

# Renaissance laser cleaning of historic monuments

**The technology of laser renovation of monuments originates in the 1970s and has been associated with spot cleaning with a spot with a diameter of up to a few millimeters. The last years of rapid technological development have made it possible to partially automate the process of removing diapers and eliminating its imperfections, but also to reduce the size of the devices. As a result, mobile manual cleaning systems began to appear, which ensure a high quality of the cleaned surface and achieve unprecedented efficiency. The main advantage of current solutions is the automated cleaning of surfaces up to several centimeters in width and height.**

## Laser ablation

Each of these devices is based on the process of laser ablation, i.e. producing a very concentrated but very short laser pulse to vaporize the contaminants from the surface of the cleaned object to a gaseous state.

The essence of the entire monument cleaning process is the selection of the appropriate wavelength of light and laser beam parameters for both the surface to be cleaned and the dirt to be removed. This is a real challenge for people who are new to their experience with lasers. There is a growing selection of instruments on the market, which can be found under the terms "laser cleaning" or "laser ablation". The vast majority of them are industrial devices that allow you to work only with metal surfaces. This equipment can be dangerous to historic objects (despite the technology described as non-invasive), and the result of this process is in the hands of the operator and the device itself.

## Choice of technology

Modern laser sources make it possible to create very universal cleaning devices, the range of parameters of which allows cleaning almost any surface of historic buildings. However, this is not possible without additional solutions, which are used simultaneously in the preparation of the energy distribution of the laser pulse, the automation of its shift in the X and Y axes, and the calibration. with the use of properly prepared software. The cohesion of the operator's experience with the latest technological solutions is necessary to obtain the required quality in the conservation of monuments.

## 1D scanners

One of the first steps in automation was the use of a head with a 1D galvanometric scanner in the X axis. This solution automatically moves the laser beam along an X axis (left / right ). The effect of this solution is the ability to clean with a "line". However, it has been noticed that at the same time what is called the purging effect occurs at the edges of the sweep. It results from the nature of the work of the scanner which, by moving the beam to the end of the working field, must slow it down and start moving it to the other side. Inhibiting the beam at the edges of the scan exposes the surface to its action longer than in the case of the full width of the scan. This leads to the cleaning of the edges of the scan and the formation of visible marks (burns) on the cleaned surface.

This is not the only problem with 1D scanners in applications. In order to clear the working field in the X axes, you have to manually move the head in the Y axis (up / down). This not only causes the analogous problem of uneven exposure of the surface to the laser and cleaning the surface of the entire working field. Holding the laser in one place for too long can damage the surface. Depending on the material, its degradation can manifest itself in





different ways, for example the facet of the red brick will turn gray, visible fragments can appear in the sandstone and the wood can be burnt.

## 2D scanners

The use of a second galvanic-metric motor in the laser head made it possible to create a scanner operating in the X and Y axes. Thanks to this, the influence of the operator's hand movement was significantly reduced, the risk of material damage has been reduced and the uniformity and aesthetics of the cleaning effect have been improved. Depending on the lens used, scanners of this type can automatically clean a surface with dimensions up to  $18 \times 18$  cm. Just press the radiation emitting button and keep the head of the device still.

This type of sweeping provides the highest cleaning efficiency and uniform surface coverage, but despite the significant improvement in surface safety and cleaning quality, the problem of cleaning effect persists. Finding a solution turned out to be more difficult than expected. As a result, some manufacturers have started to use less efficient scans in the form of circular sinus shaped paths or the like. Their geometry (eg a circle) allows the beam to move at a constant speed without slowing it down in individual parts. In this solution, the purging effect disappeared, but the problems of uneven surface coverage and the possibility of its damage returned.

Few cleaning equipment manufacturers have managed to produce an X and Y scan almost perfectly. Devices with such a scan are distinguished by high efficiency, thanks to which they can be used successfully both for cleaning sculptures or entrance gates, as well as for large-area work, such as facades.

## The future of laser cleaning

The laser monument renovation process has always met the highest quality standards, but has never been so efficient and easily achievable. Year after year, we see more and more technological progress and invest in the latest solutions. We are convinced that the laser cleaning market is starting to recover and it is a future method of removing layers in monument conservation.

