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TREATMENT OF FERROUS BODIES

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This invention relates to the treatment of ferrous bodies, and, more particularly, to the treatment of steel strips, sheets, wire, and the like, which have become embrittled by hydrogen, such as frequently results from acid pickling operations.

The phenomenon of hydrogen embrittlement, or as it is sometimes called, "acid brittleness," is known to become manifest in steels that have been subjected to ordinary acid pickling operations—particularly, where such operations must be carried out for a prolonged period of time to insure adequate cleaning of the metal. Thus, it is frequently the case that cold reduced steel stock, after annealing, presents the optimum property of ductility, which property, after the stock has been pickled in the usual way, becomes markedly impaired.

The present invention deals with the treatment of ferrous bodies, similar to those mentioned above, which, in accordance with usual processing, or otherwise, have become embrittled by hydrogen with a corresponding diminution of ductility. It is the primary object of the present invention to remove such hydrogen embrittlement from steels, and to restore the ductility values thereof to their optimum values.

Ferrous metal, which has become embrittled as herein contemplated, can be cured in accordance with the present invention by varying the mean mass temperature of the metal through a substantial range of temperatures, varying, say, from 100° above room temperature to 100° below room temperature, and by repeating the relative heating and cooling operations until ductility is restored to the desired value.

One way of giving effect to the present invention is to raise the mean mass temperature of the steel under treatment by immersing it in boiling water, or boiling soda, or alkali, solution, and then cooling it in cold water to approximately room temperature. It is usually necessary to repeat the heating cycle one or more times to effect substantially complete removal of the hydrogen embrittlement.

The invention has likewise been successfully practiced by cooling the embrittled steel for 100° or more below room temperature, and then immersing in warm water to restore room temperature, repeating the chilling and warming cycles as in the first example given. There does not seem to be any critical values to which the relative heating and cooling of the metal must be held. It seems necessary only to provide a substantial temperature differential, being limited, as a practical matter on the upper side, by the oxidation temperatures of the metal, with no apparent limit presenting itself at the lower end of the range.

Nor has any specific temperature differential—that is, number of degrees spread between the hot and cold values—presented itself as critical. It is believed, however, that the greater the differential, the less the number of repetitive cycles that will be required to eliminate or reduce the embrittlement. Therefore, even though a very small range of, say, 25 to 50 degrees might suffice if applied a sufficient number of times, more extreme ranges are preferred, being limited, as has been said, by the oxidation temperature of the metal on the upper side, and only by practicable, economic practices on the lower side. In this way, the number of cycles may be held to a minimum.

As a typical illustration of one grade of steel processed in accordance herewith, a heat comprised of the following analysis: Carbon .03/.05, manganese .28/.36, phosphorus .010 max., sulphur .030 max., silicon .010 max., copper .06 max., was hot rolled into strip from a 29" x 6" slab, finishing at 1560° F. on the hot mill, and coiled at .095" gauge at 1250° F.

This hot strip was pickled continuously in the usual manner, and then cold reduced on a three-stand tandem mill to .0363". The strip was then sheared into sheets 26⅛ x 77¼". Thereafter, the sheets were box annealed at approximately 1250° F. for a period of fourteen hours at temperature in a deoxidizing atmosphere. The sheets were then temper rolled to approximately 1" extension on a mill having grit blasted rolls. Thereafter, they were pickled for about thirty minutes in 7% sulphuric acid solution maintained at 170° F.

After the pickling last described, the sheets were subjected to the treatment provided in accordance with the present invention. They were first rinsed in cold water, and, thereafter, were rinsed in cold soda solution until quite cold. The sheets were then immersed in boiling soda solution until hot throughout. Thereafter, they were reimmersed in cold water until cold throughout. They were again dipped in boiling soda solution for twenty to forty minutes, or until hot throughout their mass, after which, they were given a final rinse in cold water until cooled to room temperature.

Olsen ductility values in inches, run on specimens taken from each edge and from the center at front, middle, and back portions of each sheet, gave a composite value, as annealed, of .414",

After pickling, these same specimens showed a lower composite ductility value of .386". Upon being subjected to the above described treatment in accordance with the present invention, ductility values were restored to .424" average, which not only equals the "as-annealed" values, but shows an augmentation in ductility thereover.

