ASSEMBLY AND SETUP OF UNTYPICAL TOOLS IN CNC LATHE

Montaż i bazowanie nietypowych narzędzi w tokarce CNC

Сборка и базировка нестандартных инструментов в токарном станке

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DOI: 10.15199/160.2019.4.7

Abstract: In the paper, the possibilities of measuring and setup of cutting tools, using electronic microscope, were presented. The problem refers to applying the tools mounted in unconventional places of the machine tool workspace. In this case, standard measuring systems of cutting machines do not allow a correct measuring and setup of the tools. The presented method is characterized by a flexibility of placing of the mounted tool, high resolution and repeatability. Additionally, the discussed method allows checking the geometry and the state of wear of the cutting edge of the tool, e.g. the chipping of the blades.
Keywords: cutting tools, tool setting, tool assembly, chipping control
Streszczenie: W artykule zaprezentowano możliwości pomiaru i ustawienia narzędzi skrawających za pomocą mikroskopu elektronicznego. Problem dotyczy narzędzi montowanych w niekonwencjonalnych miejscach przestrzeni roboczej obrabiarki. W takim przypadku standardowe systemy pomiarowe obrabiarek nie pozwalają na prawidłowe mierzenie i bazowanie narzędzi. Przedstawiona metoda cechuje się elastycznością co do miejsca aplikacji, dużą rozdzielczością i powtarzalnością. Ponadto omówiony sposób pozwala na kontrolę geometrii i stanu zużycia krawędzi skrawającej np. pod kątem wykruszenia ostrzy.
Słowa kluczowe: narzędzia skrawające, ustawienia narzędzi, montaż narzędzi, kontrola wyszczerbień

Introduction

In the computerized numerical control (CNC) machines, the rate and precision of preparing the tools and the elements to the machining process is very important due to the expected effectiveness. Their accurate measuring and position in the workspace is indispensable for a correct work. It is a preparatory process which consists of a series of operations, performed by the operator. Manual measurements, setup and introduction of the data concerning the offsets are time-consuming operations, endangered by errors. At present, there are universally employed measuring systems together with the dedicated software, integrated with the lathe control system. To read the position of the tools, they utilize measuring systems of the lathe axis. The probes for setup of the tools are easy in installation in the machining centres and allow making the operations automated. They ensure considerable saving of time, a precise measurement, automatic correction of tool offsets and eliminate the errors of manual setup. The modern solutions allow obtaining information on a radial and linear profile of the tool and state of cutting edge. They enable also a current monitoring of the tool wear. The measurement after a specified time period and automatic introduction of the current correction gives a guarantee of stability of the machining process [2, 3, 5].

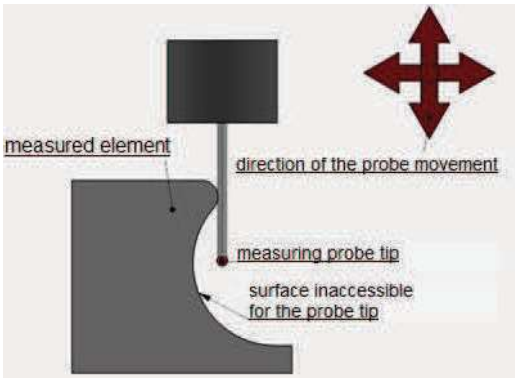
Methodology

In the machine industry, the contact and non-contact measuring systems are employed. In the first case (Fig.1), a physical touch of the tested object with the tool probe is necessary. The principle of its functioning consists in deviating of a contact part from neutral position due to the contact with the examined tool. Then, information from the probe is transmitted to the measuring device by a wire or in a wireless way, e.g. by radio or infrared light. Such method of performing the measurements has many advantages. It is characterized by resistance to the contamination in the workplace, simplicity and small dimensions of the subunits. The drawbacks of the method include the fact that the measurements implemented by the discussed method may deform the low-rigidity elements. The successive limitation concerns the size of the touch probe tip which cannot always be located in small workplaces [2 -5, 7].

The measurement of elements with complicated shapes becomes troublesome or even impossible when there is no possibility of the “approach” due to the kinematics of the machine. The problem is presented in a form of scheme in Fig. 2.

