Modeling of construction spindle's nodes machining centre

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Summary. The decision of the problem of the determination to softness formative spindle's nodes machining centre tools with NC drill-milling-bore of the group, equiped module complete set of the equipments is present. They are received correlations (the accounting cards, nomogram), allowing to model design two support spindle's nodes with changing complete set of the equipments. The analysis of the influence deformation of supports on two-set rolling bearing on balance of softness of the under investigation nodes tool within their worker of the zone. The order of the using the offered procedure is shown on tool - a representative drill-milling-bore of the group.
Key words: spindel, instrumental block, softness, 3D-modeling.

INTRODUCTION

The Analysis trend developments metal cutting production has shown perspective such design tool, which possess the raised technological possibility on the base machining centre and multi operation tools with NC. Efficiency of the introduction of such equipment is connected with system development of the cutting and auxiliary instruments on module principle. The variety of the types instrumental's block, including auxiliary and cutting instruments on the one hand and increasing of the requirements to quality product does necessary undertaking the studies on provision of stiffness of formative spindle's nodes.

PUBLICATION AND METHOD ANALYSIS

The study to stiffness of formative nodes processing centre average standart size conducted [20]. The Influence of the type, amount and locations bearing on efficiency spindle's node has considered [11]. The analysis of the springy system "chuck-piece" in turning automatic machine tool on criterion of stiffness has realized [10]. The analytical dependency of the features of the moving the executive organ from constructive parameter tool-hexapod is presented in [14]. The detailed analysis of the influence supports on rolling bearing light series on accuracy and stiffness to speed precession spindel's nodes has conducted [3]. The advantage of the use the noncontact drive tool for increasing technical level are considered in work [6, 13].

Author [20] brings the experimental estimation of the change to stiffness in worker space machine system and her relationship with layout factor and standard size. The study relative to fixed variant of the adjustment main drive and does not take into account the influence instrumental block on value of stiffness that particularly characteristic for machining tool.

The springy system "equipment tooling-instrument" or "equipment tooling - piece" occupies In balance of stiffness tool significant place. The great study of the springy system "chuck-piece" is presented in work [10]. It Is offered united model chuck - "beam with restraint" in the manner of springy-friction joint, allowing raise accuracy in calculation strain features of the springy systems tool. Together with that, unlike turning automaton tools in multi-objective tool vastly enlarges the types of the applicable equipment tooling.

OBJECTS AND PROBLEMS

The purpose given work is increasing to efficiency of the process of the designing formative nodes to account of the building unified solid and analytical models (the formula-trench), as well as algorithm of the determination springy-strain features spindle's nodes (SN) multi-objective tool, rig with by module equipment tooling.

THE MAIN SECTION

The modern formative nodes machine tool present itself closed-loop dynamic systems, using module equipment tooling. [2, 8, 16, 19]. Final accuracy and stiffness made product is defined constructive feature of the instrumental equipment, including its are founded- size: lengths to cantilever , diameter to cantilever and others [15].

For study tense-deformed conditions and use the finite element methods [9, 12] necessary to build 3D-models of the separate piece and assemblies SN [4, 5].

As base design is considered SN ram-type drill-milling-bore machine with NC models SF68VF4 [7], built-in in two-stage drive main motion. In mode of the co-ordination with swivelling table provides processing the pieces with all sides, as well as coaxiality boring hole without reline up pieces. Designed by 3D-model of the drive tool SF68VF4 with use resource KOMPAS-3D on task of the parametric relationships and assotiations between separate component 3D-assemblies was submitted for fig.1.

