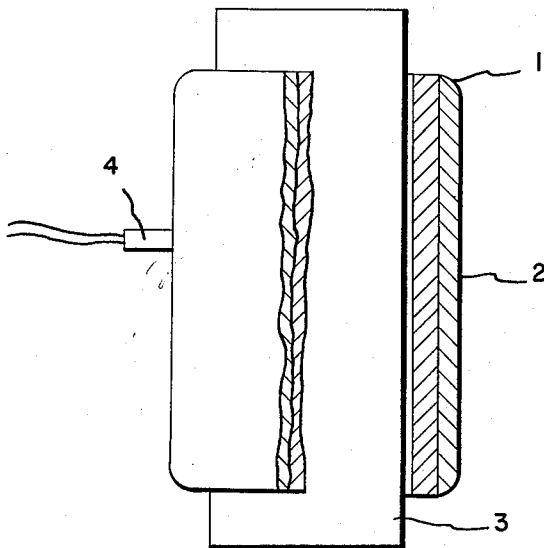


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METHOD FOR PREPARING BUSHINGS

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INVENTORS

REID EARNHARDT

JAMES P. SWED

BY

Thos A. Wilson
ATTORNEY

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METHOD FOR PREPARING BUSHINGS

Reid Earnhardt, Pitman, and James P. Swed, Gibbstown, N.J., assignors to E. I. du Pont de Nemours and Company, Wilmington, Del., a corporation of Delaware

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The present invention relates to a novel method for hardening the inner surface of a hollow object of austenitic manganese steel. This invention is particularly applicable to the preparation of bushings by hardening the inner surfaces of sleeves of austenitic manganese steel.

Austenitic manganese steel, also known as Hadfield's manganese steel, is widely used in the fabrication of heavy duty equipment subjected to impact, abrasion, and heavy pressure because the steel becomes work-hardened as the result of such usage. However, hardening prior to actual usage is frequently desirable to prevent deformation or damage before the actual work-hardening is obtained.

In U.S. Patent 2,703,297, a method for work-hardening austenitic manganese steel prior to usage is described. According to this method, a layer of detonating explosive is placed contiguous to the surface of the portion of the object whose hardening is desired, and the explosive is then detonated. The shock wave and the super pressure generated by the detonation produces a lattice distortion within the steel which results in work-hardening of the steel. The hardening obtained is greatest on the surface on which the explosive is located and diminishes rapidly with depth.

In a number of pieces of heavy equipment, such as clam shells and slag conveyors, austenitic manganese steel is used in the fabrication of bushings subjected to impact and abrasion. If the inner surfaces of the bushings are not work-hardened prior to use, considerable wear and deformation will occur before the work-hardening by usage will provide a satisfactory surface. None of the prior art methods of hardening, including the use of explosives, are satisfactory for hardening the inner surface of a hollow object. Hammering or peening an inner surface of a hollow object such as a sleeve is not practicable unless the object is very large. If an explosive charge is positioned within a hollow object, the confinement provided will cause the object to be shattered or at least deformed, even with the minimum amount of explosive required to produce surface hardening and if auxiliary support is provided.

Accordingly, an object of the present invention is to provide a method for work-hardening the inner surface of a hollow object of austenitic manganese steel. A further object is to provide such method wherein effective hardening is accomplished rapidly and economically. Other objects will become apparent as our invention is more fully described.

We have found that the foregoing objects are attained when we surround the outer surface of a hollow body of austenitic manganese steel with a layer of a detonating explosive, position a mandrel of a deformation-resistant material within the object, and detonate the explosive layer.

In order to more fully describe our invention, reference is made to the accompanying drawing which is illustrative only, the invention not being limited to the specific embodiment shown. In the drawing, 1 is a sleeve of

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austenitic manganese steel, 2 is a layer of a detonating explosive, 3 is a pin of a deformation-resistant material and 4 is an electric initiator.

In carrying out the method of the present invention, the explosive layer 2 may be applied as a preformed sleeve, may be coated on the sleeve 1, either in the form of a paste or a slurry, may be wrapped around the sleeve 1 in the form of a ribbon, sheet, or tape, or may consist of a packaged loose explosive composition. We prefer to coat the sleeve 1 with a paste-like explosive composition because of ease of application. The explosive-covered sleeve 1 is then slipped over the mandrel 3, and initiator 4, which may be a conventional blasting cap, is positioned in detonating relationship to the explosive layer 2. Upon initiation of the explosive layer 2, the pressures generated constrict sleeve 1 at high velocity, causing the inner surface of sleeve 1 to impinge on the outer surface of mandrel 3. The impact and the compression produced by the interaction of the two surfaces cause the inner surface of sleeve 1 to be work-hardened. By the nature of the compression force, the hardening is substantially uniform over the entire surface.

To further illustrate the present invention, reference is now made to the following examples.

Example 1

An austenitic manganese steel bushing, made oval to facilitate locking in the bushing housing, had an inner diameter of 1.156 inches, a major outer diameter of 1.750 inches, a minor outer diameter of 1.500 inches, and a length of 1.938 inches. The bushing, after annealing, had a Rockwell C hardness of 20 on both inner and outer surfaces. The bushing was slipped over a mandrel of hardened tool steel having a surface hardness of Rockwell C 62 and a diameter of 1.130 inches. The outer surface of the bushing was then coated with Composition C-3 (mononitrotoluene/dinitrotoluene/TNT/tetryl/RDX/nitrocellulose), the quantity used being sufficient to provide a layer equal to approximately 4 grams of explosive per square inch of outer sleeve area.

