LASER WELDING CONTROL USING THERMOINSPECTOR SYSTEM

Application story
Laser welding control using ThermoInspector

Introduction

There are 3 possibilities of how to weld plastic using laser beam:

- Spot welding (both plastic or metal welding)
- Circumferential welding (both plastic or metal welding)
- Contour welding (transmission) – welding head moves towards the object or vice versa. This defines the characteristic motion curve. (typical for plastic welding). Normally fibre laser or solid-state laser is used.

LED laser, used for contour welding, has standard wavelength of 1μm. This wavelength in near infrared is ideal to let laser go through the material which is transparent for this wavelength (clear plastic). On the other hand, it provokes heat excitation on the opaque (for this wavelength) plastic layer (black plastic) which leads to welding two different layers together. The heat itself would not be enough to cause the welding which is why there is need of pushing the two plastic materials together either by gravity force or pressure machine.

This principle is also described on the figure 1.

![Figure 1: Laser welding principle](image1.png)

![Figure 2: Spot welding control by ThermoInspector](image2.png)

The thermal camera is ideal to control laser welding process, but it is important to consider its capability to have as big density of pixels on the laser beam as possible.

How does Workswell ThermoInspector control work?

There are two possibilities of using ThermoInspector control during laser welding depending on the welding process:

- With defined measurement delay - due to the thermal propagation from the weld spot to the object surface. (It takes few milliseconds.)
- Without defined measurement delay - trigger in ThermoInspector is set to the moment when weld head leaves from the direct view on the welding contour. (The time necessary to move the machine corresponds to the time of temperature propagation on the surface.)

The region of interest is selected from the obtained thermal image and represents the area which contains the most important information to control the welding process. This ROI is always selected near the welding spot (generally 20px from the middle of the spot) as shown on the figure 3.
The ThermoInspector assembly is unique not only for the temperature measurement, but especially for the quality control and its possibility to work in real time.

The importance of thermal camera measurement does not only depend on absolute temperature values. Minimal and maximal temperatures must fit the tolerance band which has to be set before the measurement.

Tolerance band is made from many graphs of temperature measurement in time of the same product, in the same place (same condition). Due to the measured temperature, an envelope is set (figure 4).

Even the thermography control of welding process is very effective, it is not possible to express with absolute certainty if the product is of high quality or not, the only possibility to do that is using the blasting test. Quality of the weld is affected by many factors such as laser power, force needed for pressing two layers together, time of welding etc.
Main advantages of Workswell ThermoInspector

- Repeatability
- Possibility to detect the place where the excitation of the heat is highest
- One specific wavelength measurement – higher speed and precision
- Possibility of using more thermal camera simultaneously to accelerate the detection
- Weld slice localization:
  - Thermal profiles evaluation – along the welded contour there are obtained about 20 - 30 temperature profiles (shown in red on the figure below). The maximum values are searched in each of them.

![Figure 6: Thermal profiles along the weld contour](image)

- Another approach to the same problem – the contour is surrounded by an annulus in the cases of circular contours. Annulus is divided into many temperature profiles (see figure below), which are evaluated as well as in the previous approach.

![Figure 7: Thermal profiles in the annulus](image)

Positioning of the thermal camera

- Spot welding: 45° from the laser beam axis.
- Circumferential welding: welding head axis is connected to the thermal camera and object is rotating (creating circumferential welding).
- Contour welding (transmission): thermal camera is fixed to the object and covers the entire contour area. (This approach requires multiple cameras.)
It is important to have camera with wide FOV and small resolution. Typical configuration of thermal camera from Workswell company can be:

- Workswell WIC 640, focal length 19 mm, FOV 32° × 26°
- Workswell WIC 336, focal length 19 mm, FOV 17° × 13°

![Figure 8: Positioning of thermal cameras during laser welding process](image)

![Figure 9: Contour welding in ThermolInspector](image)
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