Fig. 1. System of touch measuring probes [11]
Rys. 1. System dotykowych sond pomiarowych [11]

Fig. 2. Difficulties occurring during the measurement, using a probe
Rys. 2. Utrudnienia występujcie podczas pomiaru sondą pomiarową



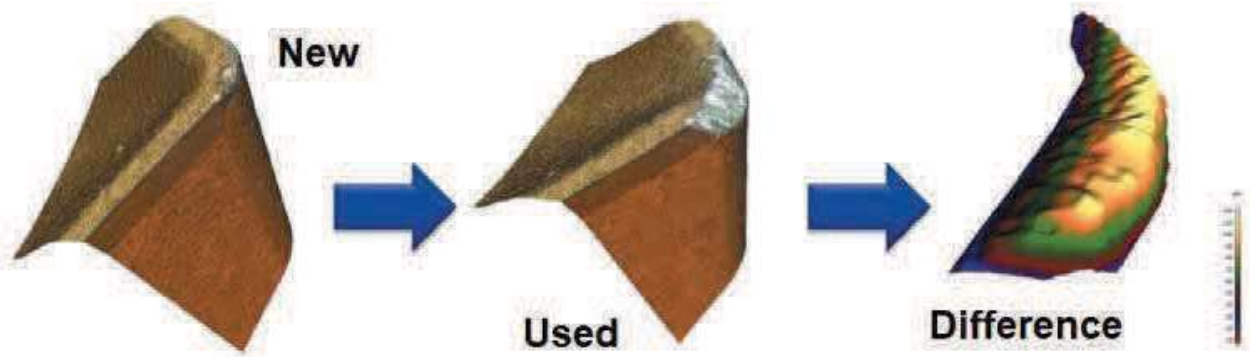
Contactless measuring systems are more and more frequently used in CNC lathes. Their growing popularity results from their significant advantages e.g. they offer the possibility of measuring the element sensitive to the deformation caused by touch; they also allow detecting the cutting edges. They may be used even at a high rotary speed of the spindle.

The systems, operating on the principle of measurement of reflection of laser light from the tool surface are characterized by a high level of resolution, perfect linearity and the possibility to measure the objects with a coarse surface. During the contactless measurement, the tool rolls over the laser radius and cuts it, releasing the measurement. Optical probe utilizes the phenomenon of shadowing the light ray or change in the level of lighting. The application of the discussed probes gives the possibility of measuring the tool before the treatment (in order to introduce the correction to the machining program) as well as during the process in order to compensate the worn edge. It is also possible to perform the measurements from a big distance from the object. We may distinguish the measurements where the transmitter and the receiver are situated in one element, or in the separate elements. The laser beam measures the length, diameter or contour of the tool. Difficult conditions of workspace are the limitation of the method; hence, the systems of treatment with a compressed air, removing chips and refrigerant are employed [1, 6, 8].

Fig. 3. System of contactless measurement of the tool, using laser beam [9].
Rys. 3. Układ bezdotykowego pomiaru narzędzia za pomocą wiązki lasera [9]

Apart from the measuring systems, constituting the integral part of the equipment of industrial lathes, a series of other solutions are successfully used. We should indicate here the coordinating machines, optical scanners, CT scans and many other solutions. In the context of the discussed problem, all of them have one common property, i.e. independent constructions which are not usually installed inside the machines. Due to their destination, they will be unsuitable for the precise setup of the tools in the lath. Despite it, we should pay attention to the optical micrometers. Similarly as laser systems, they allow the non-contact measuring of geometric size or coarseness, utilizing various measurement principles. The additional advantages of the discussed equipment include a high efficiency and a high precision. The measurements of the properties, as implemented by surface geometry technology create the new research possibilities and enable a new look at the problems of the cutting edge characterization. Wear of the tools and their state after a specified period of work are typical and universal problems during the machining process. The control of chipping and micro-cracks is significant. When using a microscope, we are able to scan a tool before

Fig. 4. Comparison of a fragment of a new tool and a worn tool [1]
Rys. 4. Porównanie fragmentu narzędzia nowego i zużytego [1]



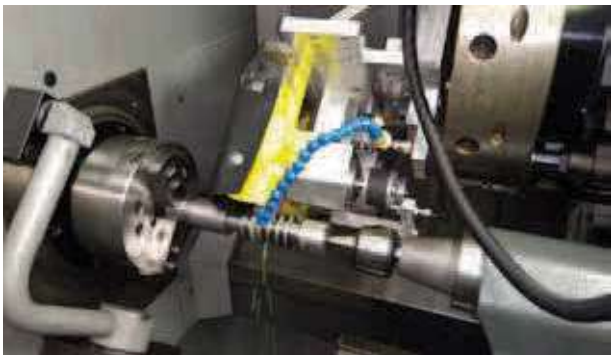
treatment and after its completion (Fig. 4). It gives the possibility of reconstructing its full three- dimensional geometry. The obtained result allows conducting the accurate analysis of the edge quality. Owing to the application of the appropriate software, it is possible to overlap the obtained images each other, or to compare with CAD model and develop a map of deviations. The models may be analysed irrespectively of the type of the edge or a type of material [1].

