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REVIEW ON SHOT PEENING AND IMPROVEMENT OF FATIGUE STRENGTH

SARVESWARA REDDY S

Research Scholar, Department of Mechanical Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Andhra Pradesh, India. Corresponding Author Email: nagasarvesh@gmail.com

K V DURGA RAJESH

Department of Mechanical Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Andhra Pradesh, India.

FRANCIS LUTHER KING M

Department of Mechanical Engineering, Swarnandhra College of Engineering and Technology, Narsapur, Andhra Pradesh, India.

Abstract

The shot peening (SP) procedure, which is utilized to enhance the surface qualities, is the subject of this research. The fundamental use of SP processes and their many applications are covered in this paper. In-depth discussion is given on the various materials involved as well as the surface layer characteristics of metallic materials. The advantages of SP, including enhanced surface hardness and roughness, are discussed for a variety of materials. In order to identify the important factors influencing the quality of SP, optimization of SP is examined. Applications of SP in various industries, like medicine, are presented. According to a number of research studies, SP generates residual compressive stresses that form in the materials and enhance these surface layer features. The requirements of surface property and several methods of evolution are covered in this review study.

Keywords: surface quality, optimization, residual compressive stresses, roughness, hardness.

INTRODUCTION

To resist crack propagation [1] in the surface, SP [2] is employed by bombardment of the surface with hard shot [3]. It has been demonstrated that SP is a useful technique for boosting material resistance [4] to several type of stress induced damage [5], notably damage brought in by cyclic loading [6]. SP is increasingly being employed in many industrial fields [7-9], especially in the aerospace industry [10] and biomedical [11-13], because it can be applied to broad variety of structural components regardless of the shape [14]. SP will enhance the fatigue strength [15] of the highly stressed automotive parts [16] resulting higher performance with increased strength [17]. While SP treatments improve the effect of surface defects [18], they also have few drawbacks like enhancement of surface roughness as shown in Fig.1. SP process has many important variables [19] and that should be chosen with the utmost care.

The poor choice of the variables may degrade the fatigue performance of SP [20]. Hence a thorough knowledge about the effects of SP might lead to an improvement of the process in terms of fatigue resistance. This review paper's goal is to examine SP's advantages for enhancing the components needed for diverse industrial applications. Also, it covers the numerous techniques for enhancing the materials' fatigue strength as

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well as the factors that affect that strength. Fig. 2 displays a schematic representation of SP.

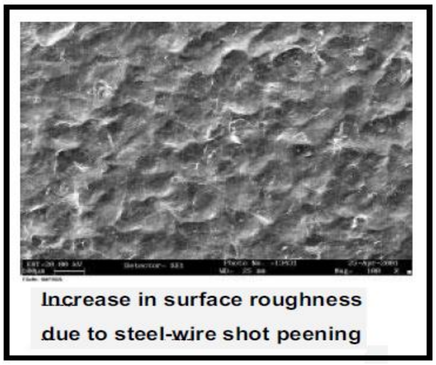

Fig 1: Examples of Surface Damage Produced By Shot Peening

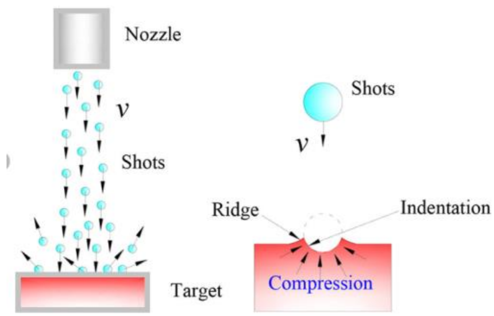

Fig 2: Schematic Diagram of Shot Peening

T5-treated high-strength magnesium alloy ZK60's surface properties and high cycle fatigue (HCF) performance were examined by Lie et al [21]. They performed SP using glass beads with an average diameter of 0.35 mm and an Almen intensity range of 0.02 to 0.40 mmN. Their study suggested that SP significantly alters the surface microstructure and texture of ZK60-T5, producing residual compressive stress in the surface deformation layer. The ZK60-T5 magnesium alloy exhibits a noticeable overpeening effect.

Before and after SP, the surface characteristics of (TiB + TiC)/Ti-6Al-4V were examined by Xie et al [22]. The findings demonstrate that higher reinforcement levels and more intense SP reduce surface roughness. SP intensifies compressive residual stresses and hardness, which is primarily caused by plastic deformation and a high dislocation density in the near surface layer. They also claim that the higher compressive residual stresses and hardness following a suitable SP treatment are advantageous for industrial applications. The stress formation during SP is presented in Fig.3.

