DE-CONTAMINATION WITH LASER LIGHT

Dipl.-Ing. J. Sommer, M. Savelsberg, Clean Lasersysteme GmbH,

Technology overview

CleanLASER was founded in February 1997. From the very beginning, the business has focused exclusively on developing and sale of innovative devices specifically for precise cleaning and surface preparation by harnessing the remarkable properties of pulsed laser systems.

CleanLASER is the only global manufacturer of fiber-coupled, compact, mobile or stationary laser cleaning equipment, both automated and handheld, with up to 1000Watt of laser power. Each laser system is built with special know-how gained from a successful history of delivering latest technology to leading companies all around the world. Today more than 350 devices are working worldwide.

Pollution and coatings are gently removed without damage to the base material. The laser can be applied precisely. Therefore there is no need to clean the whole component; merely the required area can be cleaned or a layer can be removed and waste could be minimized.

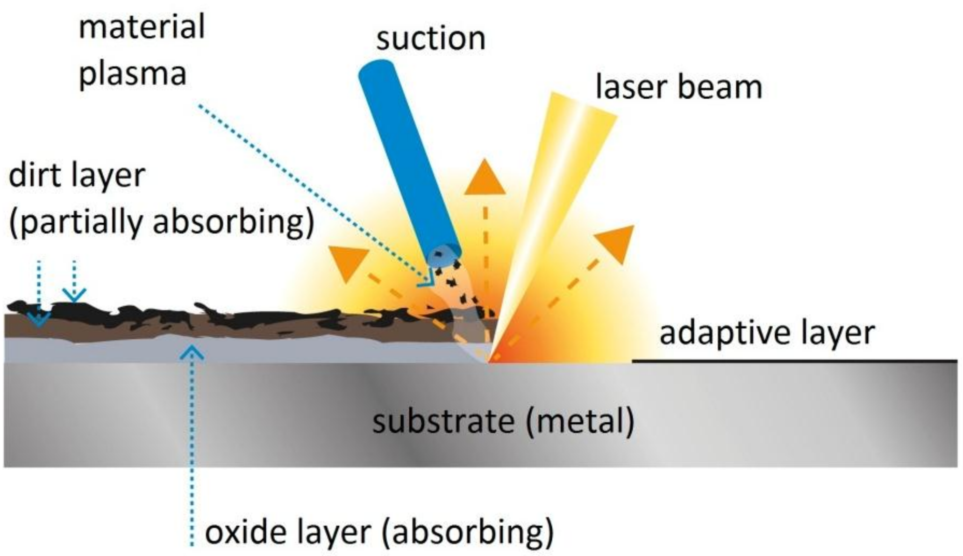
Therefore, the managing partners of Clean-Lasersysteme GmbH were awarded with the German Environmental Award by The German Environment foundation (DBU) in the year 2010.

Main benefit for the customers is the economic and ecological effect of the cleaning method. The vision to clean with light became a technically mature method, by which surfaces are treated contact-free and media-free, which leads to a significantly reduced amount of waste. Compared to conventional methods, abrasives and chemicals are redundant. Thus a mono-material waste disposal is guaranteed. Dust and noise are a thing of the past. A connected suction system will collect all removed particles.

How it works

The laser energy is produced inside the resonator. There is a so called q-switch integrated which provides short single pulses with a very high peak power. This peak power is necessary to start an ablation process without damaging the substrate material.

The focused laser beam precisely vaporizes the target coating or contaminant. The powerful, very short, rapid and moving laser pulses produce micro-plasma bursts, shock waves and thermal pressure resulting in sublimation and ejection of the target material.

