The application of NX9 system's Motion Simulation module in constructing elements of the cutting machines kinematic scheme

Aplikacja modułu Motion Simulation systemu NX9 w konstruowaniu elementów układu kinematycznego obrabiarek

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The article presents a method of 3D visualization and motion simulation of cutting machine's kinematic scheme, at example of conventional milling machine by using NX 9 system's Motion Simulation module. Characteristics of chosen parameters were determined by solver RecurDyn.
KEYWORDS: motion simulation, NX 9, RecurDyn, kinematics system

One of the capabilities of CAD systems is the creation of 3D solids assemblies, which visualize the movable mechanical systems of machines and devices, on the basis of which it is possible to generate parameters of selected kinematic pairs of assemblies [1, 2, 3].

Machines with extended kinematic system include, among others, conventional cutting machines. The machine design assumptions concern both the economic considerations of production, the greatest number of products and the reliability of the machine itself. In order to meet these criteria, proper operation of the machine is necessary and, above all, the proper design of individual components and modules, which meet the requirements of the modern production process [4].

The purpose of this paper was to present the possibility of modeling complex kinematic assemblies and generating characteristics of selected parameters using Motion Simulation and Recur-Dyn solver implemented in NX 9 system.

Preliminary assumptions

The subject matter of the analysis was the kinematic system of a conventional cantilever milling machine (Fig 1). It consisted of three smaller systems, of which a horizontal spindle drive was selected for modeling the assembly. Selected kinematic system consisted of a spindle drive motor, belt transmission, six fixed gears and one sliding threes and two sliding twos. The wormwheel models, as well as the involute tooth profile were generated parametrically in the NX 9 system [5].

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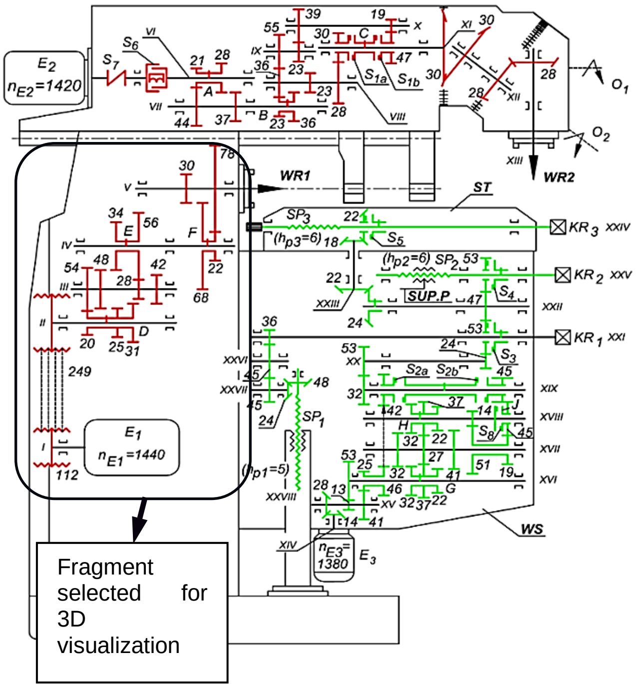

Fig.1. The kinematic system of the conventional UFM3Plus cantilever milling machine in the form of Scheme 2

Preparation of the simulation

Assemblies for simulation were prepared in the Motion Simulation module. All solids performing the same movement are grouped into members using the *Link* function. Then the nature of the work of members is determined by the *Joint* function. The complex functions grouped in the *Couplers* menu or the connection type functions in the *Connectors* menu are used to define the interaction between the cooperating wormwheels [3, 6]. Functions *Couplers* allow to define the cooperation on the basis of forced resetting, e.g. defining gear ratios. For this case, the correct tooth geometry is not required. The *3D Contact* feature, which is part of the *Connectors* function group, uses the geometry and materials of the cooperating elements to automatically select the value of the friction coefficient, e.g. between the lateral surfaces of teeth in contact. The defined gear ratio allows to forward movement to another assembly member based on contact with an earlier member. For this case, the correctness of the modeling of the involute profile of the tooth is important. In addition, the movement of sliding elements was defined by the *Cylindrical* function, taking four degrees of freedom (leaving the movement and rotation). The programmed simulation is shown in Fig. 2.

