

Chapter 14

Laser-Based Manufacturing Processes for Aerospace Applications

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ABSTRACT

In this chapter the latest developments in Laser manufacturing technologies and processes, used in the aerospace industry, are discussed. Current developments in the aerospace industry are characterised by the reduction of manufacturing and exploitation costs. Thus, the need for implementation of advanced manufacturing technologies and processes in the aeronautic industry, offering cost effective products with improved life cycle, is becoming more and more imperative. Lasers can be used in many industrial machining processes for a variety of materials including metals, ceramics, glass, plastics, and composites. Laser beams, used as machining tools, are not accompanied by problems such as tool wear, tool breakage, chatter, machine deflection and mechanically induced material damage, phenomena that are usually associated with traditional machining processes. The effectiveness of Lasers depends on the thermal nature of the machining process. Nevertheless, difficulties arise due to the difference in the thermal properties of the various components.

INTRODUCTION

The advantages of laser processing in many production applications in terms of cost, time, quality and flexibility, have led a substantial number of aerospace related companies the latest years to adopt laser processing systems, despite their high investment costs. Lasers present high flexibility as manufacturing “tools”, since a number of different in nature processes can be realized with the same laser source,

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including machining, welding, surface and heat treatments, in a variety of materials such as metals, plastics, composites, ceramics wood and glass. Moreover the development of high power lasers (> 2-3 kW) in combination with high speed moving (flying) optics or work piece positioning devices met in today's laser systems, have increased dramatically the production rates of laser processing.

However it is common practice in many industrial environments such technologies not to be fully exploited due to lack of adequate technical know-how. Usually laser equipment is utilized mostly for laser cutting and rarely laser welding of a very specific family of materials, including in most cases mild steels, stainless steels and sometimes Aluminum Alloys. Laser drilling has been used for producing cooling air holes, whereas laser cutting has been used fabricate a large variety of sheet-metal parts such as compressor vane segments. Laser welding, although very popular in other industrial sectors, such as the automotive, is considered as a niche application in the aerospace related industries finding however few applications in aero engine manufacturing such as the production of compressor stator cascades and join cover plates to the cast cores of high-pressure and low-pressure blades.

The laser was invented in 1960 and has offered to industry a new form of energy. The energy generated from lasers can be employed to heat, melt and vaporize most materials; therefore a laser beam can be the energy source in laser material processing; a number of excellent books presents various aspects on the topic, see (Chryssolouris, 1991, Kannatey-Asibu Jr, 2009 & Steen et al., 2010).

There are various types of lasers with different characteristics depending, to a large extent, on the active medium used for the laser action. The principal laser categories include solid state lasers, gas lasers, liquid dye lasers, semiconductor (diode) lasers and free electron lasers. Ruby and Nd:YAG are examples of solid state lasers. Both are extensively employed in manufacturing applications (Akinlabi et al., 2012).

Laser material processing represents a great number of methods, which are increasingly applied in different industrial sectors as promising alternatives to conventional manufacturing processes. Nowadays, the use of lasers in industrial engineering is an emerging field with a wide variety of applications, for example, in electronics, aerospace, molds and dies and biomedical applications.

A detailed bibliometric research concerning the topic “Laser manufacturing” AND “Aerospace” is beyond the scope of this chapter. However, by using the Scopus® scientific database important information can be retrieved. A search with TITLE (laser surface treatment) and SUBJAREA (physical sciences) return 848 documents, with first paper relative to engineering published in 1974. Only from 1984 and then, more than 10 papers per year are published. China (81), France (71) and Japan (63) are the countries with the highest numbers of authors. Another search with TITLE (laser) AND TITLE (aerospace) and SUBJAREA (physical sciences) return 154 documents, with first paper actually relative to aerospace applications published in 1982.

LASER MATERIAL REMOVAL

Mechanical material removal processes are the backbone of industrial manufacturing practice. These processes provide a great deal of flexibility, since the shape of the tool and the kinematics of the tool and workpiece define the geometry of the part. The material removal mechanism is a very important aspect of removing processes. As per Chryssolouris, 2005 the basic material removal processes, rely in one or more of the below mentioned mechanisms:

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