ACTA TECHNICA CORVINIENSIS
BULLETIN OF ENGINEERING

[1.] JOZEF MAJERÍK, [2.] NINA DANIŠOVÁ

HARDENED STEEL GRINDING REPLACEMENT BY HARD TURNING TECHNOLOGY

Abstract:

This article solves the problem of functional surfaces creation machined without and with coolant after mixed cubical boron nitride application. Workpiece material is tool steel C120U. The hardness value is within HRC = 49÷62. Various cutting speeds at constant feeds and depths of cut are chosen in depending on hardness in turning. The research article studies quality ratios according machined surface integrity is considered:

- *Microgeometry of machined surface,*
- *The changes of physical-mechanic properties in surface layer,*
- *Microstructure of the surface layers,*
- *Physical-chemical condition of surface functionality,*
- *Residual stresses beneath the machined surface,*
- *Tribological characteristics of the surface functionality.*

These ratios creates the influence of fatigue strength assumption against wear, anti corrosion stability, fit quality etc.

Keywords:

Hard turning, cubical boron nitride, grinding, surface integrity, residual stresses beneath the surface, surface microgeometry, microstructure of surface layers, surface functionality, tool wear

INTRODUCTION

The assignment of surface integrity investigation is new theory creation in term of new trends in technological praxis. Its very important to improve surface functionality of machined parts in qualitative aspect. The hard turning replacement is also possible to apply instead of roug and finish grinding. Tard turning technology requires stabile and solid machine tool with minimal allowances in guiding and last but not least techological system Machine Tool – Cutting Tool – Workpiece – Fixture stiffness. It was applied the polycrystalline cubical boron nitride CBN, as cutting material which is advisable to hard turning. Composition of CBN consists of BN (50 ÷ 75%) and ceramics binder.

Hard turning technology of hardened parts is very useful, because maching time is really shorter, lower invested costs, lower amount of operating sections and integrated shape. Workpiece geometry is realized for one clamping. Minimal charges for ecology – dry machining.

THE EXPERIMENTAL PROBLEM PURPOSE

The main purpose of this experimental method was considered surface layers aspect of specimen samples made of C120U hardened steel. All samples were manufactured by dry hard turning, grinding and turning with coolant in term of surface integrity. C120U steel is alloyed tool steel with medium capacity of

Carbon. This type of steel was chosen as a compared material, by reason to reach high hardness after hardening (64 HRC) and which is then tempered for 60±2 HRC. C120U achieves good core toughness, worse heat texturization, good machinability and hardening disruption insensibility.

In experimental process were evaluated following aspect of machined surface by hard turning and grinding on specimen samples:

1. *microgeometry of machined surface (Ra, Ry, Rz, Rq), machine SURFTEST SJ-301,*
2. *The change of physical-mechanic surface layer properties (hardness HV0,1 a HV0,2) on LECO machine.*
3. *Surface layer microstructure, at devices OLYMPUS IX70 and NEOPHOT 32,*
4. *Residual stress of I.st. type measurement beneath the surface on HZG 4 apparatus.*
5. *Machined surface wearing on tribological apparatus.*

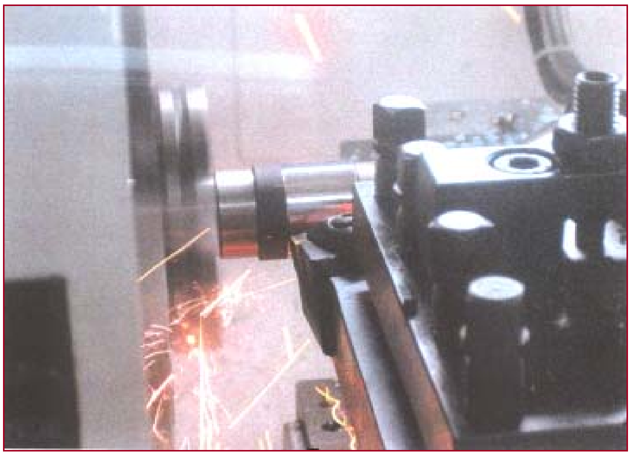

FIG. 1: Hard turning process with CBN insert at HARRISON ALPHA 1400 S machine tool

