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# IMITATIVE RESEARCH STIFFNESS OF CONICAL CONNECTION OF FACE-MILLING CUTTER FROM SHAFT SPINDLE 6R12

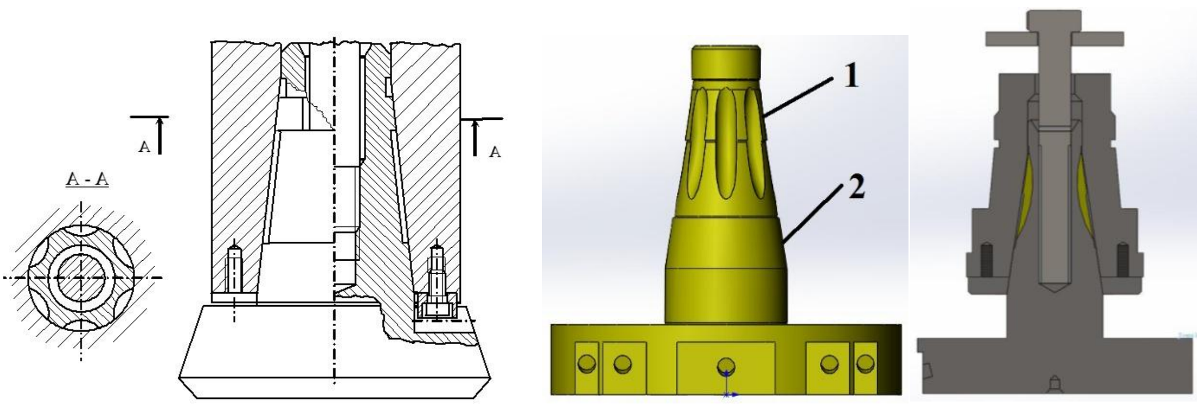
Significant to stabilize working conditions face-milling cutter (F-MC) plays and fixes it on the machine-tool, that is the accuracy and stiffness of the shaft connection with the spindle of the machine tool. Due to the existing errors in the manufacture of conical surfaces of the shaft and spindle, there is an unevenness of the fitting in the joint and even the absence of actual contact on the part of the length of the connection.

The stiffness of the conical joints depends to a large extent on the difference in the angle of the cone of the shaft and the spindle. The most unfavorable case is when the spindle taper angle is larger than the shaft taper angle. In order to overcome the mistakes made in the manufacture of conical creature stocks, an average duct was made with the removal of two seat belts. But in this situation it is possible to contact one of them.

Recently, designs of hollow conical shanks are being developed. Such shanks have a number of advantages including high static and dynamic stiffness. Therefore, it is relevant to model the static behavior of the conical hollow shank cutter during loading.

To improve the tapered coupling F-MC with a cone 7:24, a hollow shank with two contact bands is proposed. (Fig.1,a,b). The smaller pin belt (Fig. 1, b, pos.1) is made hollow with reduced radial stiffness (Fig. 1,a.). For this purpose, the threaded connection of the shank is moved to the side of the big belt (Fig. 1, b, pos.2), and the small belt is executed with a reduced contact area.

To model the behavior of the conic hollow shank cutter during loading, a solid-state parametric 3D model of the cutter and a part of the spindle of the machine 6P12 was developed in the SolidWorks software product (Fig. 1, c)




a) b) c)

Fig.1 Model for studying the static behavior of a modified shaft: a is a schematic representation of a spindle joint and a modified shank; b - 3D model of the improved shaft; c - 3D model of spindle connection and modified shaft.

The simulation of the behavior of the conical hollow shank cutter during loading is not a trivial problem. To adequately simulate such a connection, it is necessary to determine the method of valuating the accuracy of this conic connection and to make variations of the 3D model for various combinations of marginal dimensional deviations, to determine the type of study, the parameters of the computational process, to form adequate contact conditions, to simulate the effort from twisting the knuckle, to form sensors for displaying displacements at specified points.

Cone shaped tolerances (TFR, TFL) were not taken into account, because the first method of rationing the accuracy of the cone was chosen - the common valuation of all types of tolerances by the admission of TD. Since TD is the tolerance of the diameter of a cone in any section, we confine ourselves to the cross sections of the base of the cut-out spindle cone. As it comes to tool cones, the 6th grade of accuracy is chosen. The combination of cone tolerance fields in the indicated sections will look like this:

- *hole ∅19,8H6((+0,013)/0), ∅19,8p6((+0.035)/(+0,022))*
- *shaft ∅34,9H6((+0,016)/0), ∅34,9p6((+0.042)/(+0,026)).*

A central radial load of 2000 N was applied to the F-MC.

