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CASE CARBURIZED HIGH TEMPERATURE BEARING MEMBERS

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4 Claims. (Cl. 148—31)

This invention relates to carburized bearing members for use up to about 600° F., and to steels for the production of such bearings.

The term "bearing member" is used herein in the broad sense to refer to steel parts which move in contact with one another or with another part, particularly under conditions requiring the use of a lubricant. The term is used with particular reference to roller bearings but it contemplates also other similar members which move relative to another member in contact therewith such, for instance, as ball bearings, gears, wrist pins, and a variety of similar members.

Bearings at present are commonly made from, for example, SAE 4600 carburizing steel or SAE 52100 through hardened by oil quenching. These are limited in usefulness to a maximum temperature of about 350° to 400° F. There is presently a demand for bearing members that will operate satisfactorily at higher temperatures, say on the order of 600° F. High speed tool steels, for instance of the 18–4–1, the 8–4–1 and the 12 percent Cr–1.5 percent carbon varieties, can satisfy many elevated temperature bearing requirements up to about 1000° to 1100° F. However, a variety of factors militate against the use of such tool steels for bearing manufacture. Thus, because they are so highly alloyed they are unduly expensive, they are difficult to process and grind, and heat treatment on a production basis is subject to the disadvantages that exceptionally high hardening temperatures, commonly in excess of 1850° F. and more usually in excess of 2200° F., are required with very close control of the hardening atmosphere.

It is among the objects of this invention to provide carburized bearing members adapted for use at least to 600° F., that are of relatively simple and inexpensive composition, which when properly heat treated possess high case and satisfactory core hardness at room temperature as well as case hardnesses of at least 52 Rockwell "C" (Rc) at 600° F., which possess stable core hardness and structure both in use at elevated temperatures and also at room temperatures, and which possess good annealing, carburizing and machining characteristics.

A further object is to provide such members that are resistant to tempering of martensite formed on hardening whereby the members will possess recovered case hardness of at least about 58 Rc at room temperature after prolonged heating at 600° F.

Yet another object is to provide carburizing grade steels for the production of bearing members in accordance with the foregoing objects.

Other objects will appear from the following specification.

The invention is predicated upon my discovery that its stated objects are attained by carburizing members formed from steels containing from about, by weight, 0.16 to 0.21 percent of carbon, about 1.25 to 1.65 percent of chromium, about 0.50 to 0.70 percent of manganese, about 0.90 to 1.10 percent of molybdenum, and about 0.90 to 1.25 percent of silicon. The remainder of

the steels consists of iron together with elements and impurities in amounts normal to steels of this composition and in amounts that do not adversely affect the characteristics of the products of this invention. For most purposes it is preferred that the steels contain not over about 0.025 percent each of phosphorous and sulfur. Within the foregoing ranges it is preferred to use steel containing about 0.19 percent of carbon, 1.45 percent of chromium, 0.60 percent of manganese, 1.00 percent of molybdenum, and 1.05 percent of silicon.

The steels may be produced and processed, as by forging, in accordance with the practices that will be understood by those familiar with the art for steels of the compositions stated.

As exemplifying the invention, reference may be made to a 300 lb. induction furnace heat containing 0.21 percent of carbon, 1.46 percent of chromium, 0.61 percent of manganese, 1.01 percent of molybdenum, and 1.00 percent of silicon, thus corresponding to the preferred embodiment. This heat was forged to produce 1½" rounds from which slices ⅜" thick were cut for testing to determine the properties.

Samples of the steel were subjected to widely differing carburizing procedures including carburizing with a mixture of natural gas and a carrier gas, carburizing with straight natural gas followed by a diffusion period, and pot carburizing in a carburizing compound. In all instances case gradients, case depths and maximum surface carbon were found to be satisfactory for bearing uses.

