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METHOD OF STRENGTHENING THE SURFACE OF METALLIC SPRINGS BY WARM WORKING

William R. Johnson, Bristol, Conn., assignor to Associated Spring Corporation, Bristol, Conn., a corporation of Delaware

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This invention relates broadly to the manufacture of metal articles and, more particularly, to the improvement of the physical and mechanical properties thereof. While the invention is of general utility in the manufacture of articles of all kinds from both ferrous and non-ferrous metals, it is described in this specification as applied to the manufacture of springs from carbon steel.

It is a well known and conventional practice in the manufacture of springs of all types to improve the performance of the spring by controlling the direction and magnitude of the stresses in the outer fibres of the spring and, at the same time and by the same means, to remove some of the surface imperfections. This is done by such processes as shot blasting, tumbling and the like and results in higher fatigue limit, greater yield strength and greater spring life. These known processes are invariably carried out at room temperature in practice and must be followed by some method of partially relieving the stress in the outer fibres in order to restore the elastic limit of the metal.

In a further development in the art to which the invention broadly relates, it has been found that the mechanical and physical properties of steel and articles made from steel may be improved by warm drawing or extruding steel bars at about 500° F. Various specific processes using this basic method are disclosed in United States Letters Patent granted to La Salle Steel Company, Nos. 2,767,835-6-7-8. It is claimed that in the practice of these methods the improved properties are secured without increase in warping value and with reduced residual stresses and stress control without the necessity for additional steps employed in other processes for stress relief. It will be found that in these processes the material acquires most of its hardness and other physical properties as a result of the warm working.

In United States Letters Patent No. 2,717,846 to Richard F. Harvey, issued September 13, 1955, there is disclosed and claimed a process which is asserted in the specification of the patent to improve the physical properties of a steel article of manufacture, such as a spring, and which consists in austenizing by heating above the critical temperature, then cooling to a temperature range between 300° F. and 700° F., and shot blasting in the latter temperature range. In this process the material acquires most of its hardness and other physical properties as a result of the heat treatment itself and the shot blasting produces only a marginal increase in these properties if, in fact any at all, because of the austenizing step.

The present invention has to do, in general, with processes such as those described, and is therefore intended to provide an improved process for improving the physical and mechanical properties of springs made from ferrous and non-ferrous metals, such as by raising the fatigue limit, giving greater yield strength, and increasing the life of the spring. A specific objective of the invention has been to provide such a process which will result in deeper penetration of the mechanical working to which the spring is subjected during the practice of the process, thus producing a deeper layer of compressive stresses at and adjacent the surface than is produced by known methods. A second specific objective of the invention has been to produce a spring having a yield point higher than that produced by the practice of known processes. A third specific objective has been to provide a process for improving the physical and mechanical properties of a spring without the necessity for stress relief after shot blasting, tumbling or other mechanical working, thus eliminating this final step which is required in known processes. A further specific objective of the invention has been to provide, as a new article of manufacture, a spring which has the deeper surface layer of compressive stresses, and the higher yield point provided by manufacture according to the present invention or, stated otherwise, a spring manufactured in accordance with the process of the present invention.

In the manufacture of springs by the method provided by this invention the spring is first formed to the desired shape. For example, in the manufacture of springs from carbon steel the steel wire or strip is wound into helical shape, or otherwise formed into whatever configuration is desired. The formed spring may then be subjected to processes which impart to the spring material its principal physical characteristics, such as hardness and strength. As is well known, this may be done by heat treatment or cold working and may be performed before or after the spring material is formed into spring shape.

When the spring has been formed and its major physical characteristics have been imparted to it, it is subjected to mechanical working at a temperature above room temperature and just below the softening point of the metal from which it is made. If the spring is made of carbon steel it will be mechanically worked in accordance with the invention at a temperature above room temperature and just below the softening temperature, which will in turn depend on the steel microstructure, and will in general therefore be worked in the range of temperatures just below 600° F. and within the range of 300° F. to 600° F.

The term "mechanical working" as used in connection with my invention includes shot blasting, tumbling or similar known procedures which impact and plastically distort the structure of the spring at and adjacent to its surface and impart compressive stresses to a deep layer adjacent and including the surface.

In accordance with the invention the spring is maintained at the specified temperature or within the specified temperature range during the entire period when it is subjected to mechanical working. It has been found that the temperature of the spring will be reduced if it is subjected to mechanical working, such as shot blasting or tumbling, by means, such as shot which are themselves either cold or at a temperature less than that at which the spring being treated is maintained during treatment. Accordingly, the shot or other devices which are imparting mechanical working to the spring are themselves maintained at the same temperature, or within the same temperature range, as the spring during the entire period of mechanical working, which is below the softening point of the metal of the spring in all cases and is below the tempering temperature in the case of carbon steel.

In a typical example of the practice of the invention a spring is formed by coiling a carbon steel wire, which has been subjected to heat treatment or cold working processes in order to impart to the spring the major part of its physical characteristics, such as hardness, it being understood that the invention is applicable only to the manufacture of articles to which the major part of their physical properties have already been imparted at the time when the processes according to the invention are practiced. After heat treatment or cold working the spring is heated to a temperature in the range specified, which is the range just below the softening temperature,

this being, in the case of carbon steel, within the range of 300° F. to 600° F. If the spring is to be mechanically worked by shot blasting it may be maintained at the specified temperature for a period of twenty minutes and during that entire period is subjected to shot peening. During the entire period of shot peening the shot themselves, as well as the spring, are maintained at the specified temperature in order to prevent any reduction of the temperature of the spring during shot blasting.

