

# **“Laser welding of Ti6Al4V alloy by disk laser: analysis and optimization”**

## **Abstract**

Titanium alloys have been successfully applied in many industrial fields because of their better performance and lighter weight than other commonly used structural materials. The conventional welding methods used for titanium alloys are tungsten inert gas (TIG) and plasma arc welding. In recent decades, autogenous processes with highly concentrated energy sources have become popular; these joining processes are laser and electron-beam welding. The power source can be concentrated in very small areas so as to achieve energy densities up to 10,000 times higher than those of the arc processes. Laser welding allows joints to be made with limited distortion. The fully-automated process, ensures high productivity and high-quality joints. Laser technology is acquiring industrial interest because the electron-beam processes have limitations, such as the need to operate in vacuum, the increased costs and the emission of X-rays. Titanium alloys are widely used in the aircraft industry, because of their high strength-to-weight ratio, corrosion resistance, operating temperature and bonding with composite materials (electrochemical compatibility, similar coefficients of thermal expansion). The criteria for the design, manufacture and operation were changed to obtain structures that are lighter and more efficient than the ones made of aluminum. However, the structures in carbonfiber- reinforced-polymer require the use of metal structures, especially in areas of great concentration of loads. In spite of several advantages, these alloys lead to excessive manufacturing costs related to the cost of the raw materials, the high volumes of waste and the complex and expensive finishing. For these reasons, it is cheaper to produce semi-finished products by welding simpler parts, instead of casting and forming processes; therefore, laser welding can be used due to its high productivity and quality end-products.

The aim of the thesis work is to find the better input process parameters values to weld 3 mm and 1 mm Ti6Al4V sheets using a 2 kW Yb:YAG disk laser. Both bead on plate and butt tests have been performed, and the beads quality is characterized in terms of geometric features, porosity content, microstructure, hardness and strength. This work is organized in five chapters.

Chapter 1 discusses the principles of operation and the different types of laser including disk laser, used in the experimental part.

Chapter 2 presents the properties of titanium and its alloys, highlighting the various fields of application.

Chapter 3 presents a review of the different technologies used for welding of titanium alloys, focusing primarily on laser welding and its mechanisms.

Chapter 4 describes the titanium alloy, equipment and methodologies used in the experimental work.

Finally, Chapter 5 presents the results obtained.