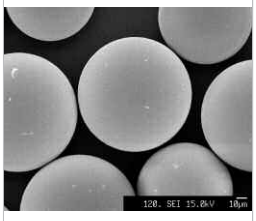
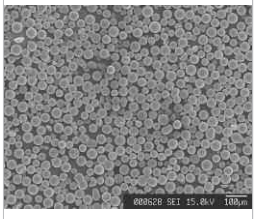
An Introduction
Fine Particle Shot Peening



Low sodium glass bead shot peening particle



Low sodium glass bead fine shot peening particle

Mitsubishi Heavy Industries, Nagoya Aerospace Systems is using fine particles made from low-sodium glass which differs from glass beads specified in AMS 2431/6. Low sodium glass beads have a lower consumption rate than that of glass bead.

Images are courtesy of Mitsubishi Heavy Industries, Ltd., Nagoya Aerospace Systems

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Fine particle shot peening (FPSP) is fine, powder-like spherical media (20-200 µm in diameter) thrown against metal surfaces at speeds of more than 100 m/sec. The typical hardness of FPSP media, which can be metallic, ceramic or glass, is 750-1000 HV. The machine used in the process is a modified pneumatic shot peening system. Like conventional shot peening, fine particle shot peening improves fatigue strength and stress corrosion fracture resistance. Its greatest additional benefit is that it produces a very smooth surface finish. However, the idea to use fine particles was likely motivated by economy, not efficiency—a creative thinker looked at the fines from cast steel shot production and wondered if they could be put to good use.

Component designers should understand the advantages and disadvantages of both processes. The following is a comparison between conventional shot peening and fine particle shot peening.

Shot Peening Advantages

- Greatly improves strength and fatigue resistance
- Well-known process that is relatively inexpensive to implement
- Has substantial research and quality controls to enhance its value
- Media and equipment are readily available
- Creates a pebbly surface that is advantageous in certain applications

Fine Particle Shot Peening Advantages

- Improves surface hardness and wear resistance
- Ultra-smooth surface is ideal for bearings, seals, or close-tolerance areas
- Will not distort close-tolerance parts
- Will not damage soft or fragile parts

Shot Peening Disadvantages

- Pebbly surface finish isn't suitable for all applications
- Can distort close-tolerance parts

Fine Particle Shot Peening Disadvantages

- Limited availability in U.S. and Europe
- Media can be difficult to use and few equipment and media manufacturers are experienced with it
- Limited depth of compression might make it unsuitable for some applications

Entrepreneurs will see that the first two "Fine Particle Shot Peening **Disadvantages**" could easily be changed to "Fine Particle Shot Peening **Opportunities**." The technology is already being exploited in Japan. Fuji Kihan Company and Fuji Seisakusyo Company have patented a fine particle peening process that they market to the Japanese automotive and worldwide motor sports industries. According to an article posted at the JETRO (Japan External Trade Organization) web site, Fuji Kihan has licensed this technology to over 130 companies. Eighty percent of these are Japanese auto and auto part manufacturers. Japan also has a Fine Particle Shot Peening Society.

The scope of the process is evident in several papers presented at the 2008 Tenth International Conference on Shot Peening (ICSP-10) in Tokyo.* An excellent example of Japanese FPSP research was presented by M. Yoshizaki of Hino Motors. Mr. Yoshizaki presented "Improvement in Tooth Surface Strength of Carburized Transmission Gears by Fine Particle Bombarding Carburized Process." The abstract reads:

> Gear surface fatigue endurance tests were carried out using gears treated with the fine particle bombarding (FPB) process under three different peening conditions. Shot peened gears by a conventional impeller-type machine were used as comparison. The results showed that FPB increased the tooth surface strength (pitting resistance) by 1.21 to 1.28 times in Hertzian stress compared to the conventional impeller-type shot peening. Next, the influence of FPB on the tooth surface properties such as residual stress, hardness, roughness, surface texture, etc., were examined. After obtaining the results, the following factors of FPB that influenced tooth surface strength increase were discussed: (a) high residual compressive stress produced below the surface, (b) greatly increased hardness below the surface, (c) excellent conformability of the tooth surface, (d) micro hollows on the tooth surface generated after running. The author pointed out that the latter two were unique factors caused by FPB and contributed much to the improvement of tooth surface strength.

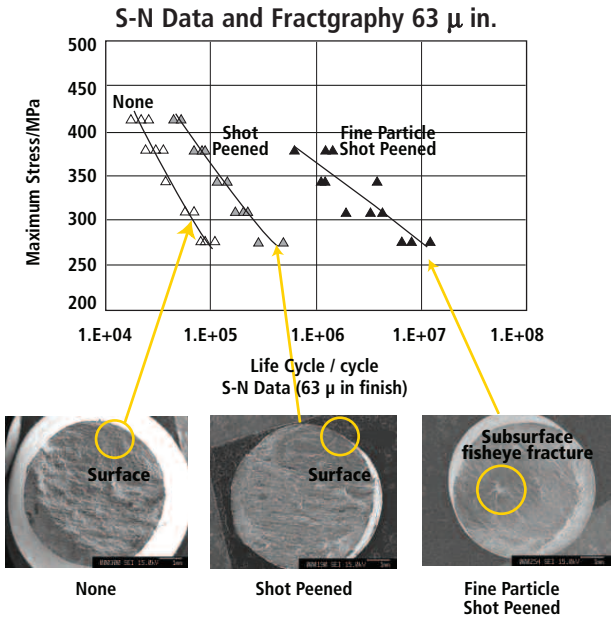
Additional ICSP-10 paper topics were "Fine Particle Bombarding Technology and Functional Development of Metal Surface," "Improvement of Corrosion Resistance of High-Strength Aluminum Alloy by Fine-Particle Bombarding Treatment," "Influence of Fine Particle Bombarding on Surface Strength of Carburized Steel Under Rolling Contact Condition,"

*ICSP-10 Proceedings are available for purchase at www.shotpeener.com

"Formation of Homogeneous Lamellar Structure with Nano-Scale Grains Under Material Surfaces by Fine Particle Bombarding," "Effect of Fine Particle Bombarding on Thermal Fatigue Property of Tool Steel for Die Casting" and "Applicability of Fine Particle Peening on Surface Modification of Aluminum Alloy."

