Advanced Science and Technology Letters
Vol.53 (ISI 2014), pp.29-32
http://dx.doi.org/10.14257/astl.2014.53.07

Research on the wear mechanism of ceramic tool in turning of nickel-based superalloy GH4169

Yubo Liu[1,2,a], Yongde Zhang[1,b]

[1] School of Mechanical and Power Engineering Harbin University of Science and Technology Harbin, China

[2]Heilongjiang university of Science and Technology，

Harbin,150022 China

[a]ysclx@126.com,[b]zhangyd@hrbust.edu.cn

Abstract. The dry cutting experiment for nickel-based high temperature alloy GH4169 was conducted with Al_2O_3-SiC_w whisker toughening ceramic blade WG300 and Si_3N_4-Al_2O_3 ceramics (Sialon) blade SX9 .The main wear mechanism of ceramic cutting tools were analyzed by means of observing the wear morphology about cutting tools with scanning electron microscope, and measuring concentration of each element in wear tiny region lying in the ceramic tools with Energy Dispersive Spectrometer (EDS).

Keywords: superalloy, ceramic tool, wears mechanism.

1 Introduction

Today nickel-base superalloy plays an increasingly important role in aerospace. Because of its excellent performance, GH4169 was widely used in the casing, turbines, combustion chamber, the space shuttle, nuclear reactors and other high temperature applications.

In this paper, by studying the wear mechanism of tool and analyzing the main forms of tool wear in the speed turning GH4169 with Al_2O_3-SiC_w whisker reinforced ceramic blade WG300 and Si_3N_4-Al_2O_3 ceramic (Sialon) blade SX9.

2 Experimental Scheme Design

Experiments were on EMCO-Maxxturn 65 Turning Center, Machine maximum speed: 5000r/min; Cutting conditions for dry cutting. A nickel-based superalloy GH4169 bar was selected as the workpiece material for the experiment, of which heat treatment is solution and aging.

Al_2O_3-SiC_W whisker reinforced ceramic blade WG300 and Si_3N_4-Al_2O_3 ceramic (Sialon) blade SX9 was selected as the main cutting tools in the experiment. After the cutting process, the tool flank wear values were measured under the use of Dino-Lite

ISSN: 2287-1233 ASTL

digital microscope and the blunt standard was set as: The average wear value in flank VB ⩾ 0.3mm；wear value in Groove VN≥0.6mm.

3 Data Analysis of Experiment

Abrasive wear was that the workpiece surface was sheared and plowed by friction and then the trough-like indentation was generated by the abrasive action of furrows when hard particles in the workpiece are pressed into the friction surface, under the action of some certain loads, and then slided. As fig.1 shows: SEM photograph of flank wear in cutting speed 250m/min happened in WG300.

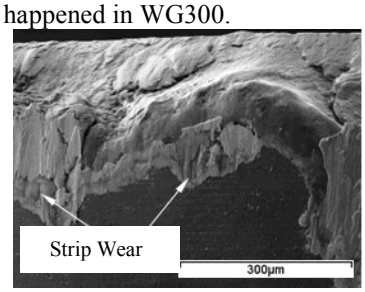
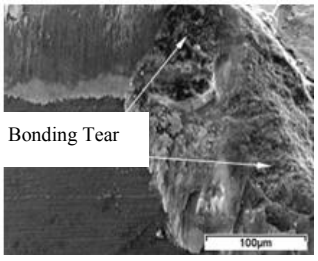
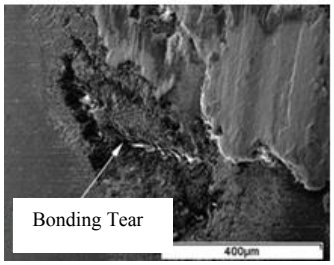


Fig. 1. Abrasive wear in WG300

When WG300 was in 190m/min and 310m/min cutting speed, the attrited morphology of trench edge in flank were showed as Fig.2 (a) and 2 (b).



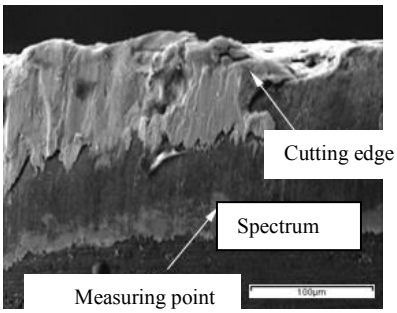
(a)Cutting speed 190m/min



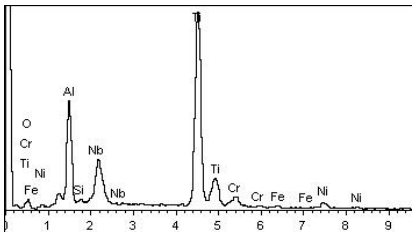
(b)Cutting speed 310m/min

Fig. 2. Adhesive wear in WG300

For Al_2O_3-SiC_w Whisker ceramic tools WG300, Ti-rich region located under the edge of the flank wear belts. The analyzed results about Measuring points, in the wear area in blade of WG300 in the cutting speed 190m/min and 310m/min, were shown as Fig. 3 and Fig. 4.