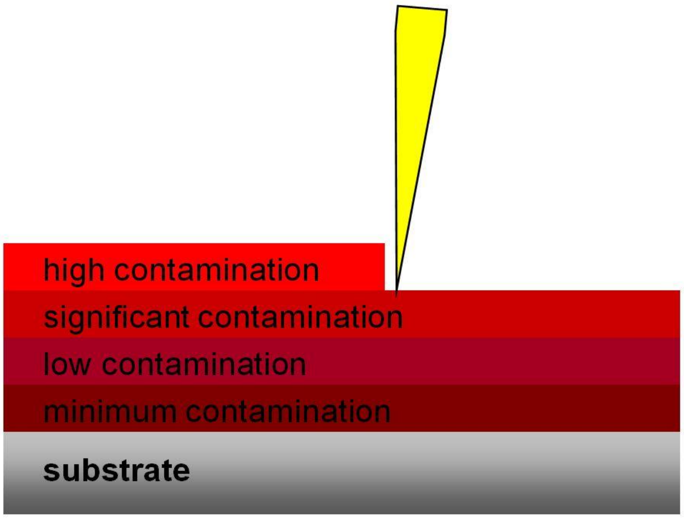


Picture_01: schematic drawing of the cleaning process

Optimizations of laser parameters result in a maximum interaction with the target material and at the same time a sensible cleaning effect for safe removal without damaging the substrate. Metal surfaces are well-suited for many laser cleaning applications. The coating, residues or oxides elected for removal are affected while the laser ablation stops by reflection from the metal surface. Laser beam power density is accurately and easily adjusted to achieve the desired cleaning result. A unique advantage compared to other conventional methods. Vaporized materials are captured at the source by a laser fume extractor filter unit –this means no emissions to contaminate the working area and beyond no clean-up.

Actual situation

The use of laser for oxides removal leads to a usage for de-contamination purposes. The model describes that the contamination gradually decreases in direction to the substrate. So the upper (oxide) layers are the most contaminated. The laser can remove these oxides and also the contamination.



Picture_02: schematic drawing of contamination level of oxides on the surface

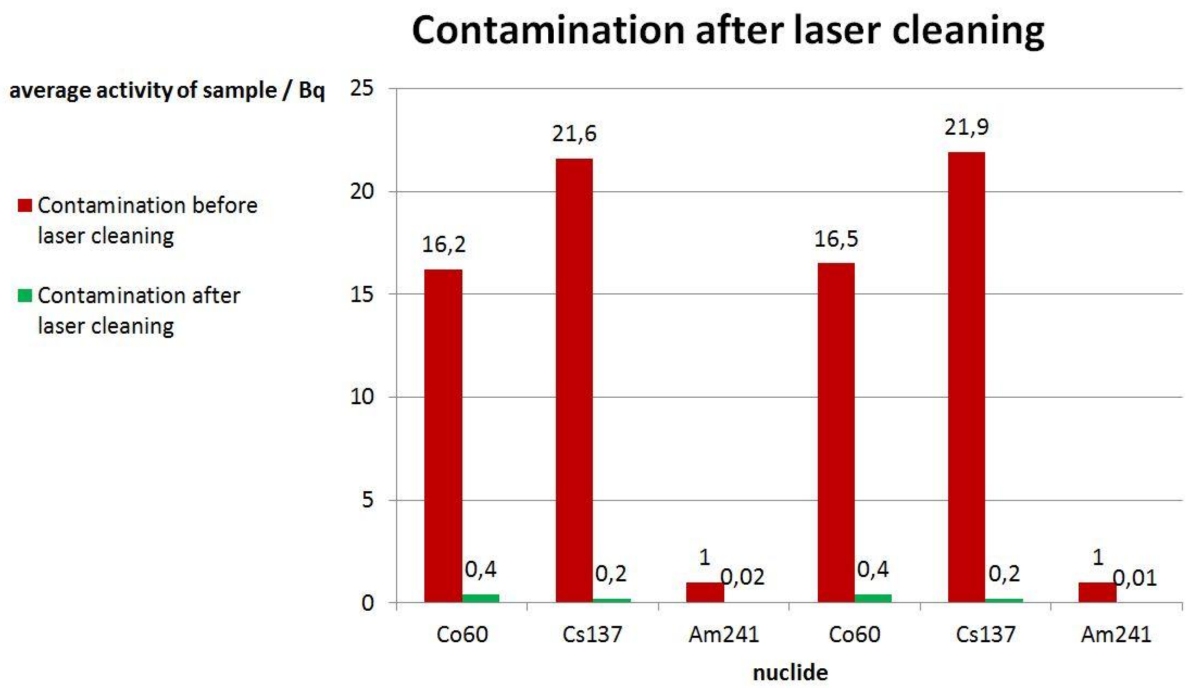
In respect to the picture_02 all layers can be cleaned and the contamination will be reduced significantly. Depending of the material and thickness of the contaminated layers a few passes are necessary.

The environmental friendly cleaning method is already tested in different areas of the world. Several (confidential) projects show the efficient de-contamination of nuclear contaminated material. Main focus of the de-contamination is the treatment of metal parts. In general the cleaning of other base materials is also possible but due to physical limitations not economically useful today. All laser applications in the field (customer laser devices) are based on the decontamination of metal parts (rust and oxide removal or paint removal).

The nuclear de-contamination of metal with laser is tested in USA, France, Switzerland, China, Japan and Germany and further tests are scheduled. The trials show very promising results. De-contaminations rates of up to 1000 were achieved.