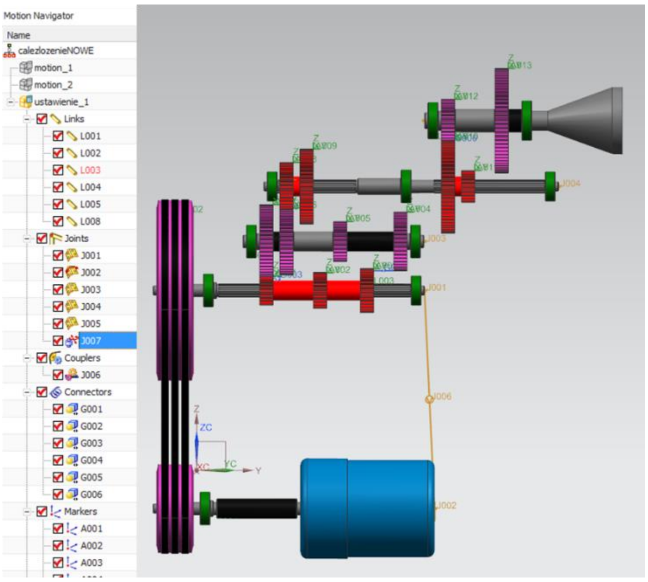

Fig. 2. Set of declared functions and a view of the kinematic system prepared for the simulation

The simulation time was 15 seconds. The number of steps that considerably affected the accuracy of the solver calculation was assumed to be 1000. The declared engine rotational speed was in accordance with the actual features for the machine, which was n = 1440 rpm.

Simulation results

The results of the simulation are shown in the graph of the angular velocity versus time (Fig.3).

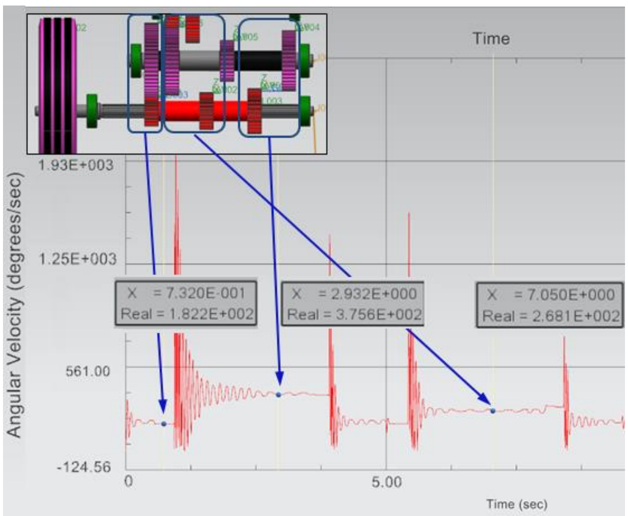

Fig. 3. The angular velocity of three ratios for simulation *3D Contact*

Significant oscillations in the initial phase of the wormwheels cooperation result from the movement of the system during meshing. Attention is drawn to the nature of the graph in moments of stable gear operation, from which it is possible to read moments of meshing and subsequent teeth disengagement. The module enables the actual angular speed reading for each gear operating torque.

The angular velocity graphs (Fig. 4) were also compared for *3D Contact* simulations based on the contact between gear teeth of cooperating wormwheels and *Gears* simulations, belonging to the *Couplers* function group and using declared gear ratios.

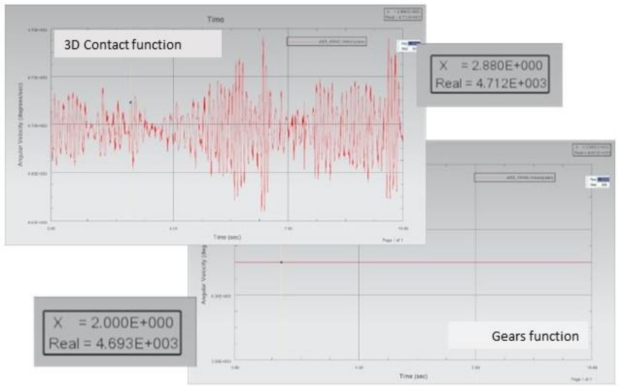

Fig. 4. Comparison of angular velocity graphs for simulation using *3D Contact* function and *Gears* function

Both functions used for simulation allowed for achieving the angular velocities of approx. 4700 °/s (783 rpm). However, for *3D Contact* function, this speed varies significantly from the average, which is due to the contact nature of the motion simulation.

Conclusions

Representation of the kinematic 3D visualization system allows the user to continually verify the modeled system as well as to update, modify and analyze the correctness of the motion of the entire mechanism. The extensive capabilities of defining the relationship between assembly members and the type of cooperation allow to maximize the user's design capabilities, as well as to reduce time and design costs through early error detection (already in the modeling phase). The ability to generate - based on the friction simulation and the interaction between the teeth of wheels - the characteristics of parameters such as strength, torque or angular velocity, allows to register changes of these parameters at the moment of meshing and disengagement of successive teeth.

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