Analyzing the profilograms we can draw the following **conclusions**:

1) the surface roughness machining by block-modular milling cutter below, indicating tool work is smoother and has less vibration,

2) profilogram of surfaces machining by block-modular milling cutter no explicit jump microroughnesses values, which may indicate more precise positioning of the cutting block in the housing module and less elastic forced off of the cutting inserts.

REFERENCES

1. Режущий инструмент со сменной режущей пластиной : пат. BY №19226/ Н.Н. Попок, В.А. Терентьев, Р.С. Хмельницкий, А.В. Сидикевич ; дата публ. 09.03.2014.
2. Способ установки сменной режущей пластины в режущем инструменте : пат. BY №19260 / Н.Н. Попок, В.А. Терентьев, Р.С. Хмельницкий, А.В. Сидикевич ; дата публ. 26.03.2014.
3. Попок, Н.Н. Совершенствование системы закрепления пластин режущих и блоков резцовых в блочно-модульных режущих инструментах / Н.Н. Попок, А.С. Максимчук, С.А. Портянко // Вестн. Полоц. гос. ун-та. Сер. В. – 2015. – № 2. – С. 16–22.
4. Popok, N. Improving of fixing system of cutting plates in block-modular cutting / N. Popok, A. Maksimchuk // Materials of VI junior researchers' conference. Part 3. – Novopolotsk : PSU, 2014. – P. 102–104.
5. Popok, N. Stiffness of block-modular cutting tools / N. Popok, A. Maksimchuk // Materials of VII junior researchers' conference. Part 3. – Novopolotsk : PSU, 2014. – P. 97–100.

UDC 621.91.01/02

STIFFNESS OF THREADED CONNECTIONS IN MODULAR BORING TOOLS

ANDREW GERASIMOV, NIKOLAI POPOK
Polotsk State University, Belarus

Modeling of precision treaded connections in SolidWorks. Experiments were carried out to reduce the backlash in threaded connections of boring tools.

Introduction. Important advances in electronics, electrical engineering and machine tool industry in recent years have helped to create automated machine tools with numerical control (CNC), which became widely used in the series, and even small-scale production. They have given possibility not only to improve performance but also production flexibility through fast change of control programs on the machine. Due to the use of CNC machines multioperational machines (machining centers) were created, which have made it possible to handle parts in a single setup with automatic change of a greater number of tools installed in the machine shop.

The unification of the individual elements of cutting and auxiliary tools has created tool systems for CNC equipment that can quickly and easily be readjusted by changing the nomenclature of manufactured parts.

Aggregate-modular design principle of modular tool units can be illustrated by an example of the creation of tools for bore holes (Fig. 1). Unit is connected with the spindle by means of cartridge 1 with cone 7:24. Extender 2 of enlarged diameter helps to increase stiffness of the mandrel. Adapter 3 is for adjusting the length and number 4 is the boring head.

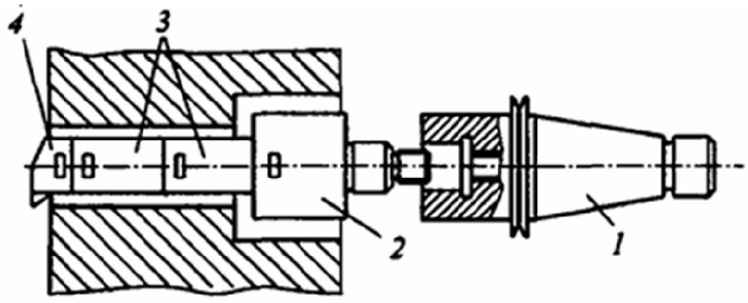


Fig. 1. Tool boring block of standard modules:
1 – insert; 2 – extension; 3 – adapter; 4 – boring head

The disadvantages of modular tool units are their reduced stiffness and accuracy as compared with solid tools. The more modular elements are in the block, the lower is stiffness and accuracy. In order to increase the accuracy of blocks, it is recommended to use elements for adjusting the size of the cutting tools [1].

In metal treatment, where it is necessary to get precise holes, boring heads are finding increasing application. They allow setting the size of the tool with high precision and achieving high-quality and accurate processing. The ability to control the size of the tool can improve the processing efficiency by reducing tooling costs and improve performance through the use of cutting teeth made of modern instrumental materials (hard metal, mineral ceramics and super-hard materials), allowing the use of higher cutting data [2].

Boring heads have higher performance as compared to other boring tools.

Formulation of a problem. There are many ways to make the preload in the micrometric threaded connection of microbors. [3]. However, the easiest way to get the resilient member is to use a slotted spring.

