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Paweł KUBICA, Piotr OCIEPKA*

Department of Engineering Processes Automation and Integrated Manufacturing Systems, Faculty of Mechanical Engineering, Silesian University of Technology, Gliwice, Poland
*piotr.ociepka@polsl.pl

APPLICATION OF ADVANCED CAx SYSTEMS FOR DESIGN AND PERFORMANCE OF TILTING TABLE IN VERTICAL MACHINING CENTRE

Abstract: In the article design process of tilting table, which is additional tooling of triaxial, vertical machining centre Harnaś R550, has been describe. Thanks to this modification, a possibility of machining axial-nonrotating elements by means of various angular positions – so-called indexed machining, was gained. The proposed tooling in CAD environment has been modeled. After calculation of the forces, which may arise at the machining, strength test by FEM has been carried out in order to select appropriate components of the designed tooling. Based on developed structure the prototype has been built, which on real machine has been mounted. Afterwards, machining accuracy of control items has been compared, carried out by three different methods, including use of tilting table and CAM software.

1. Introduction

In the era of progressive globalization of the world-wide market economy, basically all production spheres are under the pressure of rationalization, striving to obtain better and better products in the shortest possible time. Changing market trends force manufacturers to quickly introduce new products on the market. It causing that engineers who create new solutions must use efficient IT tools that are able to significantly speed up their activities while maintaining the profitability, quality and durability of new products. Modern CAD/CAE class programs have great opportunities in relation to conducting advanced strength and fatigue tests, kinematic and dynamic analyses or analyses related to product vibroactivity [9 – 14]. They allow to simulate and then analyse many phenomena that occur during the work of devices. Thanks to such tools, we can consciously shape the properties of objects at the early stages of the design process. We can very quickly carry out initial tests on the considered device, which in turn allows to reduce the scope, time and costs of research conducted on real objects (prototypes).

In reference to mechanical engineering, competitive production conditions force the modernization of existing process chains to obtain more favorable technical and economic results.

Fig. 1. Vertical machining centre R550 (left) [5] and rotary table used as a drive (right) [7]

To enable an increase in machining efficiency, while preserving the requirements setted for shape, dimensional accuracy and surface quality, it is necessary to develop machines not only in terms of construction but also in terms of the control system [3, 6, 8].

The designed tilting table has been run on vertical machining centre R550 AFM DEFUM with FANUC 0i_MD (Fig. 1.) control system. As a drive, rotary table CNC 170R of production GSA+ was used (Fig. 1.).

2. Project and implementation

The tooling in the form of tilting table was designed in CAD environment, in Autodesk Inventor program. In the first step, individual parts of table has been modeled and next the virtual assembly of entire tooling has been created. In further stage carried out strength analysis with application of numerical method - FEM - to determine the degree of strain of selected components.

Before starting the strength calculations and selecting the cross-sections of the designed parts, it was necessary to determine the forces acting on the entire mechanism during machining (machining forces). They were determined by theoretical way. It was assumed that the machined material would be 42CrMo4 steel. HSS high-speed steel tools will be used for machining. Three liminal variants has been assumed:

- drilling in full material with a drill Ø30mm (purposeful, nontechnological assumption),
- face milling with a Ø80mm cutter with carbide inserts,
- peripheral milling with a Ø30mm cutter.

After the calculations were made, it was determined that the greatest strain occurs during drilling, when the theoretical axial force exerted during this process is 7103 N. The obtained results are shown in Table 1.

Tab. 1. Calculated values of forces in relation to the analysed cases

Kind of machining	**Tool parameters**	**Calculated value of force, [N]**
Drilling	HSS drill Ø30	7102,88
Face milling	Cutter with carbide inserts Ø80	1152,8
Peripheral milling	HSS cutter Ø30	676,65

The strength analysis by FEM was carried out in Autodesk Inventor. Fig. 2. presents sample result from the analysis.

