

Mechanics and Mechanical Engineering
Vol. 17, No. 4 (2013) 317–323
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Damage of the Surface Layer Gears in Grinding Process

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Received (10 March 2013)

Revised (16 May 2013)

Accepted (20 July 2013)

The influence of the grinding process on the condition of the surface layer (SL) obtained by the treatment of the gear with grinding wheels Al_2O_3 , CBN, GF, SG, alloy steels with different parameters of the grinding process and the type of cooling liquid – lubricant (CLL). The stress distribution at the surface layer, structural changes, secondary hardening, forgiveness SL and drastic damage–microcracks have been presented in comparative studies.

Keywords: Grinding, gears, cooling liquid

1. Introduction

The nature of the work of two gears is a complex tribological system in which change bending stresses, contact information and we have to deal with friction antifriction reversible slide and slip values. Hence the fatigue strength is important, both the bending and mainly pitting resistance, important from the point of view of operation [4, 5, 6]. Properties of the surface layer (SL): residual stress, surface roughness [6], in addition to the material properties of which are made of gears, the strongest influence on the fatigue strength of the teeth. There are two processes in terms of the quality of the surface essential gears: thermo-chemical processing and finishing.

The first of these processes creates a material with altered structure and chemical composition and various mechanical, physical, etc. Many methods of thermo-chemical treatment can be taken into account in the production of gears, for instance carburizing, vacuum carburizing, nitriding, hardening, quenching and tempering, etc. [5, 6].

It is well known that compressive residual stresses are present in the above mentioned heat-treated (nitrided, carburized, hardened) they affect the growth of fatigue in gear wheels [5].

Grinding covers the: for finishing treatments used in the production of gears largest share in industrial practice. This process is very important because it is used as the finishing operation of grinding and has a direct impact on the performance characteristics of the gear. There are two groups of methods that dominate teeth grinding - grinding worm gear hobbing grinding wheel, the so-called, reishauer method, and grinding hobbing divisions, for example the Niles method [4, 5].

2. Changes in the surface layer grinding process

2.1. Analysis of structural changes

Preparation of the steel by heat treatment directly affects the formation of structures in the grinding process. Heat released during grinding Al₂O₃ grinding wheels, SG, GF, the impact on the distribution of micro-hardness and stresses in SL. Steel 45 may be an example.

Fig. 1 shows figure steel 45 where coincidences using appropriate heat were obtained for the different structures of the material. On the Fig.1a we see stream structure troostytu of hardness 42 HRC (low tempering). In the case of Fig. 1b, a hardness of a sorbitol has been received 30 HRC (high tempering).

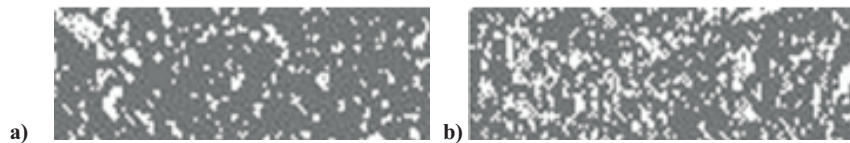


Figure 1 The structure of 45 hardened carbon steel in water: a) tempered low, b) tempered high (area x 500)

The type of material structure affects the form of wheel wear. Illegal use of abrasive grains in the grinding of carbide determines the strength of grinding wheel wear. Figure 2, presents images of the temperature distribution in the SL in the process of grinding wheel with 60K GF – PPS: $v_s = 26,5$ [m / s] $v_w = 0,1$ [m / s], $a_e = 0,05$ mm] between PCS: a) 45, b) 40H, figure 3a) 38HMJ, 3b) 15HN after carburizing and quenching. When the grinding wheels with Nilles method, the size of cut and length of the grinding wheel contact (or forehead joint) with the tooth, varies along the contour in subsequent positions hobbing (Fig. 4) and depends on the curvature of the tooth. It can be assumed that change in the ground layer, and thus uneven temperature distribution in the tooth grinding process results in changes in strain along the polished profile [3].

Fig. 4. presents the case of damage to the SL in the grinding process, scorching spot. The end result of tribological damage the gear.

