Patented Jan. 6, 1953 2,624,688

UNITED STATES PATENT OFFICE

2,624,688

SUBZERO TREATMENT OF CHROMIUM ALLOY STEEL

Ernest J. Svenson, Rockford, Ill., assignor to Odin Corporation, Chicago, Ill., a corporation of Illinois

No Drawing. Application October 27, 1945, Serial No. 625,010

2 Claims. (Cl. 148—21.55)

1

This invention relates to the composition of metals, and to methods of treatment for increasing their resistance to wear or for producing or magnifying other desired characteristics.

While the invention concerns, generally, the composition and treatment of metals, it has particular reference to the composition and treatment of engageable and relatively shiftable parts of operating machines and mechanisms, wherein problems of wear, friction, galling, and the like are presented. The principles of the invention have been applied to a pumping mechanism of the rotary blade type. In a pump structure of this type, when employed in the high pressure pumping of fluids, extremely high unit pressures are produced between parts slidable relative to each other at high speed; and extremely close tolerances must be produced and maintained between certain of the relatively shiftable parts, and the face surfaces thereof preserved, so as to maintain volumetric and mechanical efficiency. In accordance with the principles of the present invention, a blade type rotary pumping structure is produced of improved mechanical and volumetric efficiency, of minimized wear, and of high pressure capacity.

Accordingly it is an object of the present invention to provide improved metal compositions and methods of treatment, particularly adapted for use with engageable and relatively shiftable machine parts, enabling those parts when subjected either to low pressure or high pressure engagement, to maintain an improved mode of contact, vibrationless and positive, with minimum wear, and with preservation of the relatively engaged facing surfaces.

A further object of the invention is to adapt the principles hereinbefore set forth to the relatively movable parts of a rotary blade type pump, whereby to produce a high pressure pumping structure of greater mechanical and volumetric efficiency, of longer life, and of minimized wear.

Various other objects, advantages, and features of the invention will be apparent from the following specification.

The pump structure herein contemplated corresponds mechanically with the pump structure of my copending application, Serial No. 622,397, filed October 15, 1945 now Patent No. 2,588,430 issued March 11, 1952 and entitled "Rotary Blade Pump," of which the present application is a continuation-in-part. In order to afford a full understanding of the principles and features of the present invention, and their mode of application, reference is made to the aforesaid ap-

2

plication for a description of the mechanical structure of the pump.

As more particularly pointed out in said companion application, the factors of the shape of the cam surface of the cam member which imparts simple harmonic motion to the blades, and the reduced area of contact between the blades and the cam provided by the blade bevels, combine to facilitate fluid-tight and vibrationless contact between the blades and the cam surface, to promote high volumetric efficiency even when the structure is subjected to high pumping pressures. Similarly factors such as the arrangement of the parts, including the floating driving connection between the drive shaft and the rotor, the bearing support for the drive shaft, the two part concentrically apertured housing structure, and the annular, coaxial, and balanced disposition of the various fluid pressure channels and ports all combine to preclude distortion between the rotor and the side plates, and between the blades and the rotor, side plates, or cam, when subjected to high pressure pumping, whereby to promote volumetric and mechanical efficiency and minimize wear. However, the extremely small clearances preferably employed to promote volumetric efficiency (on the order of a few ten thousandths of an inch or less) between the rotor and the side plates, between the blades and the side plates, and between the blades and the rotor slots; as well as the high speed, high unit pressure engagement between the blades and the cam; raise problems of heat dissipation, fluid tightness, friction, and wear resistance having to do with the metallurgical aspects of the parts as well as with their mechanical arrangement. The problem of wear and deterioration of the facing surfaces of the side plates is further aggravated by the fact that the plate surfaces swept by the blades during operation are cut up by the inlet and exhaust plate ports.

In accordance with the present invention the composition and treatment of the cam, the blades, the rotor, and the side plates are so provided, in combination with the mechanical arrangement, to promote and maintain fluid-tightness, low friction, and wear resistance, thus providing high pressure volumetric efficiency, high mechanical efficiency, and maximum life and preservation of the face surfaces of the relatively slidable and contacting parts.

