Published by :
http://www.ijert.org
International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 11, November - 2017

Application of Coatings Technology in Titanium Alloy Processing

Zubing Yang[1],Yuyao Guo[1],Deqiang Meng[1],Kuanyu Tang[1],Xiang Hou[1],Wei Lin[1]
1. Tianjin Key Laboratory of High Speed Cutting and Precision Manufacturing,
Tianjin University of Technology and Education, Tianjin 300222, China

***Abstract*—Titanium alloy has high strength quality ratio , better strength, toughness, and malleability. In addition , Titanium alloy also has good oxidation resistance and corrosion resistance, and at high temperature it can maintain good strength. These advantages make the titanium alloy widely used in aerospace, automotive, chemical and medical devices. It is the key to realize high speed and efficient machining of titanium alloy. In cutting tools coatings technology have more and more widely application, the performance of the surface of the coatings can significantly improve the cutting tools performance, improving the high temperature hardness, heat insulation, thermal stability, impact toughness, and so on. So these can greatly improve the cutting speed and tools life.**

Key words—Titanium alloy; cutting tools; tools coatings

Titanium Alloy Characteristics and Applications

Titanium alloy is much stronger than other metal structure materials, can make parts with high strength, rigidity and light quality. he thermal stability of titanium alloy is good, high temperature strength , Under the 300 ~ 500 ℃, its intensity is about 10 times higher than the aluminum alloy, the working temperature is 500 ℃.This is one of the important reasons for the heavy use of titanium alloys in aircraft. Titanium alloy works in humid atmosphere and seawater medium, its corrosion resistance is better than stainless steel, it is resistant to point erosion, acid corrosion and stress corrosion. It has excellent corrosion resistance to alkali, chloride, chlorine, nitric acid and sulfuric acid. At the same time titanium alloy material has high hardness, high melting point (1667 ℃), non-toxic, no magnetic characteristics. In 1953 , Titanium was first used on the DC2T engine pods and fire walls produced by Douglas corporation in the United States, thus revealing the history of the application. In the field of aerospace, titanium alloy is mainly used in aviation engine fan, compressor, such as compressor disk, blade, navigator, link, etc., the plane frame, skin, fuselage clapboard and parts such as landing gear. Replacing the original nickel-base high temperature alloy with titanium alloy can reduce the weight of the compressor by 30%~ 35%.The use of titanium and titanium alloys in ships has greatly extended the service life of the equipment, reduced the weight, and improved the technical and tactical performance of the whole ship. At present, Titanium has been successfully used for various types of power submarines, surface boats and civilian ships. In addition, the titanium alloy also in nuclear submarine pressure hull, seawater pipeline system, condenser and heat exchanger, fan blades, propeller and shaft, springs, the carrier of fire fighting equipment, propeller, water-jet propulsion, steering and other Marine has been successfully used on the parts. In commonly used surgical implant materials, titanium and titanium alloys with excellent biocompatibility, corrosion resistance, mechanical property and processing performance, become the most attractive biomedical metal materials, mainly used as artificial knee joint, the joint stocks and denture, dental implants, root metal stents, etc. Currently, Ti6Al4V is still widely used in medical implants.Ti-3al-2.5 V alloy is also used as the replacement material for femur and in clinical practice because of its good cold forming, corrosion resistance and mechanical properties.

I. DIFFICULTIES THE PROCESSING OF TITANIUM ALLOY

(1) small deformation coefficient: this is a obvious feature in the cutting of titanium alloy materials. In the cutting process, the contact area between the chip and the rake face is too large, Shavings are much larger in the front edge of the cutter than in the general material, working in such a long time can lead to serious tool wear, Friction also occurs during walking leading to increased tool temperature.

(2) high cutting temperature: on the one hand the aforementioned small deformation coefficient will lead to a part of the temperature rise. In the machining process of titanium alloy, the cutting temperature is mainly due to the small thermal conductivity of titanium alloy, and the cutting edge of the chip and the tool contact length is short, under the influence of these factors, It is difficult to conduct the heat generated during the cutting process, are mainly deposited near the tip, causing the local temperature is too high.

