Заключение. Эффективным направлением повышения работоспособности режущего инструмента с ПСТМ на основе КНБ является изменение состава его рабочего композита за счет введения в него составляющих, которые, без снижения механических свойств материала, минимизируют химическое взаимодействие инструментального и обрабатываемого материалов в зоне резания.

Для оснащения режущего инструмента разработан ПСТМ на основе КНБ, содержащий нитрид кремния. Материал имеет высокие механические свойства, а также обеспечивает формирование в зоне резания азотсодержащей среды, что позволяет обрабатывать детали из труднообрабатываемых сплавов на основе Ni и Fe с высокой скоростью резания.

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APPLICABILITY OF WATERJET CUTTING FOR DIFFERENT MACHINING OPERATIONS

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ЗАСТОСУВАННЯ ГІДРОАБРАЗИВНОГО РІЗАННЯ ДЛЯ РІЗНИХ ОПЕРАЦІЙ ОБРОБКИ

Сьогодні гідроабразивне різання не має собі рівних у багатьох аспектах різання й змінили технологію виробництва різних видів виробів. Гідроабразивне різання (AWJ) може бути використане у швидко переналагоджуваних верстатах, розрахованих на кілька видів обробки: фрезерування, точіння й свердління за одну установку, що було продемонстровано на практиці. У наступних розділах альтернативні операції будуть обговорюватися більш докладно. Гідроабразивне різання має гарні шанси для застосування як метод обробки через відмінні характеристики.

Сегодня гидроабразивная резка не имеет себе равных во многих аспектах резания и изменила технологию производства различных видов изделий. Гидроабразивная резка (AWJ) может быть использована в быстро переналаживаемых станках, рассчитанных на несколько видов обработки: фрезерование, точение и сверление за одну установку, что было продемонстрировано на практике. В последующих разделах альтернативных операции будут обсуждаться более подробно. Гидроабразивная резка имеет хорошие шансы для применения в качестве метода обработки из-за отличных характеристик.

Today the waterjet is unparalleled in many aspects of cutting and has changed the way of production in the case of many products. The abrasive waterjet (AWJ) may be used for flexible machine tools, capable of multiple operations including cutting, milling, turning and drilling in one setup, has been demonstrated in practice. In the following sections the alternative AWJ operations milling, turning will be discussed in more detail. Because of its excellent properties waterjet has a good chance to be applied as a cutting method.

1. INTRODUCTION

Machining processes include different technologies, from which the cutting technologies have significant importance. The waterjet cutting is a cold cutting process, which does not cause fracture in the material. The main advantage of waterjet cutting is that it is possible to cut a complicated planar curve with which any other technology is not workable, so it is widely used by different industries, such as airplane and automotive manufacturing.

The principle of waterjet cutting is the process during which a high-pressure water column is converted into a high-speed water jet. The obtained high-speed water jet will attack the workpieces and remove material. Two types of waterjet cutting exist today, including plain waterjet and abrasive waterjet cutting. The difference between them is the added abrasive powder in case of the abrasive waterjet cutting. This additive increases the effect of waterjet erosion. Due to this effect, the range of the machinable materials increases. The great advantage of the waterjet cutting in contrast with other technologies is that this is a cold cutting process. This technology does not cause fracture in the material, and suited to cutting different materials, therefore the application field is wide. The essence of the abrasive water-jet cutting is the erosion process [1]. After passing the nozzle the water has very high speed in the mixing chamber, abrasive powder is mixed to the water and the abrasive water is homogenised in the mixing tube. (Figure 1) Outcoming from the abrasive tube the jet attacks the workpieces and makes the material remove and in the meantime different phenomena take place, like for example plastic deformation or rigid fracture. This phenomenon can be explained with the different types of erosion, rigid and ductile erosion.

Depending on the cutting mechanisms two types of erosion are differed: ductile and rigid erosion. In cutting of ductile erosion material removal is caused by plastic deformation, or ideally by a micro machining mechanism removing small chips while in brittle erosion material removal is accomplished with the help of crack growth and intersection of cracks. Either ductile or rigid the material is, the material removal is accomplished by the result of number of discrete impacts, when small particles erode the surface of the machined material [2].