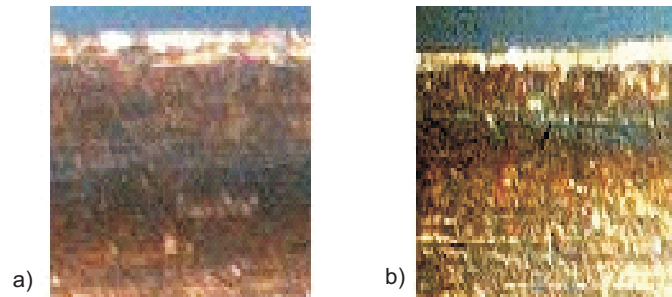


Figure 2 Temperature distribution of steel flat samples: a) 45, b) 40H – Sanded

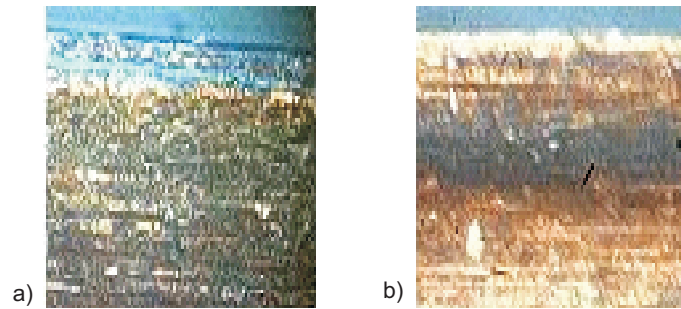


Figure 3 Temperature distribution of steel flat samples: a) 38HMJ, b) 15HN – Sanded

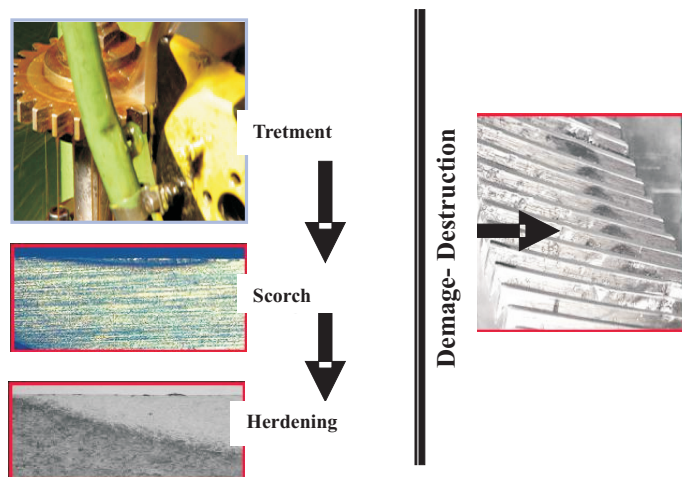


Figure 4 SL damage in the conventional grinding wheels grinding Al_2O_3

3. Analysis of the distribution of microcracks formed during grinding

During the studies a number of defects, different distributions of microcracks or micro-chipping of all parts of the SL. Samples have been observed by flaw in a longitudinal magnetic field. Here are several examples in Fig. 5 (in steels 45, 40H, 15HN).

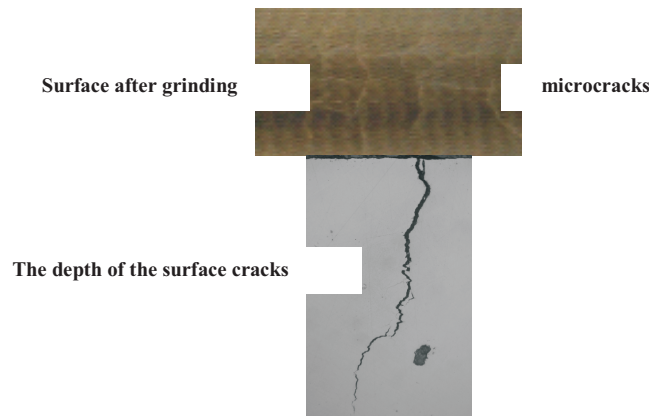


Figure 5 Distribution of microcracks in SL abrasive grinding process involving GF 60K VX mist (results obtained in the mode studies)

As described earlier, the damage is the most drastic at flaps in the grinding process. This applies mainly to grinding abrasive corundum ences and aloxite. These type of damages occur in the event of structural changes such as secondary hardening. Very hard layer with a thickness of 0,04 [mm] passing in the zone layer which was tempered. High volume of unit pressure the big causes cracking of the film during operation.

The value of microcracks into the material ranged from 0,14–0,68 [mm], depending on the chemical composition and hardness of the material test sample (very extreme cases, curing grinding).

