Project name: Detailed analysis of subsurface layers produced by high speed machining of aero engine component applications

BEAM-TIME APPLICATION (Project) REPORT

24.06.2013 - 25.06.2013 *(Date of the report : 24-02-2014)*

General information

Name of the rapporteur	Name of the rapporteur's organisation
Rachid M'Saoubi	Seco Tools AB
Type of research (nanotechnology/health care/chemistry etc.)	**Name of the research facility**
Material Science and Engineering	Helmholtz-Zentrum Geesthacht, HEMS Beamline P07 at DESY
Date of the measurement, duration	**Location of the event**
24-25 June 2013	Hamburg
National Industrial Liaison Officer from rapporteur's country participating in the measurement	

Description of the project

Research description (short summary as written in the application)

In aero engine component applications where heat resistant alloys are employed (ex. Ni based alloy IN718 and Ti based alloy Ti6Al4V), it is necessary to control the surface integrity of the machined part in order to ensure sufficient fatigue performance of the component during its service life condition. Microstructure alterations of the material subsurface subsequent to machining have been reported in a few investigations where the presence of so-called "white layers" has been evidenced. The characteristics of such layers appear to depend on the work material but the mechanisms leading to their formation are not well understood, partly due to the practical difficulties of characterising such thin layers (~1-10 μm). Hence, it is proposed in the present investigation to characterise into details the physical, metallurgical and mechanical state of such layers in the context of two different component applications, i.e. machined IN718 and Ti6Al4Valloys. We have previously together with Linköping University successfully characterized surface layers on cutting tools using X-ray scattering techniques (Odén et al., Appl. Phys. Lett 94 (2009) 053114; Rogström et al., Thin Solid Films 520 (2012) 5542). Using similar techniques, our aim is to understand the phase composition and residual stress state in the altered surface layer of the machined material. This will complement the current use of high resolution scanning and transmission electron microscopy techniques to characterise these layers.

Work material, cutting tool and machining tests

Finish turning experiments will be performed on 3 different alloys, indicated in the table 1 using reference cutting data conditions. In total about 8 machined surface specimens will be produced, i.e. 4 surfaces produced with new tools and 4 surfaces produced with worn inserts.

Part-financed by the European Union

Table 1 Material and tools investigated

Work material	Cutting tool	Cutting Tool condition	
Nickel based alloy IN718	Carbide/Ceramic tool	New	Worn
Nickel based alloy Udimet 720	Carbide/Ceramic tool	New	Worn

Investigation of the subsurface layers with High energy X-rays

Since the thickness of the altered layer subjected to severe plastic deformation during the cutting process may lie within ~1-10 µm, adequate X-ray analysis method will have to be to access these layers. Such method shall be utilized to obtained information regarding :

- Phase composition
- Mechanical state (residual stress)
- Deformation texture

Summary of activities (experiments performed, beam-time used, preliminary overview of results, next steps and other relevant information)

Preliminary results

High energy X-Ray diffraction experiments in transmission geometry have been performed on the machined surfaces of different Ni based alloys (IN718, Udimet 720). The diffracted beams were collected by a 2D detector and the vertical x-ray beam size was chosen to 5 µm to obtain the desired depth resolution. Exposures were taken in 5 µm steps, resulting in a depth profile from the machined surface to a depth of 200-250 µm. A large number of experimental data has been gathered and the analysis of the results is in progress.
Preliminary results are presented here for the case of machined IN718 material.

Figure 1 displays a metallographic cross section of the machined surfaces of IN718 obtained when machining with a new and worn carbide tool, respectively. The effect of tool wear on inducing severe plastic deformation in the machined subsurface is evident.

This can also be seen when examining the peak broadening from the X-ray diffractograms collected at different depth beneath the machined surface (Figure 2) where the strain hardened layer thickness were estimated to ~75 µm and nearly 200 µm for new and worn tool, respectively.

Figure 3 displays X-ray pole figures obtained in the near surface of machined IN718 and indicate the presence of a "shear induced" deformation texture similar to what we have previously observed in laboratory X-ray diffraction studies.