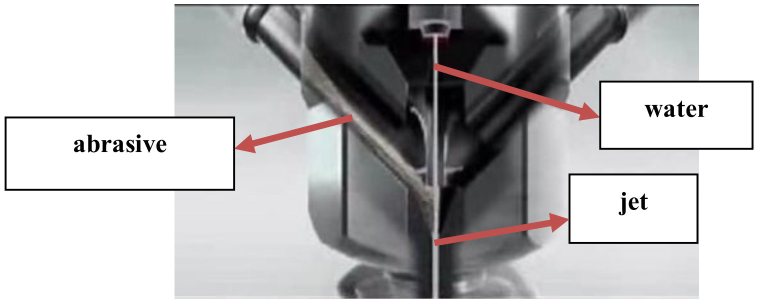

Figure 1 –Abrasive waterjet cutting head

Advantages:
- the cutting does not result in substances harmful to the environment, since it does not use any lubricant and coolant and there is not gas-output
- slag does not occur on the cutting surface
- there is a wide range of the workable materials
- the thickness of the machinable materials can be up to 30 cm
- the loss of material can be minimized due to the small cutting gap (0.03-1.6 mm)

- complex formations can be created
- the temperature does not increase on the cutting surface, so the internal properties of the cut material do not change

Disadvantages:
- accuracy problems
- the short lifetime of the nozzle
- the formation of aqueous vapour
- the splashing water and other materials during the cutting
- the high noise level

The abrasive waterjet cutting is an environment-friendly technology, due to the small loss of material and the non-existing chemical pollution. Moreover, there is no need for any lubricant and other pollutant. Almost all of the materials can be machined by waterjet cutting.

The most important materials, which can be cut by this technology are:
- non-metallic materials: the simple and the reinforced plastics, rubber, leather, paper;
- textile;
- rigid materials: armour-glass, ceramics, rocks, concrete, construction and cladding materials;
- tough materials: coloured metals, ferrous and non ferrous metals at any state of heat treatment;
- soft, combustible materials, plastic foams.

Technological parameters of waterjet cutting

The quality and the accuracy of the abrasive waterjet cutting are determined by numerous factors. The most important are the following:
- the water pressure and flow rate
- traverse feedrate
- the diameter and the geometric accuracy of the water nozzle
- the length and diameter of the abrasive nozzle
- the distance of nozzle to the workpiece
- the type of abrasive powder, the size of particle
- the abrasive mass flow
- the hardness of workable material
- cracks properties
- the thickness of plate

From among these parameters the feedrate, the pressure and the abrasive flow are the easiest and the most common altered configuration parameters to be altered.

2. APPLICATIONS OF ABRASIVE WATERJET MACHINING

Waterjet technology has been advancing rapidly for the past three decades. In mechanical engineering the abrasive waterjet cutting has the most important role from among the waterjet technologies. The versatility of the abrasive water jet in cutting almost any engineering material is a very special feature of this technology.

2.1 Milling with Abrasive Waterjet

Several concepts of milling with abrasive waterjet are developed, such as rotary multiple waterjet head, process parameter variation principle, multi traverse milling, mask milling, discrete milling.

The main difficulty when milling with abrasive waterjets is controlling the depth of the cavity. In conventional milling the depth of cut is geometrically determined by the tool shape and the feed. In case of abrasive waterjet milling there is no direct contact or feedback from the workpiece, the depth of cut being determined by the mechanics of the jet material interactions. An attempt to develop a concept of abrasive waterjet milling that bases on continuously-varying dynamic variables is not successful either. Several authors use the multipass linear-traverse cutting as a milling strategy. This principle is based on the superposition of several kerfs to obtain a cavity of the defined geometry [3].

In order to obtain a precise jet penetration depth, the knowledge about which parameters that control the process is important. A problem inherent in the AWJ process is the sensitivity to disturbances, which tends to impede any attempt to control depth of cut. The disturbances mainly occur as uncontrolled process parameter deviations influencing the efficiency of material removal. Typical process parameters having major influence on the efficiency and quality of an AWJ milling operation include traverse rate, water pressure, abrasive mass flow, abrasive grain size, standoff distance, attack angle, nozzle diameter ratio, mixing tube length.

Figure 2 – Milling with Abrasive Waterjet

The traverse rate is an important parameter in controlling depth of cut as it directly controls the jet-material energy transfer. Abrasive mass flow is a very important parameter, not only for determining the efficiency of the milling process regarding material removal rates, but also as a disturbance parameter if there are variations over time during the milling operation. The water pressure is a relatively important factor in influencing depth of cut and surface waviness. This parameter determines the jet power and also increases the energy transfer to the surface [4].

2.2 Turning with Abrasive Waterjet

Turning with waterjets (Figure 3) is similar to turning with a conventional single point tool in a lathe. The workpiece is rotated while the tool is traversed parallel to the axis of rotation and incrementally fed towards the centre of rotation. Jet forces on the workpiece are negligible. To improve the finish of the turned surface the jet traversed back and forth along the component, but without lateral feed.

