LaserPeen™ Process

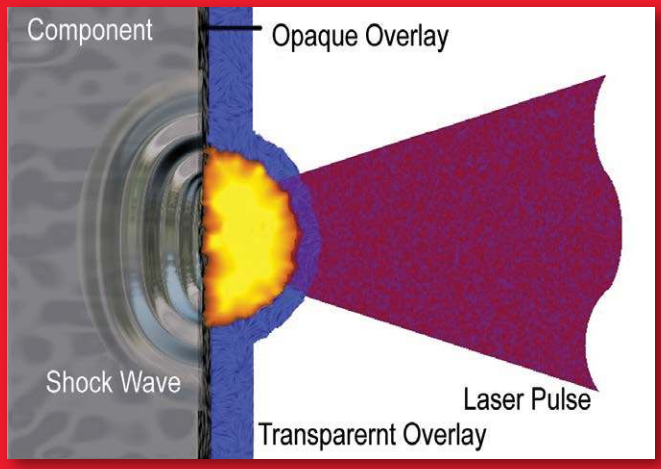
SERVICES & EQUIPMENT

Endurance with Confidence

LSP Technologies

Steps of Laser Peening

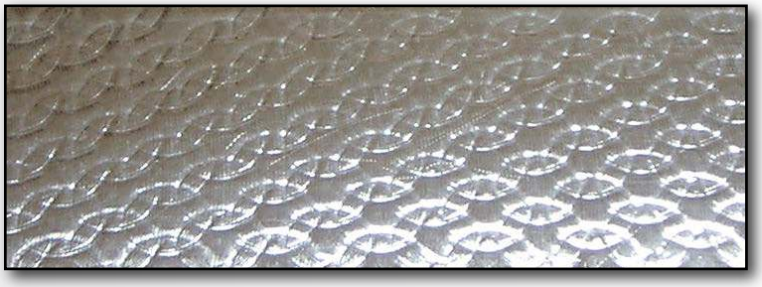
1. **Opaque overlay**
   LSP Technologies uses an opaque overlay to protect the part surface from direct thermal contact with the laser-induced plasma and generate a consistent reaction with the laser beam.



What is Laser Peening?

Strength & Endurance!

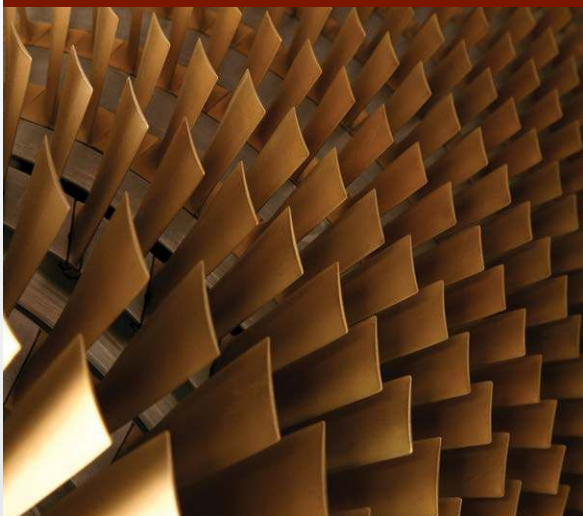
Laser peening is the only contact-free fatigue prevention method for metallic components that prevents failures from fatigue and other surface deterioration effects by inhibiting crack initiation and propagation. Laser peening is a mechanical cold work process not a heat treatment. It is the leading technology for imparting deep compressive residual stresses with precise process control and with the ability to access hard-to-reach features on critical parts.



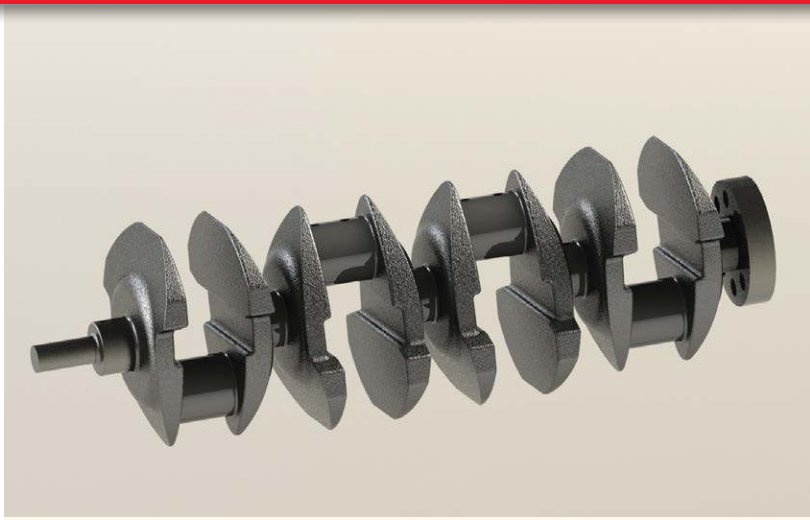
Example of laser peening spot pattern (enhanced for visibility)

