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Comparative assessment of the mechanical and electromagnetic surfaces of explosively clad Ti–steel plates after drilling process

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ABSTRACT

The present work pertains to the analysis of surface topography of explosively clad material such as titanium plated steel in drilling process. The study was conducted for different types of indexable insert drills with different configuration of the tool coatings and for WC-Co drill tool. In this context, surface topography of the drilled holes especially in the region of contact area was analyzed. Metrological analysis was performed using stylus-based and optical profilometry. In this paper the differences between mechanically and electromagnetically measured surfaces are highlighted. It has been observed that the parameters of the surface topography are dependent upon the type of layers of the clad and the type of drill.

1. Introduction

The surface topography, alongside the 3D functional parameters, influences the performance of the engineered surface. In industrial practice geometric product specification and assessment is an important issue. The measurement and characterization of the geometric features of machine parts is importance when trying to determine a functional properties of surfaces and in the control of process parameters during manufacturing. The calculation of the geometric features is based on the coordinates of the points on the surface measured with various measurement techniques (optical, tactile, etc) [1]. The design of new industrial applications requires investigating new materials, including multilayer materials such as bimetals [2]. The calculation of the geometric features is based on the coordinates of the points on the surface measured with various measurement techniques (optical, tactile, etc) [3,4]. Explosive welding (EXW) is a solid state process of the most widely employed methods for bimetals surface modification that uses explosive force to create an electron-sharing metallurgical bond between two metal components. Advantage of this process is possibility to joining of similar and dissimilar materials that cannot be joined by any other techniques. Current developments in advanced technologies are required for industrial applications superior material properties such as corrosion or/also wear resistances [5]. Vast studies on EXW have been concentrated on the extensive investigations in which empirical and numerical models have been published [6–8] and several authors studies [9–13] have been concentrated on the relationship of microstructure and properties of bonding zone in EXW process. Zhang et al. [14] described three complementary impact welding technologies: explosive welding, magnetic pulse welding (MPW), and laser impact welding, which have been used to provide metallurgical bonds between both similar and dissimilar metal pairs. Ben-Artzy et al. [15] observed wavy interface morphology in MPW similarly to that of the EXW. Kahraman et al. [16] presents stainless steel–titanium plates joined by EXW employing oblique geometry route at different explosive ratios. The bonding was investigated using optical and scanning electron microscopy (SEM) and tensile-shearing, bending, hardness and corrosion tests were carried out. Optical and SEM examinations showed that a transition was observed from smooth bonding interface to a wavy one with increasing explosive ratio. It was also observed that grains near the interface were elongated parallel to the explosion direction. Song et al. [17] examined microstructure of EXW joints formed among parallel Ti and steel plates by electron microscopy. They observed that for intermetallic inclusions are often accompanied by micro-cracks of similar dimension. Raghukandan [18] investigated

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clad low carbon steel–copper plates using nitroglycerine explosive. He adopted a four-factor, five-level, center rotatable experimental design with 31 trials for single replication. Models were developed to find the bond and shear strengths of the explosive clads at 99% confidence levels. He discussed effects of flyer thickness, loading ratio, angle of inclination and stand-off on the clad strength. Karolczuk and Kowalski [19] presents fatigue characteristics in the form of relation between strain amplitude and fatigue life for titanium Grade 1 and S355J2 + N steel. Paul et al. [20] analyzed two sets of Al/Cu and Ti/Ni sheets bonded through the EXW. They applied optical, scanning (SEM) and transmission (TEM) microscopy in the research studies. Whereas, Merola et al. [21] presents differences between stylus and optical profilometry (by confocal profilometer) for a new roughness measurement protocol. These studies was conducted for 35 retrieved ceramics femoral heads. They noted that further studies are needed in order to better understand the morphology of metal transfer from the surface roughness point of view.

This paper focuses on research problems related to the surface topography and metrological problems after drilling process of explosively cladded Ti–steel plates. The main purpose of this study was to determine the effect of the drilling parameters and metrological analysis method on surface quality in topography inspection. In this paper the differences between mechanically and electromagnetically measured surfaces are highlighted. The aim of this study was also to determine the surface topography inside the drilled hole between the flyer plate and base plate interface.