The preservation of the cam member and its blade engaging surface against wear and deterioration is of prime importance. In accordance with the present invention an extreme hardness coupled with a high ductility, and a molecular stability, is imparted to the cam, so as to enable it and its cam contours to maintain their size and facing surfaces against wear and disintegration, with minimized friction and smooth contact between the cam and the blades, while at the same time preventing the cam body from cracking, flaking, or other deterioration. While the processes hereinafter to be described are applicable to various high carbon alloy steels, to increase their hardness and strength as operating machine parts, a particular preferred composition for the cam will be set forth which has been found when the cam is treated in accordance with the invention to result in a cam having the desired characteristics of molecular stability, and extreme hardness and high ductility, and which also illustrates the manner in which a relatively inexpensive steel may be processed to produce a very high hardness and ductility, for the purposes required.

The metal of the cam thus may comprise a carbon chromium steel of the type frequently used for ball bearing races, rollers, and the like; and having for example the following principal composition:

Carbon	.92	1.02
Manganese	.95	1.25
Silicon	.50	.70
Chromium	.90	1.15

As will be understood, the steel may also have the traces of other elements usually to be found, such as nickel, copper, and molybdenum.

The steel may be hardened by preheating to 1250°–1300° F., followed by rapid heating to a hardening temperature of 1575°–1600° F.; and then quenched in light oil having a temperature of approximately no less than 100°–110° F., the piece being kept moving in the bath until cool. Promptly as the piece reaches room temperature after hardening, it is tempered or drawn at approximately 200° F. for a period of approximately three hours, if the piece is of average size, or correspondingly longer if the piece is large. This processing will give to the piece a Rockwell "C" scale hardness of substantially 67.

To further refine the molecular structure, and to add the necessary ductility for wear, the piece is permitted to stand for a time, for seasoning, and is then subjected to a deep freeze cold treatment at a temperature of −100° F. or colder, preferably substantially −125° to −150° F., for at least three hours, or more if the piece is large. The piece is then permitted to reach room temperature and is preferably, although not necessarily in all cases, then again tempered in an oil bath at approximately 200° F. for one hour or more, depending on the piece size, then cooled in air to room temperature, and then again deep frozen at −125° to −150° F. for eight to ten hours or more, depending upon the size of the part and the seasoning time between the original tempering and the time of the first deep freeze. A longer seasoning time requires additional time in the second deep freeze—requiring perhaps twenty-four hours or more in a particular case. After the second deep freeze, the piece is again tempered at approximately 200° F.

Whereas the original tempering produced a Rockwell C hardness of approximately 67, the additional seasoning and freezing operations not only refine the molecular structure for high ductility and wear, but also add from one to three

more points Rockwell C hardness. These subsequent seasoning and freezing operations also arrest growth and change in the molecular structure in the service of the part.

By means of the foregoing treatment a relatively inexpensive bearing steel of the type set forth may be provided with both high hardness and high ductility, as well as arrested molecular growth. The arrested molecular characteristics preserve the size of the cam member notwithstanding continual temperature changes in service (viz., the cam member will always return to its original size at normal temperature), whereas the hardness and ductility produce a wearing surface of minimized friction, maximum life, and a surface which will not gal when subjected to the high unit pressure rapid sliding action of the blades.

It has further been found that the part treated as above may be subjected to machining operations after treatment, and will last throughout a long life of service in use, without cracking, a difficulty encountered in conventional high hardness structures. Thus by way of example ball race steels are usually drawn or tempered at 400°—500° F., thus imparting a Rockwell C hardness well below 60, to preclude cracking in service. The bearing type steel above described, when treated as set forth, will not crack in service. It also maintains its size and contour.

Whereas the dissipation of heat is not a matter of difficulty in connection with the cam, the blades, due to their relatively small mass and size, become hot in high pressure service; and are required to maintain their desired characteristics notwithstanding high temperature operation. The blades are preferably of high speed steel, of which various specific types can be used. By way of illustration one high speed steel suitable for use is that known as 18—4—1 high speed steel, comprising essentially the following composition:

Carbon	.72
Manganese	.25
Silicon	.20
Chromium	3.75
Tungsten	18.25
Vanadium	1.15

Again, as will be understood, traces of other elements may be present, incidental to the manufacturing processes.

Another suitable high speed steel is that of the molybdenum type of the following essential composition:

Carbon	.80
Chromium	4.00
Molybdenum	4.25
Tungsten	5.50
Vanadium	1.50

In processing the blades the steel is preheated to 1550°–1600° F., followed by rapid heating to a hardening temperature of 2375°–2400° F., and then subjected to an interrupted quench by cooling in oil until the steel has reached a dull red condition at approximately 1000°–1050° F., and then removed from the oil and cooled in air to below 200° F. Promptly upon completion of the quench, the steel is tempered or drawn by placing in a tempering salt bath held at a temperature of approximately 1050° F. for a period of two hours whereby to produce a Rockwell C scale hardness of approximately 64–66, somewhat less than that of the cam.

