SHOT PEENING - HISTORY

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Man since earliest times has endeavored to improve the materials he uses for his daily needs. Through each period of history his armor, weapons, tools and vehicles constantly required improvement in order to protect himself and provide for his needs more effectively. The cold hammering of metal by the early armorer, metal craftsman and skilled blacksmith was an art. The shields, breast plates, spear-heads, knives and swords were harder and stronger because of cold hammering. Today the process is no longer an art but a controlled mechanical process, originally called "Shot Blasting" by Zimmerli[1] and later termed "Shot Peening" by Almen[2].

Shot Peening is a carefully controlled mechanical process of cold working metal by pelting the metal surface with round metallic shot thrown at a relatively high velocity. As the artisan of old used the hammer to improve metal, today we use the controlled Shot Peening process to increase the fatigue life of metal. This process is the most versatile of cold working applications - i.e., tumbling, peen hammering, swaging or pressure operations by balls and rollers.

It is evident that many factors influenced the development of Shot Peening. The classic stretching tests of metal by Bauschinger[3] of Munich, and the investigations of fatigue of metals by Moore and Kommers[4] were comprehensive and fundamental studies important to developing the increased fatigue life of metal by Shot Peening. The earliest recorded

(1) ZIMMERLI, F.P.: Deceased, former Chief Engineer, Barnes-Gibson-Raymond Division of Associated Spring Corporation.

(2) ALMEN, J.O.: Retired, Former Head of Mechanical Engineering Department, General Motors Research Laboratory.

(3) BAUSCHINGER, J.: A summary of his work in W.C. Unwin's "Testing of Materials in Construction", 2nd Edition, pp. 93-102, Longmans Green and Company, London.

(4) MOORE, H.F. and KOMMERS, J.B.: "An Investigation of the Fatigue of Metals" Bulletin No. 124, Engineering Experimental Station, University of Illinois, 1921.

information relating to what is now known as Shot Peening was a transaction entitled "The Work Hardening of Steel by Abrasion" by E. G. Herbert of Levenshulme, Manchester, England. He presented this paper before the Iron and Steel Institute[5] at Glasgow, on September 22, 1927. It was reported the following week in Engineering[6] in an article headed "The SuperHardening of Hard Steel." This report discloses the invention by Herbert of the "Cloudburst" process. The process is described as a method of increasing the hardness of metal with a rain of steel balls. An abridged version of his transaction appeared in Engineering in October, 1927[7]. Herbert in another article in Engineering in 1929[8] refers to "his invention, the Cloudburst process for producing a work hardened surface on metals by bombardment with hard steel balls." He tells of presenting a paper on this subject before the American Society for Steel Treating[9] in 1928. There is no indication in any of these transactions that Herbert was interested in the fatigue durabilities; rather he was primarily interested with the increase in hardness.

The first to recognize the beneficial influence of cold working to increase fatigue resistance was O. Foppl of Germany. In Stahl and Eisen[10] he published an article entitled "Compression of the Surface of Steel Machine Parts." Five fatigue specimens are shown which were peened with a hammer having a 4 mm ball end. Of the five shown, four broke in the non-peened section under fatigue loading, not withstanding the reduced section where peening had been applied. This is the first known publication in which

(5) Iron and Steel Institute Journal, V116, No. 2, 1927, pp. 265-291.
(6) Engineering, September 30, 1927, p. 421[a].
(7) Engineering, October 7, 1927, pp. 470-472[a].
(8) Engineering, November 1, 1929, pp. 569-571[a].
(9) American Society for Steel Treating Transactions, Vol. 16, No. 1, July, 1929, pp. 77-92.
(10) Stahl und Eisen, Vol. 49, April, 1929, p. 576.

(a) Photostatic copies of these articles included with this paper.

fatigue durability is shown to improve with peening[11].

In December, 1935 the transactions of ASME contained a paper by E.E. Weibel on "The Correlation of Spring Wire Bending and Torsion Fatigue Tests." He describes the use of Shot Peening to prevent fatigue failure in torsional fatigue tests. Weibel makes a reference to the work of Foppl and in his acknowledgements, refers to F. P. Zimmerli. It was not until October, 1937 that J. H. Frye and G. L. Kehl presented a paper before the American Society for Metals, in Atlantic City, entitled "The Fatigue Resistance of Steel as Affected by Some Cleaning Methods"[12]. This paper describes the increased fatigue life obtained from specimens which had been treated by shot blasting[11].

Through the late 1920's and during the 1930's, man found constant need to improve the materials he used in everyday life. As his mode of transportation improved he found that in the expanded use of the automobile - as paved roads were lengthened into highways, higher speeds developed - the various springs, gears, steering knuckles, brakes and many other parts had to be improved to meet these demands. The challenge was met and new processes, such as Shot Peening, were developed to allow man to travel farther, faster and more safely than he had ever traveled before. Recorded evidence and reported "shot blasted cleaning methods" indicate that Shot Peening was used to increase the fatigue life of metals since the late 1920's. In October, 1940 at the 22nd annual convention of the American Society for Metals, in Cleveland, Ohio, at the Symposium on the Surface Treatment of Metal, F. P. Zimmerli[1] presented a manuscript entitled "Shot Blasting and Its Effect on Fatigue Life."[b] In this paper he states "in 1929 the company with which the author is

(11) "How, When and by Whom Was Mechanical Prestressing Discovered" by G. F. Bush, J. O. Almen, L. A. Danse and J. P. Heiss. Paper presented by G. F. Bush at Biennial meeting of Division 20, SAE, ISTC 1962.