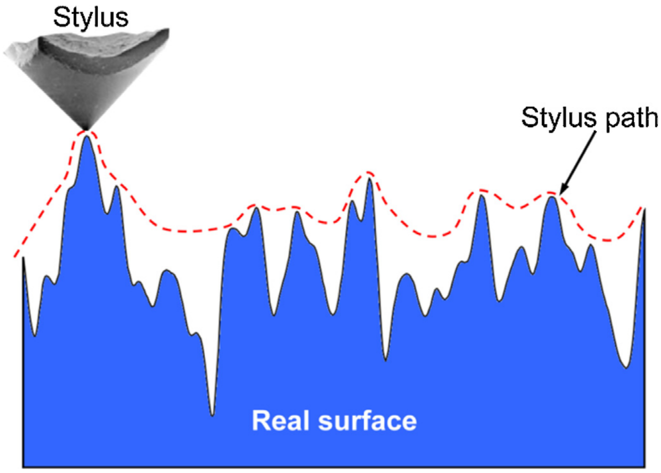


Fig. 1. Graphical interpretation of stylus path in surface topography measurements.

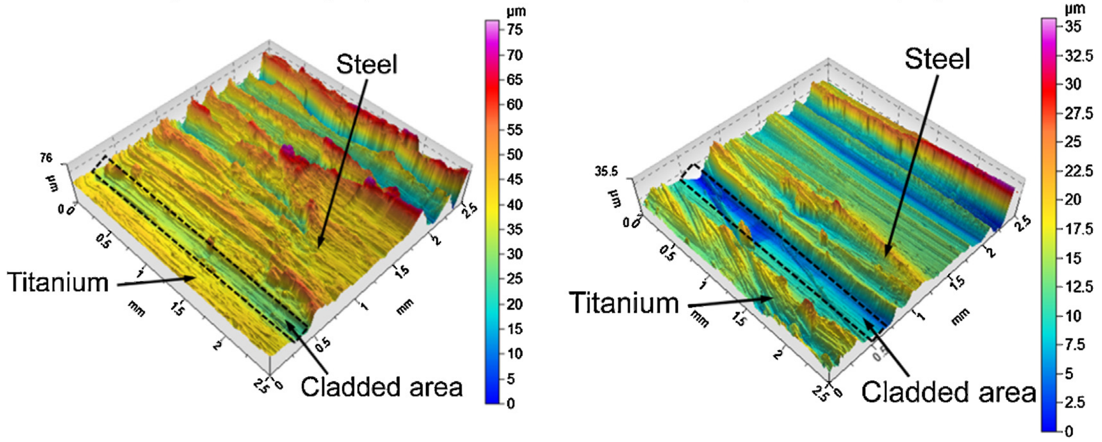
2. Material and methods

2.1. Workpiece material, tool specification and surface generating method

The investigations were performed for explosively clad materials. The workpiece material was composed of two layers. The base layer was 25 mm thick carbon steel P265GH. The flyer plate was made of 5 mm thick Grade 1 titanium. Drilling process was

a) Tool No 1 (T1)

b) Tool No 2 (T2)



c) Tool No 3 (T3)

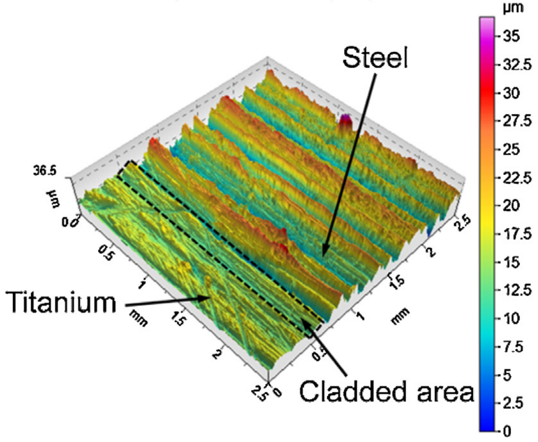


Fig. 2. Surface topography of drilled samples using TOPO-01P profilometer.

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