After tempering, the blades due to their different composition are of finer molecular structure and of greater ductility than the cam after its first tempering. While the subsequent processing of the blades is perhaps somewhat less essential than in the case of the cam, as the problem of cracking is not presented, preferably the blades are subjected after the above tempering to the seasoning, freezing, and drawing operations as hereinbefore set forth in reference to the cam structure, at least the final drawing operation, however, being at the higher temperature of approximately 1050° F. above set forth. These operations materially increase the hardness and the life of the blades under high pressure and high speed operation.

It will be noted that the cam and blades are thus of essentially different composition, and it has been found that this different composition characteristic not only enables each part better to perform its intended service, but also reduces the friction between the parts, and eliminates galling.

More particuarly, while applicant does not wish to be limited by the theory stated, it is believed that the cam and blades exhibit their improved cooperative function because one is of essentially pearlitic structure whereas the other is essentially martensite with pearlite, or martensite with cementite, due to the differences in composition and treatment; thus enabling their high unit pressure engagement with low friction and the elimination of galling, in a manner commonly believed to require the use of different classes of metals, such as steel or bronze, but beyond the pressure ranges feasible between steel and bronze.

The side plates are preferably of bronze, or the like, and thus considerably softer than the blades or cam, and also of essentially different material. One suitable bronze which may be employed, by way of example, is that known as Lumen alloy No. 15-A having essentially the following composition:

Copper	87.50
Tin	11.00
Lead	1.50

Deoxidized with phosphorus.

Another suitable bronze alloy may be as follows:

Copper	86.0–90.0
Iron	.25 max.
Nickel	1.0 max.
Tin	5.5–6.5
Lead	1.0–2.0
Zinc	3.0–5.0
Phosphorus	.05 max.
Others	.2 max.

It is to be understood, however, that the foregoing bronze compositions are not by way of limitation as other high quality bearing bronze alloys may be employed. However, a high hardness bronze should not be used, for if the side plates are too hard undue friction between the plates and the blades will be produced, tending to melt the side plate material. The bronze alloys referred to above have a Brinell hardness number in the range of 65–100, and preferably the hardness should be in this general range.

Preferably the side plates are centrifugally cast. After casting and partial machining, the pieces are then preferably subjected to deep freezing, as in the case of the cam, either once or a plurality of times. The freezing maintains the metal stable and arrests molecular growth, so that it does not flow.

In most instances the composition and treatment of the rotor is of lesser importance than that of the cam. The rotor should be sufficiently similar in basic material to that of the cam so that its coefficient of expansion due to heat is the same. If great accuracy in pump operation is required, the rotor may be of the same material as the cam—similarly processed. One preferred steel which may be used is that commercially known as Nitralloy, suitably heat treated in a conventional manner, then machined, and then nitrided.

Reference has been made heretofore to "Rockwell C scale hardness" and to "Brinell hardness number." In connection with the Rockwell C scale designations, it is to be understood that C scale hardness determinations substantially above a hardness of 62–64 cannot be made by standard C scale equipment in a satisfactory manner due to chipping of the testing diamond point. Accordingly in making C scale hardness determinations above the range of 62–64, a Rockwell A scale Brale diamond penetrator may be employed, and the results transferred from the A scale to the C scale equivalent.

In connection with the Brinell hardness number designations, it is to be understood that the determinations may be made by use of a 10 millimeter Brinell Hultgren Ball.

It will be noted that in accordance with the foregoing composition and treatment of the materials a cam member is produced of stabilized molecular structure, and of extreme hardness and also of high ductility. The blades are of high heat resistance, of somewhat less hardness than the cam, and of essentially different metal. The side plates, of bearing bronze, and the rotor are also of essentially different material than the blades, and different than each other. This combination of materials produces a stabilized structure with a minimum of friction. It also provides a smooth and vibrationless contact between the blades and the cam, and preserves the relatively contacting wearing surfaces of the parts, thus promoting volumetric as well as mechanical efficiency.

It will be seen that the invention provides compositions of materials, and modes of treatment of general applicability, particularly to contacting and relatively shiftable machine parts in various types of machines and mechanisms, and including bearing structures, either of the sleeve or anti-friction type. It also provides a particular combination and relationship of materials in a rotary blade pump, for the purposes and advantages set forth.

