sciendo CzOTO 2019, volume 1, issue 1, pp. 583-590

THE USE OF NEW TECHNOLOGY TO IMPROVE THE QUALITY OF PRODUCTION ON A CNC MACHINE TOOL

doi: 10.2478/czoto-2019-0074
Date of submission of the article to the Editor: 20/11/2018
Date of acceptance of the article by the Editor: 27/01/2019

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Abstract: The article presents an analysis of the modification of the production process on a CNC machine tool. The process was modified by using a new deep hole drilling procedure. As a consequence, an improvement in the quality of manufactured elements in series production has been achieved. The applications were supported by metrological analysis of the product.
Keywords CNC machine tool, production, quality, technology

1. INTRODUCTION

Machining, in other words chip machining - it consists creating an element with specific dimensions and shapes, while maintaining the appropriate accuracy of dimensions and shapes of the detail as well as surface roughness. The rest of the material is removed during machining in the form of chips. Machining is one of the methods of shaping objects, thanks to it you can obtain objects with very complex shapes and small surface roughness while maintaining very high dimensional accuracy from technical drawings (Olszak, 2017; Boral et al., 2018). Turning on computer controlled lathes is much cheaper, faster and much more precise than when the lathe is controlled by a Turner with many years of experience (Stryczek and Pytlak, 2018). Features of CNC machine tools affecting the fact that serial production becomes more profitable:

- greater efficiency due to faster machining, also because of shorter main, auxiliary and preparatory and finishing times,
- uniform accuracy and quality of workpieces,
- reduced number of production defects,
- shortened production cycles,
- increased flexibility of production - serial production of machining is profitable, and details made by CNC are perfectly matched to the customer's requirements
- the use of this technology is more susceptible to changes in drawing thanks to the ease of introducing adjustments in the program.

At present, the numerical control of machine tools is developing very intensively, mainly due to the industry's need for continuous cost reduction, increasing the productivity of machine tools and the continuous development of micro mechanics which demonstrates the need for small elements with very narrow tolerance fields often made of difficult to machining materials (Golebski, 2017; Petru et al., 2017). The constant development of control systems and microcomputers to compensate for the smallest errors and inaccuracies of the machine tool through more accurate machine error maps helps to meet such requirements. The machines themselves are also subject to evolution, in which better and better drives and measuring systems are mounted, which are designed to compensate for, for example, the temperature deformation of the machine's skeleton (Boral et al, 2017). One of the most interesting trends in the machine industry is the gradual addition of the possibility of preparing the entire technology along with the selection of tool holders, reading the offset and giving the exact dimensions of the tool mounted on the tool holder, which only allows the operator to attach the appropriate tool indicated by the software on the selected places and the machine tool by measuring the count the corrections to be made in the program (Sadilek, 2015). At the moment most of the production of metal elements is burdened with tolerances of shape or dimension errors on the order of 0.1mm to 0.05mm, however, more often the designer faces the need to reduce elements, which also changes the dimensional tolerances as well as shape and position errors (Djurović, 2015). Tolerances with small elements are often an order of magnitude smaller or 0.02mm to 0.01mm. Such changes in tolerance require the use of other more accurate machine tools and more technologically advanced machining tools, such as special carbide drills, sintered carbide inserts or cooled by the center of the taps. Here the problem of production efficiency and the time of implementation of the element for serial production appears (Borkowski and Ulewicz, 2009). The time of implementation consists of micro-tools, verification of their strength, selection of appropriate tool working passes and specification of machining parameters, which will allow to obtain the highest possible productivity with as few tool changes as possible during production of a full production series. The process of full implementation of the detail for serial production can last from 2 weeks to 2 years (Borkowski and Ulewicz, 2014).

