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[1.] Martin ROSIPAL, [2.] Miroslav FAKTOR, [3.] Michal ŠÍPEK, [4.] Vladislav OCHODEK

EVALUATION THE QUALITY OF MACHINED SURFACE AFTER MACHINING WITH USING BARKHAUSEN NOISE

ABSTRACT:
This paper deals with application of Barkhausen noise for analysis of surface integrity in turning and grinding operations. The stress state is analyzed in relation to tool wear. The results of measurements show that the residual stresses are not homogenous on the machined surface. This homogeneity depends on tool wear and stability of cutting process. Application of non-destructive testing through the Barkhausen noise is more suitable for grinding operations. Application of Barkhausen noise testing for turning operation will require the next research.

KEYWORDS:
Barkhausen noise, grinding, turning, residual stress

INTRODUCTION

There are many methods applied for measurement of residual stresses induced in the surfaces. Micro magnetic and X - rays methods are non - destructive methods for measurement of these stresses. Micromagnetic methods based on the Barkhausen noise are suitable for evaluation of surfaře integrity. This method is based on the continuous rotation of magnetic field that results into the non continuous magnetization of material. This discontinuity is named as the Barkhausen noise.

Barkhausen noise is damped with increasing depth. The main reason is the damping effect of eddy current influencing electromagnetic fields of the moved Bloch walls. The Bloch walls rotate under the external load to the orientation of magnetic flow. The compressive stresses decreases intensity of Barkhausen noise and the tensile stresses increase this movement [2,1,6,7] (Figure 2.). Hardness of structure influences intensity of Barkhausen noise too, this influence represents Figure 1.

Barkhausen noise is the suitable tool for investigation of surface integrity, especially for analysis of the thermally induced damage. Surface integrity is very important in the scope of finishing operations on parts. Nowadays, there is tendency to replace the final grinding operation on hardened parts with turning process.

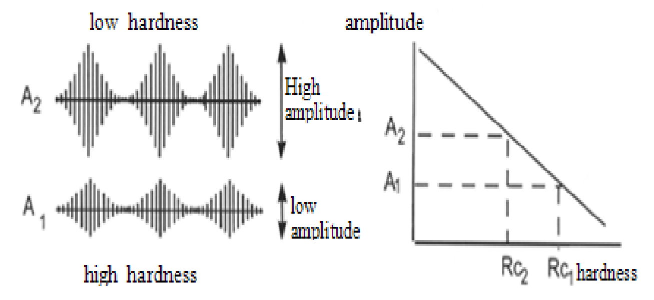

Figure 1. Influence of hardness on character of Barkhausen noise [2,3,4,5]

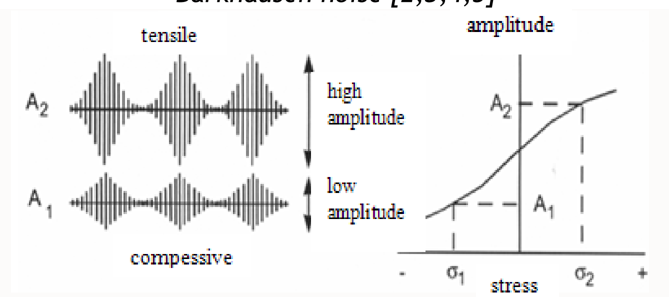

Figure 2. Influence of stress on character of Barkhausen noise [2,3,4,5]

This enables to reduce the cutting time and machining cost for some operations. Technologies of turning and grinding have some advantages and disadvantages concerning the technical, economy and ecology aspects of machining. There is no problem to produce the surface of the same roughness or of the same precision. On the other hand, the final surface after *grinding differ form the final surface produced through the turning in the scope of thermal and mechanical load and in relation to the tool wear. And so, this paper deals with analysis of these aspects. Measurement of residual stresses, surface roughness and dimension stability was carried out on the parts after grinding and turning in this paper.*

CONDITIONS OF EXPERIMENTS

Experiments were carried out on the roll bearing steel 100Cr6 of hardness 62 HRC. There were made the rings of external diameter 48 mm, internal diameter 40 mm and width 7 mm. These rings were ground and turned under the constant cutting conditions in relations to cutting time, respective the related removed material. Series of the 3 ring were inspected after the certain passes of tool (these passes relate to material removal and cutting time are in Table 1.).

Table 1. Intervals of measurements of rings and related removed material

time (min.)	0	2,5	7	13	20	30	36	44
Removed material (cm^3)	2	6,2	19	37	56	87	105	130

Cutting conditions for turning operations:
Lathe SUI 40, dry machining, mixed ceramic tool DNGA 150408S015256050 with TiN Coating a_p=0,25mm, f = 0,09 mm, v_c = 90 $m.min^{-1}$.
Grinding machine: 2BuD, Grinding wheel A 98 80 K9V, Cutting fluid - Emulzin H (2%), a_p = 0,025 mm (10 passes + 3 spark out passes),v_f = 6,7 $m.min^{-1}$, v_w = 0,44 $m.min^{-1}$, v_c = 28 $m.s^{-1}$, single crystal diamond dresser.
Tool wear in turning operations were measured on the laboratory microscope BK5. Analysis of stress state was analyzed on 24 rings (3 rings per each 8 series) in 8 points on the periphery of the rings. There was analyzed area of the envelope curve of Barkhausen noise MBN (related to stress state of surface) and the maximum amplitude of the noise MBN max (related to the hardness of the rings).

