and polished surface is accelerated.

Another object is to provide a non-metallic compound film between the frictional surfaces of non-ferrous metal of the machine elements which has the effect of preventing a welding or cohesion of the projecting portions of the frictional surfaces which contact one another, effective to act as an agent to aid the lubricant used, usually oil, in wetting the frictional surface, and effective as a very fine polishing agent which not only hastens the breaking-in but also renders the broken-in surfaces more smoothly and accurately fitting.

It has been found that application of a flash coating of various metals to gears and the like greatly increases the load-carrying capacity during breaking in. Particularly, is this true when an extreme pressure lubricant is utilized for lubricating during this period. The thickness of metal flash coatings is known to be in the order of one fifty-thousandth to one two-hundred fifty-thousandth of an inch. In the case of the thinner flash coating and particularly where the underlying metal has an ordinary, as distinguished from a mirror, finish, the flash coatings are in fact not continuous coatings but comprise discrete deposits of the coating metal on the high spots of the base metal surface. Also flash coatings of various metals in the thinner ranges readily alloy throughout either a major portion or the entire thickness of the coating. In some cases merely storing at atmospheric temperatures for a short time, for example a month, will suffice to produce the above alloying action and in other cases a mild heat treating operation is necessary to accelerate the process. It is therefore to be noted that these flash coatings are not only of a different order of thickness, but of a different type, than coatings of from one-thousandth to several thousandths of an inch or even thicker, which have been applied to machine elements by the prior art.

Methods known in the art of metal coating may be utilized for the application of the flash coatings in the present process. For example, contacting with aqueous solutions of salts of metals as disclosed in "Metal Coloring," by Hiorns (published by MacMillan Company of London, in 1929), particularly methods such as disclosed on pages 299-313.

The flash coating may be deposited by well known electroplating methods, if desired, but the thickness of coating should be carefully controlled within the limits of flash coatings. However, because of the fact that electroplating involves the provision of expensive electrical and control equipment, other simpler methods of application of the metal flash coatings are preferred. It is not necessary to use electroplating processes to obtain the flash coatings of this invention and avoidance of difficulties attending electroplating processes comprises one of the advantages of the present invention.

A very convenient method of applying metal flash coatings in accordance with the present process comprises spraying the metal on the base

to be coated by the well known "Schoop" process. When utilizing the metal spray process it is preferred to either preheat the ferrous surface and spray it with the metal while hot or to first spray the surface and then heat to produce a bonding of the sprayed metal to the frictional surface by an alloying action. When the metal spray method is utilized the area of application of the metal flash coating can be easily limited to only those portions of the machine elements, for example the teeth of gears, which it is necessary or desired to treat.

Improvement in load carrying capacities of metal surfaces treated according to this invention are illustrated by the following: A flash coating of tin was applied to the steel surfaces of a set of Timken cups used for tests in the S. A. E. testing machine (described in the S. A. E. Journal, vol. 33, page 402, 1933). A flash coating of copper was also applied to a second set of cups. In both instances the coatings were extremely thin, but tenaciously adherent to the underlying metal. From the standpoint of physical appearance the coatings may best be described by saying that the ferrous metal surface was merely colored by the deposited metal. The results obtained in the S. A. E. testing machine using a non-corrosive extreme pressure gear lubricant containing a sulfurized fat, were as follows:

Gear lubricant	Treatment	S. A. E. tester total load at failure
Non-corrosive sulfur-containing mineral oil.	None.....	850
Do.....	Copper flash coating on 1 cup..	1920
Do.....	Copper flash coatings on both cups.	1500
Do.....	Tin flash coating on 1 cup.....	5500+
Do.....	Tin flash coatings on both cups.	5500+

(+ sign indicates no failure at total load of machine.)

The beneficial action of the pretreatment of this invention when used in combination with extreme pressure lubricants appears to result from the fact that the frictional surface is rendered more active by the deposited metal so that the extreme pressure ingredients of the lubricant more readily act on the surface to aid lubrication. It also appears that in the case of thin flash coatings, particularly where the coating metal is deposited on the high spots or peaks of the frictional surface only, the production of a smooth highly polished surface is accelerated by an increased rate of wear on the peaks. At the same time scratching, scoring or "spot welding" at the peaks or points is prevented by the film formed from the coating metal and the extreme pressure lubricant.