4. Curing surface layers grinding process

The Fig. 6 shows the effect of the impact of heat produced in the process of grinding steel 40H in the soft state, the parameters of the grinding process (PPS): $a_e = 0,06$ [mm] $v_s = 26,5$ [m / s], $v_w = 0,1$ [m / s], $B_p = 8,72$ [W s/mm²].

Fig. 6 distribution of the surface layer of hardened steel 38HMJ, grinding ground 3SG 60K (magnification 50x, etched Nital, the results obtained in of model studies).

Distribution of the individual layers was obtained for low speed of the subject matter, the amount of heat generated in the grinding is high. Secondarily is produce and hardened white layer with very high hardness of about 60 HRC, the area includes the value of the changes presented in Fig. 6, and is approximately.

Distribution of the individual layers was obtained for low speed of the subject matter, the amount of heat generated in the grinding is high. Secondly is produce and hardened white layer with very high hardness of about 60 HRC, the area includes the value of the changes presented in Fig. 6, and is approximately 0,213 [mm]. It includes a transitional area of change of hardness of 20 HRC less than the secondary layer, and further extends to the area with a hardness of 52 HRC.

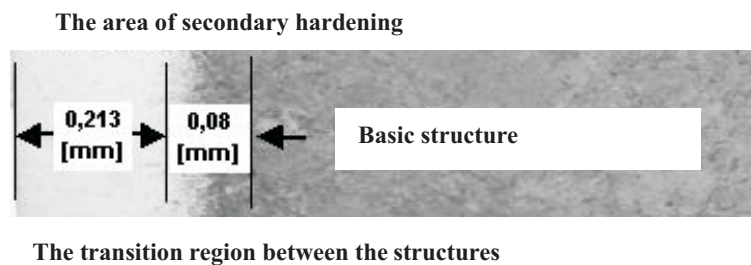


Figure 6 Distribution of the surface layer of hardened steel 38HMJ, grinding ground 3SG 60K (magnification 50x, etched Nital, the results obtained in of model studies

Fig. 7 shows the observed distributions of residual stresses generated during testing. Depending on the energy of the grinding process various waveforms obtained stresses. In case of Fig. 7a to 45, with the parameters of the grinding process (PPS): $v_s = 26.5$ [m / s] $v = 0.1$ [mm], and $e = 0.05$ [mm], $B_p = 5, 84$ [the s/mm²], involving liquid cooling – lubricating PCS (S), abrasive 38A60K, residual stresses at a depth of 0.04 mm remained at zero. Above this depth, an increase in stress – positive increase in temperature resulted in remission of the surface layer, residual stress reached 400 MPa, tensile stresses are Fig. 7b) 40H steel, PPS vs. 26.5 [m / s], $v = 0.1$ [m / s], $ae = 0.05$ [mm], $B_p = 5.24$ [W s/mm²], PCS emulsion (E), grinding GF K60.

With similar grinding process, various grinding wheels, grinding steel case Fig. 7c 40H grinding of mikrokorundu 3SG60K, the state of the surface layer in this case was as follows. The process resulted in secondary quenching and micro layers deeper areas of forgiveness which is very unfavorable in terms of tribological system. The abrasive grinding with cubic boron nitride of the same material with similar parameters of the cutting process did not cause any damage to the WW Fig. 7d. They remained at the level of compression in the area to a depth of compression depth in the study area.

