Optics and Laser Technology 101 (2018) 440–445

Contents lists available at ScienceDirect

Optics and Laser Technology

journal homepage: www.elsevier.com/locate/optlastec

Full length article

A post-processing study on aluminum surface by fiber laser: Removing face milling patterns

Ersin Kayahan *

Kocaeli University, Electro-Optics and Systems Eng., Umuttepe, 41380 Kocaeli, Turkey
Kocaeli University, Laser Technologies Research and Application Center (LATARUM), 41275 Yeniköy, Kocaeli, Turkey

ARTICLE INFO

Article history:
Received 15 April 2017
Received in revised form 6 October 2017
Accepted 29 November 2017

Keywords:
Fiber laser
Milling trucks
Aluminum surface

ABSTRACT

The face milling process of the metal surface is a well-known machining process of using rotary cutters to remove material from a workpiece. Flat metal surfaces can be produced by a face milling process. However, in practice, visible, traced marks following the motion of points on the cutter's face are usually apparent. In this study, it was shown that milled patterns can be removed by means of 20 W fiber laser on the aluminum surface (AA7075). Experimental results also showed that roughened and hydrophobic surface can be produced with optimized laser parameters. It is a new approach to remove the patterns from the metal surface and can be explained through roughening by re-melting instead of ablation. The new method is a strong candidate to replace sandblasting the metal surface. It is also cheap and environmentally friendly.

1. Introduction

High strength aluminum alloys are utilized extensively in defense, aerospace, molding, automotive and structural applications. AA7075 alloy is a high strength aluminum alloy of the 7000 series family based on Al-Zn-Mg system, in which Mg combines with Zn, and forms the strengthening precipitates, such as MgZn2 and Mg3Zn, contributing to the improvement in mechanical properties [1,2]. Any improvement of the physical properties of aluminum surfaces is especially important for the automotive industry.

The surface roughness of a metal surface strongly influences its properties such as abrasion and corrosion resistance, tribological properties, optical properties as well as visual impression [3]. Hence, in industrial manufacturing sandblasting, grinding and polishing techniques are widely used to reduce the surface roughness of the desired metal surface. Metal surface processing using lasers can be used in surface cleaning, surface polishing and surface hardening as an alternative. Lasers have recently been used for various purposes other than metal cutting and drilling such as surface polishing of tool steel [4], cleaning of polymer surfaces [5], micro-channel milling [6], glass polishing [7], optical fiber polishing [8] and surface polishing of metals [9–11]. The polishing of metal surfaces depends on initial surface roughness and type of materials. Although the mechanism of the polishing process is a question of whether it is ablation or re-melting, there is no loss of material in the polishing by re-melting, only the peaks and valleys become re-localized depending on the surface tension [9]. Continuous lasers (CW) are generally used for macro-polishing and roughness (Ra) values of surfaces greater than about 0.5 µm should be used for macro polishing [10].

The objective of this paper is to explore the effectiveness of using a 1064 nm wavelength, 20 W fiber laser to remove milling patterns and enhance physical surface properties of AA7075 aluminum surfaces. It also discusses a new phenomenon; laser roughening by re-melting.

2. Experimental details

The study was conducted using AA7075 alloy with a commercially available industrial Ytterbium fiber laser (1064 nm) with a maximum output power of 20 W, a pulse duration of 200 ns and pulse repetition rate of 10–100 kHz. The system was equipped with a galvanometric scan mirror that allows the beam to be deflected. A special computer program has been designed to be used for laser marking so that marking parameters and the characters are properly marked. The laser beam was focused on the target through a 160 mm focal length F-T lens. The experiments were carried out in two steps. The first step was the preparation of flat A7075 surfaces produced by different milling parameters such as

* Address: Kocaeli University, Laser Technologies Research and Application Center (LATARUM), 41275 Yeniköy, Kocaeli, Turkey.
E-mail address: kayahan@kocaeli.edu.tr

