United States Patent Office 3,061,209 Patented Oct. 30, 1962

3,061,209

ABRASIVE GRINDING BALLS

Albert L. Bard, Independence, Mo., and Arthur M. Johnsen, Middletown, Ohio, assignors to Armco Steel Corporation, Middletown, Ohio, a corporation of Ohio

No Drawing. Filed Jan. 13, 1958, Ser. No. 708,357
3 Claims. (Cl. 241—184)

This invention relates to grinding balls such as are used in ball mills. Ball mills are used in various industries for comminuting various materials. For instance, in the southwestern United States, in the cement and copper mining industries, grinding balls are used in rotating ball mills in reducing the copper ore and other materials into finely divided particles.

In a pulverizing or grinding apparatus commonly known as a ball mill, various sizes of loose grinding members or elements are utilized to grind by means of a combination of a rolling, rubbing and pounding action. These grinding elements are ordinarily referred to as balls, even though they are not truly spherical. Sometimes they are referred to as slugs. For this reason, the term "ball" as used in the specification and claims is not used in its narrow sense of "sphere," but in the sense in which it is used in the ball mill art, that is, to designate one of a collection of loose grinding elements, which are caused to roll and tumble about in a suitable container such as a drum or the like, in a grinding mill.

In order for a grinding ball to be an effective grinding medium, it must have a certain combination of characteristics. It must be hard and abrasion resistant so that it will not erode faster than the material which is being pulverized. At the same time, it must be tough enough so that it will not fracture and split up upon use in the mill, as by impact with the material which is being comminuted, or by impact with other balls or the mill lining, or by the crushing action of the load on grinding balls at the bottom of the mill.

Our experience with grinding balls has shown that it would be very desirable to have a grinding ball in which extremely hard particles are embedded in order to make the grinding ball more highly abrasive. There is a demand for a grinding ball carrying finely divided abrasive such as alumina, tungsten carbide, titanium carbide, silicon carbide, and the like. Various attempts have been made to incorporate abrasive particles into grinding balls but these have not come into widespread use. The reason why the incorporation of abrasive particles into a grinding ball presents difficulties is that generally speaking abrasive materials are very light. Abrasive materials having a Moh hardness of 7 or above such as alumina, silicon carbide, and various borides and the like, are all too light to be incorporated into molten iron or steel because they float to the surface before they can be trapped and held in the freezing metal. Others, such as tungsten carbide, which would do the job, are too heavy and would sink to the bottom in a molten mixture before they could be trapped and held in the freezing metal.

If powder metallurgy is employed, it is a simple matter to distribute the abrasive particles uniformly through the powdered iron and when the material is compacted and sintered, a uniform product is obtained. However, an abrasive ball produced by powder metallurgy will not be "metallurgically" hard. The iron itself will be soft enough to deform under impact and the ball will not retain its original shape. Heat treatment of such a ball is difficult because of the fact that the abrasive particles have an insulating effect in that they do not readily conduct heat between the adjacent iron particles. If powdered iron is used in the powder metallurgy technique, there is the further disadvantage that the ball cannot be hardened by heat treatment.

With the foregoing considerations in mind, it is an object of the present invention to overcome the difficulties heretofore encountered and to produce an abrasive grinding ball which will not only have particles of abrasive embedded in a matrix of iron, but which will be tough and hard so that it will not split or crack or deform when used in a ball mill.

It is another object of the invention to provide a grinding ball as above outlined by powder metallurgy techniques, first forming a cylindrical or other shaped compact, and then forging the sintered compact to a ball to further compact the particles, and then heat treating the forged ball to give it the required hardness.

These and other objects of the invention which will be pointed out in more detail hereinafter or which will be apparent to one skilled in the art upon reading these specifications, we accomplish by that composition and by that series of method steps of which we shall now describe exemplary embodiments.

A grinding ball having the desired qualities could be prepared by the addition of abrasive material to the molten steel if the abrasive could be prevented from either settling out, or floating out, of the molten steel. Similarly it may be possible to add to the molten steel certain alloying ingredients which, upon solidification of the steel, would produce scattered inclusions of refractory compounds of an abrasive nature.

