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PROCESS OF REBUILDING STEEL STRUCTURES

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FIG. 1.

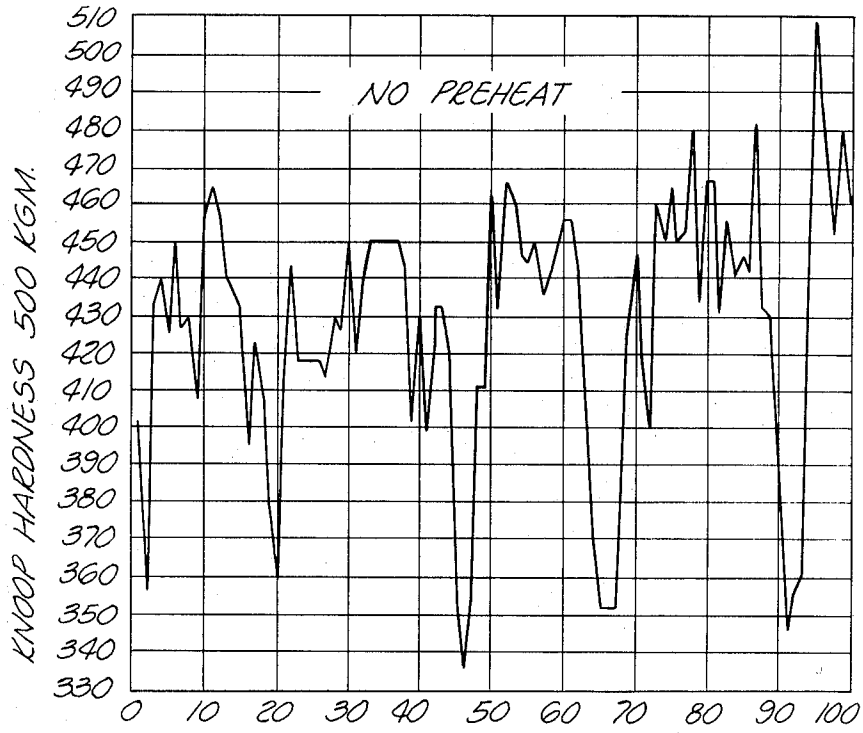
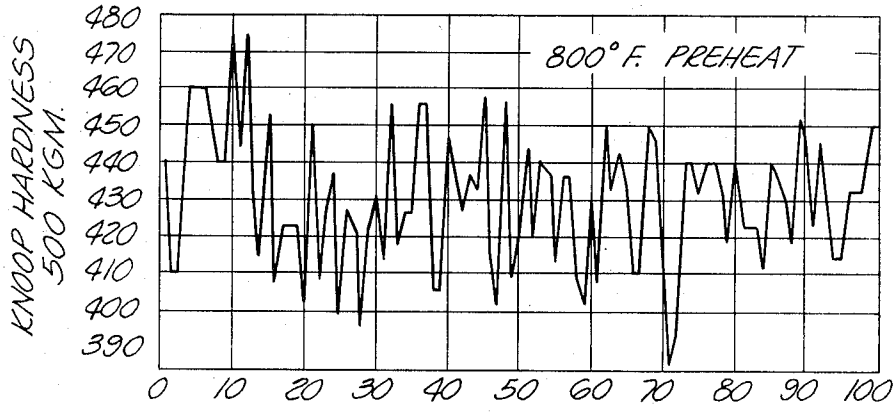


FIG. 2.



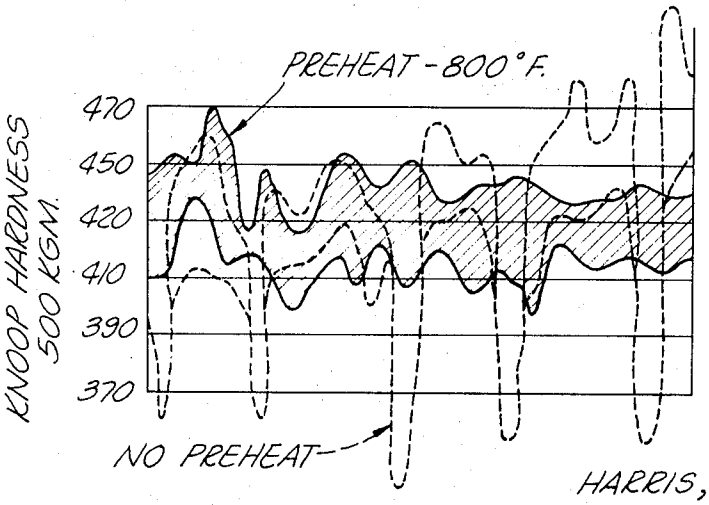


FIG. 3.