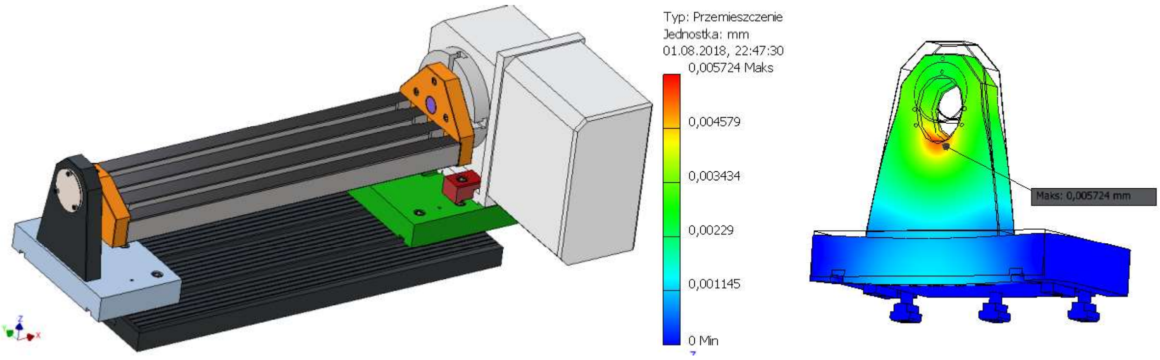

Fig. 2. Model of tilting table and strength test by FEM in Autodesk Inventor

The material used to build the tooling was mainly EN-GJS-500-7 ductile iron. It is resistant to abrasion and compression and insensitive to variable strains. Due to high cohesion, it dampens vibrations well (Fig. 3.) [1].

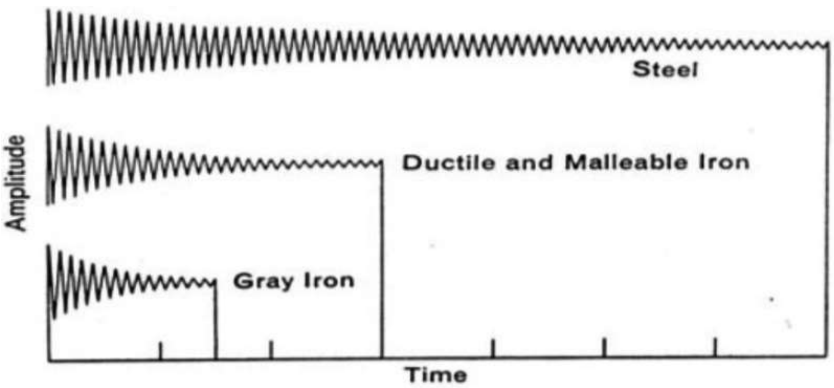

Fig. 3. Amplitude of vibrations of various materials [4]

In the next step, the model was analyzed for the proper functioning of the machine, possible collisions of parts and assemblies and the possibility of implementing the assembly process. After correct verification of these activities, technical drawings were accomplished, simultaneously developing production technology.

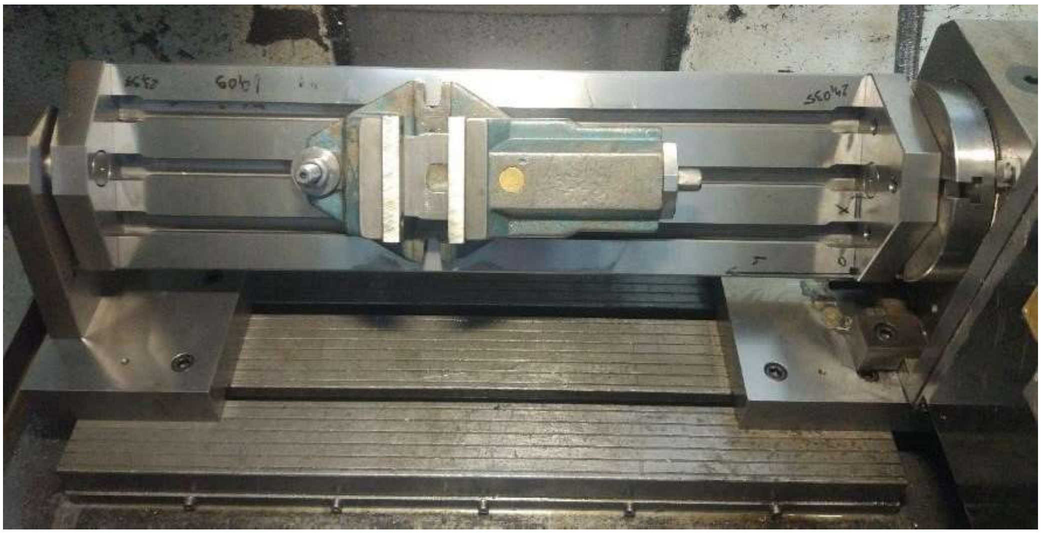

Fig. 4. Ready assembled tilting table in machine with example vise

In order to check the quality of the evolved tooling, the accuracy obtained in three different machining methods was compared in reference to a control items, specially designed for this purpose (Fig. 5.). It was necessary to make a planes at an angle of 30° and 45°, a perpendicular groove 8H7 and two holes M6 with countersinks, inclined at an angle of 25°.

