NOVATEUR PUBLICATIONS
INTERNATIONAL JOURNAL OF INNOVATION IN ENGINEERING, RESEARCH AND TECHNOLOGY [IJIERT]
NATIONAL CONFERENCE ON INNOVATIVE TRENDS IN ENGINEERING & TECHNOLOGY-2016
11TH & 12TH MARCH 2016
CONFERENCE PROCEEDINGS ISSN NO - 2394-3696

Paper ID: NITETMECH19

A REVIEW ON TURNING OF TI6AL4V ALLOY

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ABSTRACT

Ti6Al4V alloy considered as extremely difficult to machine materials. Titanium and its alloys have several promising inherent properties like low strength-weight ratio, high corrosion resistance etc. but their mach inability is generally considered to be poor.
Ti6Al4V is the most widely used titanium alloy. It features good machine-ability and excellent mechanical properties. The Ti6Al4V alloy offers the best all-round performance for a variety of weight reduction applications in aerospace, auto-motive and marine equipment.
The main objective of this work is to optimize the surface roughness of Ti6Al4V alloy by precision turning operation. In finishing operation surface roughness is a major concern. This finishing operation will be performed on CNC lathe machine under lubrication condition. The proposed work is to perform machining under the selected level of cutting parameter to estimate the surface roughness generated as the result. This all result will be analysed in Minitab software.

KEYWORDS:- Ti6Al4V, surface roughness etc.

INTRODUCTION

The high strength, low weight ratio and outstanding corrosion resistance inherent to titanium and its alloys has led to a wide and diversified range of successful applications which demand high levels of reliable performance in surgery and medicine as well as in aerospace, automotive, chemical plant, power generation, oil and gas extraction, sports, and other major industries. In the majority of these and other engineering applications titanium has replaced heavier, less serviceable or less cost-effective materials. Designing with titanium taking all factors into account has resulted in reliable, economic and more durable systems and components, which in many situations have substantially exceeded performance and service life expectations. Titanium is available in several different grades. Pure titanium is not as strong as the different titanium alloys are.

MACHINE ABILITY

This project is purely based on the machining of Ti6Al4V alloy, if we consider the machinability of this alloy using the rating system based on AISI B1112 steel, the machinability of Ti6Al4V is rated at 22% of B1112. In general, low cutting speeds, heavy feed rates and copious amounts of cutting fluid are recommended. Also, because of the strong tendency of titanium to gall and smear, feeding should never be stopped while the tool and work are in moving contact. Non- chlorinated cutting fluids should be used to eliminate the possibility of chloride contamination. It should be noted that titanium chips are highly combustible and appropriate safety precautions are necessary.

MACHINING

Ti6Al4V alloy considered as extremely difficult to machine materials. Titanium and its alloys have several promising inherent properties (like low strength- weight ratio, high corrosion resistance etc.) but their mach inability is generally considered to be poor. Titanium and its alloys have high chemical reactivity with most of the available cutting tool materials. Also due to the low thermal conductivity of these alloys the heat generated during machining remains accumulated near the machining zone. Consequently the cutting tools are more prone to thermal related wear mechanism like diffusion, adhesion wear. Hence, on machining, the cutting tools wear out very rapidly due to high cutting temperature and strong adhesion between tool and workpiece material. Additionally, the low modulus of elasticity of Ti6Al4V alloys and its high strength at elevated temperature makes the machining further difficult.

CNC turning is widely used for machining of symmetrical components in a variety of industries such as automotives, aerospace, chemical, biomedical, textile and other manufacturing industries. In the machining process, errors may occur due to the problems in the machine tool, machining methods and the machining process itself. Of these, the errors that arise due to high cutting forces are the major problems for machining process. In turning, cutting forces and surface finish are important parameters by which the performance can be assessed. Hence it is important to minimize the cutting forces and maximize the surface finish.

Ti6Al4V is the most widely used titanium alloy. It features good machine-ability and excellent mechanical properties. The Ti6Al4V alloy offers the best all-round performance for a variety of weight reduction applications in aerospace, auto-motive and marine equipment.

Ti6Al4V also has numerous applications in the medical industry. Biocompatibility of Ti6Al4V is excellent, especially when direct contact with tissue or bone is required.

ApplicationsTi6Al4V is typically used for:

– Direct Manufacturing of parts and prototypes for racing and aerospace industry.

– Biomechanical applications, such as implants and prosthesis.

– Marine applications.

– Chemical industries.

