Modelling and Computer Simulation of Burnishing Rolling Process

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Abstract. In this study the methodology of modeling and computer simulation of the process of burnishing rolling is presented. Process was considered as a geometrical and physical boundary and initial value problem, with unknown boundary conditions in the contact area. 3D dynamic explicit method for burnishing rolling process with taking into account surface after turning (as previous treatment) under ANSYS/LS-DYNA environment was established. The results of computer simulations are presented i.e. displacement, surface deformation, states of strain and stresses, depth of stress deposition, elastic recovery of the material. Developed application using the incremental theory in updated Lagrange description allows to analyze the geometric structure of the surface and the distribution of stresses in the surface layer at any time during the burnishing process.

INTRODUCTION

The surface quality after previous treatment has significant influence on its quality after burnishing rolling. It is recommended that outline of the surface roughness under burnishing was regular, determined and periodical. After burnishing rolling of such profile, one receives also regular, determined and periodical profile. Burnishing rolling of the surface with a stochastic roughness profile (e.g. after grinding) causes that the achieved burnished surface is also with stochastic surface roughness profile. On the surface the secondary cavities are formed and material overflows, resulting in deterioration of the burnished surface quality. Previous studies have shown that the surface roughness after the process of burnishing the regular, triangular asperities depends on the material type of asperities (yield stress Re, Young's modulus E), the geometrical parameters (vertical angle θ of asperities, the distance f, the volume V (or surface outline area S), rounding of asperities volleys and the peaks. Authors, with the assumption that the asperity of the surface after previous treatment is regular, symmetrical, and triangular and that it is symmetrical deformity, single out three qualitatively different cases of the material flowing in the product's Surface Layer (SL) during burnishing rolling process depending only on the vertical angle θ of the asperity.

Numerical simulations of the process of burnishing can confirm the ability to control distribution of stresses. Numerical algorithms can be used for an assessment of the influence of the surface after previous treatment on the burnished product. They facilitate a better understanding of the phenomena which occur in the zones of contact and strains, and therefore can constitute the basis for the development of guidelines for the selection of the conditions of burnishing process considering the required technological quality of the product.

NUMERICAL RESULTS

Exemplary results of model displacement and deformation of the finite element mesh grid in subsequent time steps are shown in Figure 1. In the first picture there is an example of the object that is prepared in previous treatment (for example in turning process) under burnishing. The model consists of two triangular, regular asperities on the surface of the shaft, which constitute the actual details of the surface prepared to be treated. Then the moment, when the tool moves to the rotating part of shaft is visible as well as its immersion and then the deformation of asperities vertexes. Further immersion of the burnishing tool (until a value equal a half of the asperity height) and rotation of the shaft causes increasing asperities squeeze until it is completely smooth out. After removal of the burnishing tool visible surface asperities of the rough, input surface are smoothed.

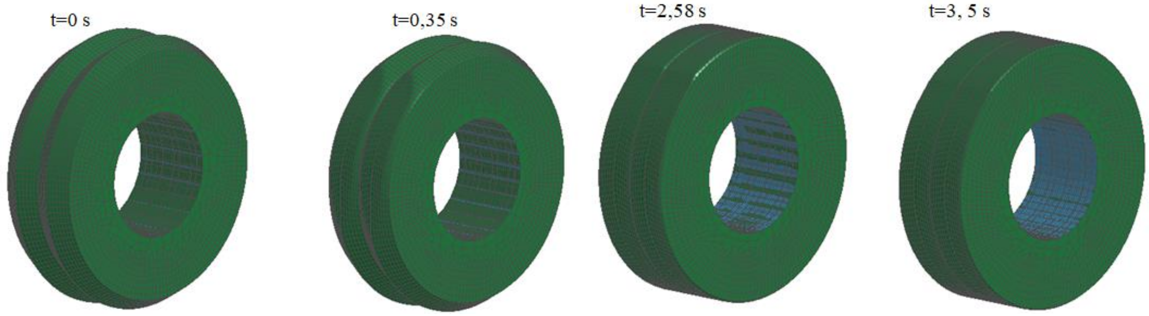

FIGURE 1. Displacement and deformation of the finite element mesh grid in subsequent time steps

During simulations and experimental researches of the burnishing rolling process an attention was drawn to the elastic strain of the material of the burnished product, which takes place after moving away the burnishing element. The phenomenon was called elastic recovery Δu_0. Computer simulations made it possible to observe and quantify the size of the material elastic recovery during the burnishing rolling process (the result for the node from the vertical angle of the asperity).

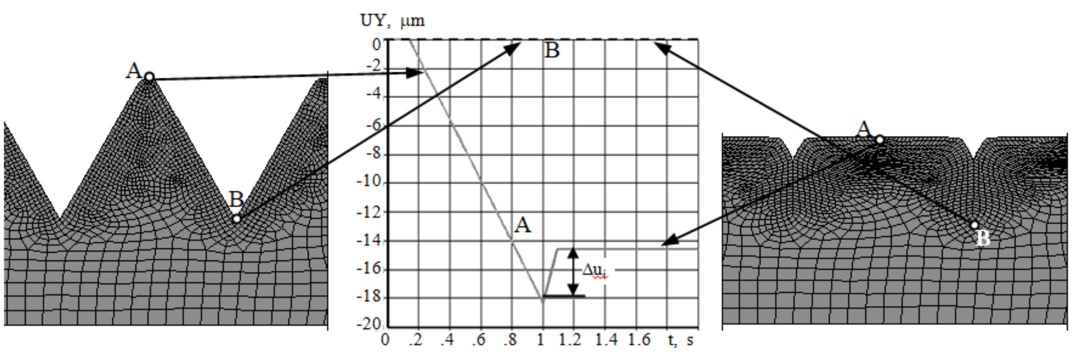

FIGURE 2. Graph of displacement (Y axial) of chosen asperities nodes for the apex angle $\theta = 60°$ in squeezing process with plane punch: A – peak of asperity, B – bottom between asperties

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