Briefly, in the preferred practice of the invention, we resort to powder metallurgy and mix powdered iron or steel and finely comminuted abrasive particles in the desired portion, compact them into a roughly cylindrical compact and then sinter the compact at a temperature of about 2000° F. or higher, or in any event just below the melting point of the powdered metal being used, having in mind the atmosphere being used. For example, a suitable atmosphere may be achieved by carrying out the sintering operation with the compacts packed in coke.

The compacted slug is then reheated to forging temperature and given a number of forging blows. The forged ball is then heat treated to secure the final physical properties desired. It will be understood by those skilled in the art that if powdered iron is used, steps must be taken at some stage of the process to render the iron heat hardenable.

A typical abrasive for reasons of economy is alumina (Al_2O_3) and preferably it is finely comminuted to at least 100 mesh. It will be understood that the more finely the abrasive is comminuted, the more dense it is possible to make the ultimate grinding ball; and naturally also the less alumina is used, the denser the ball can be made. The upper limit of the amount of abrasive which may be added appears to be about 30% of alumina by volume. Excellent results are achitved with alumina between 3% and 10% by volume. The iron or steel powder and abrasive powder are thoroughly and uniformly mixed and are compacted into roughly cylindrical compacts and placed into individual crucibles and packed with coke. After sintering at a temperature of 2000° F. or higher, a slug is produced which is ready for forging.

The slugs are heated to forging temperature and forged in suitable dies to bring them to spherical shape. As an example, we have forged the cylindrical slugs with three blows, the first blow achieving a substantially ball form and the second and third blows consolidating the flash formed in the first blow. The forging operation increases the density of the balls and renders them more readily heat hardenable.

The forged balls are then reheated, passed through sizing machines and heat treated. We have found it convenient to reheat the forged balls in coke prior to sizing and heat treating.

Balls manufactured as above described have an excellent appearance and cannot readily be distinguished from regular forged steel grinding balls now being produced, and as taught in the Hagenbuch and McCoy Patent No. 2,182,805. Tests for hardness on balls produced as above show that whereas with no alumina the R_c hardness at .015 inch depth ranged from 64 to 66, with 10% alumina by volume the R_c ranged from 61 to 64, and with 30% alumina it ranged from 58 to 61. For commercially satisfactory grinding balls the hardness at the surface should hold to a depth of ¼ inch from the surface, and drop only a little to the center of the ball. It will be understood that hardness is necessary to prevent rapid wear and damage to the ball surface in use.

With 3 to 10% alumina, the ball density is not lowered greatly and its hardness is not greatly affected while the advantages of abrasive loading are achieved.

It will be understood that other abrasive materials may be used instead of alumina, although tungsten carbide is relatively expensive and it would be desirable to use not more than 3% by volume of tungsten carbide on account of the expense factor.

It will be clear that various modifications may be made without departing from the spirit of the invention. We do not intend to limit ourselves except as set forth in the claims which follow.

Having now fully disclosed the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. A forged, heat treated and hardened grinding element for use in ball mills and the like, comprising a matrix of ferrous material with abrasive particles uniformly distributed therethrough, said matrix having a surface R_c hardness of from 58 to 64, said uniform surface hardness being substantially within the range stated to a depth of at least one-quarter inch.

2. An abrasive grinding element according to claim 1, wherein the abrasive particles are alumina, in the form of particles of a size no larger than 100 mesh, and wherein the alumina constitutes approximately 3% to 30% by volume of the grinding element.

3. An abrasive grinding element according to claim 1, wherein the abrasive particles are tungsten carbide, in the form of particles of a size no larger than 100 mesh, and wherein the tungsten carbide constitutes approximately 3% to 30% by volume of the grinding element.

References Cited in the file of this patent

UNITED STATES PATENTS

1,451,335	Hanks	Apr. 10, 1923
1,895,354	Taylor	Jan. 24, 1933
2,182,805	Hagenbuch et al.	Dec. 12, 1934
2,398,719	Rasmussen	Apr. 16, 1946
2,404,598	Sachse	July 23, 1946
2,558,327	Weston	June 26, 1951

FOREIGN PATENTS

164,564	Austria	Nov. 25, 1949
171,179	Austria	May 10, 1952
578,280	Great Britain	June 21, 1946