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Methods of assessing the dynamic stability of the cutting process using UNIGRAPHICS NX

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Annotation. The article deals with the determination of the stability of the cutting process at the Nyquist criterion. Attention is paid to the use of CAE systems to solve this problem. The result of this method is to improve the reliability of technological operations.

In today's production of metal, when high-speed machining becomes widespread [1], the task of providing the dynamic stability of machine tools comes to the fore, specifically the ability of the dynamic system of the machine to resist the emergence of self-oscillation. It depends on the static and dynamic characteristics of all the elements involved in technological system [2], and the parameters of the cutting mode. The most commonly used criterion for assessing the stability of a dynamical system is the frequency Nyquist criterion, according to which the dynamic system will be stable, if the graph of the amplitude-phase frequency characteristic (AFC) does not include the point with coordinates [-1, i0] on the real axis.

$$W_{dc}(i\omega) = W_{ees}(i\omega) \cdot W_{cp}(i\omega) \quad (1),$$

where $W_{dc}(i\omega)$ - transfer function of the dynamic system, $W_{ees}(i\omega)$ - transfer function of the equivalent elastic system of the machine together with tool, an instrument and the workpiece, $W_{cp}(i\omega)$ - transfer function of the cutting process.

Nowadays, with the widespread technology of "digital production", it is possible and appropriate it is possible and appropriate to make a calculation of these functions with the use of three-dimensional modeling and finite element analysis [3].

One of the most common systems for solving problems of "digital production" is UNIGRAPHICS NX. One way to obtain an equivalent response of the elastic system in this software is as follows:

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1. The preparation of modular three-dimensional model of the machine with a device, tool and workpiece, and technological elements of the system should be the ones that participate in the processing of the part.
2. The dynamic calculation of a prepared model is made in NX Advanced Simulation . module. Setting solution is a frequency analysis of the direct method (SOL 108 - Direct Frequency Response).

To build a APFC it is important to note the following: in the setting step, in the *Request output* parameter you must move the tab to put option IMAG, which allows us to derive the real and imaginary part of the transfer function, allowing you deduce the module and phase of the transfer function. In both cases calculated data will is sufficient to construct APFC.

3. At the end of the calculation it is necessary to select the assembly *NastranOP2 Files - Sort2 Results* in the *XY Navigator*, upload a results file, from the list from the list *Displatsement* select a component of movement, which strongly affects the accuracy and the change of cutting parameters (in the case of turning - along the radius of the workpiece) [4].
4. The transfer function of the cutting process can be obtained from the following relations:

$$W_{cp}(i\omega) = \frac{K_p}{1+T_p^2\omega^2} - i\frac{K_p T_p \omega}{1+T_p^2\omega^2} \quad (2),$$

where Kp - cutting rigidity; ω - angular frequency; i - imaginary unit; Tp - time constant of the chip. These parameters are determined by the cutting conditions according to [5].

Therefore data required to calculate the transfer functions can be calculated in MicrosoftExcel or a mathematical packages. It is important that these data were calculated with the same frequency as in n. 2.

5. The resulting transfer function of the dynamic system is determined using the following relations:

Module of the transfer function:

$$A_{dc} = A_{ees} \cdot A_{cp} \quad (3),$$

where A_{dc} – the module of the dynamic system, A_{ees}- the module of the transfer function of the equivalent elastic system, the A_{cp} - the module of the transfer function of the cutting process.

Phase:

$$\varphi_{dc} = \varphi_{ees} + \varphi_{cp} \quad (4),$$

Where φ_{dc} – phase of the dynamic system, φ_{ees}- phase of the transfer function of the equivalent elastic system, φ_{cp} - phase of the transfer function of the cutting process.

So you can build a dynamic response of the system and evaluate its stability according to the Nyquist criterion.

Application of this technique allows to evaluate the possibility of the technological system to ensure quality, and performance with the release of a given product. Application of three-dimensional model and design applications allows you to find the weak link of the technological system and carry out targeted operational measures in order to ensure the production of the given parameters [6].

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