Study and design of hollow core wave guide for LASER beam propagation

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Summary

In most of the components, plastics are replacing the use of other materials. Since plastic allows for a lighter product, it is also possible to obtain more complex shapes with the use of less energy for forming the plastic components. This determines a substantial increase in the use of polymeric materials in many industrial applications. The increase in production volume leads to a greater investment by industries in technologies for processing plastics.

The components that make up a product have different functions and properties. In other cases, the unique option to produce a part is to divide it down into sub-parts. For these reasons, it is often necessary to fasten several components together. Among the various joining methods, there are gluing, mechanical fixing, welding. Each type of fixing has its advantages and disadvantages.

Welding is one of the most widely used technologies in the industrial field. For plastic, different welding technologies have been studied and developed, through transmission laser, in particular, is the most widely used. There are different technologies for transmission. Some are still new and therefore need to be optimized for industrial applications.

The subject of this thesis work is concentrated on this context. Simultaneous laser welding has been studied and developed.

Laser welding was introduced several years ago and is widely used in the industrial sector. However, different technologies or applications have developed in recent years and although simultaneous welding was known theoretically, its industrial application is not widespread or is used for easy applications. In this thesis work, methodologies to make this technology suitable for many industrial sectors are researched.

The system for simultaneous laser welding through transmission consists of optical fibers coupled with a hollow core waveguide, which transmits and uniforms the energy on the pieces to be welded.

The beam coming from a diode laser source enters a bundle of optical fibers which divides the power proportionally over several branches. Therefore, each branch of the bundle has a fraction of fibers that are enclosed in a metal shell called ferrule. Each ferrule behaves as a single point of light with a Gaussian outgoing energy profile. The ferrules of many bundles are mounted next to each other and facing the waveguide, that is the element that completely uniform the laser energy.

The main part of the research is the study of hollow core waveguides. These components allow to homogenise the laser beams coming from the different sources, therefore they are the fundamental elements to obtain a good simultaneous laser welding. On the parts to be welded, a homogeneous energy contour is obtained through the waveguide, that profiles the Gaussian power distribution at the output of the optical fibers. Many tests have been carried out to evaluate the characteristic

parameters that influence the energy distribution. Geometric parameters (e.g., shape, height, etc.), materials and treatments on the materials have been studied to obtain the present result. A model of the system in an optical simulator and ray-tracing software, OpticStudio Zemax, was developed. In this way, it was possible to design the waveguide and evaluate the parameters to obtain the homogeneous energy distribution for the welding of the plastic components.

The waveguide is specific for each application. Depending on the component to be welded and the welding path, a dedicated waveguide must be designed. Often the components were very complex so the simulation and design times were lengthened, so there was the need to implement a tool that would help designers in evaluating the best waveguide parameters. In this regard, a code has been written in the SolidWorks API which allows analysing and simulating numerous solutions. When the macro was completed, it was implemented with some dialog boxes in such a way that it resembled a SolidWorks add-in. From the dialog box can be set the simulation parameters of the waveguide. Through a repetition process, the program simulates various geometric parameters and different positioning of the waveguide and ferrules on the ray-tracing software. After the simulation phase, the results established the position and the parameters with the greatest efficiency. The operator can choose the best positioning and develop the complete waveguide that matches the needs of the parts to be welded.