(3) the thermal conductivity of titanium alloy is very low: the heat generated by the cutting is not easy to spread out. The turning process of titanium alloy is a process of large stress and large strain, which will produce a large amount of heat. The high heat generated during processing can not be effectively diffused. At the same time, the contact length between cutting edge and chip of the tool is short, make the heat quantity on the cutting edge, the temperature rose sharply, the blade softened to speed up tool wear.

(4) the chemical properties of titanium alloy is very large: at high temperature, titanium alloy is easy to react with the tool material to accelerate the formation of crescent depression. However, the cutting process of titanium alloy is basically carried out at high temperatures. When the cutting temperature is high to a certain extent, nitrogen and oxygen molecules in the air and titanium can easily produce chemical

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 11, November - 2017

effects, resulting in the formation of a hard and brittle skin. Moreover, the plastic deformation that occurs on the machined surface of the workpiece during the cutting of the titanium material causes the chilling phenomenon to occur and hardens the machined surface of the workpiece material. These phenomena can make the tool wear increased, the fatigue strength of titanium material is reduced.

(5) the tool wear easily: tool wear is the result of many factors combined effect, in the cutting process of titanium materials, it can easily cause the tool chipping phenomenon, Titanium material under the condition of high temperature generally showed stronger chemical affinity between cutting tool material, cutting tool and titanium alloy materials are also prone to caking phenomenon, all these lead to the tool life to be too much short.

Therefore, we must pay attention to two aspects of titanium material cutting, that is, to maintain a low cutting temperature and improve the rigidity of the tool / material to be cut, coated tool is a way to improve the rigidity of the tool.

II. STATUS OF COATINGS OF TITANIUM ALLOY CUTTING TOOLS

High chemical activity of titanium alloy and low thermal conductivity leads to high cutting temperature in the cutting process, violent chemical reaction and rapid failure of the tool. The reason of tool wear is complicated, not only the function of mechanical friction, but also the physical and chemical functions of cutting force and cutting temperature. For the cutting difficult of titanium alloy, tool material hardness, high strength, thermal conductivity should be large, chemical stability and red hardness should be better. Currently recognized the better processing of titanium alloy tool material is diamond cutting tool, but because of its high cost, so the coating cemented carbide cutting tools is still occupied the main position in the market of titanium alloy cutting tool material.

The Traditional cutting theory think the coating tool is not suitable for processing titanium alloy, because most of the traditional coating are Ti-C and Ti-C-N coating, and Ti elements in the coating is easy to affinity with the workpiece and lead to rapid tool wear. Ezugwn had used high-speed steel substrate with Cr-N and Ti-C-N coating to cut the TC4 titanium alloy which uncoated WC carbide tool TC4 titanium alloy, the research shows that the Cr-N coating tool is better than the Ti-C-N coating tool and the uncoated carbide Tool. At the same time, under the same cutting conditions, the Ti6A14V cutting experiments were carried out using single layer Ti-N PVD coating and multilayer Ti-N / Ti-C-N / Ti-N PVD coating. The results show that the multi-layer coating tool performance is better than the single layer.

In recent years, due to the continuous maturation of foreign coating technology and coating method, the coating composition is constantly complicated and diversified. Even for each workpiece material, there is a most suitable coating material, and there is a gradient coating, Nano-coating, soft coating, super hard coating and other coatings with better performance. Therefore, more and more coated cutting tools have been applied to the high-speed machining of titanium alloy abroad and show good superiority.

III. DEVELOPMENT DIRECTION OF CARBIDE COATED CUTTING TOOLS

Diversification of tool coating components ,the differences between the physical properties and lattice types of the single coating and the substrate materials lead to a large residual stress between the substrate and the coating, and the resultant strength is not strong. To add new elements in a single coating (such as add zirconium, vanadium and hydrofluoric acid can improve the wear resistance, adding silicon can improve the hardness and prevent chemical diffusion, join, yttrium aluminum and chromium could improve oxidation resistance) could be prepared for multiple tool coating materials, greatly improve the comprehensive performance of the tools. Coating materials have also been developed from the very beginning of TiN, TiAlN, TiCN to dozens of coating materials such as TiSiN, TiSiCN, TiAlSiN, AlCrN, AlCrSiN, TiBN, CrN, ZrN and Al_2O_3.In order to meet the diverse needs of cutting, the new coating materials will also have great prospects for development.

