Hardened Metallic Structure

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2 Claims.

1. This invention relates to hardened metallic structures and particularly to tubular structures adapted to withstand sudden loads and high pressures.

An object of this invention is to provide a metallic structure, which is particularly adapted for use in tubing form, of such structural characteristics as provide an article of great resistance to suddenly applied loads and bursting pressures, in which trapped stresses are largely avoided, and which has great resistance to the starting of surface cracks under repeatedly applied loads. The above and other objects which will be apparent are accomplished by the invention hereinafter described and illustrated in the accompanying drawings which show in section a tubular structure illustrative of one embodiment of this invention.

As illustrated, the invention is shown in conjunction with a tubular structure having a wall of hardened metal, the inner portion of which has a hardness of approximately 60 to 62 Rockwell "C," and the outer surface of which has a substantially lower degree of hardness, such as approximately 25 Rockwell "C." Between the two extremes the degree of hardness within the wall decreases in a continuous manner from the inner portion to the outer surface. In a tube subjected to bursting pressure, the stress to which each part of the tube wall is subjected lessens from the inside to the outside.

In the present invention the decrease in hardness from the inside to the outside parallels the decrease in stress. In other words, the rate of decrease in hardness corresponds generally to the rate of decrease in the stress from the inside to the outside of the tube. For example, assuming a line to represent zero hardness, a dotted line to represent a hardness of 60 Rockwell "C," which is the hardness of the inner portion, and a dotted line to indicate a hardness of approximately 25 Rockwell "C," which may be the hardness of the outer surface, a substantially flat curve would indicate approximately the varying degrees of hardness of the material between the two extremes, and this curve should parallel but not be lower than the stress curve for the tubular structure in question.

One example of the present invention, is a tube having a bore of 4.5 inches, a wall thickness of 1.325 inches, and an outside diameter of 7.15 inches. In such a tube the hardness can vary from 60 Rockwell "C" at the bore to 25 Rockwell "C" at the outer diameter, for example. This tube will withstand the same internal pressure as though hardened uniformly without stress to 60 Rockwell "C." At the same time the tube has gained greatly in ductility, machinability, and toughness.

In producing such a tubular structure, the wall is first hardened entirely through to the highest degree required, for example to a hardness of approximately 60 Rockwell "C." Preferably, this is done by electro-magnetic induction heating and quenching. Thereafter a drawing heat is applied to the outer surface, and a quench is simultaneously applied to the inner bore, for the purpose of maintaining the original hardness at the inner diameter. The rate of heat input applied to the outer face must be so proportioned to the heat capacity of the tube and so related to the rate of heat outtake on the inner face as to produce a hardness differential between the two faces which substantially parallels but is not less than the stress distribution in the tube.

This leaves the material adjacent the bore with a high yield strength and high elastic properties, backed up by material of progressively higher ductility and toughness accompanied by better machinability. The final product of this invention is a heat treated and hardened tube having excellent properties for external machining while at the same time providing for the maximum strength and toughness for such a tubular structure.

It will be obvious that the invention can also be employed to produce a tubular structure having a high degree of hardness at the outer diameter, by drawing the bore while chilling the outer diameter, to produce a tubular structure for use in resisting externally applied pressure. After the treatment above described a thin layer along the inner bore is drawn by electro-magnetic induction heating, for example, to a sufficient depth to permit machining, which, in the case of a gun tube includes the formation of rifling grooves.

On the completion of the machining operation the machined surface of the inner layer is hardened by heating and quenching to produce a hardened face in the bore, which is then drawn to provide the optimum hardness required for the particular use to which the structure is to be put. A tube which is adapted to take the treatment and have imparted to it the characteristics described herein is composed throughout of electro-magnetic material which is subject to being hardened by quenching after suitable heating as by electro-magnetic induction means.
It will be apparent that the present invention can be variously modified and adapted within the scope of the appended claims.

What is claimed is:

1. A metal tube composed throughout of a material which is subject to hardening by electromagnetic heating and fluid quenching, the wall of which is of one piece, the wall including a relatively thick outer layer comprising almost all of the wall thickness of graduallly and approximately uniformly increasing hardness from the outside toward the inside, a soft layer just below the bottom of the grooves and below the inside surface of the raised portions, and a relatively very thin hard layer in the bottom of the grooves and on the inside surface of the raised portions.

2. A metal tube composed throughout of a material which is subject to hardening by electromagnetic heating and fluid quenching, the wall of which is of one piece, the tube being provided with grooves and intervening raised portions in its bore, the wall including a relatively thick outer layer extending from the outside almost to the bottom of the grooves and being of gradually and approximately uniformly increasing hardness from the outside toward the inside, a soft layer just below the bottom of the grooves and

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