The explosive layer was detonated by means of an electric blasting cap. The mandrel was shattered by the detonation, and the fragments were readily removed from the interior of the bushing, leaving a relatively smooth inner surface. The inner diameter of the bushing was 1.127 inches (0.003 inch less than the diameter of the mandrel before detonation, and 0.029 inch less than the original inner diameter of the bushing). The bushing was sectioned to permit hardness measurement and the bushing was found to have an average Rockwell C hardness of 36 on its outer surface and an average Rockwell C hardness of 47 on the inner surface.

The fact that the hardness of the inner surface is substantially in excess of the hardness of the outer surface is positive evidence that the hardening of the inner surface is due to the anvil action of the mandrel rather than to the shock wave from the detonation.

Example 2

In a test identical to that set forth in Example 1, except that the mandrel consisted of a soft iron rod (Rockwell B hardness of 90), the average inner surface hardness of the bushing was 42 Rockwell C while the outer surface hardness of the bushing was 38 Rockwell C.

Example 3

In a test identical to that set forth in Example 1, except that the alloy steel mandrel was case-hardened to provide a surface hardness of Rockwell C 52, the average inner surface hardness of the bushing was increased to 39 Rockwell C. The inner diameter of the bushing was reduced approximately 0.050 inch.

Example 4

An austenitic manganese steel tubular bushing (Rockwell C hardness of 20) having an inner diameter of 1.276 inches, an outer diameter of 2 inches and a length of $2\frac{7}{16}$ inches was coated with Composition "C" to produce an explosive loading of approximately 3 grams per square inch. The bushing was slipped over a tempered (Pyrex) glass rod having a diameter of 1.237 inches. Upon initiation of the explosive charge by an electric blasting cap, the bushing was constricted to an inner diameter of 1.234 inches and had an inner surface hardness of 33 Rockwell C.

As shown by the examples, the hardness obtained on the inside surface of the bushing will be influenced by the hardness of the surface of the mandrel. However, the ultimate hardness of the inner surface of the bushing may exceed the original hardness of the mandrel because of the hardening of the mandrel which occurs during the constriction of the sleeve. Thus, any solid body which will offer resistance to the inward constriction of the bushing will have a hardening influence. Accordingly, any deformation-resistant body may be used as the mandrel. Within this category are included the materials commonly used for structural purposes, i.e., iron, copper, aluminum, glass, ceramics, etc., and the materials used in the fabrication of tools, i.e., special steels. The maximum hardness has been obtained using tool steel and this is the preferred material for the mandrel.

The present method of providing a hardened inner surface of an austenitic manganese steel hollow body is superior to the mechanical procedure not only in the reduction of time required to produce such hardened inner surface, but also in the amount of hardness produced. The foregoing is illustrated by the following example.

Example 5

Two bushings of austenitic manganese steel $1\frac{1}{4}$ inches in outer diameter, $1\frac{3}{16}$ inch in inner diameter, 2 inches in length, and having a Rockwell C hardness of 18 were slipped over snugly fitting tool steel bars having a Rockwell C hardness of 57 and processed as follows:

(A) One bushing was surrounded by a layer of composition of 85% PETN and 15% inert binder, the explosive loading amounting to 3 grams per square inch. After detonation of the explosive layer, the outer surface of the bushing had an average hardness of 33 Rockwell C and the inner surface had an average hardness of 36 Rockwell C.

(B) The other bushing was struck twenty times with a 2 pound machinists hammer along a straight line parallel to the axis. The hammer was raised about 24 inches and brought down in a normal manner, deformation of the surface being noted after each stroke. Hardness determinations made along the line of impact showed the average hardness on the outer surface was 36 Rockwell C. Hardness determinations on the inner surface directly opposite the impacted area showed that the average Rockwell C hardness was 22.

From the foregoing example, it can be seen that mechanical peening, even to an extent such that the sur-

face hardness exceeds that provided by a particular explosive loading, does not produce nearly the same inner surface hardening—in fact, the inner surface is hardened only a slight amount by peening the outer surface.

The amount of explosive required will depend upon the type of explosive used, the thickness of the bushing, the degree of hardness required, and the amount of diameter reduction involved. The minimum loading is that at which the detonation will be propagated from the point of initiation throughout the explosive layer. The maximum loading is that just below the level at which the bushing is cracked by the detonation of the charge.

To be effective, a detonating explosive composition must be used. The term detonating explosive, as used in this description, refers to an explosive composition in which the reaction zone travels through the explosive composition at a speed greater than the velocity of sound in the reaction products. The use of a plastic explosive composition which can be coated about the bushing is preferred; however, the invention is not restricted to the use of any particular type of detonating explosive.

The explosive layer will preferably extend substantially from one edge to the other of the outer surface of the hollow body if the entire inner surface is to be hardened.

If only a portion of the inner surface is to be hardened, obviously only the corresponding portion of the outer surface will be covered by the explosive layer.

The present application is a continuation-in-part of our copending application Serial No. 597,164 filed July 11, 1956, now abandoned.

The present invention has been fully described in the foregoing. Modifications and variations which are within the scope of the invention will occur to those skilled in the art. Accordingly, therefore, we intend to be limited only by the following claims.

We claim:

1. A method for hardening the inner surface of an austenitic manganese steel hollow body which comprises positioning a layer of a detonating explosive composition on the outer surface of said body, inserting a mandrel of a deformation-resistant material inside said body, initiating said explosive charge and thereby hardening the inner surface of said hollow body to a substantially greater degree than the outer surface of said body.

2. A method as claimed in claim 1, wherein said body is a bushing.

3. A method as claimed in claim 1, wherein said mandrel is of tool steel.

4. A method as claimed in claim 1, wherein said explosive composition is coated on the outer surface of said body.

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