Standard measuring systems in a form of probes are installed in the specified places of workspace of the lathes. After calibration of the system, the basic elements are not rearranged. In consequence, it works according to one scheme. It is a certain limitation. The lathe, on which the studies were carried out, may be the example. It is equipped in one probe for measurement of the tools, as it is given in Fig. 5.

Fig. 5. Measuring probe of the lathe [10]
Rys. 5. Sonda pomiarowa tokarki [10]

In the case of unconventional solutions, such accessories of the lathe do not have the possibility of determining the position and geometry of the tools which will not be installed in the turret lathe head. If we want to outline the essence of the problem more precisely, we should refer to a wider range of the studies. Their

Fig. 6. Grinding in the lathe
Rys. 6. Szlifowanie na tokarce



aim is to develop the technology, giving the possibility of grinding the screw surfaces in the universal CNC lathe. To this end, a special device was constructed (Fig. 6 and 7). It is assembled in the mentioned tool head. It moves as any tool, in accordance with the kinematics of the machine, using its drives and numerical control.

Fig. 7. Grinding tool
Rys. 7. Przyrząd szlifierski

In this case, we operate the grinding wheel, which is set up under the selected angle in relation to the axis of the treated object and it has its own drive. The presented solution is the first part of the research stand. The correct work of the grinding wheel requires appropriate preparation of its grinding surface. The mentioned process, called a dressing process, requires diamond dressers to be used. Due to the fact that the tool head is already occupied and besides it, the whole tool is moved, the dressers had to be installed in another, immobile place. The problem was solved via construction of additional special tool, constituting the second part of the stand. It is mounted on the tailstock grinder guides and immobilized in the selected position. The catching element allows mounting of three dressers. It gives the opportunity of grinding wheel treatment from each side in one mounting. The unit is illustrated in Fig. 8.

The correct setup and measurement of the tools and then, transmission of these data to the control system of the machine is the indispensable for effective and correct performance of NC program. The application of measuring probe is the most convenient method; however, when undertaking the attempt to perform the mentioned operations, there were many problems encountered.

The first one includes a lack of the possibility of "driving up" the mobile measurement probe to any place of workspace as it happens in milling machines (Fig.1). In the lathes, the treated object is always found in the axis of the spindle, and only its size is a variable. Due to this fact, the application of such probe is not justified.

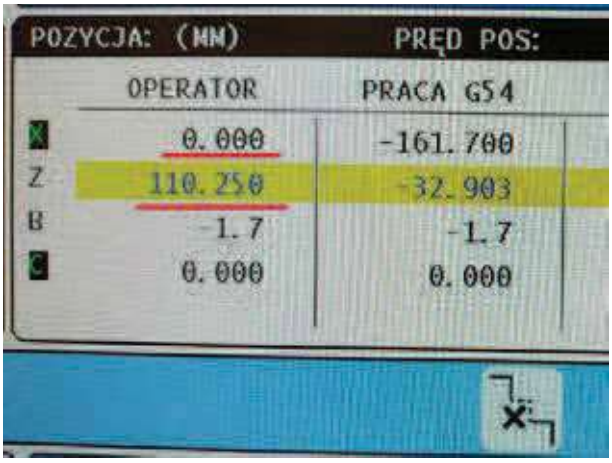
The second problem includes angular mounting of certain dressers. Even if it had been possible to use the mentioned earlier probe, there would be the problem of measuring the surface that is inaccessible for the contact part, as it was shown in Fig. 2.

The third limitation concerns the position of the dressers. The frames and sockets in the turret lathe head ensure standard distribution of the tools. It is necessary to perform only easy measurement of geometry and position of the edges. The dressers are found in a completely different place. Additionally, their manual removal from the holder "intuitionally" does not give the possibility of a precise setting up on the same height in relation to X axis.