In accordance with the above broad principles of the invention it is apparent that flash coatings of various active metals having a greater affinity for oiliness agents or the active ingredients of extreme pressure lubricants than does the ferrous or other metallic frictional surface being treated, may be utilized in the place of tin and copper. For example, silver, brass, bronze, tin-lead alloys and the metalloids arsenic, antimony and bismuth, are quite reactive with respect to sulfur compounded lubricants and may be substituted for tin or copper in the pretreating process. The metalloid flash coatings should preferably be alloyed with the ferrous metal surface before prolonged exposure to air. This may be effected by immediately immersing in oil and

heating. Means and methods known to the metal coating art may of course be utilized in the application of flash coatings of the above materials to metal surfaces.

It is known that in some instances, the relatively thick coatings heretofore applied to frictional surfaces of machine elements are subject to flaking during breaking-in. This deleterious tendency is avoided by the application of the principles of the present invention.

In those instances where it is disadvantageous to employ extreme pressure lubricants during the breaking in process, as for instance in internal combustion engines where pistons, piston rings, cylinder walls and camshafts are being worn in, the metal flash coating can be converted to a non-metallic compound which accelerates wear-in. Such a combined treatment comprises for example applying a metal flash coating and treating the metal so applied with a solution containing an active sulfur compound. A suitable treating bath is an aqueous solution containing 50% caustic soda to which is added about 1 to 5% flowers of sulfur. The sulfide film formed by this treatment serves to accelerate breaking in as previously described. It has also been observed that application of sulfide films to piston rings and cylinder walls minimize "blow-by," that is, escape of combustion gases around the piston rings, during the breaking in process. This feature is of importance in that it decreases carbon formation around the piston rings and the consequent tendency toward piston ring sticking.

Examples of alternative non-metallic compound forming treating agents adapted to form a film of a non-metallic compound with the flash coating effective to substantially reduce or eliminate scuffing or scoring during breaking-in comprise inorganic treating baths of active selenium, tellurium or halogen compounds adapted to react with the metal or metalloid of the flash coating to form selenide, telluride or halide films, such as a chloride film, as well as treating baths which react with the film to form organo compounds, for example, aqueous solutions of water-soluble acids, such as citric acid, tartaric acid, malic acid, lactic acid, gluconic acid, succinic acid, oxalic acid, maleic acid, diphenylparasulfonic acid, sulphanilic acid, thioglycolic acid, and trichloroacetic acid. The most effective organic acids are, in general, water-soluble substituted organic acids containing a substituent selected from the group consisting of mercapto, hydroxy, amino, keto and halogen radicals. Thus it is seen that scuffing or scoring of the frictional surface of the machine element having a flash coating thereon may be substantially reduced or eliminated entirely by forming a non-metallic compound film with the coating by reacting the coating with an agent adapted to form such a film. Active phosphorus compounds may also be used to form such non-metallic compound films with a flash coating of metals containing tin, silver, or lead.

The films of non-metallic compounds formed, as disclosed above, between the frictional surfaces of non-ferrous metal of machine elements have the functions of preventing a welding or cohesion of the projecting portions of the frictional surfaces which contact one another, of acting as an agent to aid the lubricant used, usually oil, in wetting the frictional surface, and of an agent which effects a polishing of the fric-

tional surfaces to render them smooth and accurately fitting.

It is to be understood that the invention is not to be limited by the specific features hereinbefore described, but that various alterations and modifications are to be included in the scope of the invention as defined by the terms and spirit of the appended claims.

I claim:

