VDOT’s Laser Coating Removal Research

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The Virginia Department of Transportation is conducting research investigating the efficacy of using high-wattage Lasers for laser ablation coating removal (LACR) systems for removing coatings from existing bridges.

High-wattage, hand-held lasers are now commercially available at costs that have increased their potential value for use in removing coatings on bridges.

The objective of this project is to determine the feasibility of utilizing high-wattage LACR systems to remove coatings from VDOT bridges.
Laser coating removal is an ablative process that can be applied to a variety of substrates, including metal. Laser energy is focused onto the surface and is absorbed into the coating, resulting in decomposition and removal of the coating and causing only a minimal increase in substrate temperature. The key advantages in the use of lasers for coating removal include their non-contact nature and the fact that they use no secondary medium that contributes to waste streams.
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Laser Ablation Coating Removal (LACR)

- Surface layer absorbs the pulsed laser energy and is converted into vapor (particles) from thermal energy.
- Fumes/particles from absorbing layer captured using an integrated 3-stage filtration unit.

1000 W Q-switched Nd:YAG laser, λ = 1064 nm, pulse mode, 83 ns

Nd:YAG = Neodymium: Yttrium Aluminum Garnet
Coatings on steel bridge beams generally tend to fail at the ends of the beams under expansion joints.
Current practice requires containment structures for removal of existing coatings.

Although coating failures are generally limited to 15% of the total beam length, the economics of containment structures often lead to the decision to recoat entire structures rather than only the beam ends.

If alternate technologies were available to allow contractors to remove coatings only at the ends of beams and to do so without containment, VDOT could potentially address more of its coating needs with current budgets.
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PHASE I
Laser processing was conducted on October 26, 2016 at Norton Sandblasting Inc. located in Chesapeake, VA

Samples taken from bridge on Rt. 685 (Telegraph Road)
Pittsylvania County, Structure #6096, b. 1932

Some samples were grit blasted for a different processing condition

El Group retained to conduct personal, area, and filter monitoring along with filter sample collection
Industrial Hygiene (EI Group) Summary

- Air monitoring results indicated that personal and area concentrations were below the OSHA Permissible Exposure Limit (PEL) as an 8-hour Time Weighted Average (TWA).

- All area and personal samples were below laboratory detection limits for sampled contaminants, except lead. However, concentrations of lead were well below the action level (AL).

- Toxicity characteristic leaching procedure (TCLP) analysis for eight metals was performed. Of the three filters, the particle filter was hazardous for lead, recommended that the filter is disposed of as hazardous waste.
VDOT’s Laser Coating Removal Research – Phase I

➢ Adapt Laser Systems CL 1000, 1 KW hand held laser
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➢ Laboratory LACR Work on Beam
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➢ Removal of thicker debris by hand accelerates LACR from beams
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➢ Laser cleaned flange
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PHASE II
Onsite Demonstration - Rt. 695 in Farmville, VA - August 15, 2017

- Laser system was transported to an in-service bridge and operated from a trailer
- Biggest issue was cleaning hard to reach places such as beam ends, bulk heads, and bearings with unusual geometries.
- All within industrial hygiene limits (VDOT contracted testing)
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Not all areas were accessible with the laser for cleaning
PHASE III
Bridge Bearing Laser Cleaning Conducted at Norton Sandblasting November 9, 2017

- Conducted to determine the capability of the Adapt Laser system to effectively clean harder access areas such as bridge beam ends and bearings.
- In order to evaluate the ability for the laser to clean tighter areas, the Clean Laser 500W system was used with the CleanCUBE H15 head (henceforth denoted CC), which consists of a laser optic head with a light aperture that is 90 degrees to the incoming optic cable line, allowing for a more maneuverable optic that also takes up less space,
- A robotically mountable optic head was used which was not ergonomically designed for human use.
- An external vacuum source used, industrial hygiene not in place
The 500W laser and CC optic appeared to remove most of the outer layer of rust and remaining paint after multiple passes, however the 1000W laser was also tested. After removing the vacuum nozzle to shorten the laser optic head length, the 1000W laser was tested leaving a surface comparable to that observed after cleaning with the CC. However even with the vacuum nozzle on the 1000W optic laser head removed, the optic was still too large for use in cleaning bridge beam ends and bearings. Therefore the 500W laser with the CC head was determined to be the only viable option for cleaning these tighter and recessed areas.
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- The bearing both (a) before and (b) after laser cleaning using the 500W and 1000W laser systems.
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PHASE IV
Additional testing was performed during July and August of 2018.

