Modelling by Finite Element of the Part-Tool Flexible Technological System Deformations at Superfinishing Process

CONSTANTIN BUZATU, ADRIANA FOTA, BADEA LEPADATESCU, SIMONA DUICU
Transilvania University of Brasov, B-dul Eroilor, Nr.29, Romania
cobuzatu@unitbv.ro, fot@unitbv.ro lepadatescu@unitbv.ro, simonaduicu@unitbv.ro

Abstract: In the case of final machining of workpieces by superfinishing, the macrogeometric accuracy is influenced by the elastic deformations of the technological system part-tool. The paper presents the possibility of modelling of the elastic deformations by finite element assisted by computer, to optimize the constructive design of the tool system to minimize the influence of the elastic deformations on the machining accuracy.

Key-words: modelling, finite element, accuracy, design, flexibility.

1 Introduction
Numerical modelling with finite element method for different phenomenon which appear in the machining processes is one of the most recently method to study the technological performances. This method allows even in the process design step to simulate by numerical method of different experiments as fundamentals processes of the research and design with computer [1].

Shortly, by finite element method are studying various phenomenon that can be described with mathematical models with one or more differential equations and a series of initial and limit conditions.

For instance, in the research of elastic deformation of the part-tool system at superfinishing process and its influence on the geometrical accuracy is one of the opportunities where numerical modeling method with finite element is applied.

The fundamental draft that is used in this method is approximation by discretisation where the system part-tool elements as continuous medium are decomposed in a finite number of geometric elements that transform analytic model in numerical model, which can be implemented on the computer.

In the paper is presented the base ideas of modeling with finite elements of the elastic deformations at superfinishing process of external surfaces.

2 Base Elements in Determination of the Elastic Deformation and Tensions State in Superfinishing Process
It is known that in design and manufacturing of different parts that have relative motions between them, the surface quality is one of the conditions for their reliability of service. In this direction superfinishing process is used mostly to ensure this requirement.

The superfinishing process performances are influenced by the factors as accuracy obtained in previous machining process and the technological and constructive parameters of the technological system.

During the superfinishing process because of the force between part and tool appears an elastic deformation on the surface contact and these
3 Aspects of Elastic Linear Contact at Superfinishing Process

Taking into account the contact shape between part and tool at superfinishing of external cylindrical surfaces (Fig.1), we can say that is a linear contact.

Fig.1 Schematic illustration of external superfinishing

Because of the force F between part and tool the contact line take with an approximation a rectangular or trapezoidal shape.

4 Mathematical Modelling of Elastic Deformations at Superfinishing Process

The difficulty of elastic contact tensions theory is the fact that the displacement of any point of the contact surface are depending be the distribution of the pressure between part tool contact [3].

To find the pressure in any contact point between part and tool is necessary to solve the integral equation of contact pressure, which is difficult because of various cutting edges of the abrasive grains. This problem can be avoided by a simulation as is shown in Fig.2 called modelling by common elastic function Winkler.

The elastic height function h that has the magnitude of the initial roughness of the surfaces and added the geometrical deviation of the contact surface) is as a rigid base compressed by other rigid with the profile z(x,y) and is given by the sum of profiles in contact modelled as:

Fig.2 Elastic modelling of the contact part-tool at superfinishing.

\[
z(x,y) = z_1(x,y) + z_2(x,y)
\]  (1)

If the deformation in the origin is \( \delta \), the elastic displacement of the function is given by the equation:

\[
\bar{u}_z = \begin{cases} 
\delta - z(x,y), & \text{for } \delta > z \\
0, & \text{for } \delta < z 
\end{cases}
\]  (2)

The contact pressure for any point is related with the motion by this point as:

\[
f(x, y) = (k/h)\bar{u}_z(x, y),
\]  (3)

where \( k \) is the modulus of elasticity of function (with a good approximation of surface irregularities in the presence of cooling liquid).

By the integration of the equation (1.3) the total charge is:

\[
F = k\pi ab \delta \quad 2\pi = \frac{k}{2} ab \delta,
\]  (4)

where \( a \) and \( b \) are the dimension of contact part-tool zone.

For the axial symmetric case when \( a = b = (2R)^{1/2} \), we have the equation:

\[
F = \frac{\pi}{4} \frac{ka^4}{hR},
\]  (5)

where \( R \) is the radius of the contact surface.

This elastic modelling offers approximative solutions to some contact problems between tool-part system at superfinishing to determine even...
in the step of technological design the elastic deformations which can have an influence on the geometrical accuracy of the manufactured surfaces.

This kind of modelling of elastic deformations was studied by K.L. Johnson [4], and we have adopted to the superfinishing process.

5 Modelling of Elastic Deformations at Superfinishing with Finite Element

Starting to the simulation model Winkler (Fig.2), in Fig.3 is shown a schematic illustration of the discrete finite elements by plane rectangular shapes.

![Fig.3 Elastic modelling with finite element at superfinishing.](image)

In Fig.3 it can be seen the connection condition, elastic elements and external charges (with uniform values at superfinishing on the contact surface tool-part).

The solving process of the elastic deformations problem is iterative, every time when other knot come into contact the rigidity matrix is modifying. For example, in knots 19-27 were introduced rigidities (springs) constants at beginning on the directions Ox, Oy to can find the pressure sizes and their sign. In this way the x coordinate of the knot will represent half of the breadth of the contact zone. Also, in every knot which come into contact with the rigidity matrix of the model is modifying together with the modification of the maximum rigidity of the elements.

6 Finite Element Programme ANSYS for Determination of Tensions and Deformations State

The programme ANSYS is a soft to modelling and analysis with finite element for various industrial processes. It can be used to find the behaviour of a simulating model of a process in certain conditions in the step of process design.

The stages of design a finite element programme for tensions and elastic deformations state are the next [5]:

- a) discretization of the model;
- b) establishing the memory with known initial data;
- c) building the rigidity matrix and force vectors which act in the knots of the network of discretization;
- d) assembly of the rigidity matrix and of the knot vector forces;
- e) calculation of translations and rotations in the network knots;
- f) calculations of the elastic deformations and of the tensions.

The logic scheme for this programme is shown in Fig.4.

7 Conclusions

The finite element method is very useful to solve engineering problems for optimization of complex processes where are not conventional solutions. The programme which is proposed to be used for the superfinishing process can give solutions even in the stage of design of the process to the questions regarding the elastic deformations and their influences on the part accuracy.
Fig. 4 Logic scheme of the finite element programme ANSYS.

References: