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# Laser Peening – A Means to Strengthen Metals

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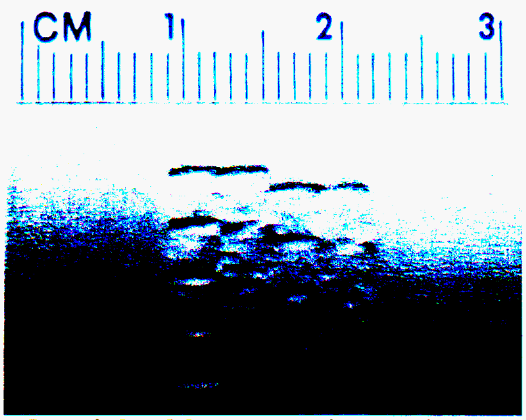
# Lasershot Peening -- A Means to Strengthen Metals

*Improve Fuel Efficiency and Reduce Emissions for the Next Generation of Light and Heavy Vehicles*

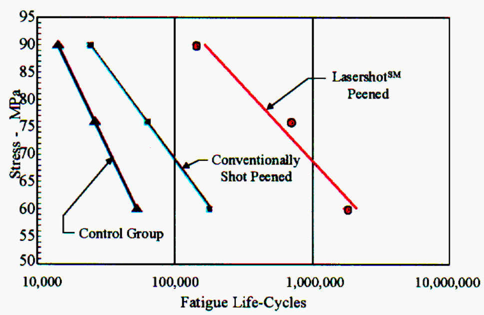
Lasershot peening is an emerging modern process that impresses a compressive stress into the surfaces of metals, improving their operational lifetime. Almost everyone is familiar with taking a strip of metal or a wire and bending it multiple times until it breaks. In this situation, when the metal is bent, the surface of outer radius is stretched into a tensile state. Under tension, any flaw or micro-crack will grow in size with each bending of the metal until the crack grows through the entire strip, breaking it into two pieces. Flexure of metal components occurs in most applications. The teeth of a transmission gear flex as they deliver torque in a vehicle. Springs and valves flex every time they transfer loads. If fatigue failure from flexing occurs in the tooth of a transmission gear of light or heavy vehicles, in a fan blade of a diesel engine, in shock-absorbers or safety-related supporting structures, significant loss of assets and potentially loss of human life occurs.




**Laser-induced deep compressive stress in metal**

Lasershot peening, better than any other technique, has the potential to extend the fatigue lifetime of metal components. In the process, the laser generates a high intensity shock wave at the surface of the metal, straining the metal and leaving a residual compressive stress. If the compressive stress is intense and deep enough, when the gear tooth or component flexes under load, the surface remains in compression and a micro-crack or flaw on the surface cannot grow.

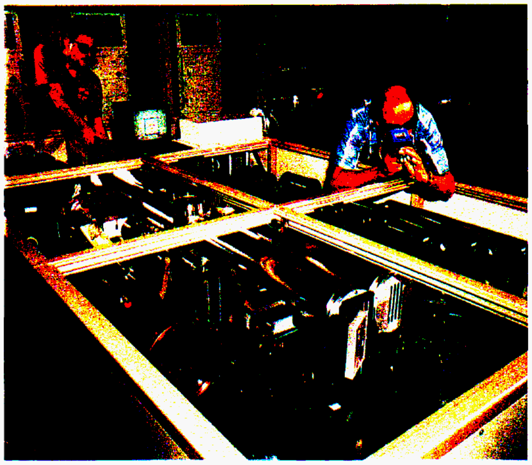
Test data on gears are showing lifetime improvements up to 6 times. Tests on structural aluminum components, such as used in the transportation vehicle are showing 10 to 15 times lifetime improvement. As shown in the Figure below, recent fatigue tests on 2024 T3 aluminum under various stress load conditions, show more than 50 times improvement in fatigue lifetime for structural aluminum test plates when compared to unpeened components and 10 times when compared to conventionally shot-peened components.




**Fatigue Life-cycle Measured in Aluminum**

The concept of the laser peening process has been known for over 20 years. However, a high-energy laser, suitable for production processing had not existed. Within the last several years, using knowledge gained from DOE funded laser fusion work and with contracts for DOD projects (US Navy, US Air Force and DARPA) LLNL has developed laser peening process. The Livermore laser has an average power at the required energy that is 20 to 50 times higher than any other available technology. This advance allows direct commercialization of the process.

LLNL has licensed the laser technology to Metal Improvement Company (MIC) of Paramus NJ and is engaged in a cooperative research and development agreement (CRADA) with them to fully commercialize this process.



Metal Improvement Company is the world's largest supplier of peening services and is introducing the technology into a broad range of applications involving the automotive, aerospace and medical industries. Current results are all very positive.

## OTT Support is Required

OTT and US Auto-industry might apply the lasershot peening technology to improve fuel economy and reduce emissions for the next generation of vehicles in two major ways:

***Reduce vehicle weight and imporve fuel efficiency***

It enables the auto-maker to strengthen metals and reduce the size of structural material (such as aluminum, etc.) needed for vehicle-safety. A typical response to failure in a component is to make the cross-section "beefier" so as to reduce the peak stress loads and thus increase the fatigue lifetime. Lasershot peening will allow metal parts be made thinner in cross-section and still attain or exceed the desired lifetime. This enables auto-maker to manufacture vehicles with lighter weight materials and hence increase *payload capacity and fuel efficiency*.

***Retard erosion inside the fuel injector tip and reduce emissions***

Erosion of the inside edge and surrounding wall of injector-orifices often leads to uncontrolled enlargement of the spray-holes which cause over-penetration of liquid-fuel in the combustion chamber. It degrades the fuel utilization efficiency and increases diesel engine emissions of unburned hydrocarbons, and oxides of nitrogen. Lasershot peening enables the auto-engine-maker to increase the mechanical strength of injector tip, so that fuel injectors with *smaller orifice-diameter and higher orifice-density*.

The development and eventual commercialization of the Lasershot Peening System will have extreme broad-based economic implications to the United States.

Although our CRADA partner is able to support transfer of the technology from the laboratory to the factor floor but they are not able to support the R&D required for process optimization. A parametric study of the laser peening process on materials of interest to the US Automakers will enable us to introduce this technology to industry more quickly. Capabilities at LLNL in advanced lasers as well as modeling of shock physics and equation of state would provide enormous advance in achieving this goal.

DOE support to develop these technologies would allow process optimization and would provide for a more effective and cost efficient process.

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