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Method for Increasing Endurance Limit of Steel Articles

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This invention relates, as indicated, to a method for improving certain characteristics of steel articles, and more particularly to a method for increasing the strength and hardness characteristics of steel surfaces, particularly in spring steel surfaces, with a resultant increase in the endurance limit of the article.

Generally speaking, this invention depends upon the working of the surface of a steel article by impinging against the surface thereof hard particulate materials, such as steel shot. It has been known that shot peening of steel springs, for example, effects a cold working of the surface, and so alters the crystalline structure of the "skin" portion as to beneficially increase the endurance limit or fatigue characteristics against failures resulting from surface defects, such as notches or scores which may result from prior operation. Such scores, notches, grooves and the like provide points of incipient premature fatigue or fracture.

In all cases, the fatigue life of the steel spring element peened at room and elevated temperatures was increased by a factor of from five to twenty times that of an unpeened spring element of the same material.

Early disclosures of the utilization of shot peening as a means of improving the characteristics of springs is found in the patent to Vorwerk, 1,946,340, and the patent to Minich, 2,077,629. Both these patentees treated the entire surface by impinging small steel balls against the surface and obtained improved characteristics, i.e. hardness and resistance to fatigue failure.

From time to time, the prior art has made improvements upon the basic concept of shot-peening. For example, it has been found that improved results are obtained when instead of indiscriminate blasting of both of the tension and compression sides of spring leaves, for instance, only the tension side should be so treated (Patent No. 2,252,823).

More recently, it has been found that the endurance characteristics of single leaf springs can be improved by shot-peening the tension surface while the spring is reverse stressed near to its yield point (Patent No. 2,608,752). When peening is done under these conditions, the spring takes a considerable set during peening which must be allowed for when designing the quench form.

It has now been found that the amount of set can be greatly reduced by carrying out the surface working operation at an elevated temperature, i.e. in the range of from about 200° F to 600° F without imposing the article to stress conditions, and consequently minimizing the extent of set imposed on the article. So far as I am aware, shot peening unstressed articles at such elevated temperatures is novel per se.

Moreover, certain articles are not easily adaptable to being shot peened under stressed conditions, e.g. bearing mounts. Nevertheless, they also require substantial improvement in fatigue characteristics for effective service and are capable of being beneficiated in accordance with the present invention. This invention is especially adapted for use in the manufacture of passenger car rear suspension springs of the single or multiple leaf types and having a predetermined contour or profile. It is also well adapted for the manufacture of flat springs having a rectilinear profile or contour. A principal advantage of this process is that contoured articles such as these do not undergo substantial change in contour or profile when shot peened in accordance herewith.

Briefly stated, then, the present invention is in a method of improving the endurance characteristics of steel articles which comprises adjusting the temperature of such article to within the range from about 200° F. to about 600° F. and shot peening the article at such elevated temperature in the unstressed condition.

Shot peening is an operation whereby hardened steel shot, preferably averaging about one thirty-second of an inch in diameter, are caused to impinge upon the surface of the steel article being treated. In one device, the shot are thrown from the periphery of a wheel which is running at high speed, or they may be directed by a high velocity air stream against the surface of the article. In either case, the shot are caused to travel at such a high velocity that, when they impinge upon the surface of the article, they will remove any scale that is present and also effect a working of the surface. Lineal velocities in commercial use range from about 80 to about 350 feet per second. Upon completion of the shot blasting operation, the surface will have a very fine grained frosty or pebbly appearance. From 2 to 10 pounds of shot are impinged per square inch of surface being treated in a period of time ranging from 10 to 60 seconds.

In order to illustrate the process of the present invention, a series of test pieces of steel, SAE 5160 2.5" by 0.246 leaf type spring, 16" long having a Brinell hardness number of 430-444 were peened at room temperature and at elevated temperature with cast steel shot having the characteristics hereinafter set forth.

All test springs were flat and fashioned from the same bundle of steel, and processed at the same time to a Brinell hardness within the range above stated. The tests were performed on a Pangborn Machine No. 4418.

As the flat spring elements undergoing test left the tempering furnace, the surface temperature of each was measured with a Pyro surface pyrometer. When the desired temperature shown in the data of Table I was attained by spontaneous cooling, the spring element was fed into the peening machine. In actual practice, the temperature at which peening is done may be attained by cooling from a tempering temperature which is well in excess of the peening temperature range, or by elevating the temperature of a per-tempered article to within the desired range.

In the fatigue testing machine after the peening operation, the central ten inches of the test elements were placed under constant stress. The test plates were preset by placing each plate at the bottom of the stroke (maximum stress) before setting up with a Huggenberger tensometer for an initial stress range of 30,000 to 160,000 p.s.i. Each piece was cycled to failure by fracture.

These tests show that peening under elevated temperature without reverse stress causes substantially less change in a 16" chord height for the spring as a result of peening, than is found when peening is done at ordinary temperatures but under stress.

The following table summarizes data obtained, the numerical values being the average of two test plates at each temperature value.

Table I

Nominal Temperature of Test Plates	Change in 16" Chord Height Due to Peening, inches	Average Fatigue Life— Cycles
Room Temperature	.052	38,100
300° F	.064	78,150
350° F	.065	76,450
400° F	.067	64,650
450° F	.068	67,450
500° F	.068	73,350
550° F	.071	71,400
600° F	.072	62,150
Stress Peen (Room Temperature)	.203	

It is anticipated that the effective temperature range will vary with the composition of the steel being treated.

In all cases, the fatigue life of the steel spring element peened at room and elevated temperatures was increased by a factor of from five to twenty times that of an unpeened spring element of the same material. It will also be observed that the amount of variation in the chord height of a 16" long specimen in the case of the stress peened material was about three times as great as the variation in the chord height due to temperature peening. Chord heights are measured at the mid-point of the elongated specimen supported by its extremities on a plane surface.

The shot analysis of the shot used in these tests is as set forth in Table II.

TABLE II

Shot analyses

Screen:	Machine 4418
.033"	2.5
.028"	10.0
.023"	23.5
.019"	12.0
.016"	20.0
.013"	13.0
.011"	8.6
.008"	8.4
Pan	0.9

Thus, there has been provided an improved process for shot peening steel articles, particularly articles subject to oscillatory motion and failure by fatigue, e.g. spring of the leaf type, bearing mountings, etc., which process depends upon the utilization of elevated temperatures in the range of from about 200° F. to about 600° F. and shot peening the articles at such temperature under normal shot peening procedures in the stress-free or unstressed condition.

Other modes of applying the principle of this invention may be employed instead of those specifically set forth above, changes being made as regards the details herein disclosed provided the elements set forth in any of the following claims, or the equivalent of such be employed.

It is, therefore, particularly pointed out and distinctly claimed as the invention:

1) The method of improving the endurance and set characteristics of steel articles which comprises in combination the steps of adjusting the temperature of the article to within the range of from 200° F. to about 600° F. and shot peening the article in the unstressed condition at such temperature.

2) The method of improving the endurance and set characteristics of leaf type steel spring elements which comprises in combination the steps of adjusting the temperature of the spring element to within the range of from about 200° F. to about 600° F. and shot peening the article in the unstressed condition at such temperature.

3) The method of improving the endurance and set characteristics of contoured steel articles adapted to be subjected to oscillatory stresses without substantially changing said contour which comprises in combination the step of adjusting the temperature of the article to within the range of from about 200° F. to about 600° F., and shot peening the article in the unstressed condition.

References Cited by the Examiner
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Other References
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