In one series of tests the specimens were carburized 16 hours in a mixture of carrier gas and natural gas in the ratio of 8 to 1, following which they were air cooled. The specimens were then ground to carbon levels of 1.00 percent, 0.70 percent and to the core. The specimens were then austenitized one hour at various temperatures followed by quenching in agitated oil, and the hardnesses (Rc) were then determined, as shown in the following table:

Percent Carbon Level	Quenching Temp., ° F.					
	1,500°	1,525°	1,550°	1,600°	1,650°	1,700°
1.00	66.5	66.5	66.6	66.4	65.6	64.9
0.70	65.0	65.5	66.7	66.4	65.4	66.9
Core	39.6	40.5	42.3	43.8	43.3	42.5

These data show that extremely high room temperature case hardnesses are developed at rather low hardening temperatures, and that hardening from 1525° F. will achieve satisfactory hardnesses in both case and core. The ability to develop such extreme hardness at rather low hardening temperatures is a desirable feature in high temperature bearing materials. Thus, bearing distortion and size changes are minimized at such low temperatures, and higher hot hardnesses are produced at the elevated temperatures of use when high quenched hardnesses are developed. That is, the load carrying capacity of a bearing at temperatures being related to the hot hardness depends also on the hardness produced by the initial quenching.

Experience has shown with this steel that for the hardening step a hold of 30 minutes at 1525° F. produced a stable core and case hardness and structure: Case 67.0 Rc; core 36.0 Rc.

Hot hardness was determined with a Rockwell tester, the sample and indenter being enclosed in a coil wound electric furnace. Hardnesses of the samples were taken at 100° F. intervals from 400 to 800° F. under an argon atmosphere. The samples were held one-half hour at each temperature before the hardness determinations.

After the 800° F. hot hardness study the recovered hardness of the air cooled material was measured at room temperature. The data obtained were as follows.

Carbon Level	Hardness As Quenched	Rc Hardness at Temp., ° F.					Recovered Hardness after 800° F. Treatment
		400	500	600	700	800	
1.00	66.5	58.5	56.2	53.5	51.5	45.2	59.2
0.70	65.5	57.5	54.8	52.8	50.0	44.5	57.8
Core	38.4	38.3	37.7	39.1	37.5	35.5	38.2

As will be observed, the case and core hardnesses at 600° F. are satisfactory for bearing work, and the resistance of the hardened bearing member to tempering is evidenced by the excellent recovered hardness after heating at 800° F.

Room temperature hardness measurements were made also on the steel specimens at the same carbon levels after prolonged tempering treatments at 500° F., 620° F. and 700° F., by standard Rockwell "C" methods. The data obtained are as follows:

Recovered hardness—Rc—after tempering following quenching from 1525° F. in oil

Carbon Level	As Quenched	Holding Time at 500° F.—Hrs.					
		8	72	128	256	500	1,000
1.00	67.7	62.7	62.8	62.3	62.6	62.8	------
0.70	67.5	62.5	62.7	62.8	62.5	62.0	------
Core	39.5	38.5	38.1	38.4	38.9	39.7	------
		Holding Time at 620° F.—Hrs.					
		8	72	128	256	500	1,000
1.00	67.7	61.6	61.0	60.6	61.0	60.8	59.8
0.70	67.2	59.5	59.0	58.3	59.0	58.3	57.7
Core	38.0	38.2	37.7	36.5	37.3	37.4	37.6

These data reveal the temperature stability of the bearing members in accordance with the invention. Thus, when hardened from 1525° F. a case hardness of 62.8 Rc is retained after 500 hours at 500° F., and about 60 Rc after 1000 hours at 620° F. Core hardnesses are shown likewise to be satisfactory. The data show likewise that the case and core hardnesses are highly stable so that the dimensional stability of the members at these temperatures is insured.

