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METHOD OF HEAT TREATMENT FOR PIPES

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The present invention relates broadly to metallurgy and more especially to a method for heat treatment of tubes fabricated from various irons, steels, alloy steels, and alloys, the physical properties of which are capable of being modified by heat treatment such as hereinafter described.

A principal feature of the present invention resides in the utilization and control of heat necessary for the fabrication of the tube so that the finished tube is completed at a temperature above the critical point of the material comprising the tube; and then subjecting the finished tube at this high temperature to the step of rapid cooling, preferably by use of a water spray. The rapid cooling of the finished tube from a temperature above the critical point for the material results in a tube having predetermined physical characteristics of increased hardness, tensile strength and yield point far above the results commonly obtained in the normal manufacture of tubes.

If it is assumed that the tubes are being made by lap welding, the metal leaves the welding furnace at substantially a temperature from between 2000° to 2200° F., and passes through the welding rolls where it is lap welded. It may then continue through a series of rolls by means of which the tube is finished to the desired size. The operations referred to according to the present method are carried on at a sufficiently rapid rate of movement so that when the hot operations on the tubes are completed the tubes are at temperatures substantially between 1400° to 1800° F. These temperatures are well above the critical points for materials commonly used in tubes and the temperature at this stage is obtained by establishing a sufficiently high initial temperature as the material leaves the welding furnace and by providing for a sufficiently rapid movement of the material through the various fabricating steps so that the tubes are formed and shaped before the residual heat has had time to dissipate.

According to the present invention, the tubes after the completion of the hot working operations, and being at a temperature of between 1400° and 1800° F., are sprayed preferably on their exterior with cold water.

The quenching operation in order to obtain the desired results involves a time factor and it is important that the temperature of the fabricated tube be reduced from above the upper critical point of the material to a temperature below the lower critical point within a period of time which will produce the particular physical characteristics desired in the end product. Where the quenching and cooling to atmosphere temperature is quickly brought about, for example, as in a steel tube of .10% to .20% carbon, the physical characteristics of the tube will be that of a substantial distribution of iron carbides throughout the mass, which results in a harder metal and relatively high physical properties and lower ductility. A less rapid cooling of a similar tube results in a tube of less hard metal and of lower physical qualities but of higher ductility. According to the present invention, the temperature of the material, the rapidity of quenching, and the temperature at which quenching is stopped are all controllable to produce the particular characteristics desired in the end product.

The higher the temperature of the material at the moment when the quenching begins, the greater the distribution of the carbides throughout the mass; for example, .15% carbon steel at a temperature of 2100° F. has the carbides substantially distributed throughout the mass and if this material is rapidly quenched at that temperature down to atmospheric temperature, the carbides are trapped approximately in the location they were in at the moment at which the quenching began. If, on the other hand, this same material is permitted to cool to 1600° F., the carbides have receded so as not to be so thoroughly distributed and the material when quenched from 1600° F. to atmospheric temperature, will be more ductile than when quenched at the high temperature. If the quenching of this same material is stopped at a temperature of, for example, 700° F., the latent heat in the material will tend to have a "drawback" or tempering effect which will so modify the condition of the carbides as to increase the ductility of the end product and at the same time slightly reduce the tensile properties.

The present invention is not concerned primarily with the particular type of method used in fabricating the tubes, but preferably is applied to methods whereby the residual heat of the material after the tube fabricating operations have been completed is substantially above the upper critical of the material used, so that an economy is obtained by not requiring reheating of the tubes prior to the temperature control which is applied in accordance with the present invention.

Excellent results, however, may be obtained by an alternate method of heat control wherein

the tubes after normal hot working operations are completed, have a temperature substantially above the upper critical point of the material, are introduced into a furnace, the entrance end of which is relatively cool, that is, sufficiently cool to permit the temperature of the material to drop substantially below the lower critical point, but still retaining a substantial amount of the residual heat. The tubes are then carried through the furnace to positions where the temperature is raised to between 1400° to 1800° F. The result of this movement of the tubes through the furnace is to first lower the temperature below the lower critical and then to raise the temperature of the tubes from the lower temperature to a temperature of from between 1400° to 1800° F. and the tubes are then ejected from the furnace at this higher temperature. As soon as the tubes leave the furnace, they are subjected to a temperature control such as hereinbefore described.

This alternate procedure results in the allotropic change from the gamma, non-magnetic phase to the alpha magnetic phase, so that when the material is again taken to a temperature above the upper critical or back into the gamma phase, and quenched from there as hereinbefore described a resulting grain refinement may be obtained which the mechanical working alone to which the tube has already been submitted may not be capable of producing.

In order that the quenching may be controlled to occur rapidly to trap the carbides at a predetermined desired point to obtain the physical condition which is required, the quenching is preferably accomplished by the use of a water spray which is applied under pressure to the exterior surface of the tube. Preferably, the tube is rotated during this quenching operation in order to obtain a uniform rate of cooling entirely around the tube. It is recognized that the quenching may be applied to the interior of the tube instead of the exterior thereon. According to the present invention the quenching is applied to one surface only, not to both.

The use of a liquid spray under pressure permits the cooling liquid to come into intimate contact with the surface of the material and thus results in a quicker, more uniform quench than is obtained by submersion of the tube in a liquid. When a hot tube is submerged, it is immediately surrounded by a film of vapor which tends to hold the liquid, in which the tube is submerged, away from the surface of the tube and also tends to result in a non-uniform chill to the tube, whereas where the tube is subjected to a spray of relatively cold liquid under pressure, the steam or vapor is carried away by the flow of the liquid and the relatively cold liquid strikes the surface of the tube to produce quick uniform results.

Where the quenching is applied to the exterior of the tube, desirable conditions of internal stresses result, in that the exterior of the tube is quickly placed under contraction, while the interior of the tube is hot and under compression. This results in a final condition whereby the exterior of the tube remains under tension while the interior of the tube is under compression. The result of this physical condition enables the tube to better withstand forces applied to the side wall of the tube.

The various mechanisms for carrying out the present invention are well known in the art, and, therefore, do not require specific illustration and description. The foregoing description of the present method, being addressed to those skilled in the art, is believed adequate for a complete understanding of the invention.

Having described my invention, what I claim is:

1. The method of heat treatment of a tube of the materials specified, comprising heating stock to a temperature above the upper critical point of the material, fabricating a tube from the heated stock, controlling the speed of fabrication of the tube to produce a fully formed and shaped tube before the temperature thereof drops below the critical point for the material, and quenching the tube while rotating the same in a liquid spray impinged upon the exterior of the tube to subject the outer portion of the tube to tension, said quenching being done from a temperature above the said critical point of the said material.

2. The method of heat treatment of tubes of the materials specified comprising heating the stock, fabricating the tubes from the hot stock, finishing and straightening the tubes, the fabrication, the finishing, and the straightening of the tubes being done while the material is above the critical point, and quenching the tubes while rotating the same in a liquid spray to quickly reduce the temperature of the tubes from above the upper critical point of the material to substantially below the lower critical point of the material to produce a product with increased tensile properties.

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