1. A process of facilitating breaking in of machine elements having relatively rough metallic frictional surfaces subject to scuffing or scoring under breaking in conditions, which comprises applying to the high spots of said surface a coating of material selected from the group consisting of metalloids and metals more reactive to sulfur than iron, said coating consisting of a flash coating having a thickness no greater than in the order of $\frac{1}{50000}$ of an inch.
2. A process of facilitating breaking in of machine elements which consists in applying a flash coating of tin to the frictional surfaces, said flash coating having a thickness of from approximately $\frac{1}{50000}$ to $\frac{1}{250000}$ of an inch.
3. A process of facilitating breaking in of machine elements which comprises applying a flash coating of a material selected from the group consisting of metalloids and metals more reactive to sulfur than iron to the frictional surfaces of said element and converting said flash coating to a thin sulfide film.
4. A machine element having relatively rough ferrous metal frictional surfaces and a discontinuous flash coating of a material selected from the group consisting of metalloids and metals more reactive to sulfur than iron and comprising deposits of said coating on the high spots of said rough frictional surfaces.
5. A gear having a flash coating of tin on the frictional surfaces thereof, said coating being of a thickness no greater than in the order of $\frac{1}{50000}$ of an inch.
6. A machine element selected from the group consisting of pistons, piston rings, cylinder walls and camshafts having on a frictional surface thereof a thin film of a sulfide of a non-ferrous metal more reactive to sulfur than iron.
7. A process of facilitating breaking in of machine elements having a ferrous metal frictional surface which comprises applying a flash coating of a metal more reactive to sulfur than iron to the frictional surfaces of said element and alloying the coating throughout at least a major portion of its thickness with the metal of said frictional surface.
8. A process of facilitating breaking in of a machine element which comprises applying a flash coating, selected from the group consisting of metalloids and metals more reactive to sulfur than iron, to the frictional surfaces of said element, said coating consisting of a flash coating having a thickness no greater than in the order of $\frac{1}{50000}$ of an inch.
9. A machine element having frictional bearing surfaces of ferrous metal, and a thin film of a sulfide of a non-ferrous metal more reactive to sulfur than iron on said frictional bearing surfaces.
10. A machine element having a ferrous metal frictional bearing surface, and a thin film of copper sulfide on said frictional bearing surface.
11. A process of treating a machine element having a frictional bearing surface subject to scuffing or scoring during breaking in which comprises applying a thin film of copper to said

frictional bearing surface and reacting said film with an active sulfur compound.

12. A process of preparing a machine element having a metal surface which tends to scuff or score under breaking in conditions, which comprises applying to said metal surface a coating of a material selected from the group consisting of metalloids and metals more reactive to sulfur than iron, said metalloid and metal coatings consisting of a flash coating having a thickness no greater than in the order of $\frac{1}{100000}$ of an inch.

13. A process of preparing a machine element having a ferrous metal frictional surface which tends to scuff or score under breaking in conditions, which comprises applying to said ferrous metal surface a coating of a material selected from the group consisting of metalloids and metals more reactive to sulfur than iron, said metalloid and metal coatings consisting of a flash coating having a thickness no greater than in the order of $\frac{1}{100000}$ of an inch.

14. A process of treating a machine element having a bearing surface subject to scuffing or scoring under breaking in conditions, which comprises applying a flash coating of a material selected from the group consisting of metalloids and metals more reactive to sulfur than iron and reacting on said coating with an active sulfur compound.

15. A machine element having a ferrous metal frictional surface subject to scuffing or scoring under breaking in conditions and a coating on said frictional surface of a material selected from the group consisting of metalloids and metals more reactive to sulfur than iron, said coating consisting of a flash coating having a thickness no greater than in the order of $\frac{1}{100000}$ of an inch.

16. A machine element as defined in claim 15 in which said element is selected from the group consisting of pistons, piston rings, cylinder walls and camshafts.

17. A process of facilitating breaking in of machine elements having a ferrous metal frictional surface which comprises applying a flash coating of a metalloid more reactive to sulfur than iron to the frictional surface of said element, and alloying the coating throughout at least a major portion of its thickness with the ferrous metal of said frictional surface.

18. A process of preparing a ferrous metal bearing surface for use with extreme pressure lubricants comprising applying to said bearing surface a flash coating of a material selected from the group consisting of metalloids and metals more reactive to sulfur than iron, said flash coating having a thickness no greater than in the order of $\frac{1}{100000}$ of an inch.

19. A process for treating a machine element having a bearing surface subject to scuffing or scoring under breaking in conditions, which comprises applying a flash coating of a material different from the material of said bearing surface and selected from the group consisting of metalloids and metals, and reacting on said coating with an agent selected from the group consisting of active compounds of sulfur, selenium and tellurium which forms with said material of said coating and on the surface thereof a film of non-metallic compound effective to substantially decrease scoring or scuffing during breaking in, said material of said coating having a greater affinity for said agent than said bearing surface has for said agent.

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