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GRINDING BALL AND THE METHOD OF MAKING THE SAME

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2 Claims. (Cl. 148—12)

Our invention relates to improvements in steel grinding balls and their manufacture, such balls, for example, as are employed in the well known ball mills and tumbling devices for pulverizing and grinding materials, for cleaning castings, etc.

Due to the combined pounding and abrading action of the balls in use, it is desirable that they possess hard exterior surfaces with accompanying high impact strength, so as not to crack and spawl. Also, it is very desirable that such balls have substantial uniformity in respect to the foregoing characteristics.

Various steels, alloys and heat treatments have been employed heretofore for making grinding balls with varying degrees of success. Generally, however, difficulty has been experienced in producing a suitable article, particularly in large size balls, without restorting to the use of expensive steels and the addition of alloying metals which appreciably increase the cost of the balls in comparison with that of the old plain carbon steel balls.

We have successfully and commercially produced plain carbon and manganese steel balls up to about two inches in diameter. Beyond the two inch size, the plain steel balls could not be produced with any commercial practicability, too large a proportion thereof cracking during or after heat treating in the manner generally employed for such a steel. In other words, the internal strains in a substantially spherical ball in excess of two inches in diameter and of plain carbon manganese steel, could not be relieved sufficiently so as to prevent failure of the mass during or subsequent to the severe quenching necessary to produce the desired surface hardness.

In seeking to remedy the foregoing condition and to commercially produce hardened steel balls of a size exceeding two inches, we have discovered that the desired articles may be successfully and economically produced from standard steel stock which may be had without the extra cost of adding alloy metal thereto. By initially forging the balls from such metal and providing a controlled and regulated heat treatment therefor, we have been enabled to economically manufacture hardened steel grinding balls in excess of two inches in diameter having high surface hardness, and resistance against impact.

The steel employed in our new hardened ball is of the class known as automatic steels, and more particularly chromium-bearing steels. For example, such steels are made for use in crank shafts, cam shafts, and the like, for which purpose they are initially formed by rolling into "rounds." In the latter process, there are produced what are known as off-grade rejects, unsuitable for their intended use because of minute surface defects, and such rejects provide the source of supply for our improved grinding balls and their manufacture.

Such a steel is a fine grained high quality standard product, and under the conditions above stated, it is possible to obtain the same at low cost without the expense of producing a special alloy for manufacturing grinding balls. It is a chromium-bearing low carbon manganese steel within the following range:

	Percent
Carbon	.40 to .55
Manganese	.70 to 1.05
Chromium	.20 to .80
Silicon	.20 to .30

the balance being iron except for an extremely small percentage of impurities therein.

As a specific example, we have successfully manufactured hardened grinding balls three and one-half inches in diameter of the following steel within said range:

	Percent
Carbon	.52
Manganese	1.05
Chromium	.30
Silicon	.22

the balance being iron except for an extremely small percentage of impurities therein.

In the practice of our invention, the steel stock of the character set forth is first forged into substantially spherical shapes or balls at a forging temperature of from 2050° F. to 2450° F., said balls being of from two and one-half to five inches in diameter or larger, each size being preferably forged and treated separately as hereinafter set forth. Commercial sizes within said range of diameters generally include two and one-half, three, three and one-half, four, four and one-half and five inch balls.

After being forged, the balls are cooled in air to a temperature above the critical range of the steel thereof, and are quenched in water, the temperature of the balls being preferably between 1450° F. and 1500° F. at the time of quenching.

In order to attain uniformity, the time of cooling is accurately controlled, as by conveying the forged balls at a predetermined constant speed in air until immersed in the quench, and the water quench is maintained at a substantially constant

temperature of from 90° F. to 110° F. by means of suitable controls.

The balls remain in the quench a sufficient length of time, dependent upon their size, to reduce the temperature thereof to from 400° F. to 600° F., and are then immediately removed to a drawing oven or bin where they are maintained for at least two hours at their residual temperature in order to adequately relieve all internal strains. We have found a residual temperature of 450° F. to be satisfactory and have attained such temperature with uniformity by conveying the balls in and through the quenching bath at a predetermined speed so as to accurately control the time of quench and hence the residual temperature of the balls.

The foregoing controlled treatment contemplates and produces grinding balls having a suitable proportion or outer layer of hard martensitic case about a softer core or center of fine pearlite. By our process, the grinding balls so produced will have a substantially uniform case having an external surface hardness of between 60 and 65 Rockwell C scale.

We have discovered that the drawing step of our method bears direct relation to the diameter of the ball, and by maintaining the balls at their residual temperatures of 450° F. for not less than the number of hours corresponding to the diameter of the balls in inches, we have successfully relieved the internal stresses and produced crack-free and well hardened grinding balls which have tested to specifications and performed satisfactorily in service. Thus, a ball two and one-half inches in diameter is drawn for two and one-half hours, a three inch ball for three hours, and so on, the balls finally being permitted to gradually cool to atmospheric temperature, whereupon they are ready for use.

By the foregoing process and the use of the prescribed chromium-bearing steel, grinding balls of commercial sizes in excess of two inches may be manufactured and sold in the price ranges of plain carbon steel balls, and with considerable saving and economy in comparison with any special alloy steel grinding balls having comparable hardness. In addition to the resistance of the present product to cracks and failure during manufacture, the grinding balls so produced possess a high resistance to spawling and cracking in the mill. In short, the grinding balls of our invention resist the severity of impact and abrasion encountered in and during prolonged service.

Various changes and modifications are contemplated within the scope of the following claims.

We claim:

1. The herein described method of manufacturing hardened steel grinding balls of a size exceeding two inches in diameter, which consists in forging the balls from a chromium-bearing low carbon manganese steel at a temperature of from 2050° F. to 2450° F., quenching the forged balls at a temperature of from 1450° F. to 1500° F. in water to a residual temperature of from 400° F. to 600° F., and then drawing said balls at their said residual temperature for at least two hours.

2. The herein described method of manufacturing hardened steel grinding balls of two inches in diameter and larger, which consists in forging the balls from a chromium-bearing low carbon manganese steel at a temperature of from 2050° F. to 2450° F., quenching the forged balls at a temperature of from 1450° F. to 1500° F. in water to a residual temperature of from 400° F. to 600° F., and then drawing said balls at their said residual temperature for a time period in hours at least equal to the number of inches in the respective diameters of the balls.

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