Future work

Further quantitative analysis of the X-Ray experimental results will be carried out in the different materials in order to determine the surface and subsurface residual stresses in the machined subsurfaces.

How would you describe cooperation and assistance from national contact points while preparing and carrying out the research at large scale facilities?

Cooperation with the Science Link contact at Helmholtz-Zentrum Geesthacht, HEMS Beamline P07 at DESY have been very smooth as well as the assistance from the research team who helped carrying out the experiments.

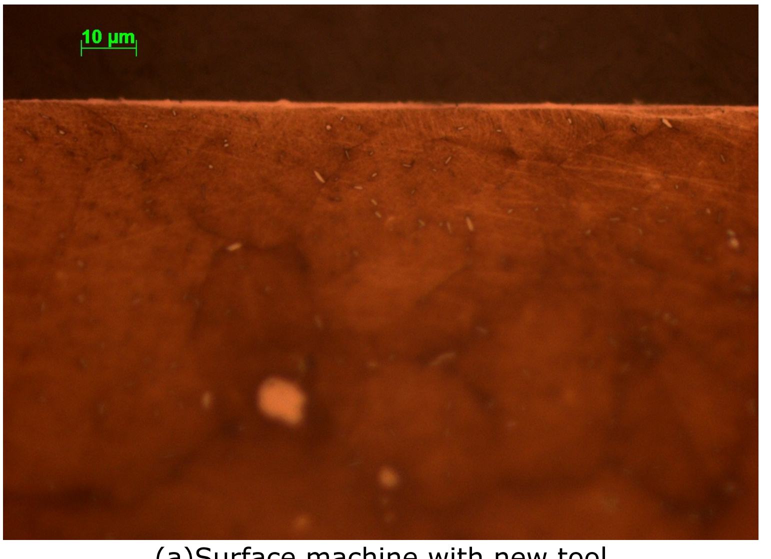
Part-financed by the European Union

Other personal remarks

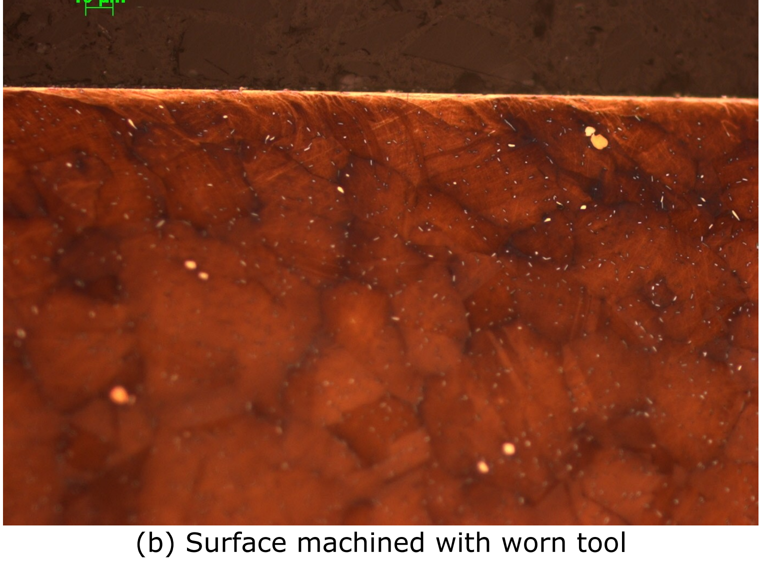
Through this preliminary work, new opportunities to assess surface and subsurface integrity of machined surfaces using advanced methods have been explored. From an industrial point of view, the knowledge gained from such in-depth investigations will help us optimise our machining process and tooling conditions for improved surface integrity in the context of difficult to machine applications.