Spindle's node given machine centre is considered as beam on two elasticity support, each of which is assembled on two-set radial and thrust bearing, is installed on scheme "Tandem-O" with preliminary preloading in the manner of distance sleeves. Author's are designed by 3D-model of the assembly cored SN with mechanism of the automatic clamp of the instrument in system KOMPAS-3D (fig.2)

Fig. 1. 3D-assembly of the drive main motion

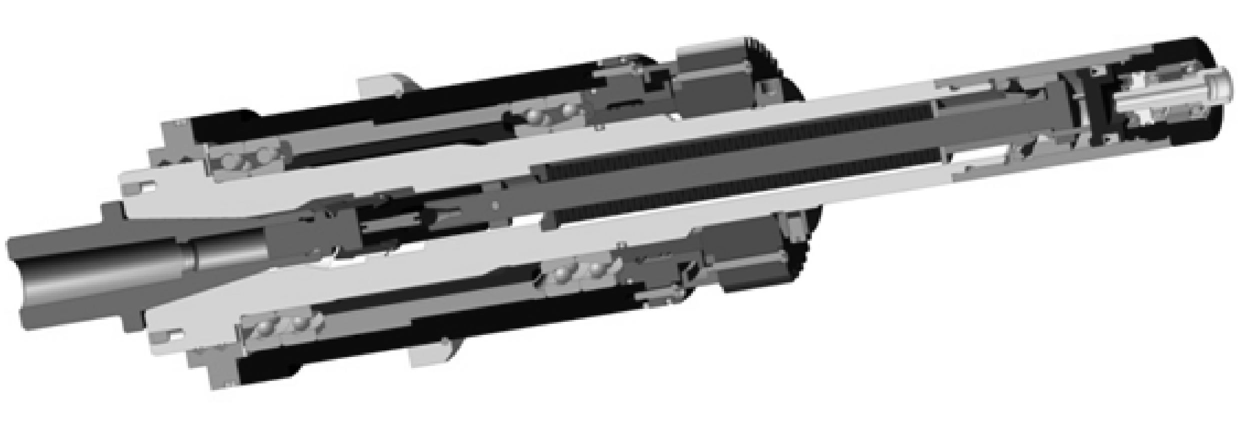

Fig. 2. 3D-assembly spindle's node

For performing the complex engineering analysis, both separates pieces, and assemblies wholly use the module APM FEM [17, 18, 21], equiped SAE - library, realizing decisions of the engineering problems by final element method (FEM). In time of the decision are assigned fastening and put loads; they are assigned coinciding face (for FEM-analysis of the assembly); the generation FEM-nets is realized; the calculation and viewing result in type of the cards of the stress and displacement.

By means of module APM FEM are executed all afore-mentioned actions and are received field of stress (fig. 3) and field of the displacement (fig.4) on ensemble of the sections of the spindle as beam.

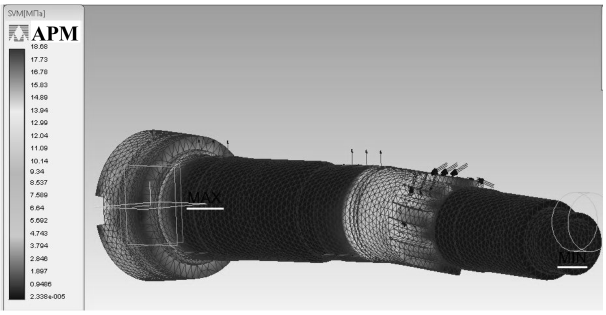

Fig. 3. Fields of the strenth of the horizontal spindle

For study of stiffness we shall form the elasticity-deformation model an two support spindle's nodes with set of the module equipment tooling (the cantilever) different standard size. The Particularity of the under investigation object is presence two components:

the unified two support SN, which can be used in distinguish machining centre;

the instrumental block - a changeable component, oriented on different range of product.

