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PRACTICAL USE OF INNOVATIVE OPERATIONS IN PROGRAMMING OF CNC CONTROLLED LATHES

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Summary

Article presents description of performed attempts of innovative operations used in modern CNC lathes control systems to make specific objects. Problems of making different operations, that requires new attempt to programming are shown. There are shown different methods of use of new operations in different control systems for accomplishing operations like relieving shape mills, making threads not along thread line or turning eccentrics and flattens. Article also shows issues that are results of technological limits in although no limitations from programming site.

Keywords: cnc lathe, eccentric turning, trochoidal turning, polygon turning, rope thread

Praktyczne zastosowanie innowacyjnych operacji w programowaniu tokarek CNC

Streszczenie

W pracy przedstawiono charakteryzację innowacyjnych operacji stosowanych w nowoczesnych układach komputerowego sterowania tokarek. Przeprowadzono badania w celu ich wprowadzenia do wykonywania określonych przedmiotów. Przedstawiono problematykę wykonywania różnych operacji wymagających uwzględnienia nowego podejścia do programowania tokarek. Zaprezentowano różne metody zastosowania nowych operacji w różnych układach sterowania. Prowadzono analizę możliwości ich zastosowania do opracowanych operacji, m.in. zataczania frezów kształtowych, wykonywania gwintów nie po linii śrubowej, toczenia mimośrodów oraz spłaszczeń. Omówiono również problemy spowodowane ograniczeniami technologicznymi z uwzględnieniem braku ograniczeń dotyczących programowania.

Słowa kluczowe: tokarka CNC, toczenie mimośrodowe, toczenie trochoidalne, toczenie wielokątów, gwint falisty

1. Introduction

Recently produced control systems for lathes allows making more and more different objects. Thanks to wider possibilities of these systems lathes became not only machines for making object with round cross section with centre in axis of main spindle. It became usual to install on lathes heads for driven tools that allow performing a milling operations on lathes. This driven toolheads in most cases use

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low power so this solution is treated more like additional option than main processing.

So it can be used to perform some additional milling operations on objects that are mostly typical for turning. Anyway it can be noticed that it is not unusual to perform drilling of small holes not in turning axis or even not along the turning axis on modern lathes. The same way can be used to make key slots or small pockets. All these operations can be now performed in one clamping position with turning that enables achieving better tolerances of mutual orientation of made geometries. That also requires constant development of control systems for lathes that are no longer limited to 2 linear axes and main spindle, but need to control more and engage some driven axes to work in dependence on other drives position. Programming of such operations is presented by Kaczyński & Filipowicz [1] in paper describing programming innovative lathe operations.

Most obvious usage of mentioned operations seems to be making on CNC lathes eccentric objects. This method enables complete elimination of additional instrumentation and machining of parts in one fixing. Of course it needs to be noticed that this method can be used only in limited field on lathes supplied only with X and Z axes [2]. Without changing the height of tool temporary cutting blade geometry is different in every angle position of spindle in such case. This changes are depending on eccentricity of machined object.

Other shape that can be machined using advanced programming of CNC lathes is spiral of Archimedes. This shape is used for making constant-breadth cams and in construction of relieved blade milling tools. In this case pitch of the spiral is dependent on required tool clearance angle so changes of geometry are not significant. Bigger problem makes a dynamics of moves of cutting tool while machining [3]. While making of particular milling tool lathe has to perform full shift of the value that is required by relieving the produced blade and go back to initial position for every blade of machined tool. So this has to be as much jump and back moves in every full turn of main spindle as there is the number of teeth in machined mill.

Using the same control algorithms some of the producers or control systems for lathes made a subroutines for turning polygons. In this case more than anywhere problem is temporary shift of tool geometry. In extremal case (corner) in perfect conditions this change should be performed during single change of spindle angle from minus to plus extremal angle. Using a specific polygon and twisting each section is everything that needs to be done to make thread with this method. However it is required to use a tool with high rake and clearance angles, that are not available in currently produced tools. The exception is rope thread [4], which can be made with such method profitably cause of its geometry. Article presents review of practical use of mentioned advanced functions of CNC controlled lathes.