Development and new design of boring tools with micrometric adjustment blades solved the problem of sample backlash (it was reduced to the required value) in the threaded connection of the boring head. It was found that the amount of movement and the sample are affected by several factors: the parameters of the split grooves on the sleeve housing and the efforts of its pre-compression or wedging (to provide preload) [4].

Modeling and experiment. Initially three-dimensional solid models of split bushings and screws were created in the program SolidWorks (Fig. 2).

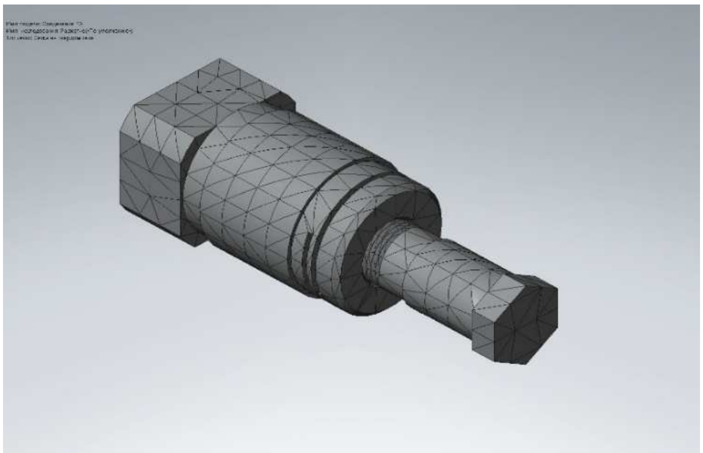


Fig. 2. Connection, broken into finite elements in SolidWorks

After analyzing the structure, using FEM program SolidWorks (Fig. 3), we can make preliminary conclusions about the acceptability of this type of backlash in the threaded connection of cutting tools.

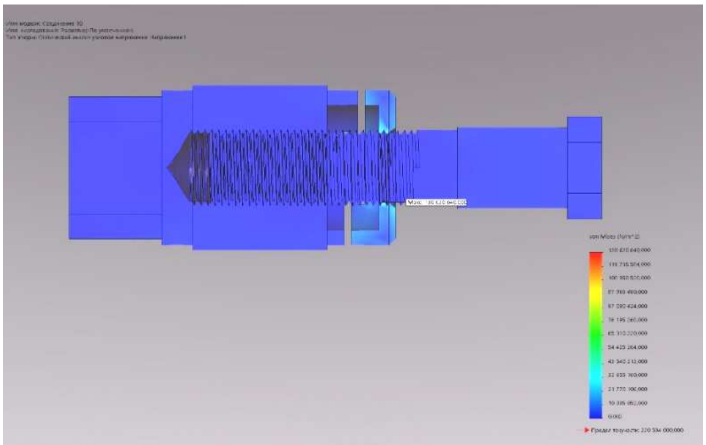


Fig. 3. Map of stresses distribution, resulting in the program SolidWorks

Having conducted research and having made necessary calculations, using SolidWorks software, experiments were performed on real samples of split sleeves.

For the purpose of estimation of slots influence on the accuracy of the thread connection the plan-matrix of the complete factorial experiment (CFE) was made. In our case there were three factors: width of the slot, step and depth of the slot. To reduce the number of models we used two levels of each factor. Thereby we had 8 models $n = q^k = 2^3 = 8$ [5]. The plan-matrix of CFE is shown in table.

Plan-matrix of CFE

Sample #	The width of the groove, mm	The step of the groove, mm	The depth of the groove, mm
1	1	1	18
2	1	1	21
3	1	1,5	18
4	1	1,5	21
5	1,5	1	18
6	1,5	1	21
7	1,5	1,5	18
8	1,5	1,5	21

During the experiment, while screwing and unscrewing the screw, torque that occurs in the threaded joint was measured (Fig. 4).

Fig. 4. Measurement of torque with a torque wrench

The rigidity of sleeves is measured using the ZIP 05-82 (Fig. 5).

