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Influence of specially designed high-stiffness ball burnishing tool on surface quality of Titanium alloy

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Abstract

This paper deals with effect of specially designed high stiffness ball burnishing tool on surface quality of the material. Main objective is to find optimum depth of penetration to achieve surface finish equivalent to high polish and to study effect of different burnishing parameters on surface roughness. Experimental investigations based on initial surface roughness, using response surface methodology with central composite design, were conducted to develop regression model for surface roughness. The effect of selected process parameters (speed, feed, depth of penetration and number of passes) on surface quality of the material was studied. The material used in the investigations was titanium alloy, which is widely used in aerospace industry. It is worth noting that high stiffness tool with depth of penetration approximately equal to Rp (Maximum peak height) gives surface finish equivalent to high polished surface. Authors proposes use of high stiffness tool instead of conventional elastic tool system.

Keywords: High stiffness ball burnishing tool; surface roughness; speed; feed; depth of penetration; number of passes.

1.Introduction

Surface quality plays an important role in improving functional performance of a component[1]. Surface quality of a component improves resistance to wear, corrosion properties, fatigue strength of the component [2]. Conventional machining processes like turning, milling leaves inherent irregularities on the surface.

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These irregularities increase friction between two components in assembly and hence wear increases and life of component decreases[3]. To overcome these problems, conventional finishing processes like grinding, honing, lapping are employed. These methods are based on chip removal. Instead of using traditional methods, burnishing is a cold working, chipless process which produces finished surface with improved surface hardness. Ball burnishing is becoming most popular post machining finishing process. In this process hard ball or roller is presses against a surface in such a way that it will just cross elastic limit of the material and plastic deformation of material will takes place. As a result of plastic deformation of material better surface finish and improved surface hardness of component can be achieved, in addition to this residual compressive stresses are induced on the surface of the component, which in turn improves mechanical properties of material [4][5][6][7][8].

Burnishing process reduces surface defects and also modifies microstructure of the machined surface[9][10]. Burnishing is done for both inner as well as outer surfaces of cylindrical components. The main applications of burnishing processes are in aerospace and automotive industries[11][12].

Titanium alloy is selected for experimentation due to its wide use in aerospace industry, surgical implants and marine applications[13]. Titanium and its alloy have excellent high strength to weight ratio which is maintained at high temperature and very high corrosion resistance. It is also used for compressor blades, offshore pressure vessels and rocket cases. However titanium and its alloy does not meet all the requirements of different industries. Hence there is need to improve mechanical properties of titanium alloy. Burnishing can be used to improve its properties. Many researchers studied effect of force, speed, feed and number of passes on different work materials like Al alloy, steel, brass and cast alloy [14][15][16]. However very few researchers have studied effect of burnishing parameters on Titanium alloy[17][18]. In the present study newly designed high-stiffness ball burnishing tool for CNC lathe is used. Authors have tried to investigate effect of speed, feed, depth of penetration and number of passes on surface roughness and hardness of titanium alloy considering initial surface roughness using response surface methodology.

2. Experimental Investigation

Experimental investigation was carried out on round bars of titanium alloy (Ti-6Al-V) which was commercially available $(\alpha+\beta)$ of aerospace grade 5. Chemical composition of the material is given in table 1. Round bar of 25mm were cut to 225 mm in length and turned to 23 mm diameter on the computer numeric controlled lathe machine having Fanuc controller (Sandip Institute of Technology & Research Centre, Nashik, India) using carbide tip tool having 0.8 mm radius. And burnishing was carried out after turning immediately so that accuracy should not be affected due to clamping and unclamping of the workpiece. In newly designed burnishing tool carbide ball having diameter 14 mm is used as roller. Ball is kept on outer race of the bearing so that it can freely rotate during burnishing process. High stiffness spring is used in the tool, so that prior to burnishing when we apply depth of penetration, spring will be get compressed, but after that during burnishing process compression of spring should be very small. This gave us superior surface finish. When burnishing tool moves along the length of the material will be get deformed in to valley superior finish. And we can get better surface finish.

Table 1 Chemical Composition of Titanium Alloy (Ti-6Al-4V) used for experimental investigation

Element	*Ti*	*Al*	*V*	*Fe*	*O*	*C*	*N*	*Y*	*H*
Wt (%)	Bal	6.1	4	0.15	0.12	0.02	0.01	0.001	0.001