The radius of the dresser is the fourth problem. Standard probe of the lathe allows measuring the tool from few sides. When knowing the position and radius of the grinding disc edge, the programmed calculation of the compensation of its contact point with the material for the arc passage. Due to very small dimensions of the dresser diamond, the measurement with the mobile head "from milling machine" would not give a reliable result as

Fig. 8. Microscope scanning
Rys. 8. Skanowanie mikroskopem

Fig. 9. The result of measurement of distance between the dressers in Z axis
Rys. 9. Wynik pomiaru odległości między obciągaczami w osi Z



it is not known what part of the probe tip will touch the diamond.

Due to the earlier mentioned limitations, the solution of the problem owing to the application of electronic microscope was presented. The method of its mounting was illustrated in Fig. 8. We should pay attention to the fact that small dimensions of the instrument give a big flexibility in respect of the application of different variants of assembling. In the discussed case, the standard tool frame and ER collet were employed and the appropriate bracket and the handle for microscope were placed inside. The whole set was mounted in one of the sockets of turret lathe head.

Fig. 10. The left dresser
Rys. 10. Lewy obciągacz

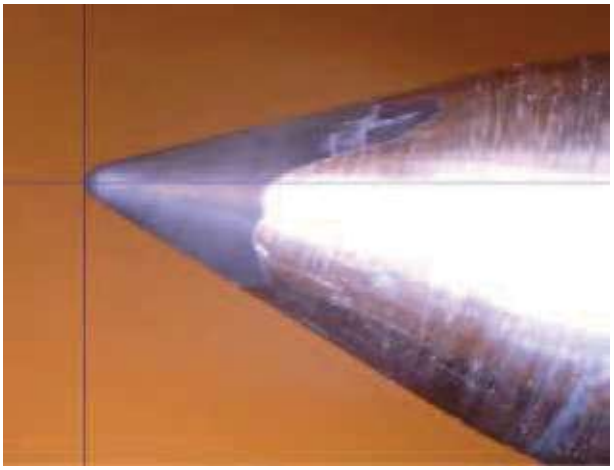


Fig. 11. The right dresser
Rys. 11. Prawy obciągacz

The measuring process is carried out during the preparatory work, before the assembly of target grinding tool. The microscope has USG interface to be connected with computer. The discussed procedure requires preliminary setup of the first dresser. To this end, it is necessary to fix the microscope via approaching of the head. After regulation of sharpness on the screen of the computer, a distinct image will be obtained. The software of the producer enables display of auxiliary lines. The point of their crossing should be found at the end of the dresser (Fig. 10). Then, the operator resets the position of X and Z axes in the lathe control system. It is possible to compare the obtained position and any earlier setup. Then, the microscope should be moved in the vicinity of the second dresser. In relation to X axis, the microscope must return precisely to the same position (Fig. 9, section OPERATOR, position X 0.000) and only Z axis is operated. When the dresser is visible on the screen, its diamond must be set up at the point of crossing of the same auxiliary lines, displayed in the computer program. To this end, the removal of the dresser from the handle until the moment of obtaining the required position, as it is given in Fig.11. When employing the lathe control system, it is necessary to read out a new position of the head (Fig. 9). In this case, the diamonds of the dressers are spaced at the distance of 110,25 mm.

When having information on the distance of zero point of operator in regard to X and Z axes from the selected measuring basis and knowing the mutual spacing of the dressers, it may be recognized that they are univocally set up in the workspace of the lathe. The grinded dressers, intended for precise profiling were employed. The producer declares the size and radius of the diamond. The obtained information should be considered in the further work on preparation of NC program. The process of profiling of grinding wheel is reverse in regard to standard turning, i.e. the tool remains immobile and the treated object is moved.

Summary

The presented method of measurements and setup of the tools enables the solution of the problems which may be encountered in the selected cases. It is the universal and inexpensive solution. Its application is supported by easiness and flexibility of assembly. Certainly, it will not replace the advanced and dedicated measurement systems. It may be ad hoc supplementation of their functionality. The application of unconventional solutions, being not provided by the producer in the constructions of their machines or equipment will usually result in the additional problems. The conducted studies prove that the presented problem as well as many others may be effectively solved. The advantage of the solution as regards the presented problem includes simplicity and easiness of the application. Additionally, in the case of a very precise treatment, especially of expensive elements, there is a possibility of verifying the state of the tools before the appearance of the undesired defects, resulting from the use of a worn or chipped edge.

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