Fine particle shot peening has been so successful for the Japanese automotive industry that a suitable FPSP process is in development in Japan for aluminum aircraft parts. A. Inoue, T. Sekigawa and K. Oguri with Mitsubishi Heavy Industries presented "Fatigue Property Enhancement by Fine Particle Shot Peening for Aircraft Aluminum Parts" at ICSP-10. According to the abstract:

> Fatigue life of conventional shot peened 7050-T7451 aluminum parts was increased by several times, while that of fine-particle shot-peened aluminum was increased by more than 10 times compared with that of as-machined. The compressive residual stress on fine-particle shot-peened surface covered adequately with uniform dimples is higher than that on shot-peened surface. Fracture surface observation revealed that the fatigue crack of fine-particle shot-peened samples originate at the subsurface layer, which shows the high compressive residual stress at very near the surface and the less-roughened surface prevents crack initiation from the surface. Fine particle shot peening can improve fatigue life more than shot peening, which shows fatigue crack initiates from small flaws and laps on the surface created by shot peening.



Fatigue life is strongly affected by crack initiation position. Fatigue Life Cycle by Surface Crack initiation is one or more shorter than Subsurface initiation.
Resource: Mitsubishi Heavy Industries, Ltd., Nagoya Aerospace Systems

Engineered Abrasives (EA), a manufacturer of blast finishing and shot peening systems, is one of the few U.S. companies that provides fine particle shot peening services. EA developed their Fine Steel® peening in 1999 with General Motors in an effort to replace expensive ceramic bead peening and still effectively reduce gear tooth pitting. Engineered Abrasives' Fine Steel® peening uses fine steel at 150 microns screened at 100%. The fine particle peening gives a highly compressive residual stress on the tooth surface and the resulting small dimples retain beneficial oil for the elimination of gear tooth pitting. Fine Steel® peening is more involved than other shot peening processes. For example, it requires a special media valve for flow rate control and pressure vessel to handle the fine media. The tooling is made from tungsten carbide because of the higher wear than from conventional peening media. Media screen separator systems wear faster and hoses must be changed often. Operators need to empty media screen separator systems and dust collectors more than with conventional shot peening.

An upcoming application for fine particle shot peening in the U.S. is in the medical implant industry. Electronics Inc. (EI) has received Patent No. 7,131,303 for Shot Peening of Orthopaedic Implants for Tissue Adhesion. Proper adhesion of soft tissue to orthopaedic implants is important but has proven difficult to achieve. For example, if the implant surface to which tissue adherence is desired is too smooth, tissue cannot easily adhere to the implant and the body forms a tissue capsule around the implant, sealing it off from the rest of the body. This impairs the implant's function. Since the implant constantly moves relative to the tissue, the resulting friction causes inflammation and creates a capsule of dead tissue. Accordingly, implant surfaces to which tissue adherence is desired have been textured, but too great a degree of surface roughness can permit connective tissue and bone to grow into the fissures. The implant essentially grows into the body and removal of the implant becomes almost impossible, and, if possible, results in major bone loss. The patent Summary of the Invention cites:

> According to the invention, the portion of an orthopaedic implant to which tissue adherence is desired is treated by microbead, that is, shot that is much smaller than shot used to effect strengthening of the implant. Microbead has a diameter in the range of about 10 microns-300 microns and when used at normal intensity causes indentations on the surface of the implant of about 10 microns to about 50 microns. This does not cause compression of the layer just below the surface, but instead provides fine, shallow texturing of the implant that permits the fibroblasts of the connective tissue a surface to which to adhere. However, the implant is not rough enough that it will interlock with hard tissue, such as bone tissue. Furthermore, shot peening is a well-known and relatively simple, inexpensive and controllable process to effect the desired tissue adherence. Other methods of surface treatment are more difficult and expensive, and are less easily controlled to effect the degree of surface roughness that permits soft tissue to adhere, but that is not rough enough that hard tissue will also adhere.

The patented invention can also be a duplex peening process as noted in the patent's Description of the Preferred Embodiment:

> Method of treating a surface of a medical implant by shot peening said surface using larger shot sufficient to cause compression of the layer immediately below said surface to increase hardness and thereafter shot peening said surface with smaller shot sufficiently small to effect texturing of said surface without substantial compression of the layer immediately below said surface to improve tissue adhesion."

EI is sponsoring research of the process at a major U.S. university in preparation for commercial development.

Fine Particle Shot Peening has tremendous growth potential. In an effort to explain its merits to SAE members, Takahiro Sekigawa with Mitsubishi Heavy Industries shared a PowerPoint presentation on FPSP usage in the Nagoya Aerospace Systems, Material Research Section of Mitsubishi Heavy Industries at a recent SAE shot peening subcommittee meeting. The International Scientific Committee for Shot Peening has again included FPSP in its list of desired topics for its 2011 conference. **The Shot Peener** magazine will continue its discussion of fine particle shot peening in upcoming issues.