It will be seen that shot blasting, tumbling or other mechanical working at the warm working temperatures according to this invention do not constitute or cause a change in the shape of the article such as is produced by hot or cold rolling, heading and similar operations, all of which are intended to, and do, produce shape changes the effects of which extend entirely throughout the material of the article to which they are applied. On the contrary, mechanical working in accordance with the present invention is not intended to, and does not, produce any change in shape and its effect to restricted to a surface layer although this layer is deeper than that produced by cold shot peening, cold tumbling or other known processes.

It has been found that springs and other ferrous and non-ferrous articles which are treated in accordance with this invention have a deeper surface layer of compressive stress than articles treated in accordance with conventional processes. This is apparently and probably because of the lower yield point of the metal during mechanical working produced by maintaining the spring at the specified temperature range during the entire period of mechanical working. It has also been found that after mechanical working in accordance with this invention it is not necessary to subject the spring to any stress relieving operation.

While I have described certain steps in the practice of the method according to the invention, it will be understood by those skilled in the art to which the invention relates that other steps, as well as modifications of those described, may be practiced without departing in any way from the spirit or scope of the invention, for the limits of which reference must be made to the appended claims.

What is claimed is:

1. The method of surface strengthening a spring which comprises the steps of forming the spring to shape, treating the spring as by heat treatment or cold working to impart thereto the principal part of the desired physical properties of the metal from which the spring is formed, heating the spring to a temperature above room temperature and just below the softening temperature of the metal of which the spring is formed, and while maintaining the spring at such temperature subjecting it to surface mechanical working which does not produce any substantial change in its shape or size.

2. The method of surface strengthening a spring which comprises the steps of forming the spring to shape, treating the spring as by heat treatment or cold working, to impart thereto the principal part of the desired physical properties of the metal from which the spring is formed, heating the article to a temperature above room temperature and just below the re-crystallization temperature of the metal of which the spring is formed, and while maintaining the spring at such temperature subjecting it to surface mechanical working which does not produce any substantial change in its shape or size.

3. The method of surface strengthening a spring which comprises the steps of forming the spring to shape, treating the spring as by heat treatment or cold working to impart thereto the principal part of the desired physical properties of the metal from which the spring is formed, heating the spring to a temperature above room temperature and below the softening temperature of the metal of which the spring is formed, and while maintaining the spring at such temperature subjecting it to surface mechanical working which does not produce any substantial change in its shape or size, and during the mechanical working maintaining the mechanical working means at the temperature of the article being worked.

4. The method of manufacturing a spring from carbon steel to improve its physical properties such as fatigue limit, yield strength and life, which comprises the steps of forming the spring to a desired shape, treating the spring as by heat treatment or cold working to impart thereto the principal physical characteristics such as hardness and strength, then heating the spring to a temperature just below the softening temperature of the carbon steel, and while maintaining it at this temperature subjecting the spring to surface mechanical working which does not produce any substantial change in its shape or size.

5. The method of manufacturing a spring from carbon steel to improve its physical properties such as fatigue limit, yield strength and life, which comprises the steps of forming the spring to a desired shape, treating the spring as by heat treatment or cold working to impart thereto the principal physical characteristics such as hardness and strength, then heating the spring to a temperature within the range of 300° F. to 600° F., and while maintaining it at this temperature subjecting the spring to surface mechanical working which does not produce any substantial change in its shape or size.

6. The method of manufacturing a spring from carbon steel to improve its physical properties such as fatigue limit, yield strength and life, which comprises the steps of forming the spring to a desired shape, treating the spring as by heat treatment or cold working to impart thereto the principal physical characteristics such as hardness and strength, then heating the spring within the range 300° F. to 600° F., and while maintaining it in this temperature range subjecting the spring to shot blasting.

7. The method of manufacturing a spring from carbon steel to improve its physical properties such as fatigue limit, yield strength and life, which comprises the steps of forming the spring to a desired shape, treating the spring as by heat treatment or cold working to impart thereto the principal physical characteristics such as hardness and strength, then heating the spring within the range of 300° F. to 600° F., and while maintaining it in this temperature range subjecting the spring to surface peening by shot heated to the same temperature as the spring.

8. The method of manufacturing a spring from carbon steel to improve its physical properties such as fatigue limit, yield strength and life, which comprises the steps of forming the spring to a desired shape, treating the spring as by heat treatment or cold working to give its principal physical characteristics such as hardness and strength, then heating the spring to a temperature just below the softening temperature of the carbon steel, mechanically working the surface of the spring without any substantial change in its shape or size, and maintaining the spring and the mechanical working means at such temperature during the entire mechanical working.

9. The method of manufacturing a spring from carbon steel to improve its physical properties such as fatigue limit, yield strength and life, which comprises the steps of forming the spring to a desired shape, treating the spring as by heat treatment or cold working to give its principal physical characteristics such as hardness and strength, then heating the spring to a temperature just below the softening temperature of the carbon steel, shot blasting the spring while maintaining it at such temperature, and maintaining the shot at the same temperature while blasting.

10. As a new article of manufacture, a spring formed of ferrous material having a layer of compressively stressed material at and adjacent its surface which is deeper than that produced by cold shot peening, which has been mechanically surface worked without substan-

tial change in its shape or size while being maintained at a temperature just below the temperature at which the spring material will be permanently softened.

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