DID YOU KNOW:

Laser peening typically increases fatigue life by up to 20 times.



2. **Transparent overlay**
   The water overlay confines the plasma against the surface, significantly increasing the pressure generated.
3. **Laser pulse**
   A high energy laser beam passes through the transparent overlay and is absorbed by the opaque overlay.
4. **Shockwave**
   A shock wave is transmitted into the material with a peak stress above the dynamic yield stress, cold working (plastically deforming) the material deep into the surface
5. **Compressive residual stress**
   After the shock wave passes, the cold worked metal has deep surface compressive residual stresses remaining.



Laser Peening significantly increases resistance to HCF, SCC, and FOD

Why Laser Peen? *Best Results!*

Improvements in fatigue life and fatigue strength are proportional to the magnitude and depth of induced compressive residual stresses present in a component. Laser peening typically produces compressive residual stresses 1-2 mm deep from the surface, which is 10 times deeper than those achieved in conventional surface enhancements. Capable of reaching as deep as 12 mm, LaserPeen™ processing delivers significant lifetime improvements.

A precisely controlled and localized process, laser peening mitigates surface tensile stresses, fatigue, damage and other non-recoverable surface degradation conditions. Without laser peening, these conditions cause fatigue crack initiation and propagation, leading to premature failure. Laser peening also increases damage tolerance as well as material resistance to high cycle fatigue, fretting, erosion, and stress corrosion cracking.

Laser peening can be applied to new and fielded parts. It increases service life, extends maintenance intervals and decreases down time without requiring a change to the design of the part. Laser Peening enables the design and manufacture of lighter weight components while maintaining or improving fatigue strength.

Laser Peening Benefits

Residual Stresses

Precise control of the laser parameters provides customizable compressive residual stress profiles. Laser peening intensity is controllable to achieve the desired surface compressive stress or the depth of the residual compressive stress.

DID YOU KNOW:

Laser peening is resistant to thermal recovery. After heating, residual stresses recovery near the surface is minimal.

Proven and Mature Process

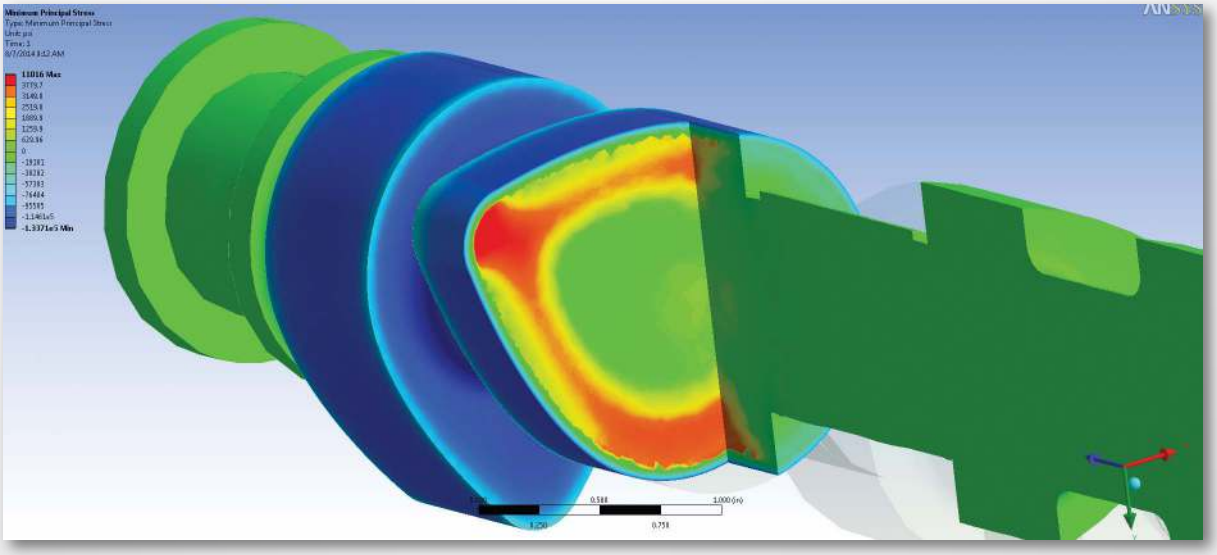
LSP Technologies' patented Laser Peening process is fully mature and thoroughly demonstrated on a variety of metallic aerospace and metal forming components. It is a TRL/MRL 9 manufacturing process. The process can be provided at LSP Technologies or at your facility by acquiring a Procudo® LSP System.