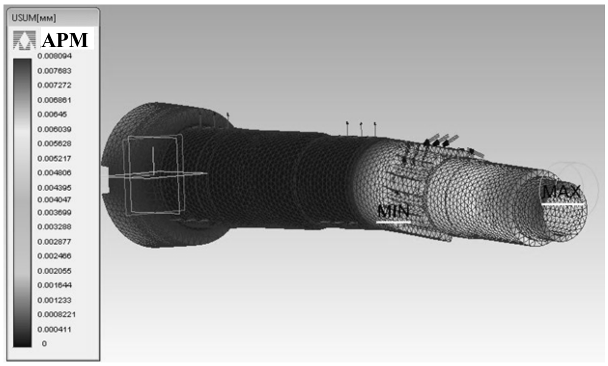

Fig. 4. Fields of the moving the horizontal spindel

The First component (fig. 5) is presented in elasticity-deformation models in the manner of steady-state card $\delta = (\Delta_2 + \Delta_3)$ [12] i.e. in the manner of analytical dependency of the displacement supports Δ_2 and strictly spindle Δ_3 from length of the cantilever ℓ_k.. System is used from four linear equations with border condition. As example shall consider spindle's nodes (fig. 5) it is enough wide-spread ram-type specialized tool to models SF68VF4.