After the long tempering treatments at 620° F. the specimens were treated to obtain hot hardness data, as follows:

Carbon Level	Rc after 1,000 hrs. at 620° F.	Hot Hardness—Rc					Recovered Hardness—Rc—After 600° F.
		400° F.	500° F.	600° F.	700° F.	800° F.	
1.00	59.8	58.5	57.0	56.5	53.0	47.6	58.5
0.70	57.7	55.0	54.8	53.0	50.0	46.2	56.3
Core	37.6	37.3	35.5	35.5	35.2	32.7	37.5

These data again demonstrate the structural stability of bearing members in accordance with the invention.

Additionally, the annealing characteristics of bearing members in accordance with the invention were determined in one test involving an isothermal treatment in which the specimens were heated to 1800° F., held one hour, cooled to 1300° F. and held for various times, followed by air cooling. After one hour at 1300° F. the hardness was 300 Brinell, after 2½ hours it was 183 and after 4 hours it was 179. Specimens were also subjected to a continuous cooling cycle involving holding at 1800° F. one hour, cooling to 1400° F., then cooling at predetermined rates to 1200° F., and then air cooling. When cooled from 1400° F. at 100° F. per hour the Brinell hardness was 179, while cooling at 50° F. per hour developed a Brinell hardness of 167. These hardnesses represent structures satisfactory for machining and cold heading.

Grain size tests made by the McQuaid-Ehn method showed that the structures remain fine grained up to 1850° F. in case and core regions.

According to the provisions of the patent statutes, I have explained the principle of my invention and have described what I now consider to represent its best embodiment. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

I claim:

1. As a new article of manufacture, a case carburized steel bearing member formed from steel containing about 0.16 to 0.21 percent of carbon, about 1.25 to 1.65 percent of chromium, about 0.50 to 0.70 percent of manganese, about 0.90 to 1.10 percent of molybdenum, about 0.90 to 1.25 percent of silicon, and the remainder iron together with impurities and elements in amounts not adversely affecting properties of the bearing member, and characterized after hardening from 1525° F. by case hardness of at least about 52 Rockwell "C" at 600° F., and by a recovered hardness after heating at 600° F. for 500 hours of about 60 Rockwell "C."

2. As a new article of manufacture, a case carburized steel bearing member formed from steel containing about 0.19 percent of carbon, about 1.45 percent of chromium, about 0.60 percent of manganese, about 1.00 percent of molybdenum, about 1.05 percent of silicon, and the remainder iron together with impurities and elements in amounts not adversely affecting properties of the bearing member, and characterized after hardening from 1525° F. by case hardness of at least about 52 Rockwell "C" at 600° F., and by a recovered hardness after heating at 600° F. for 500 hours of about 60 Rockwell "C."

3. Carburizing steel consisting essentially of about 0.16 to 0.21 percent of carbon, about 1.25 to 1.65 percent of chromium, about 0.50 to 0.70 percent of manganese, about 0.90 to 1.10 percent of molybdenum, about 0.90 to 1.25 percent of silicon, and the remainder iron together with impurities and elements in amounts normal to such a steel, and characterized when carburized and hardened from 1525° F. by case hardness of at least about 52 Rockwell "C" at 600° F., and by a recovered hardness after heating at 600° F. for 500 hours of about 60 Rockwell "C."

4. Carburizing steel consisting essentially of about 0.19 percent of carbon, about 1.45 percent of chromium, about 0.60 percent of manganese, about 1.00 percent of molybdenum, about 1.05 percent of silicon, and the remainder iron together with impurities and elements in amounts normal to such a steel, and characterized when carburized and hardened from 1525° F. by case hardness of at least about 52 Rockwell "C" at 600° F., and by a recovered hardness after heating at 600° F. for 500 hours of about 60 Rockwell "C."

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,876,152 March 3, 1959

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It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 57, in the table, last column thereof, in the heading, for "600° F." read -- 800° F. --; same table, line 60, second column thereof, for "37 6" read -- 37.6 --.

Signed and sealed this 7th day of July 1959.

(SEAL)
Attest:

KARL H. AXLINE
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