2. CHARACTERISTICS OF THE MACHINING PROCESSTECHNOLOGY IN SERIES PRODUTION

This article will show the modification of the production process of the copper connector, where the modification required a drilling process due to the small diameter of Ø1.4mm and a very long hole which length was 8 mm, i.e. about six diameters. The rolling process was also modified, with a diameter of 10 mm needed to reach 2.9 mm, giving a cutting depth of 3.55 mm. In this process, it was necessary to obtain a narrow tolerance field of 0.02 and 0.02, respectively. Fig. 1 presents the element with its dimensions and tolerances. The general tolerance for the drawing forces the surface to be made within the tolerance Ra = 2. The process of making so far consisted in drilling a 1.4 mm hole with a depth of 2mm Fig. 2 (first green lines), then a phase was made with a 60 tip angle countersink (blue line), after which a Ø 1.4 mm drill was used for machining and performed up to a set depth with six withdrawals to get rid of chips from green lines. The hole after execution was within the assumed surface tolerance, while the surface roughness varied between 1.7> Ra <1.1.

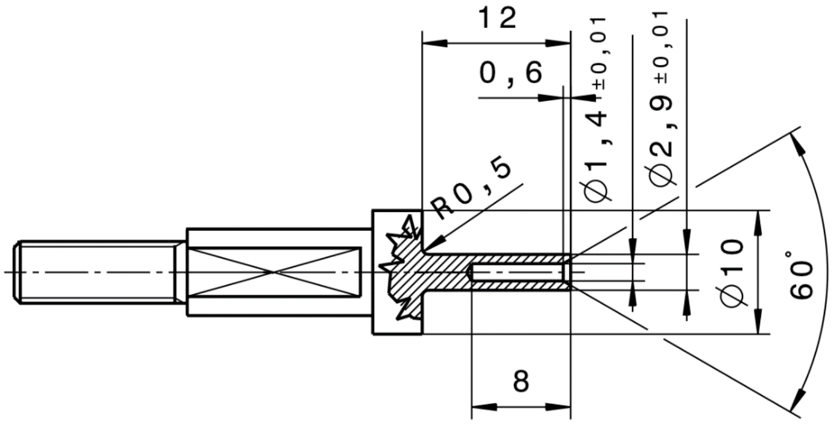

Fig. 1. Component with feature tolerances

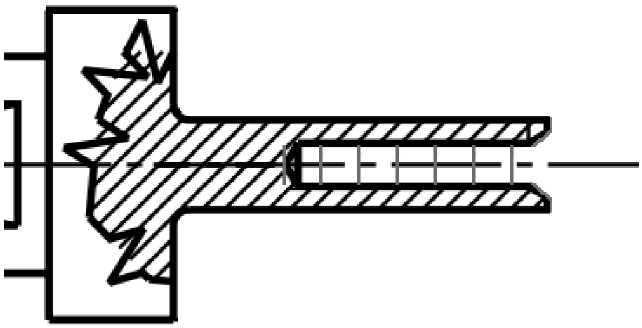

Fig. 2. Component covered with drilling steps

The component was then rolled from a diameter of Ø 10 mm to a diameter of 2.9 mm, this procedure is shown in Fig. 3. The process took place in three passages of the DCMT type knife. The depths of the first two knife passes were equal to and amounted to ap = 1.5 mm, while the last finishing cut of the knife collected ap = 0.55 mm, so a small allowance was to reduce the forces acting on the tool and to improve the surface roughness and maintain good circularity of the given diameter.

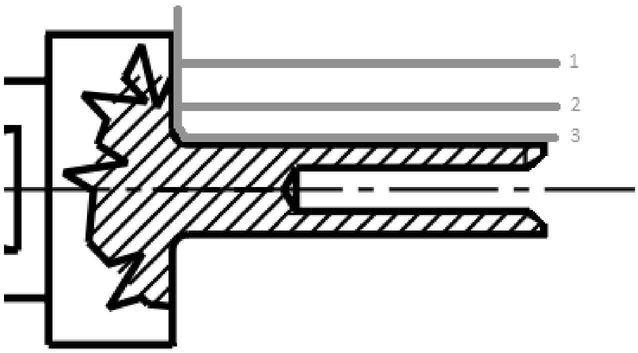

Fig. 3. Component covered with cutting steps

It took 104 seconds to make the element with such technology, of which the drilling took 8 seconds, whereas the 2.9 mm machining lasted for the first pass 4.8 seconds, the second 5.3 seconds, third pass 6.1 seconds, plus the machine departure time between subsequent processing layers 3 seconds, time total turning was 19.2 seconds.