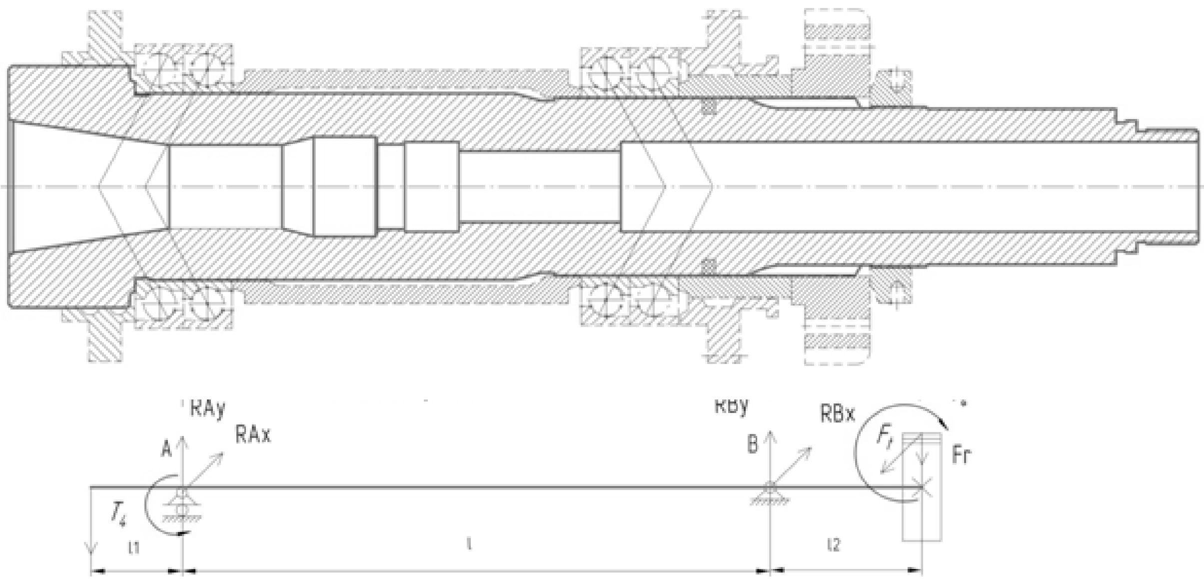

Fig. 5. Constructive and accounting scheme spindle's nodes

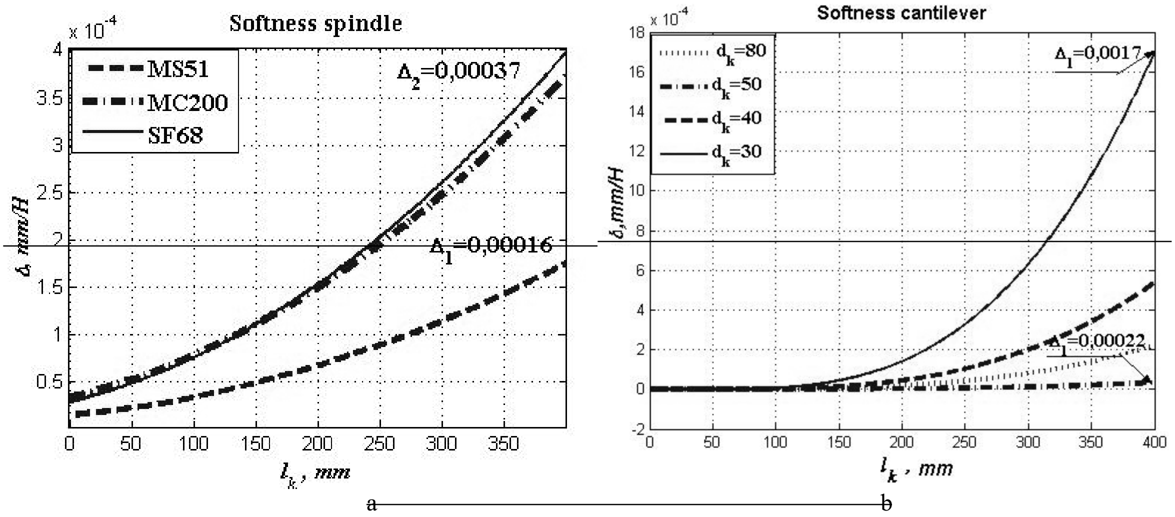

Fig. 6. Softness spindle's nodes (nomogram):a – steady-state cards; b – softness cantilever

In mathematical ambience MAPLE are received values of reactive power and moments on back (z) and front (r) support:

R_z=0,0573-0,0028 ℓ_k; R_p =0,943+0,0028 ℓ_k;
m_z= 24,97 +0,098 ℓ_k; m_p = 51,51+0,488 ℓ_k.

Computable value reaction allow to define deflection and corner of the rotate on the end of the spindlel ($x = \ell+\ell_1$) depending on lengths ℓ_k instrumental block. The tool-representatives drill-milling-boring group: mode- MS51 with cone of the spindle 30 AT5 on GOST 15945-82; the models SF68VF4 with cone 40 on GOST 936-82; the models MC200PF4V with cone 40AT5 on GOST 15945-82 are selected.

Got in work steady-state cards for tools MS51, SF68 , MC200 are provided in table 1.

Table 1. Steady-state cards spindle's nodes

Model	State card
MS51	**(-85,25-2,00 l_k+0,11 l_k^2) 10^{-8}**
SΦ68	**(30,37 +0,61 l_k+0,042 l_k^2) 10^{-8}**
MC200	**(66,75+4,85 l_k +0,069 l_k^2) 10^{-8}**

For undertaking express - calculation of one or another adjustment is designed nomograms, consisting of two parts: steady-state card (fig.6, a), built on formula tabl.1 and graphics to softness of the instrumental block Δ_1 (fig.6, b), built for cantilever of the constant section and different importances diameter d_k. The cantilever is considered as beam, restraint in supporting section and loaded in place of the cutting by single power.

Nomogrammy allow quickly to define brought about place of the cutting softness spindle's node, for what it is enough to know the overhang of the instrumental block ℓ_k and diameter d_k cantilever. . Softness beside cutter is defined by sum founded on nomogram values $(\Delta_2+\Delta_3)$ and Δ_1.

In row of the events inaccuracy determinations to general softness SN is connected with absence in accounting model given about springy character bearing support. We shall consider, what influences upon results of the steady-state calculation inaccuracy in determination of linear softness of one bearing [1, 15]. For spindle's nodes tool to models SF68VF4 design value to softness Az = 3,99 10^{-6} and Ap = 3,93 10^{-6}, mm/N. We shall take else two values of linear softness with deflections:

1. A_{z1} = 2,59 10^{-6} and Az_2 = 5,39 10^{-6} , mm/N;
2. A_{p1} = 2,55 10^{-6} and A_{p2} = 5,305 10^{-6}, mm/N, and angular softness of one bearing:

1. a_{z1} = 0,039 10^{-8} and a_{z2} = 0,081 10^{-8}, 1/(N mm);
2. ap1= 0,039 10^{-8} and ap2 = 0,081 10^{-8}, 1/(N mm)/