2. Making of relieved tools

In association with AFM DEFUM S.A. – machine making company in Andrychów there was developed a construction of special lathe. TAE 45N rope threading lathe. due to its unique design and the type of realized operation, required conducting experimental tests and on this basis, assessment of its dynamic properties. Expression “unique design” refers mainly to the feed drive system construction, which consists of two carriages (X-axis and Xs-axis) responsible for the movement in the X-axis. Sophisticated solution of two carriages responsible for the realization of movement in the X-axis is directly connected with the need to performing fast motion in the X-axis, enabling performing complex geometry of rope thread. As mentioned by Dunaj and Chodźko [5].

There was an idea to use this construction for relieved tools making, Such kind of machine is preferable for this operation cause there is a separate light drive for making short rapid moves along X axis. It allows to use X axis to program shape of machined object, and the other axis to make only short repeatable moves for relieving blades.

For verification of possibilities of realising assumed operation there was made a design of hypothetic tool for 6 grooves splines shaft with 28mm diameter. This particular shape was chosen as a relatively simple and possible to machine in short time. Chosen tool was mill with 10 teeth and clearance of 5 degrees and maximum diameter of 76mm. For checking the ability of performing the operation and enabling the preliminary angle setting there was designed wide chip spaces what can be seen on Fig. 1.

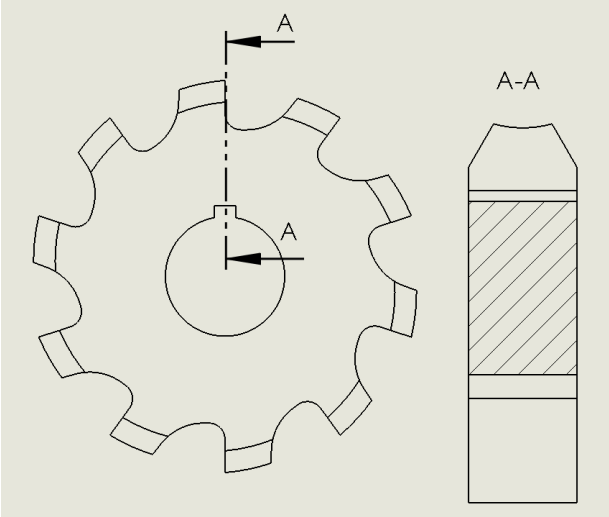

Fig. 1. Shape of machined relieved cutter

Lathe used for attempts of machining was equipped with CNC control system Fanuc 35i with enabled possibility of making a Path Table Operations (PTO) what was supposed to make eccentric threads turning possible [6-7]. Working of the PTO operations is based on creating toolpath as a direct dependence of controlled axis on position of a superior axis or spindle with omitting the interpolation system. This was wider described by Kwaczyński and Filipowicz [1]. During the attempts it became clear that such operations are very useful in making such shapes, however it is necessary to take machining parameters into account, cause they have large influence on matching the realised toolpath with theoretically programed one.

For preliminary attempts there was machined a shape of designed tool in light metal alloy. Effect is shown on Fig. 2.

Fig. 2. Effect of machining

As for the preliminary research the effect is very promising and the further research are needed to obtain all required parameters and realise complete applicable technology.

3. Making of threads with eccentric turning

As a favourable effects of rope thread making with eccentric turning was achieved there was made attempts to make with this method threads with different shape. It was related to research on possibilities of control system of mentioned special lathe.

For preliminary attempts there was chosen thread marked TR34x90 P3. It is a three start trapezoidal stub thread.