3. IDEA OF TECHNOLOGY MODIFICATION

The process of both drilling and turning invariably from the parameters of this technology gave whirlwind chips, which could not be guided Fig.4, by tangling in tool holders. The final turning chips were characterized by a very small cross-section and were the same as the drilling chips Fig. 5 These chips required the operator to stop the machine in order to remove the chip from the holder every 2 pieces. The chip removal lasted from 30 seconds to 42 seconds depending on the operator, the time of the art increased by 15 to 21 seconds. That is why the piece of the item on which the article is based is so crucial for the entire process performance. For the needs of this production, 2 technologies and special tools were chosen to reduce the number of machine stops to remove chips and speed up the mass production process itself.

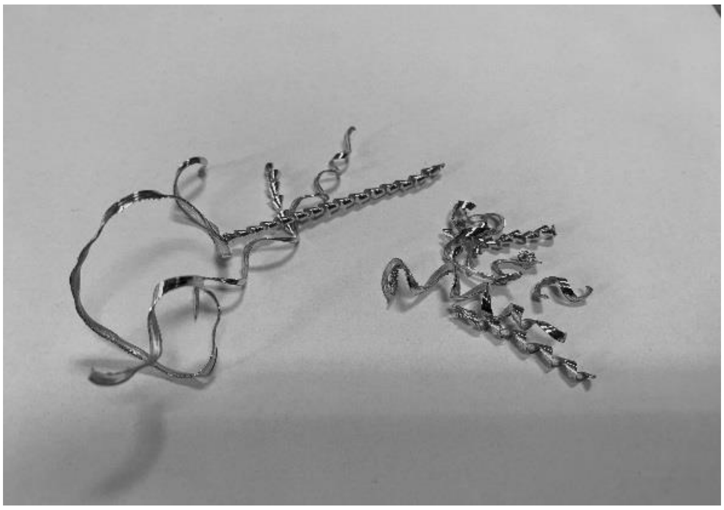

Fig. 4. Whirling chips, standard turning

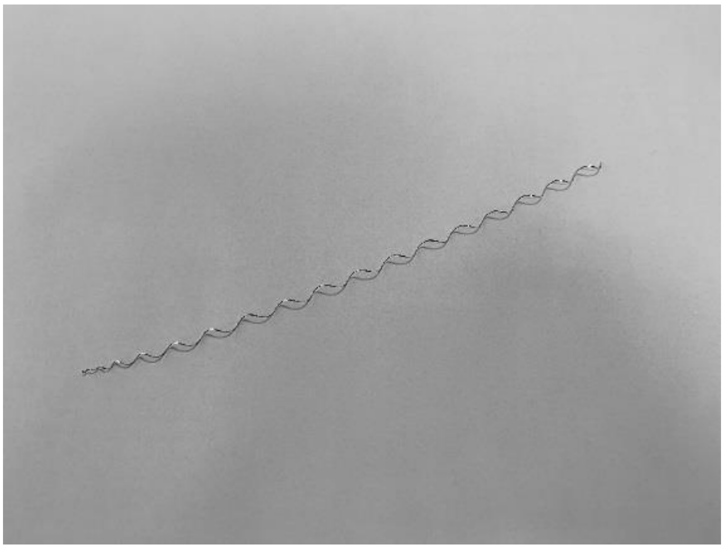

Fig. 5. Chips, drilling and finish turning

When modifying the technological process aimed at limiting the length of chips and machine time of a one-piece cycle, LFV technology and high-pressure technology of high-pressure lubricating liquid 140 bar applied to the cutting edge were used. The technologies have been modified to obtain a satisfactory production time and the chip enabling work in the production cycle without the need to stop the machine in order to remove chips from tools, as in the case of previous production.

4. APPLICATION OF PROCESS MODIFICATIONS AND ITS IMPACT ON QUALITY AND EFFCIENCY

The use of the new process was possible due to the use of a carbide drill bit 1.4 mm made of tungsten carbide with cooling through a drill and a phase made on a drill (Brown line). This process consisted of one drill entry into the material of Fig.6 (Violet line). Because of the LFV technology, which is based on the micro movements in the Z axis of the machine, very fine chips have been obtained Fig.7, thanks to the use of a cooling liquid with a pressure of 140 bar, evacuation of chips from the tip of the drill outside the element has become possible. In addition, the surface after such machining of the bore made has been found to maintain surface roughness Ra <0.8.