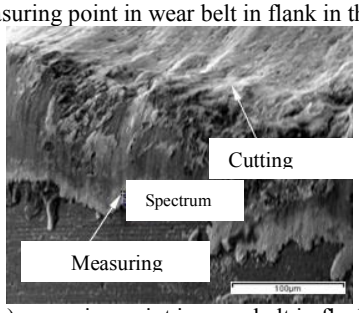


(a) measuring point in wear belt in flank

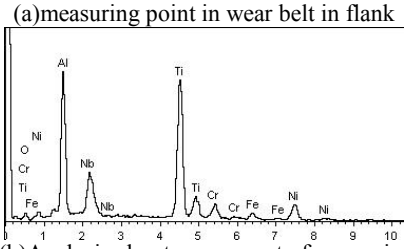


(b)Analysis about component of measuring point nent of measuring point

Fig. 3. Analysis about measuring point in wear belt in flank in the cutting speed 190m/min



(a)measuring point in wear belt in flank



(b)Analysis about component of measuring point

Fig. 4. Analysis about measuring point in wear belt in flank in the cutting speed 310m/min WG300

4 Conclusions

When milling nickel base super alloy with Al_2O_3-SiCw whisker toughening ceramic cutting tool and Sailon ceramic cutting tool, chemical reaction and element diffusion will be existed between cutter material and workpiece material, and the strength and toughness of the cutting tool substrate will be reduced for the dissolution of SiC whisker and Si_3N_4 grain in the ceramic cutting tool, which leading to the decline of the tool wear resistance. In the element diffusion process, beneficiation of cutter surface on Ti element in the workpiece material is obvious, which appears the diffusion indirectly in the area local position of WG300 and SX9, resulting the cutting tool substrate be added main elements like Ni, Fe, Cr from workpiece material and Ti element separates out on the cutter surface. With the scratch of cuttings and transitional surface, on the cutter surface, the educt will be peeled by shear, in the area of cutter surface where shear force is large enough, it will be cleared, and in the location of less shear force, it could still attach to the surface.

Acknowledgements. This work was supported by the National Science Foundation of Heilongjiang Province (Project No QC2012C029) and the Education Department Project of Heilongjiang Province(12541699).

References

1. Gao, D.Q., Li, Z.Y., Mao, Z.Y.: Cutting Performance Analysis and Parameter Optimization on Nickel-baded Alloy High-speed Cutting. Modular Machine tool Automatic Manufacturing technique.12, 10--12(2010)
2. Nalbant, M., Altin , A., Kaya, G.H.: The effect of cutting speed and cutting tool geometry on machinability properties of nickel-base Inconel 718 super alloys Materials & Design.28(4),1334--1338(2007)
3. Altin, A., Nalbant,M.: The effects of cutting speed on tool wear and tool life when machining Inconel 718 with ceramic tools. Materials and Design.28, 2518--2522(2007)
4. Sehulze, V., Autenrieth, H., Deuchert, M.: Investigation of surface near residual stress states after micro-cutting by finite element simulation. CIPP Annals-Manufacturing Technology.59,117--120(2010)
5. Wan, Y., Xi, A.: Tool wear and fracuter in high speed milling aluminum alloy. 7050－T7451. Chinese journal of mechanical engineering. 43(4), 103--107(2007)
6. Wang, J., Zhao, X. F., He, L., Li, C. H.: Study on Milling Parameters Optimization of Supper Alloy Inconel GH4169. Modern manufacturing processes and equipment.2,1--3(2012)
7. Liu, W., Zhao, J., Ai, X.: Wear Mechanisms of Al_2O_3-Based Ceramic Cutting Tool in High Speed Turning of 300M Ultra High Strength Steel. Tribology. 6(11), 564--568(2011)
8. Guo, X., Rui, Y., Zhu, S.: Study on Ceramic Cutter's Wear Mechanism When Dry Cutting Austempered Ductile Iron (ADI). Tribology. 26(1), 73--78(2006)