In certain instances the pump may be used for pumping fluids having a high corrosive action, requiring the use of corrosion resisting pumping elements. In such instances the pressure requirements are usually lower. A composition and treatment for the parts in an installation of this character will now be set forth.

In such instance the cam member will preferably be made of stainless steel. A suitable stainless steel composition is that known as Carpenter stainless No. N-1 Type 414. The piece may be carburized, hardened, and tempered in conventional manner for steel of this type. The piece is then subjected to the seasoning, deep freezing, and drawing operations as in the case of the cam member previously described, the drawing, however, being at a temperature usual for tempering a steel of this character.

Instead of carburizing, a steel may be used of the type which can be nitrided; the steel in this instance being subjected to standard hardening and drawing operations, then nitrided, and then subjected to the seasoning, deep freezing, and drawing operations as previously described, the drawing temperature, however, again being that usual for use in tempering a steel of the type in question.

A material suitable for the blades is that known as Carpenter stainless No. 2–B–FM Type 440–F having essentially the following composition:

Carbon	1.00
Chromium	17.00
Selenium	.22

The pieces are hardened by heating slowly and uniformly to a temperature of 1950°–2000° F. and then quenched in light oil no cooler than 90° F., the oil being kept well agitated during the cooling process. The pieces are tempered promptly after reaching room temperature by holding at a temperature of approximately 200° F. for one hour, producing a Rockwell C scale hardness of 62–64. The pieces are then subjected to seasoning, deep freezing, and drawing operations as in the case of the cam member first described.

The blades treated in the foregoing manner will withstand unit pressures within a moderate pressure range, for example 1000 pounds per square inch.

In case of high pressures, the cam member may be made of the above Carpenter Type 440–F steel and treated as described; and in such case the blades may be made of a tungsten or tantalum carbide non-ferrous metal having a suitable hardness slightly above that of the cam.

The side plates are preferably cast of stainless or corrosion resisting cast iron and then silver plated on their rotor and blade engaged surfaces. Alternatively the side plates may be formed of steel subjected to suitable standard heat treatment and then chromium plated. In either event the side plates are subjected to a deep freeze treatment at approximately −125° to −150° F., for the purpose of setting the molecular structure as heretofore described.

For the rotor the same steel may be used as for the cam, processed in the same manner. Alternatively certain hard bronzes known as "Ampco Metal" may be used heat treated to give a Rockwell C scale hardness of 35 or more. Ampco metal grade 22 has for example the following composition:

Aluminum	13.6–14.4.
Iron	4.0–5.25.
Others	.5 max.
Copper	Balance.

By reason of the nature of the structure provided, the blade pump of the present invention may be satisfactorily employed for pumping liquid such as oil at relatively high pumping pressures, for example 2000 pounds per square inch and above, more than twice as great as the pressures employed in connection with conventional blade pumps.

It is obvious that various changes may be made in the specific embodiments and examples herein set forth without departing from the spirit of the invention. The invention is accordingly not to be limited to the specific embodiments and examples given, except as defined in the following claims.

The invention is hereby claimed as follows:

1. The method of treating a work piece of chromium alloy steel including substantially 1% carbon and 1% manganese, which method includes the steps of preheating the work piece to approximately 1250° F. to 1300° F., subjecting the work piece to a hardening temperature by rapidly heating the same to approximately 1575° F. to 1600° F., quenching the work piece in oil having a temperature in the range of 100° F. to 110° F., cooling to room temperature, tempering the work piece at approximately 200° F. for a period of at least three hours to give a Rockwell "C" scale hardness of substantially 67, allowing the work piece to stand after tempering for aging the same, subjecting the work piece to a deep freezing operation in the range of −100° F. to −150° F. for a period of at least three hours or more, to further increase its hardness and resistance to wear, and then allowing the work piece to warm up to room temperature.

2. The method of treating a work piece as claimed in claim 1, wherein the work piece is again tempered in an oil bath at approximately 200° F. for at least one hour, then permitted to cool to room temperature, thereafter subjected to a deep freezing operation of between −125° F. to −150° F. for at least eight hours and again tempered at approximately 200° F.

ERNEST J. SVENSON.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,989,900	Vickers	Feb. 25, 1935
2,129,671	Brunner	Sept. 13, 1938
2,297,983	Rea	Oct. 6, 1942
2,401,567	Jeannin	June 4, 1946

OTHER REFERENCES

"Machinery," Oct. 1944, pp. 137–144.

"Steel Processing," Nov. 1944, pp. 721–725.