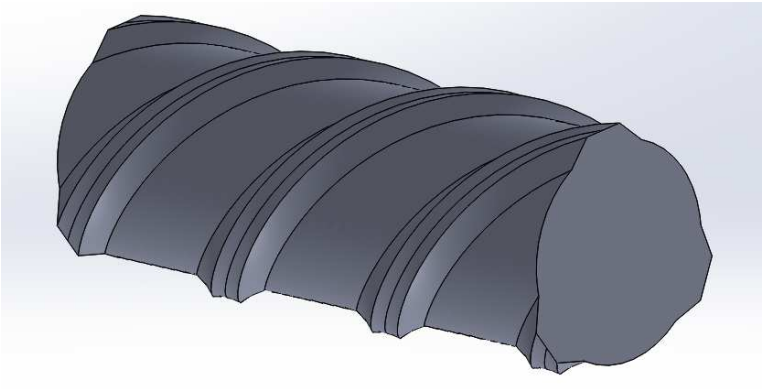

Fig. 3. Model of TR34x90 P3 thread

Such thread makes its production using typical thread turning very difficult. Large pitch makes hard to approach and retract tool while turning and while finishing the cutting cross section is very large. While eccentric turning all these difficulties are omitted. That doesn't mean that such operation is not difficult to perform.

Using a lathe without additional Y axis perpendicular to ZX plane requires usage of tool that has a large clearance to machine side surface of thread. Tools with such clearance are not available to buy so there was specially made tool of high speed cutting steel fulfilling all geometrical requirements.

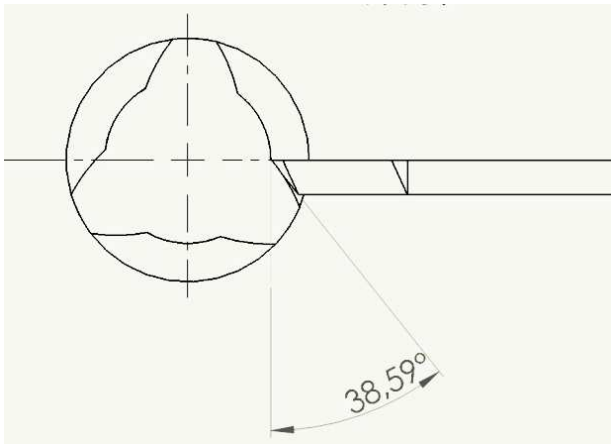

Fig. 4. Value of required clearance angle

After that all the necessary programs was prepared and the attempts was performed. Cause the tool was made of uncoated high speed cutting steel the cutting forces was significant and it was impossible to perform turning in one pass. The cutting forces was too high to provide sufficient clamping at the particular lathe. So the machining was performed in number of phases.

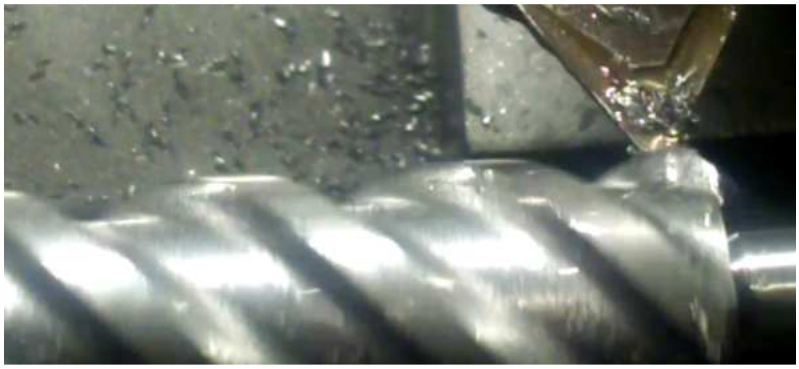

Fig. 5. Making of last cut of machining trapezoidal thread with eccentric cutting

As it can be expected machined thread had no sharp edges, what was result of using a tool with large radius and limited values of acceleration realised by machine tool drives. However achieved effects are promising.

4. Making polygonal sections

There was another attempt of usage of recognized possibilities of modern CNC systems for lathes. First idea was to make a single flat surface on turned shaft (so called D shaft), and it's development was making a polygonal sectioned shaft. Such operation seems to be quite indifficult using earlier presented features however there are some problems to solve for perform it properly.