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PROCESS OF REBUILDING STEEL STRUCTURES

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ABSTRACT OF THE DISCLOSURE

The invention concerns an improvement in the rebuilding of steel workpieces, such as rolls, platens, and the like, wherein great uniformity in mechanical properties must be achieved throughout the rebuilt layer. In accordance with the invention, the workpiece is maintained at a temperature in excess of the martensite transformation temperature of the added steel, and not in excess of about 1300° F. during the incremental building up of the added steel layer by any conventional welding process. The martensite transformation and the subsequent tempering by succeeding welding is thereby completely avoided during the building-up process, which leads to great uniformity in the finished layer when transformation does take place.

This invention relates to the building-up or rebuilding of steel workpieces with added steel, and more particularly, to an improvement therein leading to uniformity in the added layer.

In many cases where heavy steel workpieces are used, such as steel rolls used in the forming of sheet metal, such as stainless steel, aluminum, brass and the like, the steel parts eventually become worn, and because of their size and cost, it may be highly desirable to be able to rebuild the worn portion with a layer of added steel, as distinguished from rejecting the entire part and replacing it with a new one. However, when this is done, the working requirements of the so-built up steel part may be such that great uniformity in surface characteristics of the added steel layer is required. Thus, for cylindrical rolls which are used in pairs, and generally held in a state of compression by back-up rolls, and used for the production of sheet metal by the conventional method, any lack of uniformity in the surface of the rolls coming in contact with the sheet metal will be reflected in the rolled product. This is obviously a disadvantage where the sheet metal product, such as sheet aluminum or stainless steel, must have a uniform, bright surface free of any markings or striations to be acceptable commercially. Indeed, in the particular art of producing sheet metal, any possible non-uniformity in the surface characteristics of the back-up rolls which engage the working rolls in a compression relationship will be transferred to the finished product by an offset effect, the inhomogeneities of the back-up rolls causing inhomogeneities in the working rolls, which then cause like defects in the sheet metal product.

The problem is especially acute in the production of stainless steel in sheet form, where absolute uniformity and a mirror finish is expected in the product and where, because of the nature of stainless steel, the compressive forces involved are very great as contrasted with those involved in the forming of sheet aluminum, for example. It should be mentioned that the invention is by no means confined to rolls of this particular type or indeed of any type, but has wide applicability as is discussed hereinbelow.

The usual method of rebuilding a steel workpiece, such as the rolls described, is an incremental one. A steel alloy having suitable characteristics for the purpose involved is selected and is generally supplied in rod or wire form. It is then added to the workpiece by any desired welding process, essentially one portion at a time. Thus, where the workpiece is a roll, it may be set up in a lathe or a lathe-like jig and rotated slowly while the welding process proceeds, a narrow strip or "bead" of steel being added in circular fashion, or more properly in helical fashion, in the manner that a fishing pole handle is wound with cord. When one layer has been so added, if the thickness is not sufficient, additional layers may be added on top of the first. During the welding process, the added steel in the form of the welding rod is momentarily melted as it is emplaced on the workpiece or upon added steel already emplaced thereon, and it is subsequently allowed to cool below its melting point so as to solidify, at the same time becoming bonded by this welding process both to the workpiece and to any adjacent layer of added steel previously emplaced thereon.

When the process described is carried out and the added layer has been ground and finished, it often happens that the added layer is not uniform. Generally, it will appear uniform, at least initially, but upon being placed in service, it may eventually become apparent that some portions are structurally weaker than others and that the lines of weakness correspond in a general fashion to the ribbons of emplaced, welded, added metal, generally termed "beads." If the workpiece is a sheet metal forming roll, or even a sheet metal back-up roll, then the irregularities of the added steel layer will be reflected in the sheet metal product.

An object of the present invention is to provide a process for forming a layer of added steel to a steel workpiece by an incremental process whereby the added steel layer acquires highly uniform mechanical characteristics as a result of metallurgical control.

Another object of the invention is to provide a means whereby the improvement can be readily adapted to steels of widely varying composition.

Further objects of the invention will appear as the description thereof proceeds.

In the drawing, FIGS. 1 and 2 depict the results of hardness tests on steel workpieces bearing added steel, without and with respectively the benefits of the invention.

FIG. 3 is a composite graph combining the results shown in FIGS. 1 and 2 as superimposed envelopes.