In this case cards will be of the form of :

$$1.\ \delta = (-71{,}05+0{,}62\, l_k +0{,}044\, l_k^2)\cdot 10^{-8};$$

$$2.\ \delta = (161{,}67+1{,}148\, l_k +0{,}043\, l_k^2)\cdot 10^{-8}.$$

Dependencies is built on fig. 7 δ from l_k , from which follows that even significant (before 35 %) from-bending to linear softness A_0 one bearing in both sides (overestimate or understatement) from nominal of value little influences upon softness of the system spindle-cantilever as a whole.

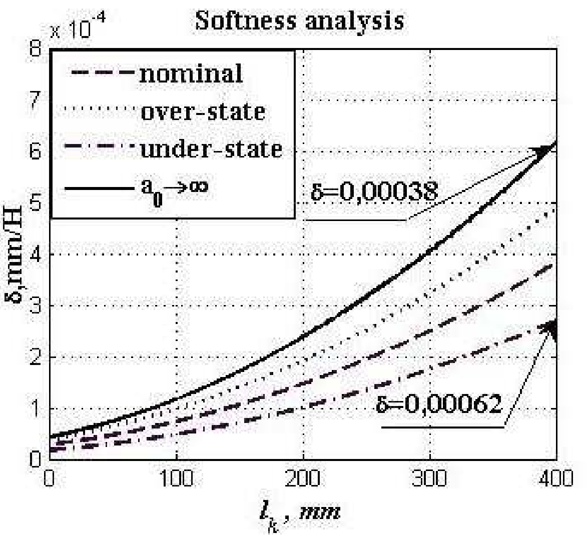

Fig. 7. Study of the steady-state card SN tool SF68PF4

On the other hand unless take into account angular stiffness of the single bearing ($a_0 \to \infty$) then received following steady-state card (fig. 7, curve, noted utter line):

$$\delta = (1093+16.09\, l_k+0.097\, l_k^2)\, 10^{-8}.$$

Obviously, account to angular softness of the single bearing turns out to be necessary since races-even importance SN increases more than 50%. Besides as can be seen from calculation, change to linear softness Az and Ap support of the spindle in it is enough broad limit without corresponding to from-changing of its diameter does not contribute the essential changes to softness SN (not exceeded 35%).

CONCLUSIONS

As a result offered approach to analysis and modeling to designs spindle's nodes on criterion of stiffness is executed building 3D-models of the separate parts and full 3D-assemblies SN and is organized complex study tense-deformed conditions to designs of the spindle. Built analytical model two-support spindle's nodes (for gamma tool), taking into account general characteristic these design on radial and thrust rolling bearing. By means of such models is realized express-calculation steady-state card in symbol type (tabl.1) for tool drill-milling-boring of the group. This vastly reduces working hours of the design work and opens the prospects of the scale studies in the field of modeling and improvements modern design spindle's nodes.

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МОДЕЛИРОВАНИЕ КОНСТРУКЦИЙ ШПИНДЕЛЬНЫХ УЗЛОВ МНОГООПЕРАЦИОННЫХ СТАНКОВ

Олег Кроль, Виталий Осипов

А н н о т а ц и я. Приведено решение задачи определения податливости формообразующих шпиндельных узлов многооперационных станков с ЧПУ сверлильно-фрезерно-расточной группы, оснащенной модульными комплектами оснастки. Получены соотношения (расчетные формуляры, номограммы), позволяющие моделировать конструкцию двухопорного шпиндельного узла с изменяющимися комплектами оснастки. Проведен анализ влияния деформационных характеристик опор на сдвоенных подшипниках качения на баланс податливости исследуемых узлов станков в пределах их рабочей зоны. Порядок применения предложенной процедуры показан на станках – представителях сверлильно-фрезерно-расточной группы.

К л ю ч е в ы е с л о в а:. шпиндель, инструментальный блок, податливость, 3D-моделирование.