In case of using lathe that has no Y axis there is once again necessity of using a tool with large clearance. In this case also tool rake angle can achieve negative values in work CS. It can be seen that values of work rake and clearance angles would be related to number of sides of machined polygon and to depth of flattening while making a D-shaft.

First made attempts shown that making a polygonal sections using table operations is possible however there was visible imperfection of surfaces caused by friction of tool and machined surfaces. Once again there is necessity of using a tool with rake and clearance angles with unusual values. Moreover it needs to be noticed that making a sharp edge would require from lathe feed drive change of moving direction in no time ergo with infinite acceleration. Such acceleration is definitely impossible to achieve what results making of imperfect sections.

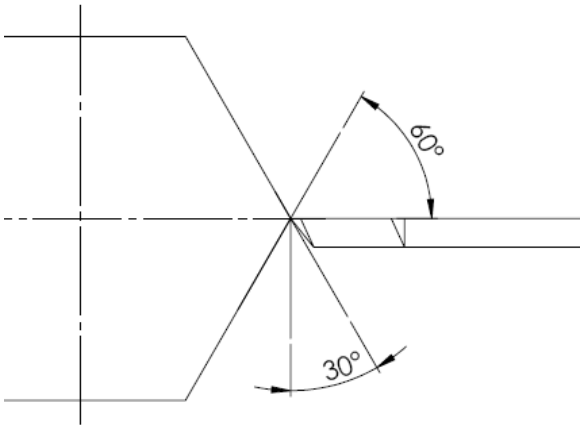

Fig. 6. Theoretically required values of cutting edge angles during turning of hexagon

Using a radius on edges in machined polygons enables to minimise those disadvantageous properties of however they make effect on machined polygon.

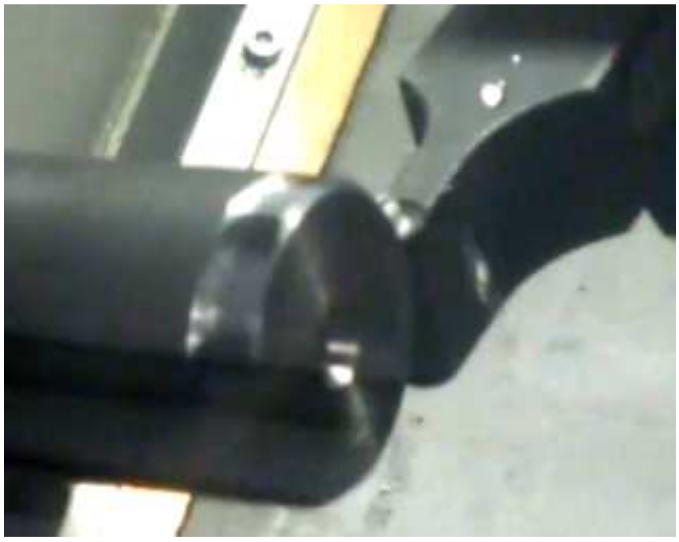

Fig. 7. Attempt of turning of hexagon

Finally performed attempts of turning polygonal sections confirmed significance of mentioned problems. While making polygonal sections with large number of sides it is quite easy to eliminate imperfections by use of corner radius and it is possible to get a tool with sufficient geometry that guarantees lack of

friction between tool and machined surface. While making octagons and hexagons this problems are still not possible to eliminate. However there are consulted possibilities of usage of tools with biggest clearance and rake angles possible.

5. Conclusions

Presented attempts show wide possibilities that gives proper usage of innovative functions of modern lathes CNC control systems. All presented samples was developed and tested to be used on lathes equipped in Fanuc and Sinumerik control systems with presented advanced functions. It needs to be noticed that presented problems was not results of programing problems. They was results of technological problems or drives limitations. That show that in practice it is impossible to separate programming issues from typical technological problems coming from the machining theory. Eventually program itself it is not a goal of technological work, it's a tool that helps achieve a goal which is a properly machined product.

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