– Gas turbines.

SURFACE ROUGHNESS

According to Srajan Kumar the machinng performance and precision turning can be improved by finding optimal depth of cut and feed. He were conducted experiment on titanium alloy materials using a set of cutting parameters as per L27 orthogonal array. Cutting zone temperature and surface roughness on the workpiece after precision turning was experimental an recorded. Analyzes of Variance was minitab software and it was found that feed rate have more authority on surface roughness followed by the nose radius. Like were depths of cut having more influence on cutting zone temperature followed by feed rate and cutting speed. Opportunity work can be focused on the dimensional accuracy experimental on the work specimen as the consequence of precision machining Raviraj Shetty concluded in two sections, first section is about identifying the effect of dry oil water emulsion and coconut oil on surface roughness under different condition on turning of Ti6Al4V, and the second section is about identifying the optimum parameters improving surface integrities.

TOOL WEAR

According to R.S.Pawade the high cutting speed and lowest feed rate and moderate depth of cut in conjunction with honed cutting edge may ensure induction of compressive stress in the machined surface. This paper extends the present trend prevailing in the literature on surface integrity analysis of super alloys by performing a comprehensive investigation to analyse the nature of deformation beneath the machined surface and arrive at the thickness of machining affected zone (MAZ). The residual stress analysis, micro hardness measurements and degree of work hardening in the machined sub-surfaces were used as criteria to obtain the optimum machining conditions that give machined surfaces with high integrity. It is observed that the highest cutting speed, the lowest feed rate, and the moderate depth of cut coupled with the use of honed cutting edge can ensure induction of compressive residual stresses in the machined surfaces, which in turn were found to be free of smeared are a sand adhered chip particles.

S. R. T. Kumara studied the condition for machining in that paper we found that influence of super finished cutting edges and their impact on active force component.

This paper presents investigations on high speed turning of Ti6Al4V alloy using super-finished cutting edge inserts generated by micro-machining process (MMP). In order to better understand the influence of super-finished cutting edges and their impact on active force components, tool face friction is analysed. The tool-chip-work friction coefficients are obtained analytically using measured cutting forces under orthogonal cutting conditions and chip characteristics. The cutting forces and chip morphology are predicted accurately using a two dimensional finite element model (FEM) using ABAQUS. The turning tests conducted under flooded coolant conditions show that super-finished cutting edge inserts substantially enhance the tool life.

S.Zhang theoretically proposed the diffusion analysis that is the constituents inside the tool could diffuse into the work piece and the layer of diffusion may form at the interface.

During high-speed machining Ti6Al4V alloy, high- temperature at the tool–chip interface and the concentration gradient of chemical species between tool material and work-piece material support the activation of diffusion process, and therefore the crater wear forms on the rake surface of the cutting tool at a short distance from the cutting edge. In this paper, the diffusion analysis was theoretically proposed. The constituent diffusion at the contact interface between tool material and Ti6Al4V alloy at high-temperature environment, the crater wear on the rake surface of the tool, and the chips collected from high-speed milling Ti6Al4V alloy with straight tungsten carbide tools were analysed by the scanning electron microscope with energy dispersive X-ray spectroscopy. The constituents inside the tool could diffuse into the work-piece and the diffusion layer was very thin and close to the interface. Compared with the diffusion of tungsten and carbon atoms, the pulling out and removing of the tungsten carbide(WC) particles due to cobalt diffusion dominated the crater wear mechanism on the rake surface of the cutting tool. P. Venkateswara Rao uses the condition for machining he conclude that cutting forces increase with increase in depth of cut and increase in feed.

This paper deals with machining Ti6Al4V material. The experimental analysis was carried out using Response Surface Methodology (RSM). The detailed experiments under dry conditions using the PVD coated TiAlN tools. In the present work the relationship of Ti6Al4V's surface roughness and cutting forces with critical machining parameters and conditions. They were studied the characterization of cutting forces in dry machining of titanium alloys considering input parameters like cutting speed (60-260 m/min) , feed (0.12 to 0.3 mm/rev) and depth of cut (0.5 to 2 mm) using uncoated inserts and they have reported that cutting forces increases with increase in feed and increase in depth of cut. The results are analyzed in Design expert V8.0.6 software. An ANOVA summary table is commonly used to summarize the test of the regression model, test of the significance factors and their interaction and lack-of-fit test.

