DOI 10.31891/2307-5732-2020-287-4-134-137
UDC 65.011.56

V.D. KARAZEY, K.S. SOKOLAN
Khmelnitskiy national university

INSTALLATION DEVICE FOR FLAT COMPONENT PARTS

When carrying out inside diameter tooling, component parts are fastened directly on the table using simple adjusting clamping straps and anvils that leads to significant reduce of labour productivity and working accuracy. Design of machine-tool device, providing a possibility of readjustment of device elements for installation of flat component parts and plates in certain range of dimensions, provides carrying out of mechanical processing in minimal quantity of placings owing to increasing of tool availability and provision of multiple-axis machining. For determination of the possibility to achieve size, shape precision and geometric relationship of "Cover" component part when carrying out surface mechanical processing on machine accessory, the examination of strain-stress state of "Cover" component part was also realized using SOLIDWORKS Simulation software. Experimental results of strain-stress state have shown that movement and stress values, originating during machining process, in offered machine accessory is insignificant, for example, deformations are not greater than 0.3 micron. Device case is the most critical part of the construction that bears all loads, imposed from clamp assembly unit and all cutting forces during processing. Working accuracy and reliability of force clamp depend on structural robustness, stiffness and stability of the case. Installation device can be set both on machines table and on mounting plates, included into different kits of assembly machine-tool devices Thus, manufacturing method is shortened by several operations. Designed construction of the device for component parts processing provides multicoordinate processing and meets the requirements of structural robustness, and also significantly reduces expenses of additional and setting-up time.

Keywords: dimensional analysis, positioning, machine accessory, strain-stress state, installation device, flat component parts.

В.Д. КАРАЗЕЙ, К.С. СОКОЛАН
Хмельницький національний університет

УСТАНОВЧИЙ ПРИСТРІЙ ДЛЯ ПЛАСКИХ ДЕТАЛЕЙ

Під час обробки отворів деталі кріпляться безпосередньо на столі верстата за допомогою простих установочних прихватів та упорів, що значно знижує продуктивність праці і точність обробки. Розробка верстатного пристрою, який забезпечує можливість переналагодження елементів пристрою для встановлення плоских деталей типу плоских кришок та плит у певному діапазоні розмірів дає можливість виконувати механічне оброблення за мінімальну кількість установок за рахунок підвищення інструментальної доступності та забезпечення багатокоординатного оброблення. Для визначення можливості досягнення точності розмірів, форми та взаємного розташування поверхонь деталі «Кришка» при проведенні механічного оброблення поверхонь з використанням верстатного пристрою також виконано дослідження напружено-деформованого стану деталі «Кришка» за допомогою програми SOLIDWORKS Simulation. Величини переміщень і напружень, які виникають у процесі механічного оброблення, у запропонованому верстатному пристрої є незначними, наприклад, деформації не перевищують 0,3 мкм. Корпус пристрою є найбільш відповідальною частиною конструкції, що сприймає всі навантаження, які прикладаються від елементів вузла затиску та також всі зусилля різання при обробленні. Від міцності, жорсткості та стійкості корпуса залежить точність оброблення та надійність затискання деталі. Запропонована конструкція пристрою призначена для встановлення та закріплення прямокутних плит та кришок, що здійснюється за допомогою прихватів. Установочний пристрій може бути встановлений як на столі верстата, так і на базових плитах, що входять до різних комплектів збірних верстатних пристроїв. Таким чином, технологічний процес скорочується на декілька операцій. Розроблена конструкція пристрою дозволяє виконувати оброблення деталей типу плит та кришок при одному закріпленні; відповідає умовам міцності, а також значно скорочує витрати допоміжного та підготовчо-заключного часу.

***Ключові слова**: розмірний аналіз, розміщення, верстатні пристрої, напружено-деформований стан, установочний прилад, пласкі деталі.*

Introduction

Big amount of flat and different thin component parts, such as covers, planes, knee bends, backing blocks, etc., are used on Krasyliv engineering plant (Krasylivskiy agregatnyi zavod) in product design.

Main operations of manufacturing method during fabrication of component parts are inside diameter tooling: drilling, hole enlarging, thread forming, reaming.

When carrying out inside diameter tooling, component parts are fastened directly on the table using simple adjusting clamping straps and anvils that leads to significant reduce of labour productivity and working accuracy.