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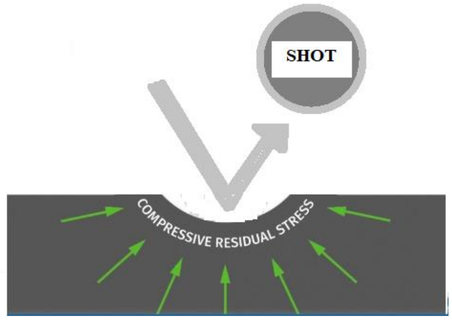
Fig 3: Stress formation during shot peening process [35]



Medical equipment composed of 17-4 PH stainless steel is thought to be appropriate for additive manufacturing when the surface is modified by SP. Walczak et al. [23] looked into the effect of SP on the surface texture, corrosion, and wear performance of 17-4PH steel fabricated by direct metal laser sintering (DMLS) additive manufacturing. The biggest improvement in surface hardening, or around 119% (from 247 to 542 HV), was seen in 17-4 PH specimens peened with steel and ceramic shots, which greatly increased their wear resistance. Their findings showed that employing ceramic beads for SP caused the material's grain size to be refined from 22.0 to 14.6 nm and its surface morphology to be reduced, both of which increased the material's resistance to corrosion. SP of DMLS 17-4PH specimens with ceramic beads at 0.6 MPa pressure produced the best surface shape, toughness, and structure, which enhanced corrosion and wear resistance. The surface structure's condition and biomedical applications are crucial factors in the effective insertion of prostheses like bone replacement, which are currently created increasingly using DMLS technology.

Żebrowski et al. [24] examined "the Effect of the SP on surface properties of Ti-6Al-4V alloy produced by means of DMLS technology". The specimens were created with the aid of an EOSINT M280 system, and their surfaces were shot peened using three distinct media—CrNi steel shot, broken nuts, and ceramic balls made of ZrO2—at three separate operating pressures (0.2, 0.3, and 0.4 MPa). They discovered that the process parameters, namely operating pressure during SP and suitable shot selection, would enable the achievement of the qualities with the enhancement of the surface layer necessary for implant equipment.

Surface properties and corrosion behavior of medical grade AISI 316L stainless steel was reported by Ahmed et al. [25]. A common material for the primary hip replacement component is AISI 316L steel. To combat corrosion and fatigue issues, they examined at how SP factors impact surface roughness. Ceramic shots were used for SP, with three different shot diameters (125-250, 450, and 850 m), two different Almen intensities (0.22 and 0.28 mmA), and two different coverage percentages (100 and 200%). By increasing the covering degree and the Almen intensity, the results showed enhanced surface micro hardness and produced compressive stresses. By reducing the contact angle, the rougher surface after shot-peening increased wettability. Lower surface roughness and enhanced corrosion resistance were produced by increasing the shot size. Additionally,

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they coated the shot-peened surfaces with hydroxyapatite (HA), which enhanced wettability even more.

The biocompatible and biodegradable qualities of magnesium alloys make them a good option for temporary biodegradable implants. Magnesium-based materials have a slew of drawbacks, including a fast rate of corrosion and low corrosion resistance. In order to overcome this problem Peral et al. [26] studied the "Effect of warm SP treatments on surface properties and corrosion behavior of AZ31 magnesium alloy". In order to analyze the specimens for grain refinement, surface roughness, work hardening, and residual stresses, AZ31 Mg alloy was subjected to conventional and rigorous SP processes at room temperature, 240 °C (near recrystallization temperature), and 360 °C. To assess the impact of the SP procedures on the specimens' corrosion resistance, potentiodynamic polarization experiments were also carried out. Their findings showed that the most important element influencing corrosion behavior was surface roughness.