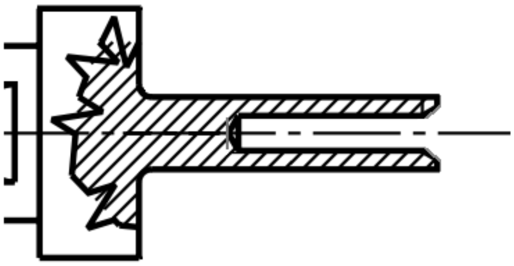

Fig. 6. Component covered with drilling steps for LFV method with 140 bar cooling system

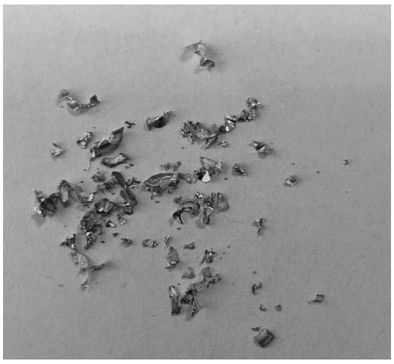

Fig. 7. Chips, drilling using LFV method and 140 bars of cooling liquid

The next modified operation was turning with a diameter of Ø 10 to a diameter of ø 2.9 mm, because of the use of LFV it turned out that the plate used for processing during the old technology could now increase ap to 3.55 mm. This made it possible to make only one knife transition Fig. 8 (Grey line) to perform the same shape as in the old technology in the course of 3 passes. Dimensional and surface tolerances have not changed in relation to the old machining. The chip changed diametrically, from the long or the flaking one managed to obtain small short chips Fig. 9. This completely eliminated the need to stop the machine to remove chips from the holder.

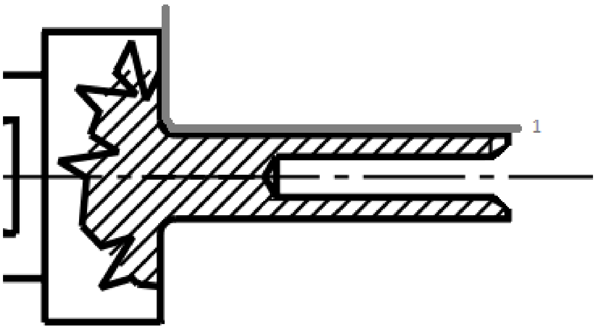

Fig. 8. Modified operation, one knife transition.

Fig. 9. Chips, turning using LFV system

The times that have been achieved in the process are significantly shorter, the machine's idle time is of special importance in order to clean the tool holders. It takes 1.6 seconds to complete the hole with the new technology instead of 8, turning time decreased from 19.2 seconds to 9.4 seconds. The total time saved is 16 seconds plus the average machine downtime due to chips of 18 seconds. The total time of mass production, compared to the old process, decreased by 34 seconds. The old production time was 105 seconds plus 18 seconds of downtime for chip removal, or 123 seconds, while the new production time is 89 seconds. In this production, the share of production costs in the element cost was 91%. After reducing the production time, this share was 82%, while the product price decreased by 21%. Production time along with side margins for 10,000 pieces of this detail would amount to 427h in the old technology, while for the new technology it was possible to reduce this time up to 309h, which gives the entire production 27%.

4. CONSLUSIONS

The object of the project according to the assumptions indicated in the article was the implementation of innovative technology, developed as part of its own experimental and development work. As part of the project, tool purchase was planned and realized, such as: special carbide drills and DCMT cutting inserts that are an integrated technological system and fully implemented technology. The technological system includes the following machining devices: BNA-42GTY CNC automatic lathe, equipped with two spindles , main with a passage of 42mm and a spindle with 34mm overhang. These spindles give the possibility of processing details up to 100mm in length, with the spindle rotation at 6000 rpm and on the capture spindle 5000 rpm. This machine has a high pressure aggregate and LFV technologies, allowing the implementation of technological tasks according to innovative technology, eight tools on the swivel head, a bar feeder and tools on the slat at the main spindle.