Fig. 5. Model and 3 series of control items: series 1. (left) made only with the help of angular vise; series 2. (middle) produced by peripheral milling method and also with the help of angular vise; series 3. (right) made only with help of designed tilting table.

The carried out tests consisted on production and measurement of a total of twelve control items in three series:

- a series of four items machined using an angular vice, where each plane, groove and holes are made separately at different fixes,
- a series of four items machined in such a way that the 30° and 45° planes are machined in one fixing using a peripheral milling method with end mill, remaining elements in an angle vise,
- a series of four items machined using a developed tilting table only, in one fixing.

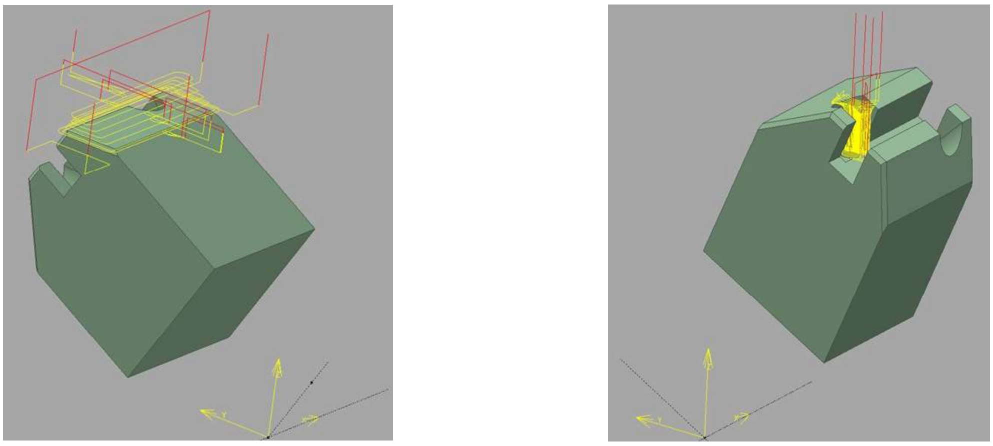

Fig. 6. Tools paths generated in CAM – hyperMILL

For create a program needed to produce control items in third series, the hyperMILL - CAM software - was used. Unfortunately, used software does not have the possibility of programming five axes, and only such allows for continuous control of the fourth axis. For this reason, when the program was generated, made use of machining at a given angular position, so-called indexed machining.

The graphs presented in figure 7. show the compared times needed to complete each series. The last of them took the most time because of the very long preparing-completion time (t_{pz}). However, if we take into account a series of 40 pieces, the third method turns out to be the fastest, because the preparing-completion time t_{pz} occurs here only once. Dimensional accuracy was also compared and it was found that the 3. series was made most accurately and had the most repeatable dimensions. The made tilting table significantly contributed to the improvement of the quality of the items being made, and also - in the case of series - to shorten the machining time.

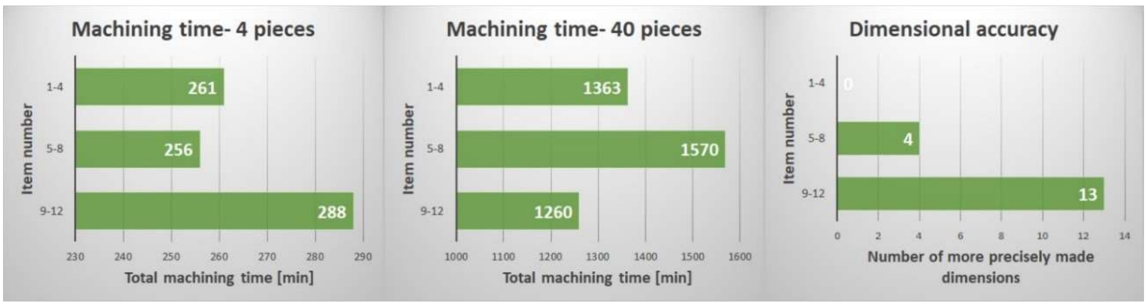

Fig. 7. Findings

3. Conclusions

The realised task was to increase the functionality of the machine, which translated into a reduction in the required number of fixings in the context of manufactured goods. The use of advanced CAD/CAE class programs during the design and engineering process significantly accelerated the creation of a new solution. The conducted tests allowed to estimate the benefits related to the time of realising manufacturing processes as well as the benefits related to the obtained dimensional accuracy of the manufactured items. Conclusions resulting from the conducted tests show that 23,53% of the dimensions were made better with the second method, so this one, where the planes at an angles were milled peripherally and the holes were drilled in an angle vice, while 76,47% of the dimensions were more accurate in the case of machining with help of the tilting table. The items made with this method were more accurate by 52,94%.

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