In a cooperation with Forschungszentrum Jülich, FH Aachen, sat.Kerntechnik GmbH and cleanLASER a diploma thesis investigates the potential of the de-contamination method.

Steel and stainless steel samples, either bare or coated with a single or a double layer of decont varnish, were contaminated with 60Co, 137Cs, 241Am in a tenfold permitted limit. Afterwards they were treated with a diode pumped and pulsed Nd-YAG 40 W laser. Each sample was decontaminated by this method. Average decontamination factor was about 40 with 60Co, 110 with 137Cs, and 100 with 241Am. REM photos show that after decontamination the samples' surfaces are strained only in an utmost minimal way. The removed activity was collected by a H14 suspended particle filter with a flow rate of 54m³/h. [1]



Graph_01: contamination before and after laser cleaning (source of values [1])

The tested laser device was a CL 40 SP with a laser power of 40W. Such systems are used for small areas. For bigger areas in the field an improvement of parameters and laser power is necessary. Therefore laser devices with up to 1000W are available.

After gaining experience how to handle a laser and regarding laser parameters in the course of pilot tests, contaminated samples were prepared and decontaminated successfully. The laser parameters could be adjusted precisely, which enabled optimized performance data for each sample surface. The laser method resulted in area rates of more than $2m^2/h$ – these rates are quite equivalent to those rates of well-established methods. Bare metal surfaces can be treated faster and more easily than those surfaces covered by decont varnish.[1]

Much better results will be achieved with high power laser device with up to 1000W laser power. These devices achieved in practical (manual) use area rates up to $4m^2/h$ on real parts and de-cont factors of approx. 500. The performance can be improved by further training, automation and smaller technical changes. Finally the results of the diploma thesis allow scaling the speed of cleaning up to $20m^2/h$ (CL 1000, automated usage, flat surfaces, depending on contamination).

Today laser devices are already in use for decontamination applications on customer side. The customer uses standard devices for manual applications. These devices have proved their reliability in several industrial plants with 24/7 usage since 2006 (3^{rd} Generation of cleanLASER devices). The scientific background for decontamination was verified by bilateral research results, which the customers do not wish to publicize too much however. At least the features (like reliability, flexibility and economic efficiency) necessary in automotive and aerospace industries could be transferred to the customer in nuclear field using the laser devices.

Even if the technology is already introduced with high power laser in the field, cleanLASER likes to invite scientific institutions helping to establish this future technology by publishing scientific studies in order to proof the possibilities and limitations.

Outlook

The next actual project will be to install a CL 500 device into an existing gantry system for cutting tubes. After the cutting process (a mechanical process) the laser will de-contaminate the tubes inside and outside. The project is planned for 2013/14 and will be realized with a partner in UK which already delivered the mentioned gantry system. In spring a demo unit (for non-contaminated material) will be installed.

Furthermore several requests from all over the world will transfer the conventional technology into the nuclear sector. Also concepts for hot nuclear areas are already designed and tested.

Conclusion

A cleaning with the laser is an available future technology now. Further research activities should determine the practical results. A first step is the diploma thesis in cooperation with Forschungszentrum Jülich, FH Aachen, sat.Kerntechnik GmbH and cleanLASER.

This thesis demonstrates that innovative laser technology is a high potential method in the field of decontamination. Tests with standardized contaminated samples verified that decontamination can easily be effected. The volume of radioactive waste material is very small. Probably the exhaust air leaving the filter under runs legal limit values. Thus special occupational health and safety actions, e.g. breathing gears or overall protective clothing for operating personnel, are needless. In order to exploit full potential of the laser method in question, further experiments are required. These might include test such as tests with different materials and different surfaces as well as examinations regarding cost effectiveness. [1]

The laser is already in use in commercial decontamination projects. The experience made in conventional industry can be transferred to nuclear industry, too. These applications focus on what have traditionally been very labour intensive and time consuming processes and have delivered huge improvements in quality, reliability of process, dramatic reductions in waste and consistent quality of the decontaminated work piece.

Finally the driving force for laser decontamination was and will be an economical effect for the customer. The way is shown through savings in waste and reduced energy consumption, advanced automation concepts and quality improvement.

The laser cleaning / de-contamination has great potential for automated or manual usage in the field of de-contamination of metal parts. Still the development is not finished and a scientific discussion should be helpful to fulfill the needs of the de-contamination community.

Sources:

[1] Diplomarbeit Untersuchungen zur Dekonatmination durch Hochleistungslaser, Aramazad Mirzakhanian, 2011, FH Aachen