Work that utilizes a flame or can generate a spark (hot work) has the potential to cause sublimation of toxic coatings.

Two coated VDOT beams were delivered to Norton Sandblasting on July 29th, 2018 for use during the testing. Beams showed variability in coating appearance, coating characterization, and structure.

On July 30th and August 1st, 2018 an industrial hygiene survey was conducted as a means of determining whether the laser ablation system can be used as a feasible engineering control and whether the laser ablation system successfully reduced the risk of employee exposure to lead and other toxic metals during coating removal and subsequent hot work operations.
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- On July 30th, Norton Sandblasting employees used a Laser ablation system to completely remove 55 linear inches of coating on the two VDOT beams.
On August 1st, 2018, VDOT employees completed task based hot work rotations on each beam as a means of evaluating whether the laser ablation system effectively removed enough leaded coating to reduce worker hazard to leaded fume during hot work operations.
The industrial hygiene survey showed that the laser ablation process can successfully reduce the risk of employee exposure during VDOT beam de-leading and during hot work conducted on de-leaded beams where the coating was completely removed.
Summary From Phases I - IV
LACR effectively removes the coatings investigated, including Lead based paints. Although microscopic investigation reveals that small paint particles remain on the surface after cleaning (which are unapparent to the naked eye), this does not appear to adversely affect subsequent coating adhesion.

The coating adhesion of LACR surfaces was determined to be the same or better as compared to that of standard (grit-blasted) steel surfaces.

LACR does not detrimentally affect the mechanical properties of the steel (ASTM structural steel A36) that was examined in this study – the tensile yield strength, ultimate strength, ductility, and fatigue strength were all on parity with expected values.
Industrial Hygiene (IH) study results show that LACR poses little risk to either the laser operator or to the surrounding environment (well below the current OSHA Permissible Exposure Limit (PEL) and OSHA Action Limit (AL) for each sample’s work area.) This could provide a potential cost-benefit, since LACR does not require the type of containment that traditional grit-blasting approaches require.

The hazardous waste generated during LACR is restricted to the vacuum particle filtration system. It is noted that this system must be disposed of as hazardous waste and that appropriate personal protective equipment (PPE) should be worn.

Field studies to perform coating removal on bridge beam ends and bulk heads with the selected laser system were problematic due to tight space limitations and geometry. The team did observe, though were unable to test in detail, alternative LACR systems which are smaller, lighter weight, and more powerful.
LACR can be employed as a lead-abatement technique in preparation for other processes, such as cutting or welding routinely performed by VDOT. Such applications would not require high productivity rates or access to tight spaces.

Tight access areas remain a challenge: e.g. bearing interior surfaces, bolt heads, pursuing additional companies with 90° heads.

Production rate was slow during Phase II.

The laser ablation process can successfully reduce the risk of employee exposure during beam de-leading and during hot work conducted on de-leaded beams where the coating was completely removed.
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Next Steps
VDOT’s Laser Coating Removal Research – Next Steps

➢ Publish a report documenting the results of the research – the draft report is currently under review

➢ Review equipment from additional manufacturers to improve production rate and access to tight areas

➢ Review possible mechanical assist equipment for holding hand held laser in place – manual use of the hand held laser causes operator fatigue
Consider the use of an induction device in conjunction with the laser. The induction dis-bonder works by the principle of induction. Heat is generated in the steel substrate and the bonding is broken. The coating is then removed entirely without disintegrating and completely free from contaminating agents, i.e. blast media. This makes disposal and recycling of waste easier and more cost effective.