Figure 4 depicts the pertinent parameters in abrasive waterjet turning. From the geometry of the process, the volume-sweep rate is

$$\dot{V}_S = \frac{\pi}{4} \cdot \left(d_{WP}^2 - d_T^2\right) \cdot v. \qquad (2.1)$$

Figure 3 – Turning with Waterjet

The volume-sweep rate is the material volume swept by the combined specimen rotation and abrasive waterjet traverse in unit time. In contrast, the true volume-removal rate is

$$\dot{V}_M = \pi \cdot h_T \cdot \left(d_{WP} - h_T\right) \cdot v. \qquad (2.2)$$

Generally, the volume-removal rate is less than the volume-sweep rate, though in a few exceptional cases (during finish turning) they are equal. The depth of cut, $\mathbf{h_T}$ is a function of several process parameters, very similar to simple cutting processes. A third major target parameter in abrasive waterjet turning is the surface quality [6].

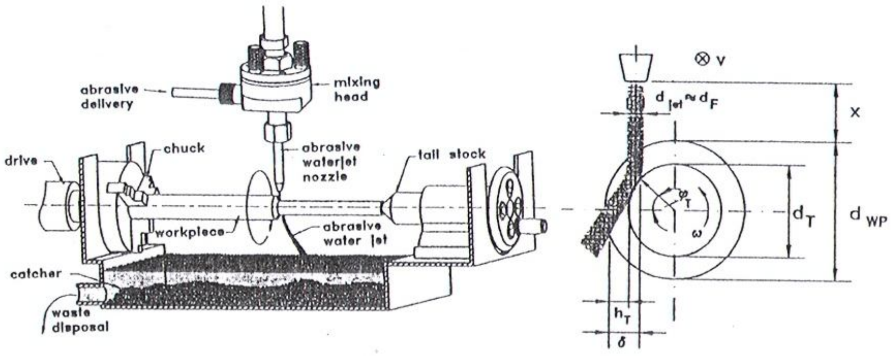

Figure 4 – Principle and geometry of the abrasive waterjet turning [5]

3. THE POSSIBLE TRENDS OF FURTHER PROGRESS IN RESEARCH WORK

The application of water jet for cutting needs further investigation in the machining procedures. As the trends for that the following tasks can be assigned: investigation of the conditions when abrasive waterjet can be applied as a cutting edge; analysis of the kinetic relations of the machining procedures; analysis of the geometrical relations of material removal and its efficiency.

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PRECISION HARD TURNING OF EXTERNAL CYLINDRICAL SURFACES BY ROTATION PROCEDURE

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ЧИСТОВЕ ТОЧІННЯ ЗАГАРТОВАНИХ ДЕТАЛЕЙ ЗОВНІШНІХ ЦИЛІНДРИЧНИХ ПОВЕРХОНЬ МЕТОДОМ ОБЕРТАННЯ

Точність обробки точінням загартованих сталей і параметри шорсткості циліндричних поверхонь дорівнюють шліфуванню або навіть перевершують його. Проте геометрична форма обробленої поверхні показує значну розбіжність. Зберігаючи надзвичайні економічні переваги точіння загартованих сталей, у новій версії був розроблений метод обертання, що усуває недоліки шорсткості поверхні, що було причиною порушення операції.

Точность обработки точением закаленных сталей и параметры шероховатости цилиндрических поверхностей равна шлифованию или даже превосходит его. Тем не менее, геометрическая форма обработанной поверхности показывает значительное расхождение. Сохраняя чрезвычайные экономические преимущества точения закаленных сталей, в новой версии была разработан метод вращения, который устраняет недостатки шероховатости поверхности, что являлось причиной нарушения операции.

The accuracy of hard turning, the roughness parameters of the turned surfaces are equal to that of grinding or even better. However, the surface topography shows significant divergence. Retaining the extraordinary economic advantages of hard turning, a new version of this procedure has been developed – the rotation turning – which eliminates the deficiencies of the surface topography that cause operation disturbances.

1. INTRODUCTION

By the term "hard turning" the precision finish machining of hardened surfaces is meant by polycrystal cubic boron nitrid (in abbreviation PCBN) tools. The extreme hardness of PCBN tools, similar to that of diamond, makes it possible to finish steel surfaces of up to 65-70 HRC hardness, with IT5-IT6 size accuracy and Rz=1÷3 μm surface smoothness. In the first 100 years of production engineering, such rather demanding quality was possible to be produced only by grinding procedure. Grinding, however, in its usual, traditional form (wide wheel, small depth of cut) is a more expensive, slower process than the new hard turning. That is why hard turning have spread at record speed for the last 2 to 3 decades and forced the traditional version of grinding back. On a world scale the piece number of components ready machined by hard turning amounts to billions [1]. The main reason for its quick spread was by all means the higher productivity, the smaller manufacturing cost, but the environment friendly character of the procedure was also significant motive power, operating dry, with no coolants or lubricants.

The accuracy of hard turning, the roughness parameters of the turned surfaces are equal to that of grinding or even better. However, the surface topography shows