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SIMULATION PROCESS OF ULTRASONIC SURFACE HARDENING

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1. Introduction

One of the objectives in surface treatment of machine parts is to increase their fatigue life by implementing pressure surface stresses. The method of surface hardening by means of mechanical-acoustic energy acting at elastic-mechanical vibration of the elastic environment in the process of elastic or plastic deformation offers real possibilities to positively influence surface quality/properties. According to available published works but also on the basis of research results of the authors of this paper [1] it can be confirmed that the process efficiency depends on a series of acoustic and technological parameters as e.g. excited vibration type in the stress-deformational area of the hardening process and value of the applied acoustic intensity. Mechanical characteristics of the material in the hardening state as well as shaping and speed parameters oh hardening are also important. Similarly, as in any hardening method, a significant factor is the kind of created contact friction and the lubricant used.

Surface layer hardening simulation by means of the ultrasonically wobbled tool using the combined method of final and discrete elements was applied in order to achieve, via surface treatment of machine parts, increased fatigue life by implementing pressure surface stresses. The applied combined method includes advantages of both materially and geometrically non-linear final elements methods and mutual interaction of a large number of bodies (discrete elements). It facilitates dynamic solution of tasks, i.e. propagation of stress waves and their mutual interaction.

2. Conditions and objectives of experimental investigation

In the proposed simulations the following conditions were considered:

- the tool tip has a shape of a semisphere
- high-frequency tool excitation of 20 kHz
- the tool is considered to be a perfectly solid body.

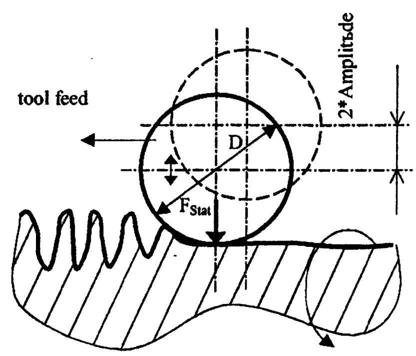
Simulation computations were carried out for selected machine part and too geometries:

• material: bearing steel	STN 14 109.6
• modulus of elasticity	E= 210 000 MPa
• Poisson´s ratio	$\nu = 0{,}3$
• initial yield point	diameter 40 mm, length 230 mm

- tool spherical area diameter 8 mm
- tool vibration amplitude $A = 36\ \mu m$
- tool feed $f = 300\ mm.s^{-1}$
- Coulomb´s friction coefficient $\mu = 0,7$ or $0,05$

The objective of the performed simulation computation was:

- determination of the residual stress in the surface layer
- determination of local plastic areas
- stress wave propagation in the surface layer.



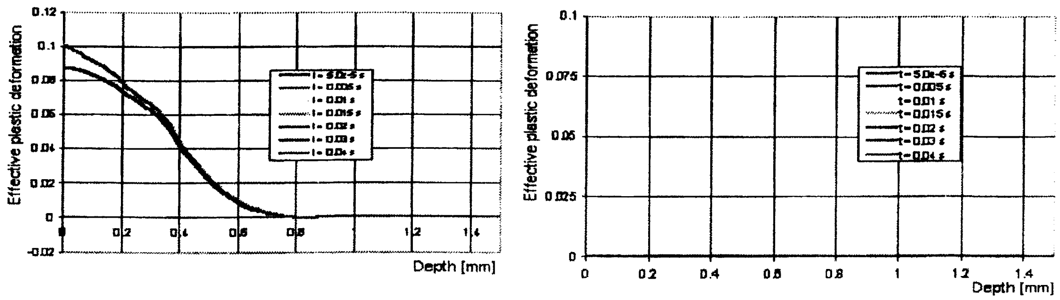
A.) Ultrasonic hardening process by surface quality enhance

3. Results and discussion

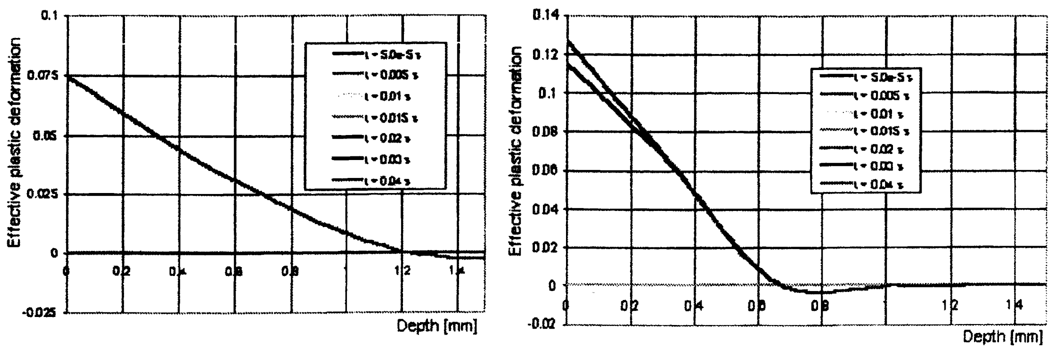
The research published by the authors in [1] was devoted to investigation of the contact surface influenced by wobbling tool after the time t = 0.00005 s, t = 0.02 s and t = 0.04 s which relates, with respect to the hardening tool feed speed, to the nearly first tool contact, then contact after 6 mm and finally contact in distance of 12 mm from the first tool contact with the hardened material.