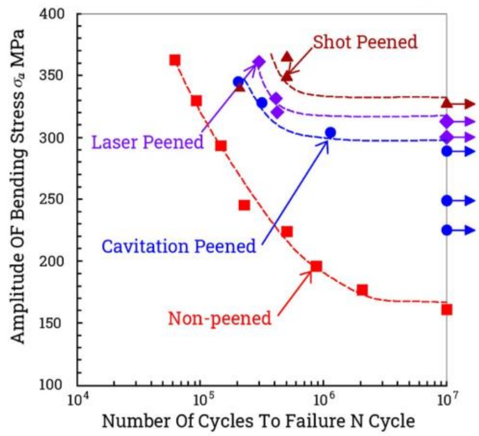
Torres, M.A.S., and Voorwald, H.J.C. [27] examined the fatigue life of AISI 4340 steel and assessed the SP of AISI 4340 steel via formation of a compressive residual stress field (CRSF) in their external surface in order to increase the fatigue life. On the AISI 4340 steel landing gear, rotational bending fatigue tests were performed, and the CRSF was assessed using an X-ray tensometry. It was discovered that the exhaustion process led to the CRSF relaxing. In order to learn more about the crack starting spots, the cracked fatigue specimens were further examined using a scanning electron microscope (SEM). By creating CRSF in solid metals and alloys, ultrasonic shot peening (USSP) is recognized as an efficient surface treatment procedure to improve the mechanical properties of materials [28]. A pre-stressing technique called USSP lengthens the lifespan of mechanical parts. The spheres that make up the shot are propelled by a sonotrode into motion, strike the treated component, and produce a CRSF to get longer fatigue life [29].

Fatigue strength of SAE 9245 steel was improved by Tekeli [30] by the application of SP process. In their work, CRSF produced through distortion stiffening at the surface was created using SP procedure. To completely convert the microstructure to austenite, the samples were heated to 850 °C and maintained there for 20 min. Austenite was then toughened by water quenching. To remove any remaining tensions from the quenching, the specimens were tempered at 500 °C. A variety of fatigue samples, some of which had just been heat-treated and others which had been shot-peened by CS 230 using a high-pressure air gun, were tested on Wöhler fatigue testing machine. Comparisons were made between the fatigue findings for peened and unpeened circumstances. SP has been shown to extend fatigue life by about 30%.

Li et al. [31]. Analyzed "the effect of micro-SP, conventional shot peening and their combination on fatigue property of EA4T axle steel". In their investigation, three different SP processes—conventional shot peening (CSP), micro-shot peening (MSP), and dual shot peening (DSP)—were used to test samples of EA4T axle steel. The impacted surface layer was described using the stress distribution, surface finish, morphology, and micro hardness. Their results suggested that the MSP accomplished the greatest surface compressive residual stress (SCRS). While DSP increased micro hardness and SCRS, in their study, it was also revealed severe flaws in the specimens' fatigue strength.

There is another method similar to SP for enhancing the fatigue performance and durability of metallic materials is cavitations peening. Soyama et al. [32] studied “the Effect of compressive residual stress introduced by cavitation peening and SP on the improvement of fatigue strength of stainless steel”. They compared Shot and cavitation peening to modify SUS316 L samples, and a displacement regulated plane bending fatigue experiment was used to gauge the samples' fatigue resistance. According to their research, shot peened specimens had a longer fatigue life than cavitation peened samples at bending stresses more than 450 MPa. However, throughout the fatigue testing, CRSF generated by both peening processes decreased. Fig.4. shows the improvement of fatigue strength through SP.

Fig 4: Improvement of fatigue strength through SP



Bagherifard, and Guagliano, [33] studied “the Fatigue behavior of a low-alloy steel with nanostructured surface obtained by severe SP”. They used standard air blast equipment to generate a nanograined layer by applying severe SP to the surfaces of specimens. The treated surfaces of samples have been characterized using a variety of experimental techniques, including microscope inspection, micro - hardness, toughness, and X-ray diffraction studies.

The development of a nanocrystallized outer surface is confirmed by their results. . Their results also proved that fatigue life has improved despite the specimen's extremely high surface roughness."The Effect of SP on Titanium Alloy on Surface Residual Stress and Roughness for Aerospace Applications," according to Kumar et al. [34]. By producing CRSF by SP, they attempted to increase the toughness of the aircraft components and reduce stress corrosion.

They used surface and sub-surface residual stresses as well as impact angle, coverage area, and Almen intensity that affect surface roughness as SP factors. To obtain larger residual stress, they used Taguchi's approach for optimizing these parameters.

CONCLUSION

Therefore, the SP process's definitions, requirements, theoretical, practical, and ultimately optimum surface coverage approaches have all been investigated thoroughly. SP processes provides a broad range of goods that are manufactured using high-quality materials and methods. The SP method has shown considerable promise because of the breadth of capabilities it offers to businesses.

However, there are a number of problems that need fixing, such as surface hardening and so on. Selecting the appropriate SP equipment is also crucial, with factors including component size, shape, and material all coming into play. There was discovered to be no one set procedure for SP method. The techniques presented in this study for regulating SP parameters provide a glimpse into their evolution. This literature study helped clarify the surface-property criteria and different evolutionary approaches.

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