The goal of this article is design of machine-tool device, providing a possibility of readjustment of device elements for installation of flat component parts and plates in certain range of dimensions, provides carrying out of mechanical processing in minimal quantity of placing owing to increasing of tool availability and provision of multiple-axis machining. The objective lies in increasing of working accuracy of component parts and in improvement of installation device for components setting. The construction of machine-tool device, providing realization of part processing of such component parts as plates and covers under conditions of one fastening, and also shortening time consumptions for readjustment, is proposed in this article.

Background

Selection of component part locating chart depends on geometric shape and design features of pieces (existence of flat surfaces, throats, apertures, etc.), size precision, form accuracy and three-dimensional positioning of surfaces relatively to each other, quality, surface roughness and toughness.

Different device locating charts on NC machines were analyzed, and on the grounds of this analysis, locating chart along three axes was chosen (in coordinate angle). Herewith intermediate product losses all 6 degrees of freedom. Ground plane, processed to-a-finish, acts as main base, lateral service acts as guiding base and end surface acts as resting base. Such locating chart is the simplest, the most reliable and accurate.

Inasmuch as inside diameter tooling operation is finishing when manufacturing given component part, its positioning on supports is carried out via processes bottom surface, which is main base.

Main quality parameters of inside diameter tooling are the accuracy and reliability. Accuracy of machine-tool device determined realization of indicated size precision parameters, departure from normal and location, distortion and undulation of processed surfaces of intermediate product.

Objective

Accuracy calculation of machine-tool devices is carried out on the basis of the theory of dimensional sequences. The last link of dimensional sequence is a requirement to size precision, geometric relationship or geometric form of processed component part.

We carry out dimensional analysis of component part when basing it in coordinate angle foremost for purpose of reaching processing accuracy of the distance between axes [1].

Chart of dimensional chains of "Cover" component part is indicated on fig. 1.

Main process tasks for this component part is receiving accurate via openings and distance between axes. In given component part the largest requirements are laid down to following surfaces:

1) Cylindrical surface Ø20H7$^{(+0,021)}$.

2) Cylindrical surface Ø10H7$^{(+0,015)}$.

3) Distance between axes of openings Ø10H7 and Ø20H7 30,0 ± 0,025 mm (IT7).

Hereafter the row A will be under examination. Number of links in A row is not greater than 4, that is why the calculation will be done according to the method of complete interchangeability [2].

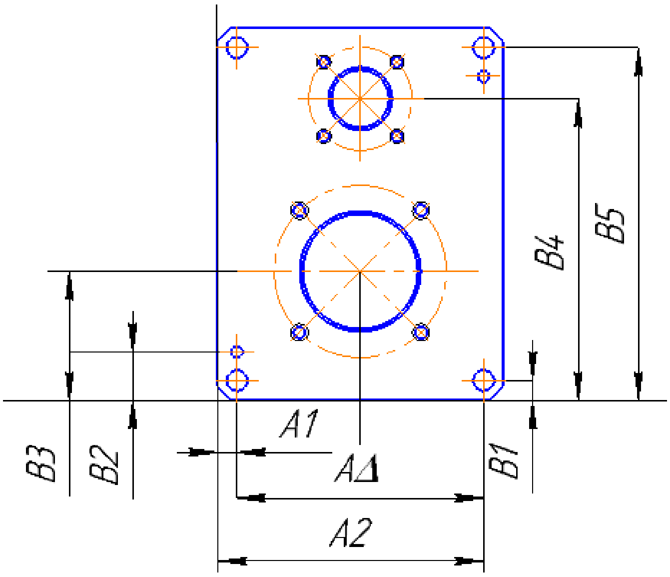

Fig. 1. Dimensional chains of "Cover" component part

Nominal value of master link is $A_{\Delta} = \sum_{i=1}^{n} A_{ЗБ} - \sum_{j=1}^{m} A_{ЗМ}$

Clearance of master link is $TA_{\Delta} = \sum_{i=1}^{n} TA_1 + \sum_{j=1}^{m} TA_2$

Upper and lower deviation of master link is calculated by following formulas:

$$ESA_{\Delta} = ES\sum_{i=1}^{n} A_{зб} - EI\sum_{j=1}^{m} A_{зм}\,; \quad EIA_{\Delta} = EI\sum_{i=1}^{n} A_{зб} - ES\sum_{j=1}^{m} A_{зм}\,;$$

$A_1 = 3{,}5_{-0{,}12}$ mm, $A_{\Delta} = 43 \pm 0{,}125$ mm,

1. $A_2 = A_1 + A_{\Delta}$ = 3,5 + 43 = 46,5 (mm)

2. $TA_{\Delta} = TA_1 + TA_2$; from whence $TA_2 = TA_{\Delta} - TA_1 = 0{,}25 - 0{,}12 = 0{,}13$ mm – corresponds to 10 accuracy degree for the dimension $A_2 = 46{,}5$ mm.