Cutting green. At present, the wet cutting method is mainly used in mechanical processing in China, which is the continuous cooling and lubricating knife of liquid (cutting fluid) with certain pressure and flow during metal cutting methods for machining parts and parts. However, heavy use of cutting fluid will cause environmental pollution problems. In the meantime, the oil smoke produced by cutting fluid in the cutting process is directly harmful to the workers, causing a variety of skin diseases. And from the cost point of view,, the cutting fluid takes up 14%-16% of the total cost in the centralized cooling liquid processing system, and the cost of cutting tools is only 2%-4%.According to the forecast, if 20% of the machining is done using dry machining of coated tools, the total manufacturing cost can be reduced by 1.6%.In addition, the use of high-speed dry cutting can significantly improve the processing efficiency, improve processing accuracy, reduce surface roughness, and more suitable for processing thin-walled parts. Therefore, no matter from the environmental point of view or from the processing performance and economic considerations, the manufacture of coated tools to meet the dry cutting conditions is an important development goal of green processing.

IV. CONCLUSION

With the continuous development of manufacturing industry, the application of titanium alloy will be more and more, on the quality and accuracy requirements unceasing enhancement, how to choose appropriate titanium alloy cutting tools, improve the machining efficiency, reduce production cost, for the automotive, aerospace, energy, the development of the important industrial sector and the improvement of the overall level of manufacturing has important significance.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 11, November - 2017

REFERENCES

[1] Ozkalafat P, Sireli G K, Timur S. Electrodeposition of titanium diboride from oxide based melts [J]. Surf. Coat. Technol. 2016, 308: 128-135

[2] Nedfors N, Mockute A, Palisaitis J, et al. Influence of pulse frequency and bias on microstructure and mechanical properties of TiB_2 coatings deposited by high power impulse magnetron sputtering [J]. Surf. Coat. Technol. 2016, 304: 203-210

[3] Bhatt B, Murthy T S R Ch, Limaye P K, et al. Tribological studies of monolithic chromium diboride against cemented tungsten carbide (WC-Co) under dry condition [J]. Ceram. Int. 2016, 42: 15536-15546. Stewart D M, Meulenberg R W, Lad R J. Nanostructure and bonding of zircomium diboride thin films studied by X-ray spectroscopy [J]. Thin Solid Films 2015, 596: 155-159

[4] J. Musil, M. Jirout, Toughness of hard nanostructured ceramic thin films[J], Surf. Coat. Technol. 2007,201:5148-5152.

[5] S. Veprek, R.F. Zhang, M.G.J. Veprek-Heijman, S.H. Sheng A.S. Argon, Superhard nanocomposites: Origin of hardness enhancement, properties and applications[J], Surf. Coat. Technol. 2010,204 : 1898-1906

[6] J. Lawal, P. Kiryukhantsev-Korneev, A. Matthews, A. Leyland, Mechanical properties and abrasive wear behaviour of Al-based PVD amorphous/nanostructured coatings[J], Surf. Coat. Technol. 2017,310 :59-69

[7] S. Veprek, M.G.J. Veprek-Heijman, P. Karvankova, J. Prochazka, Different approaches to superhard coatings and nanocomposites[J], Thin Solid Films.2005, 476:1-29.

[8] P.H. Mayrhofer, M. Stoiber, Thermal stability of superhard Ti-B-N coatings[J], Surf. Coat. Technol. 2007,201 :6148-6153

[9] S. Veprek, M.G.J. Veprek-Heijman, Limits to the preparation of superhard nanocomposites: Impurities, deposition and annealing temperature[J], Thin Solid Films 2012,522 : 274-282