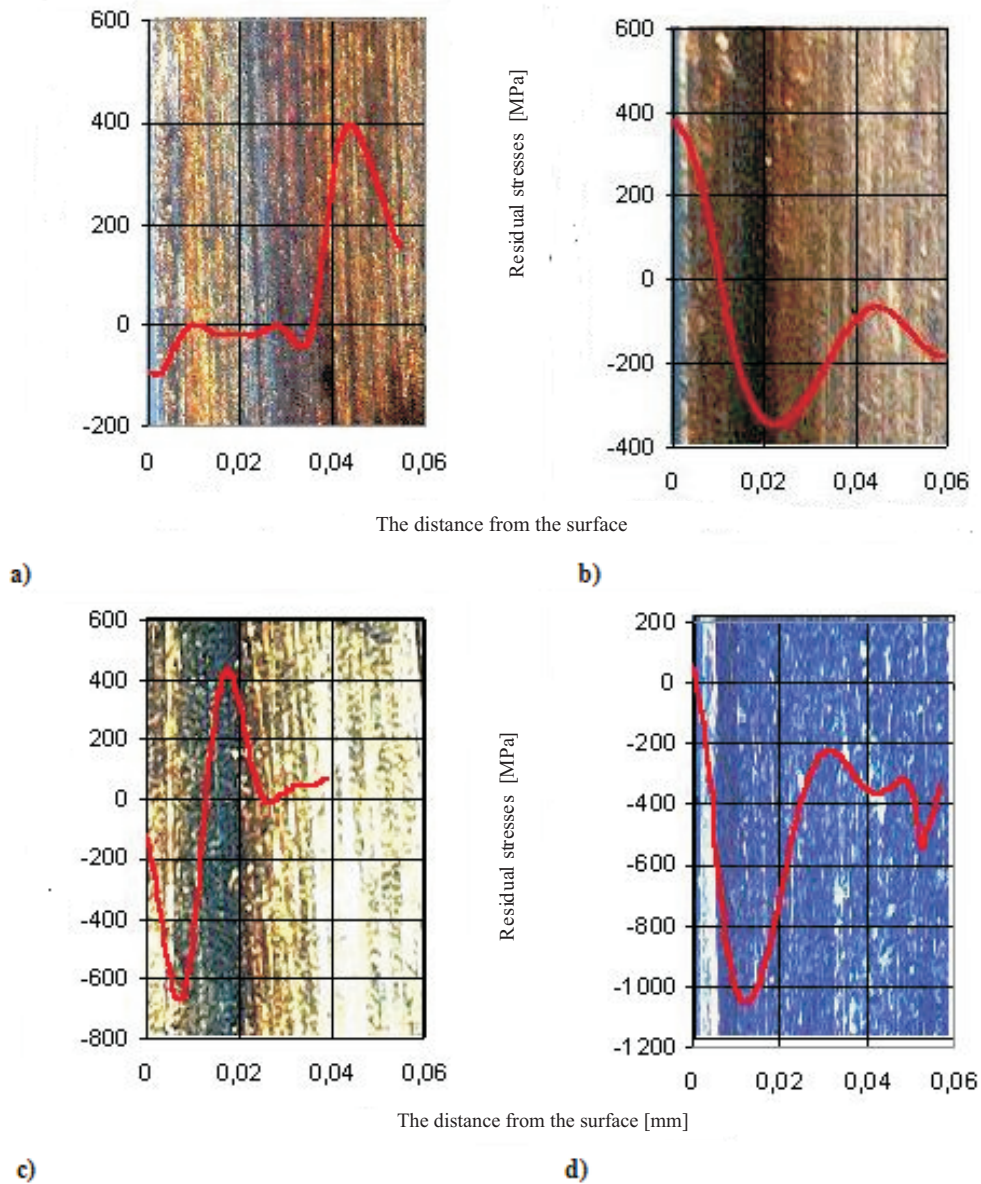


Figure 7 Distribution of residual stresses for steel: a) 45, PPS- $v_s=26,5$ [m / s], $v_w = 0,1$ [mm], and $a_e = 0,05$ [mm], $B_p = 5,84$ [W s/mm²], PCS (S), abrasive 38A60K, b) 40H, PPS- $v_s=26,5$ [m / s], $v_w = 0,1$ [m / s], $a_e = 0,05$ [mm], $B_p = 5,24$ [the s/mm²], PCS (E), grinding GF K60, c) 40H grinding 3SG60K, d) cBN grinding wheel 40H 80/63 with the parameters as above (the results obtained the model studies)

5. Conclusions

It is well known that it is extremely difficult to obtain in an efficient, conventional grinding wheels grinding electrocorundum WW beneficial properties. Results of processing are generally good for the surface smoothness, while the tensile residual stress and changes in microstructure and hardness characteristic of conventional grinding should be considered detrimental to the performance characteristics of such gear teeth as the bending fatigue strength for pitting or more.

The use of grinding wheels to grind materials such as cubic boron nitride (cBN), allows to achieve much better condition SL, but forces us to careful selection of processing conditions to ensure economic treatment despite the high cost of machining tool and its regeneration. Selection of the appropriate speed of the grinding wheel in this case has a decisive importance. Reducing the contact time of the grinding wheel and the workpiece – the amount of heat entering the SL is much smaller, and the roughness deteriorates.

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