3. $ESA_{\Delta} = ESA_2 - EIA_1, ESA_2 = ESA_{\Delta} + ESA_1 = 0{,}125 + (-0{,}12) = 0{,}005$ (mm);

4. $EIA_{\Delta} = EIA_2 - ESA_1$; $EIA_2 = EIA_{\Delta} + ESA_1 = -0{,}125 + 0 = -0{,}125$ (mm).

5. $A_2 = 46{,}5^{+0{,}005}_{-0{,}125}$ (mm).

6. In a similar manner the calculation of all other links will be done.

Analysis of dimensional chains calculation shows that all unknown technological dimensions, which have to be carried out when locating component part in the device (in coordinate angle), lie within the limits of tolerance range from 7th to 13th accuracy degree, and this value is admissible and doesn't perplex manufacturing method of processing.

For determination of the possibility to achieve size, shape precision and geometric relationship of "Cover" component part when carrying out surface mechanical processing on machine accessory, the examination of strain-stress state of "Cover" component part was also realized using SOLIDWORKS Simulation software.

The model of component part was approximated by regular grid, consisting of triangle prismatic finite elements. Component part material is structural steel 45, ГОСТ 1055-80, elastic modulus is 2×10^{11} Pa, Poisson's ratios is 0.32.

Information about the grid for the component part is indicated in table 1.

Table 1

Information about the grid for component part

Type of grid	Grid on solid body
Used spacing	Standard grid
Automatic grid seal	Off
Jacobian points	4 points
Size of the element	2,9447 mm
Tolerance	0,147235 mm
Total number of units	14596
Total number of elements	8456
Maximal interrelation of sides	2,5999