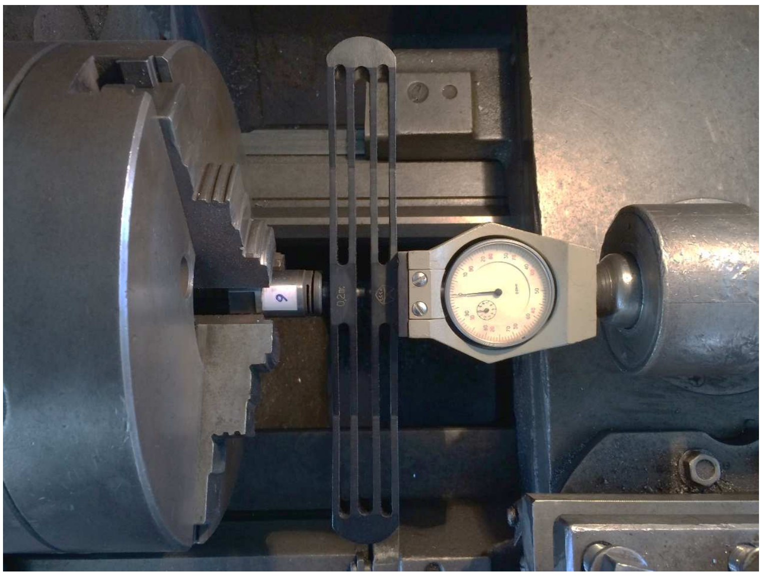


Fig. 5. Measurement of bushing hardness using ZIP 05-82

Conclusions. Having analyzed the structure using the finite element method in the program SolidWorks, we can draw preliminary conclusions on the admissibility of this type of gaps compensation in the threaded connection of micrometer screws in precision cutting tools. However, due to the nature of the calculations in SolidWorks Simulation it is impossible to set the compression of split bushing and then to screw the screw. Thus, further simulation was carried out on real models. It turned out that there are moments when screwing screws into the sleeve propped with insufficient depth of the groove. Suitable torque observed both at the width of grooves and step values in the interval of one to two pitches of the thread. Rigidity of bushings decreases with increasing of depth and width of the grooves in the sleeves.

REFERENCES

1. Кожевников Д.В., Гречишников В.А., Кирсанов С.В., Кокарев В.И., Схиртладзе А.Г. Режущий инструмент: Учебник для вузов / Под редакцией С.В. Кирсанова. - 3-е изд. М.: Машиностроение, 2007. - 528 с.: ил.
2. Аверьянов О.И. Клепиков В.В. Режущий инструмент: Учебное пособие. - М: МГИУ. 2007. —144 с.
3. Пат. 2349426 РФ, МПК В23В29/034. Расточная головка.
4. A. Herasimau, N. Papok. Cartridge toolholders and boring heads for high-precision holes treatment// Materials of VI junior researchers' conference, 2012, p.91 – 94.
5. Винарский М.С., Лурье М.В., Планирование эксперимента в технологических исследованиях. «Техника», 1975, 168стр.

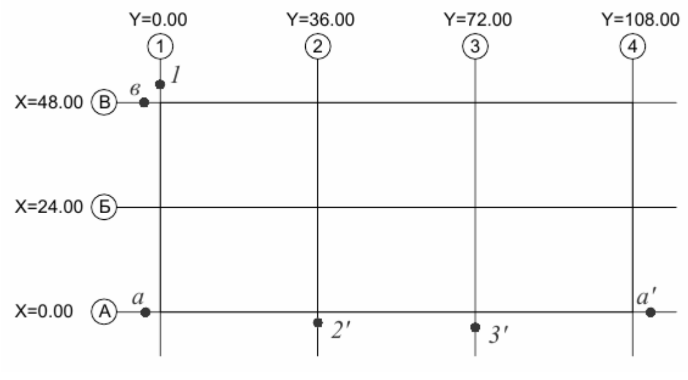
UDC 528.48

THE REFIXATION OF STAKING GRID LINES WITH LEAST SQUARE METHOD

SVIATASLAU HRAMYKA, SIARGEI SHNITKO
Polotsk State University, Belarus

We consider the problem of approximation of the results of linear and angular measurements to refixation of staking grid. Based on the least square method the new coordinates of controls are computed in the coordinate system of building site.

Let staking grid lines of the building are fixed with *n* controls, and line (x) are fixed with *k* controls and the line (y) are fixed with *m* controls. The controls have only one coordinate (x or y) based on what line they fix. For example, for the staked grid depicted in Fig, for controls *a, a', b* the coordinates of *x* are known, and for points *1, 2', 3'* the coordinates of *y* are known.



Model of the staked grid

From the new measurements the coordinates x' and y' of all controls in arbitrary coordinate system are received. It is known that the accuracy of the relative position of controls in the arbitrary system is higher than the coordinates in the system of the staking grid.

That's why the problem of coordinate transformation from the arbitrary system to the coordinate system of the building site with possibility of their refinement with least square method (OLS) is possessed. Thus, the problem can be solved in two stages:

1) coordinate transformation;
2) correction of the coordinates and estimate of accuracy.