Within the surface layer analysis there were made partial analyses of axial stress courses in the depth under the surface and the plastic deformation course in dependence on time. From a large number of outputs only those have been selected for this paper, which indicate the size and course of plastic deformation, specifically after the tool travelled 12 mm

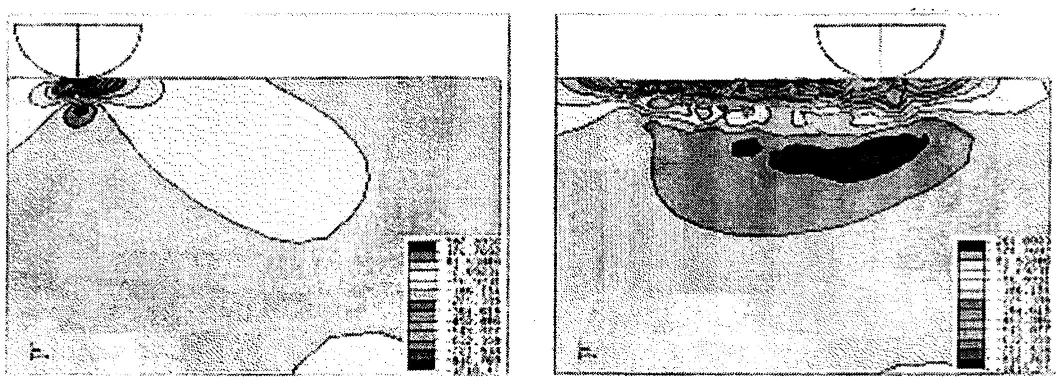
Interesting is the course of the tool contact force on the workpiece surface. Simulation was carried out in a regime when the tool touches the surface with a zero push force (a limit state) and the double amplitude causes the below presented force course. The force, after the higher initial value, gradually stabilises at the value of approximately 600 N. This is probably due to diminishing the area on the workpiece, which is deformed under the impressed ball influence during further impacts.



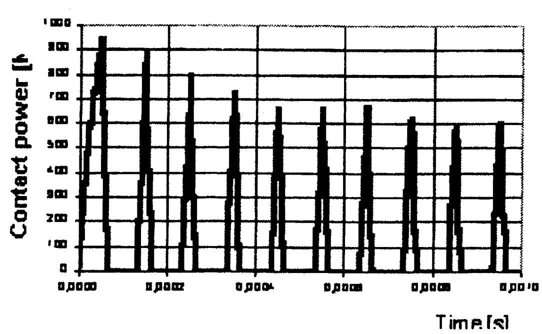
B.) The course of plastic deformation in the depth at the beginning of the motion and after the tool travelled 12 mm



C.) The course of plastic deformation in the depth at the beginning of the motion and after the tool travelled 12 mm



D.) The material stress on the start and after 12 mm the motion
D = 3 mm, A = 36 μm, f = 300 mm s-1, μ = 0,7



E.) A detail of the contact force course between the tool tip and workpiece

4. Conclusions

For simulation of surface layer hardening by ultrasonically wobbled tool a combined method of final and discrete elements was used. The obtained results show changes in material properties in the surface layer. Further simulations will continue utilising assigned parameters in experiments on the newly developed device at the working place of the researchers of this task and will be compared with experimentally achieved results [2]. The lecture will be completed by computer animation examples of the performed simulation.

LITERATURE

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ВЛИЯНИЕ РЕЖИМОВ ДУПЛЕКСНОЙ ОБРАБОТКИ НА ФИЗИКО-МЕХАНИЧЕСКИЕ СВОЙСТВА СПЛАВОВ СИСТЕМЫ Fe–Cr–B–Si

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Сплавы системы Fe–Cr–B–Si обладают высокой структурной чувствительностью к энергетическому воздействию и легирующим добавкам /1/. Лазерное модифицирование позволяет точно дозировать подвод энергии и легирующих веществ, а характер получаемой структуры определяет качество упрочненного слоя. Кроме того, они обладают высокой износостойкостью, вследствие композиционной структуры.

Лазерное легирование неметаллическими компонентами – углеродом, азотом и бором получило наибольшее распространение при использовании