THE EXPERIMENTAL RESULTS. Grinding process

Figure 3. illustrates than influence of grinding wheel tool on residual stress. Residual stresses are significantly increasing with grinding wheel tool (Figure 3.) and the stress state can lead to formation of cracks on the surface.

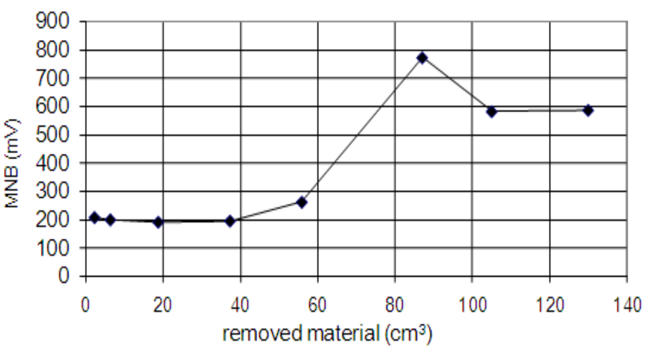

Figure 3. Influence of grinding wheel wear on area of Barkhausen noise after grinding

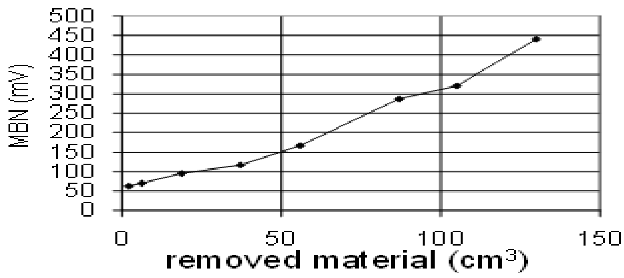

Figure 4. Variance of stress distribution around the ground parts

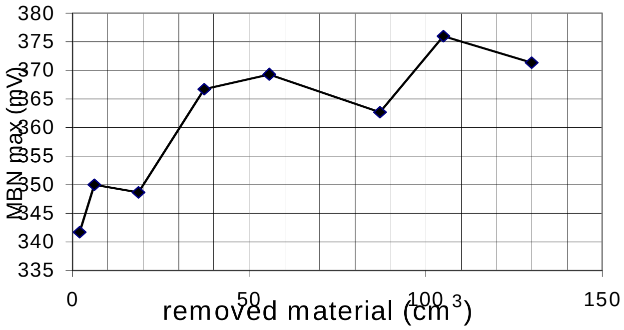

Figure 5. Influence of grinding wheel wear on amplitude of Barkhausen noise after grinding

Intensive thermal load causes surface burn and decreasing of hardness of ground parts, Figure 5. Increasing amplitude of Barkhausen noise is connected with softer structure because of the more intensive activity of Bloch walls. The decreasing stability of grinding process decreases homogeneity of the stress state on the periphery of ground part, Figure 4. (difference between the higher and the lower values of residual stress - calculated on the base of 8 points around the periphery of machined part). Figure 4. shows that distribution of residual stress is much more homogenous after the dressing that that in the last stage of the experiment, Figure 6 and 7.

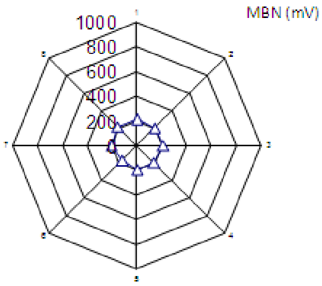

Figure 6. Distribution of stress around the periphery of ground part, ring number 1

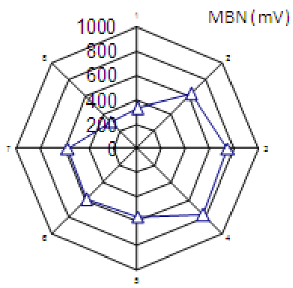

Figure 7. Distribution of stress around the periphery of ground part, ring number 24.

THE EXPERIMENTAL RESULTS. Turning process

Application of this micromagnetic method in the hard turning operation differs from the grinding process. There is the significant aspect of tool wear. There is formation of white layers of the machined surface. The thickness of these layers is increasing with increasing tool wear VB [9, 10]. Structure and hardness of this layer differ from the deeper layers under the surface. Formation of white layers is caused by intensive material flow under the cutting edge and its intensive mechanical and thermal load. Character of this white layer differs from white layers formed in grinding process [9, 10]. The structure consists of martensite and austenite and hardness of this structure can overcome 1000HV and increases with tool wear VB. Figure 9. illustrates the slow decreasing of the amplitude of Barkhausen noise with material removal and so with the increasing tool wear.