Generally speaking and in accordance with illustrative embodiments of my invention, I maintain the steel workpiece, which may be a roller, platen, die or like part, at a temperature which is greater than the martensite transformation temperature of the added steel during the process of building up a layer of added steel onto the steel workpiece. In the course of this building up, the added steel is melted by any conventional welding procedure and allowed to solidify by cooling onto the workpiece so that it becomes bonded to the latter, and indeed, to any adjacent added steel which has previously been bonded in the same fashion.

As far as the mechanics of the procedure is concerned, this has been outlined hereinabove; the procedure of forming a layer of the added steel is an incremental one. Until a preselected layer, or indeed series of overlapping layers, has been formed in accordance with the invention, the temperature of the workpiece is maintained at the aforesaid minimum temperature, which is greater than the Ms (start of martensite transformation) temperature of the added steel.

The Ms temperature is a well-known metallurgical value which is in most cases available from the literature. Thus, for a wide variety of ferrous alloys, it is available from the Atlas of Isothermal Transformation Diagrams, published by the United States Steel Corporation, Pittsburgh, 1951, Supplement 1953. Laboratory methods are

well known for determining the Ms temperature for any given alloy; reference may be made to the Metals Handbook, published periodically by the American Society for Metals. Typical Ms temperatures for commonly used ferrous alloys, particularly those used in building up layers of added steel onto steel workpieces of the types generally already described, range from about 350° F. to as high as 750° F., although these temperatures are given by way of illustration and not by way of limitation.

The maintenance of the temperature of the workpiece at a value greater than the Ms temperature means simply that the workpiece must not be allowed to cool down to or below the Ms temperature. Thus, any temperature ever so slightly higher than the Ms temperature is useable in the process of the invention. As a practical matter, to provide a safety factor to take care of interruptions in power supply, human error and the like, it is good practice to adhere to a minimum temperature of the order of 50° F. to 100° F. higher than the Ms temperature for the particular added steel to be used.

The maximum temperature at which the workpiece is maintained is set by general metallurgical considerations. 1300° F. is about as high as one may go in the general case, assuming a base metal of plain carbon or low alloy steel, without running into the danger of undesired high-temperature allotropic transformations. Again as a practical matter, one would seldom need to concern himself with exceeding the upper limit in accordance with the invention for the reason that heating a steel workpiece and maintaining it at some minimum temperature is progressively more difficult and more expensive as that minimum temperature is raised. In the general case, therefore, one pays attention to the minimum temperature. Needless to say, the temperature of the workpiece must not be so high that the added steel never cools to its solidification point. However, such a temperature is far in excess of the maximum of 1300° F. which is used in accordance with the invention.

While I do not wish to be limited by any theory of operation in accordance with my invention. I may state in a general fashion that I believe that the martensite transformation temperature should be avoided until all welding is completed in accordance with the invention for the reason that the phase change undergone by steels quite generally at the Ms temperature and below followed by high gradient tempering heat is one which is incompatible with the structure of steel added incrementally in the fashion concerned. Even though quite a temperature range is encompassed by the lower limit of the Ms temperature and the upper limit of 1300° F., I have found that added steel may be built up incrementally on a steel workpiece and will lead to a sound, homogenous, uniform, added layer even though the temperature of the workpiece may have fluctuated randomly and intermittently during the building-up process between these limits. On the other hand, if the temperature has been allowed to drop even momentarily below the Ms temperature during the incremental build-up, then this leads to unsoundness and inhomogeneity, particularly at the point or interface of juncture between added steel laid down above the Ms temperature and added steel laid down with the workpiece below that temperature. Martensite formed during welding is subject to tempering by subsequent heat (such as succeeding weld beads) nonuniformly because the heat will exist as a gradient. Martensite formed after welding during cooling of the mass will be simultaneous and uniform. Any furnace tempering (called stress relief) that may follow will be uniform.

An example showing the results obtained with and without the benefits of the invention is illustrated in the drawings. For this test, two eight-inch pieces were cut from wrought mild steel bar of thickness ¾-inch and width two inches. One of these was preheated to 800° F. and maintained at that temperature during the building up of an added layer of steel alloy, while the other was not so-

heated, but was allowed to remain at room temperature except as intermittently heated by the welding process. The Ms temperature of the added steel was 725° F.; it had the following all-weld metal composition:

	Percent
Carbon	0.12
Manganese	2.00
Silicon	0.85
Nickel	5.8
Molybdenum	5.3
Iron	Balance