Process Synergy

Shot peening, grit blasting, and other broad area coverage processes are used to improve the safety and service life of critical components. Combining laser peening with these processes provides synergistic service life extension of critical components.

LaserPeen™ Process Modeling

Finite element modeling is used to predict the magnitude and depth of the imparted compressive residual stresses. This enables rapid and cost effective development of your production ready application. The laser peening application is developed using our expertise in the interaction between the specific laser process parameters, material properties, surface contour, section thickness, the number of process layers, and the process pattern LSP Technologies efficiently evaluates laser peening parameters and part characteristics supported by extensive modeling experience and an expansive library of laser peening data.



Simulation of residual stresses in a laser peened camshaft

Fatigue Prevention with Laser Peening

Figure 1 shows a comparison of fatigue properties for 7075-T7351 aluminum specimens subjected to laser peening and shot peening. The data illustrates the typical fatigue enhancement of laser peened parts, including a 30-50 percent increase in notched fatigue strength and an order-of-magnitude increase in fatigue life.

Figure 2 illustrates that laser peening returns a damaged F101 turbine airfoil to the same life expectancy as an undamaged airfoil. As a comparison, the failure stress of the laser shock peened, notched blades averaged about 80 ksi, above the failure stress of the undamaged blades.

Laser peened components have shown increased resistance to corrosion and stress corrosion cracking. In 2024-T351 aluminum, potentiodynamic tests showed anodic current density shifts after laser peening, indicating enhancement of pitting resistance for both initiation and propagation. There was also a reduction of the passive current density on laser shock peened surfaces, indicating increased corrosion resistance.

DID YOU KNOW:
Laser peening is effective in arresting pre-existing cracks.