https://doi.org/10.1016/j.optlastec.2017.11.042
0030-3992/

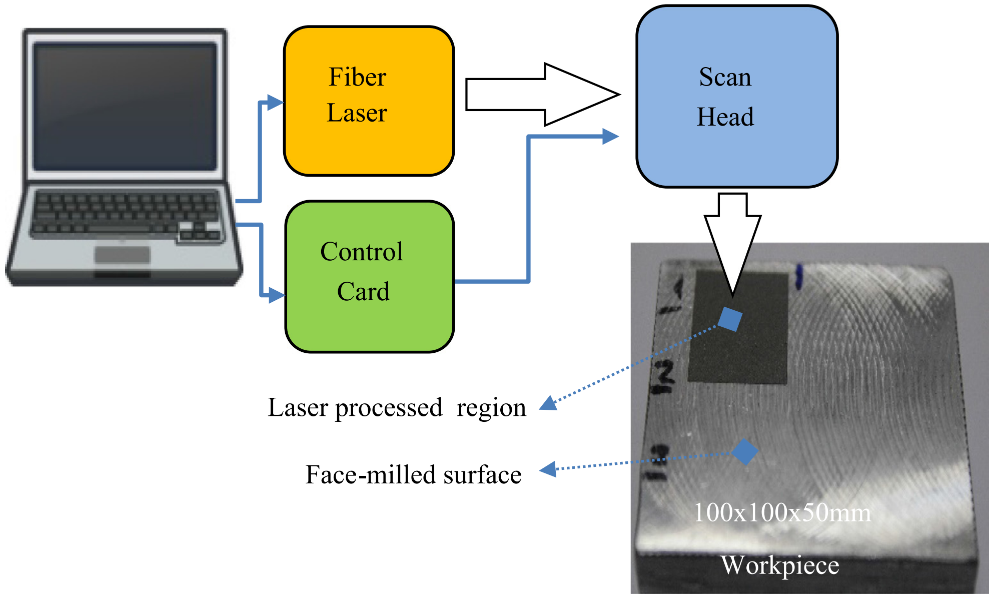

Fig. 1. Visual illustration of the experimental set-up, where the scan head is used to move the laser beam on the face-milled aluminum surface and control card is used to control two motors in the scan head.

Table 1
Chemical composition of AA7075 alloy.

Material	Zn	Mg	Cu	Fe	Si	Zi + Ti	Mn	Cr	Al	Other, each
AA7075	5.1	0.3	1.2	0.5	0.5	0.25	0.3	0.18	91.62	0.05

Table 2
Milling parameters of AA7075 surface.

Process parameter	Spindle speeds/rpm	Dept/mm	Tool longitudinal travel/mm
Value	140,280	0.4	160

spindle speed and tool longitudinal travel. The surfaces with different textures were obtained by controlling the machining parameters during this process. The dimensions of the workpieces were 100 mm × 100 mm × 50 mm. The second step consisted of laser processing. Aluminum surfaces are scanned by the laser beam with different experimental parameters such as scan velocity, laser power and line spacing. Fig. 1 shows the experimental setup schematically. Line spacing and scan speeds are 1–100 μm and 3–100 mm/s, respectively. The laser polishing experiments are carried out in air, at room temperature and no shielding gas was used. The polished metal surfaces are analyzed by optical profilometry (Ambios Xi100), light microscopy (Olympus BX51M) and scanning electron microscopy (SEM).

The chemical composition of AA7075 using in our study is shown in Table 1. The top surface of the workpiece milled with different milling parameters is also given in Table 2.

3. Results and discussion

Micro-macro end milling inevitably leaves various unwanted patterns on the aluminum surface due to tool-workpiece interactions as shown in Fig. 2. Machining parameters are shown in Table 2. These unwanted patterns repeat after the surface processing such as dyeing process. The patterns must, therefore, have been removed before any surface processing.

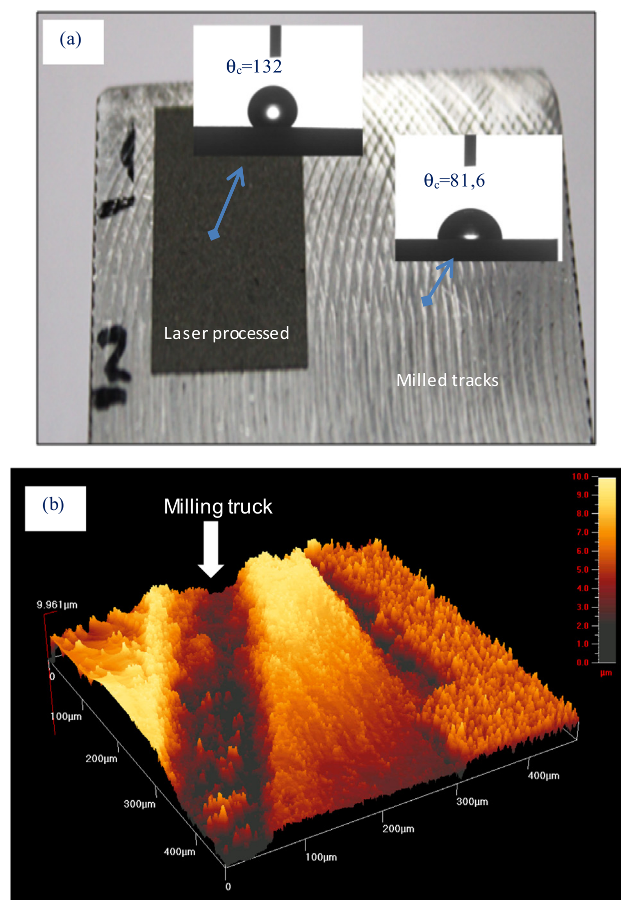

Fig. 2. (a) A photograph of milled and laser processed aluminum surface. (b) An optical profilometer picture of the milled surface. The inset pictures in (a) show contact angle measurements of laser processed and un-processed the AA7075 surface.

Fig. 2(a) shows a picture of milled aluminum surface treated by the parameters as shown in Table 2. The inset pictures show contact angle measurements of laser processed and unprocessed alu-