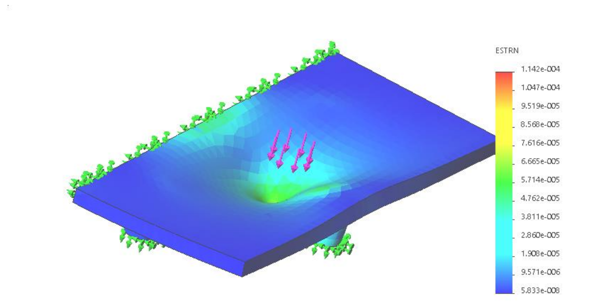

Fig. 2. Component part relocation under the effect of 1000 N cutting force

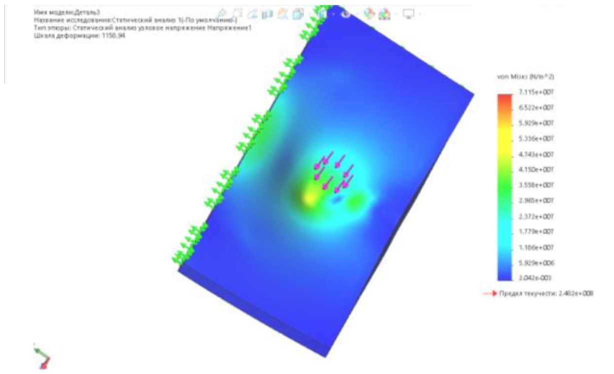

Fig. 3. Stresses in component part under 1000 N cutting force

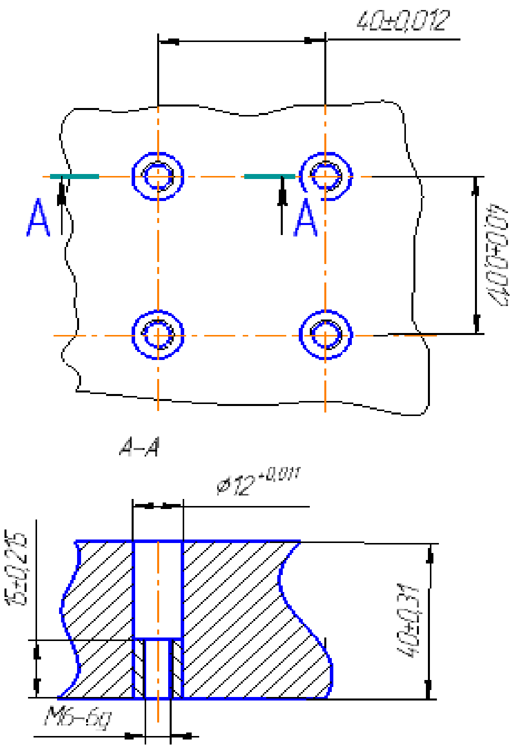

Fig. 4. Segment of installation plate

Relocations and stress, originating in component parts under conditions of different stresses on supporting surface during processing are determined, and elements of the system relocations under the action of cutting force are determined. Cutting force values, effecting on the component part are the following: maximal tension of component part drilling is P_o =1000 N, minimal tension of component part drilling is P_o =400 N.

Device case is the most critical part of the construction that bears all loads, imposed from clamp assembly unit and all cutting forces during processing. Working accuracy and reliability of force clamp depend on structural robustness, stiffness and stability of the case.

Device for flat component parts fastening consists of bearer –coordinate plate with dimensions of 400×250×40 mm.

Accurate via openings with diameter of 12 mm (Ø12H6) are made in the plate and they create grid of openings at 40 mm intervals. Thread bushings are pressed into the openings on depth of 15 mm, and they serve for setting of fastening elements (fig. 4).

Accurate cylindrical openings are determined for base of cylindrical fingers. Flat head cylindrical fingers are chosen as setting element.

Three setting cylindrical fingers with flat surface (forming main reference surface) and three cylindrical fingers, creating coordinate angle, are set on the plate. Component part is driven to the contact with these elements. Component part fastening is carried out by means of two clamp straps, fastened on the plate in thread bushing. The plate is based on machine table with the help of two spline keys.

Device construction in question is designed for setting and fastening rectangular plates and covers, carried out by clamp straps. Installation device can be set both on machines table and on mounting plates, included into different kits of assembly machine-tool devices [3].

Results

Experimental results of strain-stress state have shown that movement and stress values, originating during machining process, in offered machine accessory is insignificant, for example, deformations are not greater than 0.3 micron. After piece chucking, the unite system, which includes piece, supports and body frame of the device is created.

Research results of strain-stress state have shown that relocation and stress values, originating during mechanic processing, in proposed machine-tool device are less than standard ones.

Such technical solution in combination with rotating table of the bench provides realization of all drilling, milling and boring operations under conditions of stable fastening of the component part in one complex operation, carried out on processed center with CNC. Thus, manufacturing method is shortened by several operations.

It is confirmed, that designed technical solutions redound to intensification of technological process of mechanical processing and don’t initiate deterioration of accuracy rate.

Conclusions

Carried out researches of strain-stress state analysis have shown that designed construction of the device for component parts processing provides multicoordinating processing and meets the requirements of structural robustness, and also significantly reduces expenses of additional and setting-up time.

The task lies in increasing of the accuracy of component parts processing and in improvement of the construction of installation machine accessory. The article offers construction of machine accessory, which provides processing of component parts, such as plates and covers in single fastening and provides shortening of time consumption for readjustment.

References

1. Palivoda Yu.S. Dimensional rows / Yu.S. Palivoda, A.E. Diachuk, Yu. B. Katcapillia, I.S. Tkachuk. – Ternopil : Ternopil Ivan Puluy’s National Technical University, 2018. – 132 p.

2. Adamenko Yu.I. Engineering tolerances, fits and technical measurements. Practicum. Part I / Yu.I. Adamenko, O.M. Gerasymchuk and other. – Ivano-Frankivsk : Symfoniya-forte, 2016. – 164 p.

3. Ivanov V.O. Reserves of flexibility increasing of machine accessories for mechanic processing industry / V.O. Ivanov, V.Ye. Karpus, I.M. Degtiarov // ZhDTU Vestnik. Series “Technical sciences”. – Zhytomyr : ZhDTU, 2015. – No. 4. – P. 38–44

Рецензія/Peer review : 15.09.2020 р. Надрукована/Printed :03.11.2020 р.