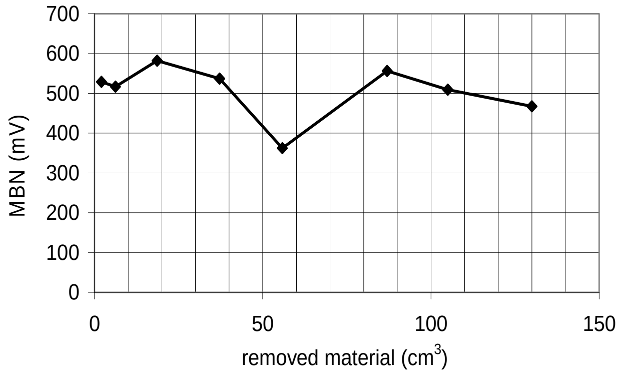

Figure 8. Influence of tool wear on area of Barkhausen noise after turning

This slow decreasing indicates the increasing hardness of the inspected structure. Despite of the higher thermal load of surface, there is no visible burn of the surface after turning. The thermal and mechanical exposure of the machined surface is very short in the contrary to grinding process.

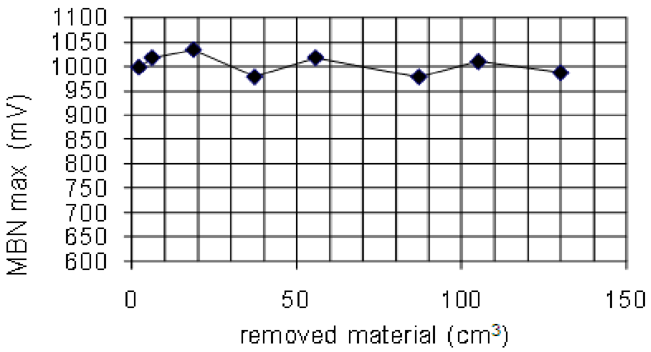

Figure 9. Influence of grinding wheel wear on amplitude of Barkhausen noise after turning

Monitoring of the stress state after hard turning through the Barkhausen noise (related area of Barkhausen noise envelop curve) is difficult, Figure 8. There is formation of the compressive stress in the thin layer under the surface and the tensile stress in the deeper layers under the surface [10]. The compressive stresses are shifted to the tensile zone with increasing tool wear and increasing thickness of white layers. Transformation of compressive stresses to tensile stresses should increases area of Barkhausen noise, but increasing hardness of machined surface eliminates this rise. And so, the curve of stress state represented by Figure 8. is not monotonous and is given by superposition of the increasing tensile stresses and hardness of the structure.

The turning process of hardened parts is less stable in comparison with grinding. Grinding operations are realized through the repeated passes and removal of thin layers. The turning process is realized per one pass and stability of cutting process is affected by deformations of parts caused by the previous heat treatment process [8]. Distribution of stresses around the periphery of turned parts is less homogenous than after grinding in the first stages of material removal, Figure 10, 11.

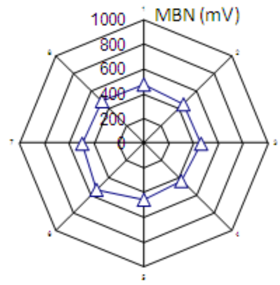

Figure 10. Distribution of stresses around the periphery of turned part, ring number 2

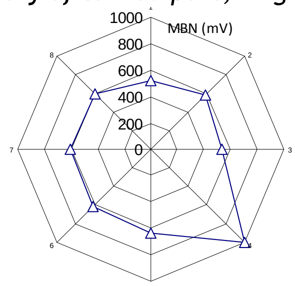

Figure 11. Distribution of stresses around the periphery of turned part, ring number 18

CONCLUSIONS

The results of measurement show that:

- *application of Barkhausen noise is very suitable for monitoring of thermally affected surfaces after grinding,*
- *application of Barkhausen noise for monitoring surface integrity after turning will requires the next research because of the contrary influence of stress state and hardness in the structure,*
- *there is decreasing homogeneity of stress state in relation to tool wear for both applied technologies.*

The higher presented conclusion should be related to the cutting conditions applied in the experimental part of this paper. Turning and grinding process are affected by many factors and their influence can modify obtained results of measurements.

Application of Barkhausen noise for investigation of surface integrity seems to be very suitable, but will require the next research focused on more detail analysis of Barkhausen noise envelope curves. The results of these experiments will be presented in the near future.

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AUTHORS & AFFILIATION

[1.] Martin ROSIPAL,
[2.] Miroslav FAKTOR,
[3.] Michal ŠÍPEK,
[4.] Vladislav OCHODEK

[1,3.] UNIVERSITY OF ŽILINA, FACULTY OF MECHANICAL ENGINEERING, DEPARTMENT OF MACHINING AND MANUFACTURING ENGINEERING, SLOVAKIA
[2.] UNIVERSITY OF ŽILINA, FACULTY OF MANAGEMENT SCIENCE AND INFORMATICS, DEPARTMENT OF INFORMATICS, SLOVAKIA
[4] TECHNICAL UNIVERSITY OF OSTRAVA, FACULTY OF MECHANICAL ENGINEERING, DEPARTMENT OF MECHANICAL TECHNOLOGY, CZECH REPUBLIC

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