Welding was carried out by the submerged arc method. After several added layers were built up on both of the test pieces, the hardness of the latter was determined in the normal fashion, by both Rockwell and Brinell methods. There was no difference evident in the hardness of the two layers as determined by these conventional methods. However, microhardness determinations were made. The microhardness indentations were spaced one-fifth millimeter apart on the specimens. The results of these tests appear in FIGS. 1 for the room temperature specimen and 2 for the specimen heated in accordance with the invention respectively. The wide excursions of hardness in FIG. 1 are apparent. The deep minimum values are spaced at approximately the spacing between successive incremental welding beads showing the adverse effect of spontaneous cooling below the Ms temperature and the influence of subsequent heat from one bead to the next. On the other hand, the microhardness readings are within satisfactorily narrow range for the sample treated in accordance with the invention, as shown in FIG. 2. For easier comparison, envelopes of the hardness determinations have been combined on a single graph as shown in FIG. 3. Here, the shaded envelope shows the substantial uniformity obtained in accordance with the invention, while the unshaded, dashed envelopes show the corresponding range of values for the unheated specimen.

Uniformity in hardness throughout the added layer is not the only advantage provided by my invention. Hand in hand with this uniformity goes an overall mechanical soundness, doubtless related to the microstructure. This is of obvious importance where the nature of the workpiece is such that the added layer is subjected to immense abrasive and wearing loads in service.

In a plant test, rolls from 26 to 30 inches in diameter and 48 to 50 inches long had been in use as back-up rolls for cast iron working rolls used in rolling stainless steel sheet. When the back-up rolls, which were a low-medium carbon steel, had been in use for some time and required rebuilding and resurfacing, this was carried out with a hard-facing alloy in the form of a one-eighth inch welding rod having the same composition as that given in connection with the test specimens of the drawings. Where the rolls were not sufficiently heated during the building-up process, the resurfaced rolls eventually caused striations which were carried over to the finished stainless steel sheet. When they were resurfaced on another occasion but with preheating so that Ms temperature was always exceeded during the welding process, in accordance with the invention, then the striations did not develop and the resurfacing operation was satisfactory in all respects. These rolls were used under working conditions such that the pressure at the bight of the rolls was estimated at about 300,000 lbs. per square inch. Accordingly, this is a severe test of the thickness and uniformity of a built-up coating of added steel.

While my invention is applicable to any added steel formed into a layer on a workpiece by an incremental welding layer, a range of alloys to which the invention is eminently suited are those steel alloys having the approximate composition of 0.1 percent to 0.2 percent carbon; 1.5 percent to 2.5 percent manganese; 0.6 percent to 1.2 percent silicon; 0 to 3 percent chromium; 0 to 6 percent molybdenum; 0 to 0.5 percent vanadium; 0 to 6 percent nickel; and the balance iron.

As those skilled in the art know, simple methods are available for determining the temperature of a steel part in the general temperature range involved in this invention. Markings may be applied with commercially obtainable crayons which indicate the temperature by melting. A wide variety of pyrometric instrumentation is also available.

It should be emphasized that while I have described my invention with the aid of specific examples in which particular compositions, temperatures, dimensions and the like have been used for purposes of illustration, great variations are possible in all of these variables within the broad scope of the invention as set forth in the claims which follow.

Having described my invention, I claim:

1. In a process of forming a layer of added steel to a steel workpiece wherein said added steel is placed in incremental portions in a molten state upon said workpiece and subsequently allowed to cool so as to become bonded to said workpiece, and subsequent increments of said added steel are placed in a like manner, so as to become bonded both to said workpiece and to previously emplaced increments, the improvement which comprises maintaining said workpiece at a temperature greater than the Ms temperature of said added steel but below about 1300° F. during said placement so that the added steel will not cool below said Ms temperature and will not transform to martensite and so that subsequent tempering of the added steel by succeeding adjacent welding is thereby avoided during the building process, whereby the added layer of steel has highly uniform mechanical characteristics.

2. A process according to claim **1** wherein said temperature is at least 700° F.

3. The process in accordance with claim **1** wherein said added steel has the approximate composition of 0.1 to 0.2 percent carbon; 1.5 to 2.5 percent manganese; 0.6 to 1.2 percent silicon; 0 to 3 percent chromium; 0 to 6 percent molybdenum; 0 to 0.5 percent vanadium; 0 to 6 percent nickel; and the balance iron.

4. The process in accordance with claim **3** wherein said approximate composition is: 0.12 percent carbon 2.00 percent manganese, 0.85 percent silicon, 5.8 percent nickel, 5.3 percent molybdenum, and the balance iron, and said Ms temperature is 725° F.

5. The process in accordance with claim **1** wherein said workpiece is a cylindrical roll.

6. The process in accordance with claim **4** wherein said workpiece is a cylindrical roll.

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