HARD TURNING AND GRINDING PARAMETERS

Machine tool: *HARRISON ALPHA 1400S,*
Tool holder: *DCLNR 2525 M12 – T – MAX – P (Sandvik COROMANT),*
Cutting tool: *VRP – CNGA 120408 T01020 – cubical boron nitride 7020 (Sandvik COROMANT),*
Clamping: *workholding device in universal chuck, upbear by centre, sample clamping for ø20H8 an to face side by nut and washer,*
Coolant: *emulsion E5% or without coolant (DASCOL 2500)*
Hard turning parameters: *C120U without and with coolant (G) HRC = 60±2*
$n = 1345\ min^{-1}$, $f = 0{,}15\ mm$, $a_p = 0{,}17$ *až* $0{,}2\ mm$, $v_c = 120\ m.min^{-1}$

Grinding parameters:
$n_o = 155\ min^{-1}$, $v_o = 0{,}23\ m.s^{-1}$, $v_k = 30{,}6\ m.s^{-1}$
$n_k = 1670\ min^{-1}$
$a_{p1} = 0{,}05\ mm$ *(roughing),* $a_{p2} = 0{,}01\ mm$ *(finishing)*
Grinding wheel: *ø350 x 40/127 – A9960K9V, coolant E5% emulsion (EMULZIN-H)*

METALOGRAPHIC EVALUATION

The microsturcture of surface layers evaluation was executed on OLYMPUS IX7 microscope. You can see in all microstructures of dry turned hardened steels thin white layer over the whole surface with 0,002 ÷ 0,003 mm width. See on Fig.2. Under the white surface layer can see influenced area by cutting temperature. Its dark layer of temperable martensite with 0,002 ÷ 0,004 mm width.

The next layer is situated bold martensite with residual austenite and metal carbides. The same white laeyr can see also in hard turned sample with coolant, but on the grinded sample cannot see this, or is very thin and very unstable. It is caused by grinding technology and very high cutting conditions during grinding.

The microstructure of grinded surface shows us the high tempered area. This argument is also confirmed by HV0,2 microhardness measured on C120U steel after grinding.

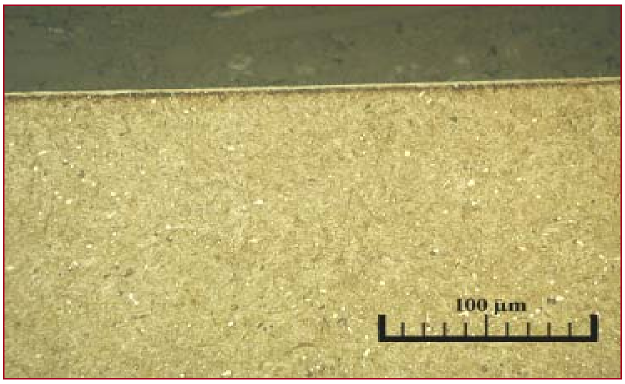

FIG. 2: Microstructure of C120U hardened steel after hard dry turning process – see continuous white layer of residual austenite on sample surface. White layer width is 0,002 ÷ 0,003 mm. Influenced area is situated under white layer (see dark cauterized layer) up until 0,004 mm. (tempering martensite)

TRIBOLOGICAL CHARACTERISTICS MEASUREMENT

The experimental samples made of heat treatment materials hard dry turned, hard turned with coolant and grinded were realized on tribological apparatus. Time duration of one tribological testing was designated to 300 min. Testing tribological arrangement continually evaluated reaction force and temperature in frictional event. We have emanated from friction ratio and driving force from frictional event construction during the calculations. Experiment approved that whereby the part surface is harder, therethrough wear is really slower.

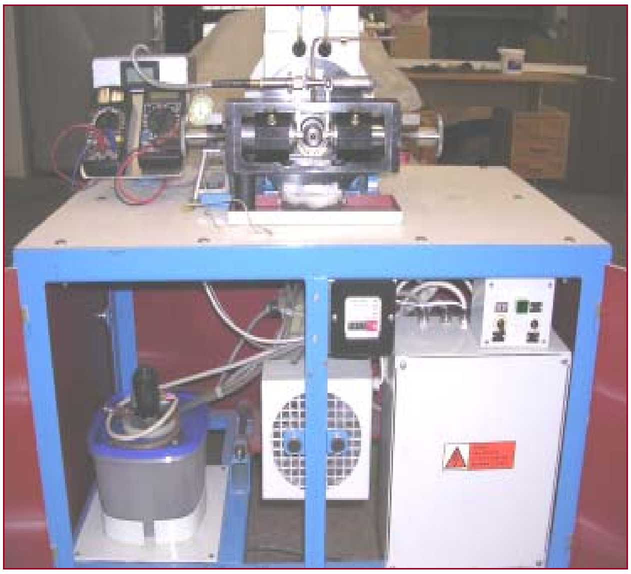

FIG.3: Tribological arrangement for radial wear testing

From individual tribological characteristics of individual hardened steels measurement and from graphs comparison comes the following knowledges:

6. *radial wearing ΔD of measured samples is always the biggest after grinding, because its done by little bigger surface roughness of grinded surfaces and heat influence where occurs to martensitic structure tempering. That is different at hard turned surfaces,*
7. *there is not difference between dry hard turned and hard turned with coolant samples in radial wear,*
8. *There are the biggest friction force and friction ratio at grinded surfaces.*

From experimental measurement results that surface wearing in tribosystems influences microgeometry and material surface average profile or surface influencing during the cutting process. Its stabilization let you say small tempering after hard turning, or big tempering of surface layers after grinding. It is also the surface hardness.

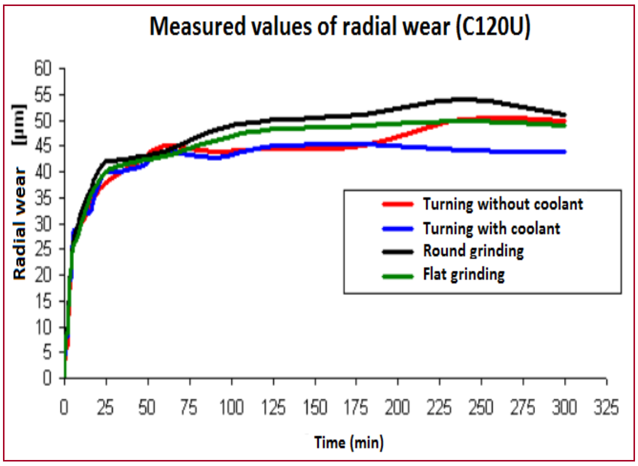

FIG. 4: Measured values of radial wear results

CONCLUSIONS

It was appreciated surface layer aspect of experimental samples made of hardened C120U steel hard turned with CBN and grinded. Experimental measurement were accomplished by microgeometry, microhardness, metalographic evaluation of surface layers and also tribological characteristics. These aspects of surface integrity are very important for surface functionality and operation durability of machined parts. Machined surface, its investigation, evaluation and technological process improvement creates important way to make better quality of production process.

REFERENCES

[1.] MAJERÍK, J.: Náhrada brúsenia kalených ocelí tvrdým sústružením. In: Strojárstvo/ Strojírenství – Mechanical Engineering Journal, ISSN 1335-2938. - Roč. 12, č. 5(2008), s. 170-171,180.

[2.] MAJERÍK, J., PAVLÍK, P.: Overenie možnosti náhrady brúsenia tvrdým sústružením s PKNB z pohľadu integrity povrchu, In: Funkčné povrchy 2006 [zborník] : Zborník prednášok z medzinárodnej vedeckej konferencie. - ISSN 1336-9199. - Trenčín. - 277 s. - ISBN 80-8075-137-4. - s. 121-128.

[3.] ZGODAVOVÁ, K., MAJERÍK, M.: Mechatronic Product Proporcionality and Inter-

Changeability Management: Mechanical Components, November 25-28,2009, In: Annal of DAAAM for 2009 & Proceedings of the 20th International DAAAM Symposium Intelligent Manufacturing & Automation: Focus on Theory, Practice and Education : World Symposium. - ISSN 1726-9679. - Vienna: Vienna University of Technology, 2009. - ISBN 978-3-901509-70-4. - p.1933-1934.

AUTHORS & AFFILIATION

[1.] *JOZEF MAJERÍK,*
[2.] *NINA DANIŠOVÁ*

[1.] *DEPARTMENT OF ENGINEERING TECHNOLOGY AND MATERIALS, FACULTY OF SPECIAL TECHNOLOGY, ALEXANDER DUBCEK UNIVERSITY IN TRENČÍN, SLOVAKIA*
[2.] *INSTITUTE OF MANUFACTURING SYSTEMS AND APPLIED AND MECHANICS, FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY,STU TRNAVA, SLOVAKIA*

ACTA TECHNICA CORVINIENSIS
– BULLETIN of ENGINEERING
ISSN: 2067-3809 [CD-Rom, online]