(12) American Society for Metals Transactions, Vol. 26, 1938, pp. 192-218.

(b) Photostatic copy of this manuscript included with this paper.

associated sent out the first production springs in this country Shot Blasted to increase fatigue limits." This was an important statement as it conclusively indicated that the process had been in use for a period of at least eleven years. J. O. Almen believes that the delay by Zimmerli in publishing his Shot Peening experience may have been due to seeking a patent[11]. However, there were other reasons also; in many cases this work was not discussed outside company plants due to shop secrecy to preserve a competitive advantage. The selling of a new process was not easy - to quote Zimmerli, "These springs were first unnoticed, then protested, and for a year or two our work was endured but not encouraged. After that, adoption was rapid and until today this method is specified on many prints." Zimmerli closed the discussion on his paper with these words: "In calling this process to the attention of metallurgists it is earnestly hoped that many others will take over where this paper left off. The development of this process and its industrial application will in our opinion be a great step forward in industrial metallurgy. New fields are now awaiting exploration and many steels can be put to new uses." The development of this process of course continued - O. J. Horger[13] reports the published work of Foppl and Weigand in 1940; Lessels and Murray, and Manteuffel in 1941; Almen[2] gave results of fatigue investigations on shot peened automotive parts and Lupfert presented results of German tests in 1943; and three technical papers and a review were presented at the ASM annual meeting in 1944.

So the contribution of Zimmerli was not alone, other men in the automotive industry had also contributed to the success of the process. At Cadillac Motor Division, General Motors Corporation, in 1926-1928, the work of L.A. Danse, Chief Metallurgist and

(13) HORGER, O.J.: "Mechanical and Metallurgical Advantages of Shot Peening" by O. J. Horger, Head of Railway Engineering and Research, Timkin Roller Bearing Company, Canton, Ohio. 1959 Sixth Edition of "SHOT PEENING" published by Wheelabrator Corporation, Mishawaka, Indiana.

H. G. Tarracks, Assistant Metallurgist was important. In their search and need for "clean steel" they found that the shot blast cleaning of valve springs, connecting rods, steering arms and knuckles, axle shafts, gears and pinions resulted in longer life for these parts. At the Buick Division, GMC in 1929, Otto Burkhardt and John Paul Heiss were doing important investigation in the shot blast cleaning of springs. The evidence, though clear cut evidence, is not possible because of shop secrecy, indicates that the work of these men, both at Cadillac and at Buick, was among the earliest in the benefits of shot blasting[11]. Many have since contributed to the improvement of this process, however no one has contributed more than J. O. Almen[2]. His invention of the Almen Gauge, a device for measuring the intensity of Shot Peening, and his outstanding work on many research projects have immeasurably contributed to the success of this process.

The improvement of shot, the engineering of controlled automated production equipment, have been important factors in making this a usable tool for all industry. However, it would not have been as successful a tool had it not been for the diligent work of the members of SAE committees who wrote the Shot Peening Manual, the specifications for Shot and for Shot Peening and also aided in writing the Federal Mil specifications. The war years of the 1940's and early 1950's saw many advances in the applications of Shot Peening - new and important uses developed so that at war's end many more peace time uses were found.

Today in our Missile and Space Age, the requirements of man's materials are varied and new. Man has improved the metals he uses to project Rockets and orbit Satellites in his traveling the space road to the stars. Shot Peening has enabled springs to take the tremendous thrust of blast-off - the unbelieveable full acceleration of gears in fractions of a second - and used in many other applications that allows our space metal to meet

unknown demands. The important development work of F. P. Zimmerli and J. O. Almen and all other men who contributed their knowledge and efforts in Shot Peening to increase the fatigue life of metal have contributed to man's life in space.

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Bibliography

HERBERT, E. G.: "The Work Hardening of Steel by Abrasion"
Engineering, October 7, 1927, pp. 470-472.
Iron and Steel Institute Journal, Vol. 116,
No. 2, 1927, pp. 265-291.
Engineering, September 30, 1927, p. 420.
Engineering, November 1, 1929, pp. 569-571.
American Society for Steel Treating Trans.,
Vol. 16, No. 1, July 1929, pp. 77-92.

FOPPL, O.: "Compression of the Surface of Steel Machine Parts"
Stahl und Eisen, Vol. 49, April, 1929, p. 576.

ZIMMERLI, F. P.: "Shot Blasting and Its Effect on Fatigue Life"
Surface Treatment of Metals, American Society for
Metals, 1941, pp. 261-278.

HORGER, O. J.: "Mechanical and Metallurgical Advantages of Shot
Peening" 1959 Sixth Edition of " Shot Peening"
published by Wheelabrator Corporation, Mishawaka,
Indiana, pp. 151-183.

MOORE, H. F.: "Strengthening Metal Parts by Shot Peening"
1959 Sixth Edition of "Shot Peening" published by
Wheelabrator Corporation, Mishawaka, Indiana,
pp. 83-127.

ALMEN, J. O.: "Improving Fatigue Strength of Machine Parts"
1959 Sixth Edition of "Shot Peening" published by
Wheelabrator Corporation, Mishawaka, Indiana,
pp. 131-148.

BUSH, G. F.: ALMEN, J. O.: DANSE, L.A.: HEISS, J.P.: "How, When
and by Whom Was Mechanical Prestressing Discovered"
paper presented by G. F. Bush at Biennial meeting of
Division XX, SAE, ISTC, May 21, 1962, Colorado Springs,
Colorado.