Several combinations of marginal variations of dimensions (Table 1) were identified for studying the connection with standard and modified shanks, which were introduced into the parametric model through the use of the tool «Equations». This study is clearly nonlinear, so a static nonlinear study in the Simulation module was used. Parameters of the computational process of nonlinear study, boundary and kinematic conditions are shown in fig. 2a, b.

In order to avoid artificially increasing the stiffness of the system, a thermosetting insert into a screw from an orthotropic material, which has a significant difference in the thermal expansion in the radial and axial directions relative to the reference geometry, was used to simulate the force from the twist of the knuckle (tightening of the cut). A thermal load (cooling relative to the temperature at which the body has a zero deformation) is applied to the thermosetting insert.

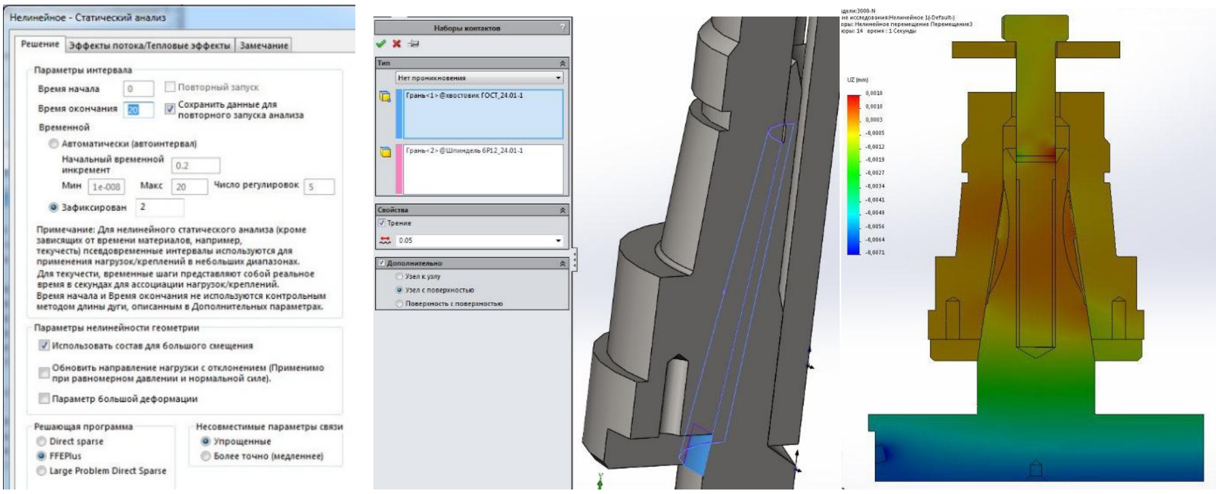
To display the constituent parts of the milling cutters, two sensors were formed in the model, the values of which were included in the table.1.

Table 1.

Combinations of boundary deviations of cones
and results of simulation of radial rigidity

| | Combinations of marginal variations of dimensions, mm | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Set 1 | | Set 2 | | Set 3 | | Set 4 | |
| | Spindle | Shank | Spindle | Shank | Spindle | Shank | Spindle | Shank |
| | 19,8<br>34,9 | 19,822<br>34,926 | 19,813<br>34,9 | 19,822<br>34,942 | 19,8<br>34,92 | 20<br>35 | 19,8<br>34,9 | 19,835<br>34,942 |
| | Standard shank, radial displacement, mm | | | | | | | |
| Axis Z*, мм | 0,0808998 | | 0,0621107 | | 0,04914 | | 0,0899449 | |
| | Modified shaft, radial displacement, mm | | | | | | | |
| Axis Z*, мм | 0,0081659 | | 0,00898946 | | 0,0118237 | | 0,00734605 | |

Notes: * - the Z axis is orthogonal to the rotation axis of the cutter.




а) б) c)

Fig.2 Parameters of the computational process (a), contact conditions (b) and diagram of movement along the Z axis (c).

The results of the rigidity study with the standard and modified shaft showed greater stiffness (less radial displacement) of the modified shaft in all cases. Thus, the assumption was made that a cavity shank with two contact belts and a reduced radial stiffness in the area of a smaller contact belt can, as a result, increase the rigidity of the system. The latter, in its turn, is one of the important factors in stabilizing the conditions of the workpiece cutter.