Materials and Design 32 (2011) 5073–5081

Contents lists available at ScienceDirect

Materials and Design

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

Technical Report

Influence of laser-mechanical treatment on surface topography, erosive wear and contact stiffness

Joanna Radziejewska *

Institute of Fundamental Technological Research, Polish Academy of Sciences, Warsaw, Poland

ARTICLE INFO

Article history:
Received 2 March 2011
Accepted 18 June 2011
Available online 25 June 2011

ABSTRACT

This paper presents the study of surface topography, erosive wear and contact stiffness after the new hybrid method has been applied for the modification of steel surface layer. A combination of laser alloying and the burnishing process, both performed in laser set up, was proposed in order to reduce surface roughness being formed during laser treatment, and to improve contact stiffness. The experiments were conducted on stainless steel, alloyed with Stellite 6, and simultaneously burnished in hot and cold conditions in one operation. The alloying process was performed with continuous laser CO_2 at different parameters. The influence of hybrid treatment parameters on surface topography was examined. This hybrid treatment reconstructed the surface topography and caused an increase in surface smoothness compared to laser alloying. More than a threefold decrease in the average level of roughness, S_a, due to the burnishing process was stated. A good correlation between the parameters of hybrid treatment and roughness was demonstrated. The study shows that laser-mechanical treatment improves erosive wear and contact stiffness compared to laser alloyed and thermal sprayed Stellite 6 layers.

1. Introduction

Laser beam machining has been successfully applied for improvement of surface layer properties. Laser alloying and cladding have been applied to Stellite layer formation. Stellite alloys are characterised by a high resistance to sliding and erosive wear and are applied in operating conditions which require very good mechanical and corrosion properties [1–3]. The specially selected chemical composition and material microstructure consisted of a plastic matrix and small hard precipitations, mainly carbides which provide a high wear resistance to these materials. Besides microstructure and chemical composition, the factor which dictates erosive wear is hardness and homogeneity of surface layer. The local heterogeneity of microstructure, pores, cracks and hard precipitations induce stress concentration and local excess of yield stress that can lead to micro-cracking formation and chipping of surface layer [4,5]. It was stated that the laser treatment provides a chemical and structural homogeneity of the surface layer, without pores, good adhesion compared to other methods such as plasma spraying and flame spraying. The problem is related to the high value of tensile stresses which are generated during laser melting, and can lead even to surface cracking [2,6]. Other disadvantages are a high roughness and the necessity of applying additional finishing treatment in the case of Stellite alloys that show bed machining capacity related to low thermal conductivity, are adverse. Additionally, it increases duration and thus cost of the treatment [7]. An alternative method to a finish by grinding is the proposed surface burnishing.

After laser treatment, a classical burnishing process was applied in works [8,9]. A reduction of surface roughness and tensile stresses were obtained in the case of laser alloying of titanium [8]. As a result of shot-peening treatment the change from tensile stresses to compressive stresses was obtained after laser hardening [9].

In the case of Stellite alloys, the classic burnishing does not lead to a smooth surface due to high roughness and hardness as well as low plasticity of the surface layer after laser alloying. A new hybrid treatment was elaborated for finishing of laser treated materials in work [10,11]. The treatment, combining the laser hardening of carbon steel with the burnishing process was performed simultaneously at the laser stage. The aim of the hybrid treatment was to reduce surface roughness formed in the laser process and induce compressive stresses. A surface smoothing effect was the result of plastic deformation of the surface layer in high temperature, while a reduction of the tensile stresses within the surface layer was due to cold work.

The laser heating process is successfully applied to support the mechanical and plastic working of materials which are difficult for machining. Such a hybrid method was applied for cutting and turning of hard ceramic [12]. The research on local heating with a laser beam while turning, milling and grinding of titanium alloys, cast iron and special steel has been described [13]. The laser-assisted burnishing (LAB), was elaborated by Tian and Shin [14]. The laser heating process was applied for steel burnishing and allowed for

* Tel.: +48 22 826 89 11.
E-mail address: jradz@ippt.gov.pl

0261-3069/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.matdes.2011.06.035