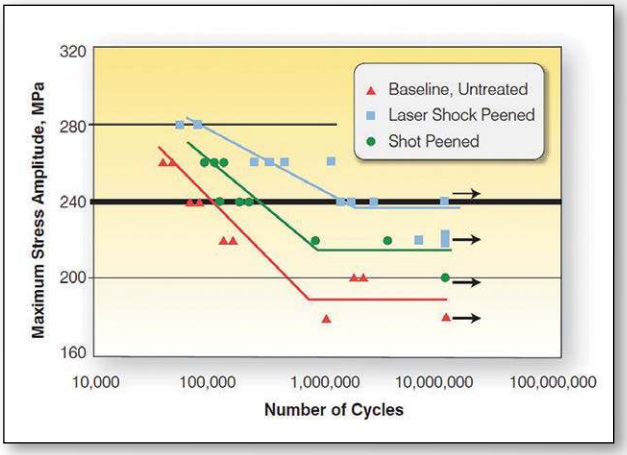


Figure 1. **Data points with arrows indicate tests halted with no failure.***

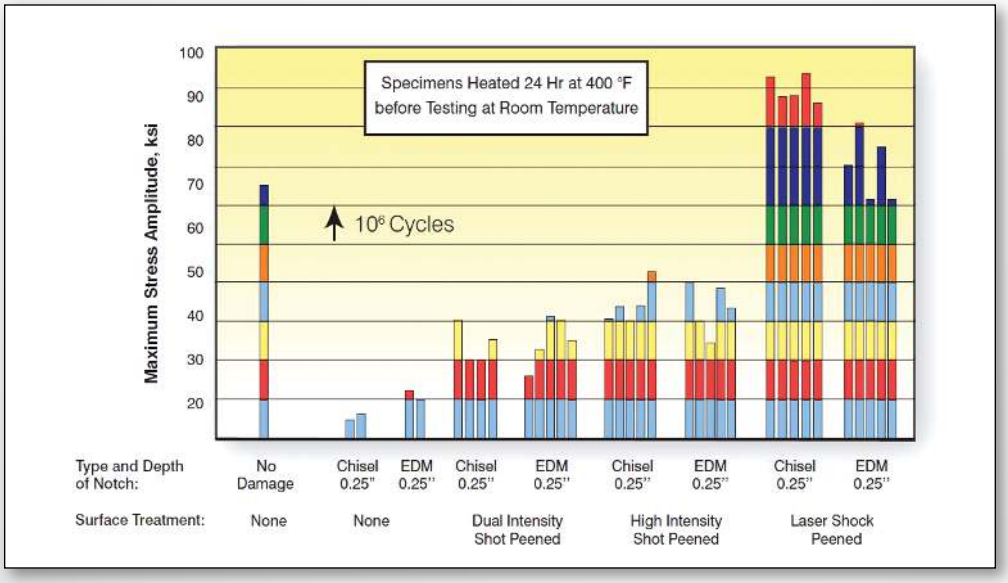


Figure 2. **Fatigue test results of blades with simulated FOD damage process by different surface treatments.***

* Please visit our website, www.lsptechnologies.com for the original paper and references "Preventing Fatigue Failures with Laser Peening"

Laser peened Pratt & Whitney F119 Engines are flying in an F-22 Raptor

The LSPT Advantage

LSP Technologies (LSPT) is the world's premier provider of laser peening services and equipment. LSPT uses its patented LaserPeen™ process to provide laser peening production services at our facility for customers that include power generation and aerospace OEMs, allowing them to achieve the component life extensions and reduce operational costs. To achieve these benefits, LSPT deploys unmatched expertise in metallurgy and engineering mechanics along with process knowledge gained over 30 years of experience in laser peening processing, and technology development at Battelle Labs in Columbus, Ohio.

LSPT was founded in 1995 as the first company to offer laser peening to general industry when we began working with GEAE and the USAF. In 2003, LSPT began production engine component laser peening for Pratt & Whitney's F119 engine on the F-22 Raptor. LSPT has laser peened more than 50,000 fan blades and other components for the power generation, aerospace, automotive, and other industries. LSPT operates laser peening work cells with 6 axis high precision robots capable of handling parts up to 400 pounds. LaserPeen™ processing is computer controlled with real-time process diagnostics and verification to the most rigorous quality control requirements in accordance with the AMS2546 "Laser Peening" standard.

Building upon our expertise in the design and operation of industry hardened laser systems for production processing and application development, LSPT is on the forefront of expanding the application and use of transformational laser technologies, Recent developments include Laser Bond Inspection, which detects kissing bonds and provides non-destructive testing of bond strength in adhesively bonded structures.

LSP Technologies operates an award-winning facility in Dublin, Ohio under an AS9100 and ISO9001:2008 registered Quality Management System for Laser Processes and Equipment Design.

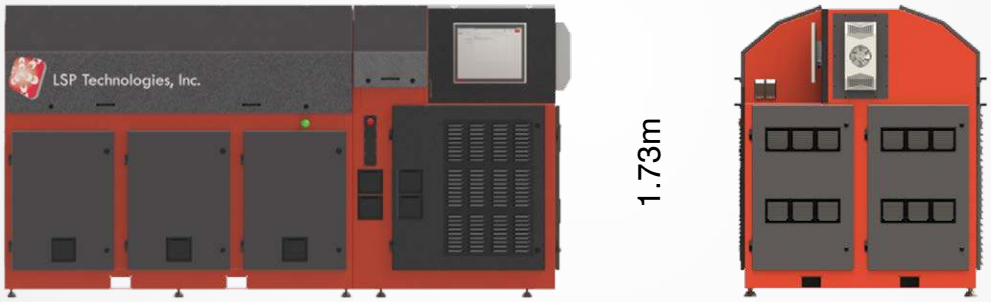
"I commit to you that we will strive to deliver our production services and equipment to you at a cost that is affordable to you, on time, and with all of the quality requirements established for your products."