Another method of giving effect to the present invention is illustrated as follows:

Samples of sheet killed steel, .035" in thickness, were produced by hot rolling, continuously pickling, cold rolling, box annealing, and temper rolling, in a manner similar to that in the example given above. These samples were processed by pickling thirty minutes in sulphuric acid solution maintained at a temperature of 160° F. They were then rinsed in water at 80° F. for five minutes; they were then immersed in a bath composed of acetone and dry ice (solidified carbon dioxide), which was maintained at a temperature of 20° F. to 30° F. below zero. After the mean mass temperature of the metal was lowered to the temperature of the bath, the samples were removed and rinsed in water at 80° F. for five minutes, or until they were substantially restored to room temperature. Thereafter, they were reimmersed in the acetone and dry ice solution for thirty minutes, after which they were rinsed in water again to restore the temperature to normal.

These samples, before pickling but as annealed, showed an average Olsen value of .403. After pickling, this value had fallen to .354, indicating a marked impairment of ductility incident to the pickling. After the cooling and reheating in acetone, dry ice, and water, respectively, the Olsen values showed a recovery of ductility to .387, or a net return from the low value of .033". It is believed that further repetition of the cooling and heating cycles would have shown further improvement in ductility values.

It is believed that many alternates can be evolved around the teaching of this invention, as where a chilling of metal to a temperature substantially below room temperature is followed by the raising of the temperature of such metal to a temperature substantially above that of room temperature, so as to produce results comparable to, or better than, those set forth herein, in a more expeditious manner than is possible by repeatedly heating and cooling through the same range of temperatures, all above or all below room temperatures alone. An obvious alternate of this suggestive procedure would be, first, to heat to a temperature substantially above that of room temperature, and, then, to chill to a temperature substantially below that of room temperature, for as many cycles as might be required to develop the optimum ductility value of the specimen under treatment.

It will be understood, therefore, that many modifications of the invention may be made without departing from the spirit thereof, and it is not intended that I be limited to the specific embodiments described, other than as is rendered necessary by the recitations of the appended claims.

I claim:

1. The method of removing hydrogen embrittlement from ferrous bodies which includes the steps of successively introducing and removing heat from such bodies a plurality of times so as repeatedly to vary the mean mass temperature thereof, while causing a heat transfer sufficient to vary the mean mass temperature of said body through a range of at least 100° F. below the bluing temperature of the body.

2. The method of removing hydrogen embrittlement from ferrous bodies which includes repeatedly varying the mean mass temperature of such a body through a temperature range approximately 100° F. from ordinary room temperature.

3. The method of treating ferrous bodies embrittled by hydrogen, such as commonly results from acid pickling, which includes repeatedly effecting a heat transfer into and from such a body to vary the mean mass temperature of the body approximately 100° F., within the range of temperatures below the oxidizing (bluing) temperature of steel down to zero.

4. The method of treating ferrous stock which includes raising the mean mass temperature of such stock to above 150° F. but preferably below the oxidizing temperature of the metal, then lowering the mean mass temperature thereof approximately to room temperature, and thereafter repeating the heating and cooling cycle until the desired ductility values are obtained.

5. The method of treating ferrous stock which includes lowering the mean mass temperature of such stock to less than 32° F., then raising the mean mass temperature thereof to at least room temperature, but not above the oxidizing temperature of the metal, and, thereafter, repeating the cooling and heating cycle until the desired ductility values are obtained.

6. In the production of steel sheets, strip, and wire, that are reduced to intermediate or finished gauge, annealed and then pickled in acid, the improvement which includes varying the mean mass temperature of the metal through approximately 100 degrees within temperatures ranging not more than 200° F. above and 200° F. below room temperature, until the ductility values thereof at least approximate the "as-annealed," pre-pickling values of such metal.

7. The method of removing hydrogen embrittlement from ferrous bodies which includes repeatedly varying the mean mass temperature of such a body through a temperature range approximately 100° F. from ordinary room temperature, but below the oxidizing temperature of the steel.

8. The method of removing hydrogen embrittlement from ferrous bodies, which includes rapidly varying the mean mass temperature of such a body approximately 100° F. within temperatures ranging downwardly from the bluing temperature of the body.

9. The method of removing hydrogen embrittlement from ferrous bodies, which includes repeatedly altering and positively controllably varying the mean mass temperature of such a body within a range of temperatures below the bluing temperature of the metal, and positively controlling the said temperature through a controlled appreciable range, for restoring the metal to at least substantially its original ductility in a fraction of the time required for the normal recovery of the ductility of the metal at ordinary room temperatures, subject only to normal temperature fluctuations.

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