Annexes

Annexes
(list of annexes; meeting minutes, graphical illustrations, tables and other supplementary data)



(a)Surface machine with new tool



(b) Surface machined with worn tool

Figure 1: Cross section of machined surface of IN718

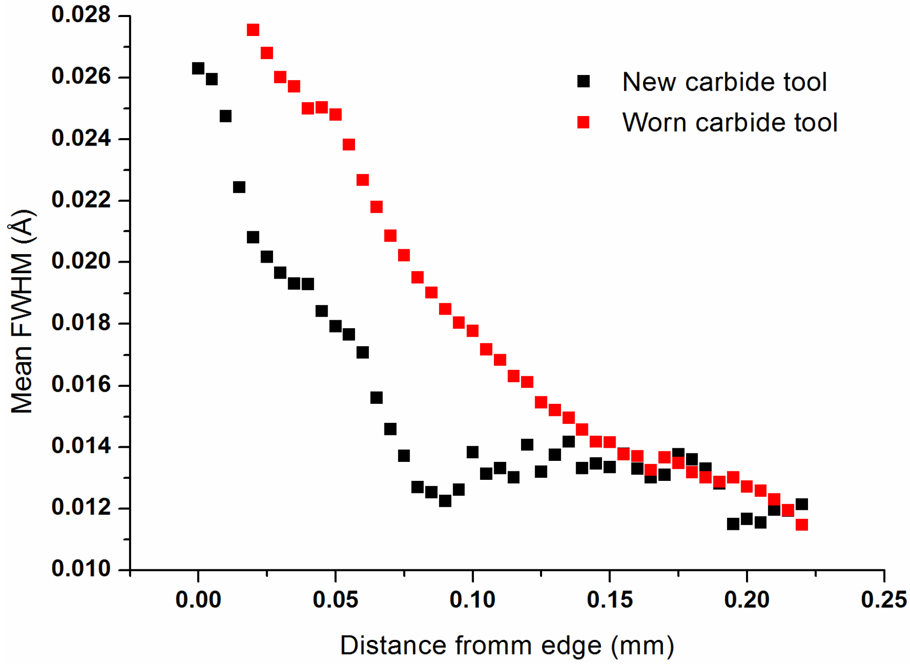


Figure 2 Peak broadening in the surface and subsurface layers of machined IN718

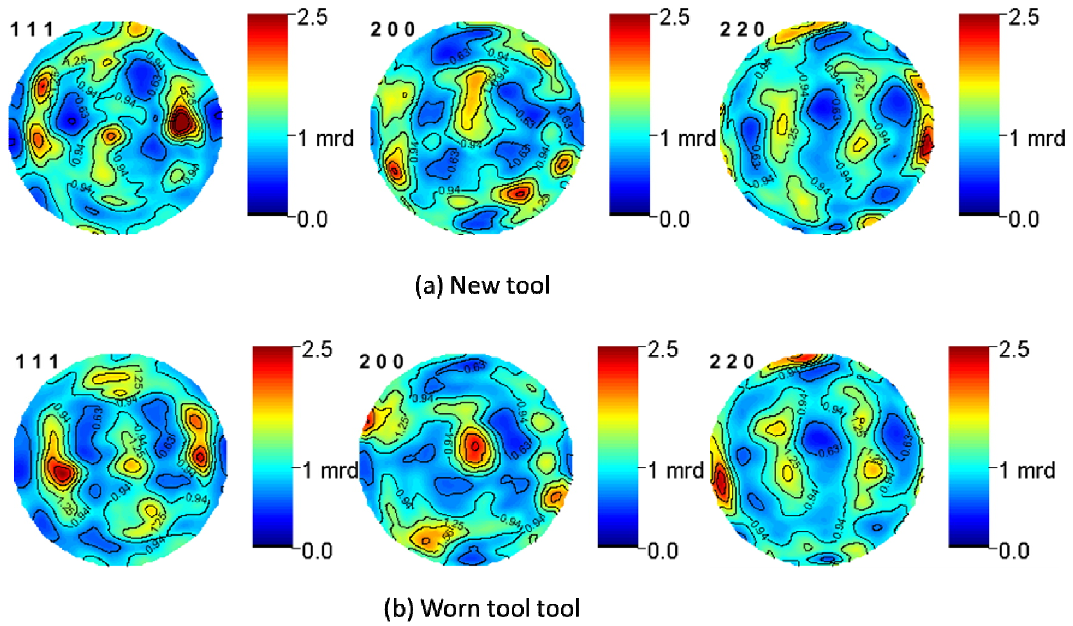


Figure 3 Xray pole figures obtained in the near surface of machined IN718