~ Jeff Dulaney, Founder, President and CEO

Procudo® LSP System

The MOST POWERFUL line of custom laser peening systems in the world

Available for purchase or lease



3.25m

1.42m

System Advantages:

- Easy interface to production line robots
- Remote monitoring
- Real time process verification
- Custom systems available

Procudo® Specs (shown):

- Energy: Up to 10 joules per pulse
- Variable pulse rate
  - Up to 20 Hz
- Variable pulse width
  - 8 – 16 nanoseconds

Laser Class 4 in accordance with FDA 21, IEC 60825-1, EN 60825-1. SCATTERED RADIATION CLASS 4 LASER PRODUCT FDA 21CFR CH.1, 1040

U.S. installations must meet ANSI Z136.9.

Avantages

Le procédé LaserPeen™ possède des avantages tels qu'une plus grande résistance à la fatigue et á un bon nombre de types de défaillances. Le martelage laser peut être utilisé pour renforcer les zones des pièces sujettes aux défaillances, ce qui augmente la durée de vie des pieces et, au même temps, diminue la fréquence des intervalles d'entretien et les temps d'arrêt, sans en modifier la conception. Le martelage laser peut également améliorer les propriétés des pièces ou des machines qui ont été reconcues, pour répondre aux exigences de la conception initiale en matière de performance, et les rendre ainsi plus légères, moins coûteuses ou plus faciles à fabriquer.

Le martelage laser est une étape de fabrication solide, qui vous offre plus de possibilités, plus de flexibilité, une capacité unique d'améliorer les produits actuels et d'en développer des nouveaux. La performance des pièces d'occasion martelées au laser peut être équivalente à celle des pieces neuves. Le martelage laser offre une plus grande résistance à la fatigue, ce qui vous permet de réduire la fréquence des défaillances et d'éliminer des inspections coûteuses et la nécessité de concevoir de nouveau les pièces avec des matériaux plus coûteux ou plus lourds.

Vorteile

Die LaserPeen™-Bearbeitung bietet Vorteile, wie z. B. verbesserte Ermüdungsfestigkeit und höheren Ermüdungswiderstand gegenüber vielen Arten von Materialversagen. Das Laser-Peening kann angewandt werden, um ohne Konstruktionsänderungen fehleranfällige Bereiche von Bauteilen zu festigen und so die Gebrauchsdauer dieser Bauteile sowie deren Wartungsintervalle zu verlängern. Zudem können Ausfallzeiten reduziert werden. Alternativ können durch das Laser-Peening die Eigenschaften umkonstruierter Bauteile oder Maschinen hochgerüstet werden, um die ursprünglichen Anforderungen an die Entwurfsleistung zu erfüllen. Dadurch werden die Bauteile oder Maschinen zeitgleich leichter, kostengünstiger oder einfacher zu fertigen.

Das Laser-Peening ist ein robuster Fertigungsschritt, der mehr Möglichkeiten, größere Flexibilität und eine einzigartige Fähigkeit zur Verbesserung aktueller und Entwicklung neuer Produkte bietet. Die Leistungsfähigkeit lasergestrahlter, gebrauchter Bauteile kann dem neuen Teile entsprechen. Das Laser-Peening bietet eine erhöhte Ermüdungsfestigkeit. So kann die Ausfallhäufigkeit verringert und auf kostenintensive Überprüfungen sowie das Umkonstruieren von Bauteilen mit teureren oder schwereren Materialien verzichtet werden.

利点

強度の向上を実現し、製品の欠陥を解消するためにレーザーショックピーニング（LSP）を使用することによって、いくつかの利点が得られます。問題の多い部品の欠陥の出やすい部分にLSPを適用すると、設計そのものを変更することなく、同部品の耐用年数および機械のメンテナンスの間隔が延長され、故障時間が削減されます。また、設計上の強度要件を満たすためにLSPを利用することで部品または機械の軽量化、製造の簡易化が可能となり、コスト削減を図るために部品または機械を再設計することも可能です。

レーザーピーニングは現行製品のアップグレード、もしくは新製品の開発向けに、他の方法よりも優れた制御、柔軟性または独特な効果を実現できる新しい製造ツールです。中古部品でさえ、レーザーピーニングを施した後は、新品よりも高い性能を発揮することが期待できます。レーザーピーニングによって得られる更なる高い疲労強度であれば、コストのかかる検査やより高価な資材を使用した部品を再設計する必要性を削減または排除することが可能となります。

LSP Technologies

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