Meysam Shamshiri use the High Pressure Waterjet Assisted Machining (HPWAM) is a machining process that involves high pressure coolant being delivered at the cutting zone. This paper investigates the performance of conventional and HPWAM when machining Ti6Al4V titanium alloy. The evaluations were based on the tool life, wear mechanisms, surface profile and chip formation. This study concludes that machining Ti6Al4V Titanium alloy under HPWAM gave better cutting performance of up to 195% improvement over machining with conventional coolant supply. The predominant wear mechanisms when machining under the cutting conditions are abrasive and adhesive wear. Surface roughness values recorded when machining Ti6Al4V alloy under the cutting conditions are generally below the 1.6 ìm rejection criterion.

He conclude that upto 195% improvement using HPWAM machining over conventional machining.

R.W. Schutz suggested the use of stream of coolant while machining. Titanium can be economically machined on a routine production basis if shop procedures are set up to allow for the physical characteristics common to the metal. The factors which must be given consideration are not complex, but they are vital to successfully machining titanium. The different grades of titanium, i.e. commercially pure and various alloys, do not have identical machining characteristics, any more than all steels, or all aluminum grades have identical characteristics. Like stainless steel, the low thermal conductivity of titanium inhibits dissipation of heat within the workpiece itself, thus requiring proper application of coolants. production rates and longer tool life. Where high speed steels are used, the super high speeds are recommended. Tool deflection should be avoided and a heavy and constant stream of cutting fluid applied at the cutting surface. Live centers must be used since titanium will seize on a dead center. A.B. Sandvik studied tool wear test were performed during orthogonal cutting of turning of titanium alloy. He conclude that the wear rate have linear depend on cutting speed.

The present work was performed at Cormorant as a part in improving the knowledge and understanding about wear of uncoated WC/Co cutting tools during turning of titanium alloy Ti6Al4V. When machining titanium alloys, or any other material, wear of the cutting tools has a huge impact on the ability to shape the material as well as the manufacturing cost of the finished product. Due to the low thermal conductivity of titanium, high cutting temperatures will occur in narrow regions near the cutting edge during machining. This will result in high reaction and diffusion rates, resulting in high cutting tool wear rates. To be able to improve titanium machining, better knowledge and understanding about wear during these tough conditions are needed. Wear tests were performed during orthogonal turning of titanium alloy and the cutting tool inserts were analysed by SEM, EDS and optical imaging in Alicona Infinite Focus. Simulations in Advant Edge provided calculated values for cutting temperatures, cutting forces and contact stresses for the same conditions as used during wear tests. It was found that turning titanium alloy with WC/Co cutting tools at cutting speeds 30-60 m/min causes chamfering of the cutting tool edge and adhesion of a build- up layer (BUL) of work piece material on top of the rake face wear land. The wear rate for these low cutting speeds was found to be almost unchanging during cutting times up to 3 minutes. During cutting speeds of 90-115 m/min, crater wear was found to be the dominating wear mechanism and the wear rate was found to have a linear dependence of cutting speed.

M.V. Ribeiro studied tool wear and found the optimum characteristics of machining parameter. Titanium and its alloys are attractive materials due to their unique high strength–weight ratio that is maintained at elevated temperatures and their exceptional corrosion resistance. The major application of titanium has been in the aerospace industry. However, the focus shift of market trends from military to commercial and aerospace to industry also been reported. On the other hand, titanium and its alloys are notorious for their poor thermal properties and are classified as difficult-to-machine materials. These properties limit the use of these materials especially in the markets where cost is much more of a factor than in aerospace. Machining is an important manufacturing process because it is almost always involved if precision is required and is the most effective process for small volume production. Due to the low mach inability of the alloys under study, selecting the machining conditions and parameters is crucial. The range of feeds and cutting speeds, which provide a satisfactory tool life, is very limited. On the other hand, adequate tool, coating, geometry and cutting flow materials should be used: otherwise, the high wear of the tool, and the possible tolerance errors, would introduce unacceptable flaws in parts that require a high degree of precision. In this work, turning tests were carried out on Ti6Al4V with conventional uncoated carbides.

CONCLUSION

The conclusion revealed that the feed rate and cutting speed where the most influential factors on the surface roughness. Our work of this thesis is to find out the optimum parameter which influences the parameters. By referring above papers when parameters get changed it directly effects on the surface roughness. Various surface treatments have been developed to increase clinical performance of titanium based implants. We observed better orientation and proliferation of human osteoblast on surface with micro roughness characterized lower or higher order roughness value.

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