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METHOD OF INCREASING THE FATIGUE LIFE OF METAL PARTS

James H. Maker and George W. Kurasz, Bristol, Conn., assignors to Associated Spring Corporation, Bristol, Conn., a corporation of Delaware
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3 Claims

ABSTRACT OF THE DISCLOSURE

Method of increasing the fatigue life of a metal part made of a hard alloy or steel by subjecting it to the steps of electrolytic polishing and surface compression, such as by shot peening.

Relation to other cases

This application is a continuation-in-part of our co-pending abandoned application Ser. No. 624,989, filed Mar. 22, 1967, for Method of Increasing the Fatigue Life of Metal Parts.

Description of the invention

The invention relates particularly to metal parts and devices made of a hard alloy or steel which are subjected to high surface stresses in use, and the particular object of the invention has been to provide a method of treatment of such parts during their manufacture which will have the result of increasing fatigue life. The invention is useful in the manufacture of any metal article made of a hard alloy or steel in which high stresses are developed in and adjacent the surface, typical parts and devices which develop such high surface stresses in use being bars, springs and spring devices, spring wire, torque rods, connecting rods, drive shafts and the like.

It is well known in metallurgical science and in the art of manufacturing articles formed of higher strength metals such as hard alloys and steel (typically SAE-1075) that defects or flaws in the surface striae produce an adverse effect on fatigue life by acting as points of stress concentration. These stress risers may include foreign matter, voids, nicks and scratches produced in the drawing or other fabricating operations, scale due to heat treatment or tempering, scratches or other defects produced in packing and shipping, and marks imparted to springs in manufacturing operations such as coiling and grinding. All of these reduce fatigue life, or strength, or both, and it has been known for many years that surface compression by shot peening, rolling or other known procedures will reduce the adverse effect of these defects and flaws on fatigue life by eliminating or masking their effect.

The process known as electrolytic polishing is also well known in the art but, to our knowledge, no use of this technique has been made in any efforts to increase fatigue life. The procedures followed in electrolytic polishing are well known and consist essentially in the removal of the exterior striae by immersing the part in a suitable electrolytic bath in which the part constitutes the anode (anodic polishing). The principal known use of electrolytic polishing has been to produce a cleaned surface, and until this invention the two procedures of surface compression by shot peening and the like and electrolytic polishing have been separately used and studied without combination of the two.

By the present invention we have discovered that the fatigue life of metal parts may be increased very greatly by combining the steps of electrolytic polishing and sur-

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face compression, with possible variations in the specific application of each of the two steps of the combined method, and that the increase in fatigue life produced by a combination of the two steps is greater than the expected additive effect on fatigue life produced by each of the separate steps.

In one series of steps according to the method of the invention, the surface of the article is subjected to the known process of electrolytic polishing under conditions sufficient to remove surface striae to an extent within the range of 0.001 to 0.010 inch of depth. In a preferred practice of this step the surface of the part was removed by electrolytic polishing to a depth of approximately 0.003 inch (0.006 inch removed from the diameter) but it will be understood that this dimension is only typical of many within the stated range and that in the practice of the invention the depth of removal will depend on the quality of the original surface. This electropolishing step removes metal and with it any surface stress risers such as defects or flaws in the removed striae, resulting in a polished surface, which in itself increases the beneficial effect of the subsequent surface compression.

In one specific method being described, the compressive residual stress of the surface area in which highest stresses are developed in use is increased by cold working to produce surface compression, which is performed by shot peening. Shot peening is in itself a known procedure and compresses the striae at and adjacent the surface, with the beneficial result of cold working on the fatigue life of the part. This peening compresses the material around any internal voids, inclusions, flaws and defects, with the resultant beneficial effects of cold working and compressive stress.

It will be understood that the sequence of steps set forth in the method described above is not critical and that the increase in fatigue life resulting from practice of the invention may be achieved even though the sequence of steps of the method is varied, and even though different specific procedures constituting each step are used. For example, surface compression followed by electropolishing has been found effective in increasing fatigue life. While this latter sequence of steps is within the method according to the invention, it is not preferred as the most beneficial effects are produced by compressing the electropolished surface. In practicing the invention the surface compression step may be followed by a second surface compression step.

The beneficial results of the practice of the invention on valve springs formed of SAE-1075 carbon steel are shown by the results of tests which are summarized in the following table and are discussed below:

Condition	Maximum stress (p.s.i.)	Median life (cycles)
Not electropolished or shot peened	110,000	300,000-600,000
Electropolished, .002 inch removed from diameter	110,000	8,600,000
Electropolished, .006 inch removed from diameter	110,000	10,000,000
Shot peened only (30 minutes)	155,000	6,000,000
Electropolished (0.006 inch removed from diameter) and then shot peened (30 minutes)	155,000	25,000,000

¹ Above.

Each result represents tests on at least twelve springs formed from the wire described above. The minimum stress in all fatigue tests was one-eighth of the maximum stress listed. Electrolytic polishing sufficient to remove .002 inch from the wire diameter raised the median fatigue life to the range of 8,600,000 to 10,000,000 cycles at the same stress. Electrolytic polishing sufficient to remove .006 inch from the wire diameter increased the median fatigue life to over 10,000,000 cycles, also at the

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same stress. Springs were now shot peened for thirty minutes without electrolytic polishing, and at the selected test stress of 155,000 p.s.i. the median fatigue life was 6,000,000 cycles, indicating that shot peening results in greater increase in fatigue life than electropolished alone. Springs formed from the same wire were then electropolished to remove 0.006 inch from the wire diameter and then shot peened for thirty minutes with 0.017 inch diameter shot. When fatigue tested at the maximum high stress of 155,000 p.s.i. their median fatigue life was over 25,000,000 cycles.

The improvement due to practice of the invention may be expressed in another way. It is well known and commonly accepted that the fatigue strength of valve spring wire at 10,000,000 cycles (the stress to which a spring can be subjected without failure for 10,000,000 cycles and without shot peening) is approximately 100,000 p.s.i. Shot peening increases this fatigue strength by 15% to 20%, or to 115,000 to 120,000 p.s.i. Electrolytic polishing without shot peening increases it to 110,000 p.s.i. Electrolytic polishing, followed by shot peening increased the fatigue strength to at least 150,000 p.s.i.

As used in this specification and the claims the term "hard alloy" refers to ferrous or non-ferrous alloys having a minimum hardness of Rockwell C-38 and minimum tensile strength of 170,000 p.s.i. and includes, without limitation, beryllium copper alloys, nickel based alloys, and titanium alloys. Also, as used in this specification and the claims the word "steel" includes all of the materials set forth in the definition of that word in the American Society for Metals Handbook, volume I, Properties and Selection of Metals, page 38, including without

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limitation hard carbon steel, stainless steel, alloy steel, precipitation hardening steel, and maraging steel.

We claim:

1. The method of increasing the fatigue life of coil springs made of a hard alloy or steel and being of the type in which high stresses are developed in the surface striae in their normal and intended use, which consists in subjecting the spring to the steps of electrolytic polishing and shot peening.
2. The method according to claim 1 in which surface metal is removed by electrolytic polishing to a depth sufficient to substantially remove surface stress risers.
3. The method according to claim 1 in which surface metal is removed by electrolytic polishing to a depth of approximately 0.001 to 0.010 inch.

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ROBERT K. MIHALEK, Primary Examiner

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