Numerical Analysis of Burnishing Rolling Process of Determined Surface

Leon Kukielka[a)], Agnieszka Kulakowska[b)], Lukasz Bohdal[c)], Marcin Kulakowski[d)]

Department of Mechanical Engineering, Koszalin University of Technology, Poland

[a)]Corresponding author: leon.kukielka@tu.koszalin.pl
[b)] agnieszka.kulakowska@tu.koszalin.pl
[c)]lukasz.bohdal@tu.koszalin.pl
[d)]marcinkulakowski@wp.pl

Abstract. In this study the process of burnishing rolling is 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 analysis covered surfaces characterized by vertical angles of the asperities $\theta=120°$. The simulation results (i.e. surface deformation, states of strain and stresses, depth of stress deposition, forces and contact pressure) were evaluated. The influence of vertical angle of the asperities after turning process on the choose parameters after burnishing rolling are presented.

INTRODUCTION

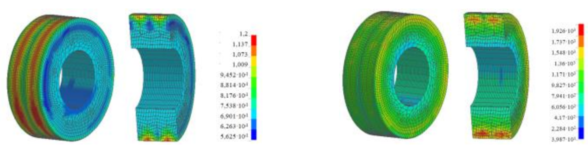
The issue of self-determined surface layer forming, which was desired for exploitation reasons, occupied researchers for many years. The researches have resulted in a multitude of technology which improve the properties of the surface layer (chipless forming and machining, thermal, chemical, etc.). In the technology appeared the trend to increase durability of machines. The economic requirements change an existing trend towards the design and manufacture of machinery and equipment with high reliability at predetermined in advance durability (not necessary very high). Such an approach of the problem has resulted in the need to study the existing and development new production technologies used in the aspect of steering possibilities of the surface layer formed properties. Burnishing rolling is used increasingly as a finishing operation. It is used to improve the surface state and/or the state of the surface layer. The burnishing rolling is used in order to: increase the smoothness of the surface, strengthening and increase its dimensionally and shaping accuracy. It is known that the surface quality after previous treatment has significant influence on its quality after burnishing rolling. It is recommended that outline of the burnishing surface roughness was regular, determined and periodical. Shaped outline of the asperity significantly differ from the theoretical outline and the quality of the product after burnishing is different from the desired quality.

NUMERICAL RESULTS

In the process of burnishing asperities are squeezed (smoothness burnishing) until the desired alignment of asperity. This results the formation of residual stresses that will lie to the required depth. Depending on the intended use of such fatigue loaded by bending and torsional moments, it is necessary to ensure appropriate maximum stress values and the desired depth of the deposition. The process of burnishing rolling was considered as a geometrical and physical boundary and initial value problem, with unknown boundary conditions in the contact area. An updated Lagrange's description was used for the description of non-linear phenomena on a typical incremental step. The increments of strains and stresses were described respectively with an increment of a non-linear strain tensor of green – Lagrange and an increment of the second symmetric stress tensor of Pioli – Kirchhoff respectively. For the purpose of a variational formulation of the incremental equation of the object’s movement for the case of stress rolling burnishing, a variational functional was used, in which there occurs only one independent field, namely the field of an increment of displacements. Moreover, it was accepted that compatibility equations are satisfied and the initial and boundary conditions are fulfilled. Such assumptions lead to the so-called compatible model for the problems of non-linear dynamics, which is expressed in the increments of displacements. Now widely computer programs group CAD/CAM/CAE/CAQ to design and simulate the behavior of structures under different conditions and to support the manufacturing process are used. These methods are widely used and appreciation in engineering practice.

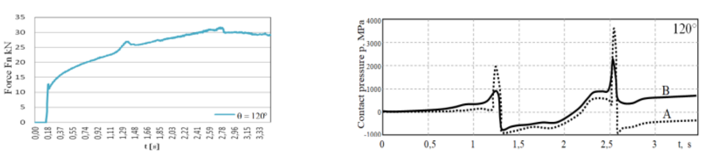
RECEIVED RESULTS

Geometrical models, zoom of the objects, selected areas with finite elements grid, numbers of elements and nodes are presented in Table 1. Numerical analysis covered two regular, triangular asperities with the vertical angle of the asperities θ=120°, distance of the asperity s=2,7 [mm]. Both asperities was characterized by a constant value of height and distance. In this paper dynamic analyses are presented. For this purpose a 3D computer model of the process in real scale in ANSYS/LS-DYNA (macro in APDL language) was prepared. In the present case the subject was treated as an elastic body (in the range of reversible strain) and visco-plastic (irreversible strain in the field), while the tool (the roller) was treated as an ideally rigid body ($E\to\infty$). Material's parameters: Young's modulus E = 210 [GPa] and Poisson's ratio ν = 0.29 were implemented. In this case burnishing speed equals v_n=0,63 m/s. The burnishing element (roller) reach to the object's surface and contact of the roller with the surface also causes the rotation of the roll. Discretisation of the object with finite elements type solid (with a linear shape function), finite element type shell and contact elements were conducted. The depth of the burnishing equals second boundary depth (h=R_t/2). Maps of reduced strain and stress in asperities after burnishing rolling are presented in Figure 1. The course of the normal force in the process of the burnishing rolling process for vertical angles of the asperity $\theta = 120°$ after previous treatment, the depth of burnishing $a_n = 0{,}5Rt$ and contact pressure are presented in Figure 2.



(a) (b)

FIGURE 1. Maps of reduced strain (a) and stress (b) in asperities with vertical angles $\theta = 120°$, for the depth of burnishing $a_n = 0{,}5Rt$



(a) (b)

Fig. 2. The course of the normal force (a) and contact pressure (b) in the process of the burnishing rolling process for vertical angles of the asperity $\theta = 120°$ after previous treatment, the depth of burnishing $a_n = 0{,}5Rt$

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