The technology implementation shows that times of the most troublesome operations and machine downtime due to problems with chips have changed considerably as shown in Figure 10.

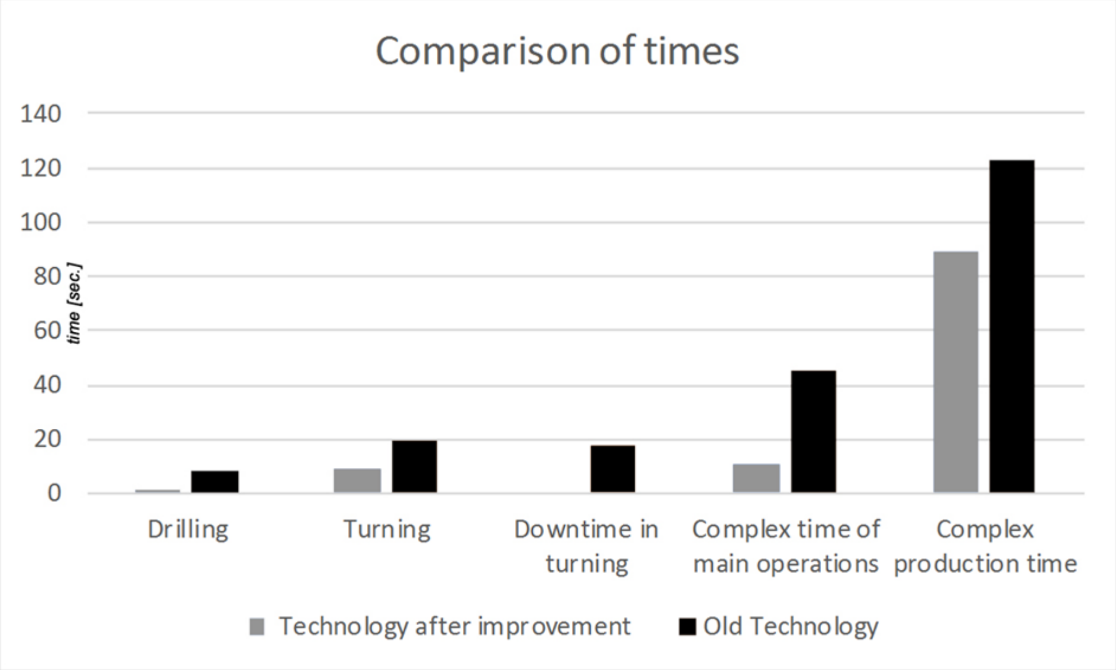

Fig. 10. Production time comparison

The technological system made it possible to obtain a very high level of accuracy (meeting the recipients' expectations in this sphere) in the assumed dimensional tolerance referring to: internal diameters of holes, external diameters, surface roughness, geometric coupling with the bases of detail. A very important argument is the fact that machining processes they were implemented taking into account high performance parameters, guaranteeing the cost-effectiveness of services performed, at the same time with additional assumptions related to high energy efficiency, ergonomics of machines and devices used in the process. The new technology indicated by the Company has been developed for the needs of complex machining of the indicated series of products of precision parts of machines and devices. The development of the machining industry for precision machine parts with very small overall dimensions is very dynamic both in terms of material modification, manufacturing method, shape, and in terms of machining efficiency, which consequently entails development in the field of manufacturing technology of individual components. An important aspect of the changes is both increasing the quality parameters (accuracy of workmanship, fewer defective products) as well as lowering production costs. Therefore, due to the significant pace of changes, there is a need to improve and increase the level of technological preparation of manufacturers, the need to improve machining processes leading to increased application of solutions in the field of process automation, the use of more integrated technological systems performing repeatable production on a large-scale scale, while increasing the quality parameters in range of accuracy. Having regard to the above, it should be clearly stated that the assumptions referred to in the article relating to technology and its implementation have been carried out to the full extent. The innovative technology implemented by the company for turning multiaxial external and internal surfaces, with the use of innovative technology involving the use of a cooling liquid lubricant with very high working pressure and LFV system, is characterized by a high level of technological efficiency resulting in particular from the applied technical solutions and process automation.

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