ВИСОКОЕФЕКТИВНІ ТЕХНОЛОГІЧНІ ПРОЦЕСИ В ПРИЛАДОБУДУВАННІ

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IN SITU CONTROL OF ROUGHNESS OF FINISHING PROCESSING NONMETALLIC MATERIAL

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The optical monitoring system for finishing processing surfaces is described. The relation of intensity of the beam reflected from a surface, to intensity of a falling beam allows to estimate a reflexion index in situ. Increase of reflexion index in process of roughness decrease is established.

Keywords: *precision surface, in situ quality control, reflectometry, roughness.*

Introduction

The polished surface quality is one of the main parameters that characterize efficiency of diamond abrasive finishing of nonmetallic materials (glass, optical and semiconductor crystals). No improvement in efficiency of these processes is possible unless reliable methods for machined surface quality are developed and implemented, including the methods that enable in-process monitoring of surface roughness parameters, reflectometric, ellipsometric parameters and optical constants, imperfections and affected layer depth. Surface quality of the processed is the main indicator which characterise efficiency of finishing precision surfaces from optic materials. No improvement of efficiency of these processes not probably if reliable methods on quality of the processed surface which not destroying control of a roughness and reflecting ability allow are not developed and carried out. Work represents process of measurement of factor of reflexion of laser radiation by a processed surface directly in the course of processing.

Methodology and results

Installation and registration technique of the surface reflection factor of details from optic materials are developed. The principled opportunity to control a surface roughness by intensity of light reflected from demonstrated. It is shown, that the technique of a surface roughness definition by the light reflection factor in a mirror direction allows to supervise operatively a surface during its machining. It is established, that by the most relevant parameter of a roughness which can be defined by the light reflection factor, is *Rz*. Dependence of the reflection factor of the optic materials polished surface on parameter *Rz* is approximated with an error 5–10 % by the formula with the averaged parameters. For samples from concrete materials the error of definition of roughness *Rz* can make 1 %, that is less on the order than an error of the profilemetric measurements. It is shown, that the method of the surface roughness quality monitoring by factor of the light reflection in a mirror direction is most effective for surfaces, typical for finish diamond-abrasive machining.

A study of the influence of surface roughness on the angular diagrams of reflection and scattering has revealed that the reflection diagrams for structure inhomogeneity materials consist of a narrow peak, a pedestal and some peaks due to speckle clusters. The scattering indicatrices for these materials depend on the surface roughness quite differently; this is attributed to the textured surface of structure inhomogeneity materials, which makes the scattering indicatrix consist of two components: reflection (scattering) from relatively homogeneous zones of the texture formations and scattering from the boundaries of these zones. Now at processing of precision optical surfaces processes of processing with direct quality assurance are even more often used: in situ control, in-process monitoring, on-machine testing of grinding and polishing of nonmetallics and metallics materials [1 – 3].

The roughness of the machined surfaces was defined using profilograph-profilometer type SJ201 Mitutoyo (Japan). The control of the machined surfaces by reflectometric method was carried out using the installation scheme which scheme is shown in fig. 1. The laser monitoring system, the device for periodic giving of the technological environment in a zone of contact of the tool and a processed detail and a technique of adjustment of the machine tool for finishing processing of precision optical surfaces are described.

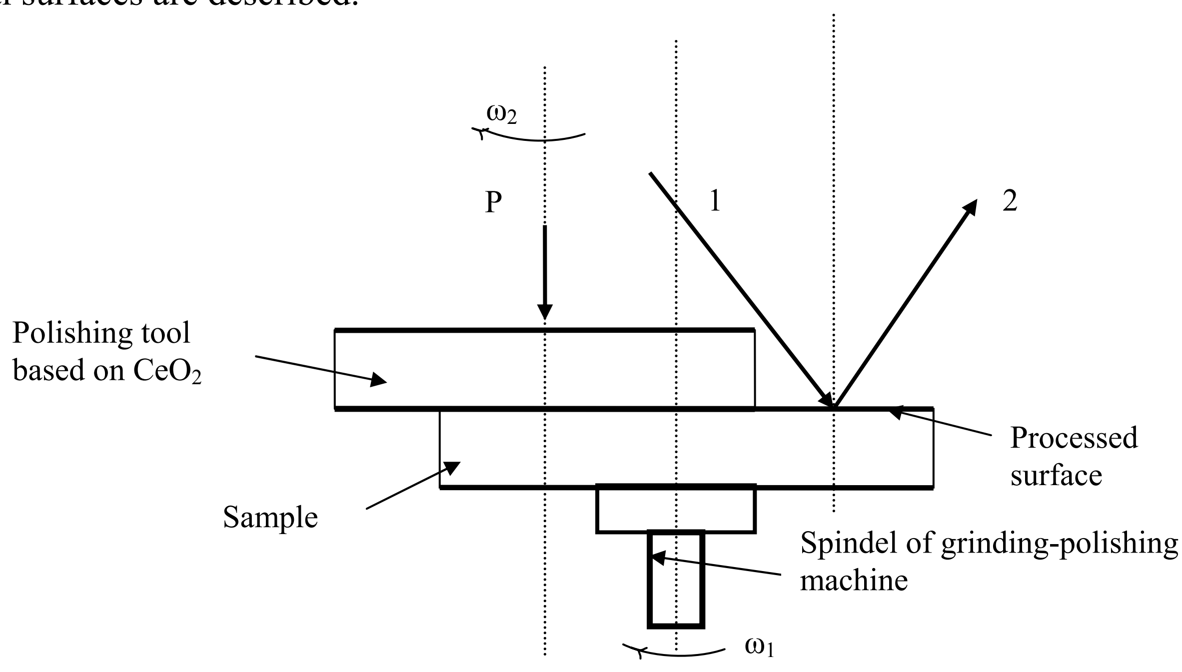

Fig. 1. Basic scheme of installation for in situ control the reflection factor

The laser beam on length of a wave of 650 nm in the form of impulses with frequency 1 kHz, modulated by a signal in the form of a meander, was divided into two beams. The first beam was registered by a photodetector, and the second went on a processed surface (beams 1). After reflexion from a surface the beam 2 by means of system of mirrors and optical filters was focused on a photodetector window. Photocurrents of photo diodes after amplification on ADC are recorded on a personal computer [4].

The relation of intensity of the beam reflected from a surface, to intensity of a falling beam allows to estimate a reflexion index in situ. Surfaces of samples from glass type K8 prepared on operations of finishing processing – three transitions of grinding by tools from diamond micropowders ASM 40/28 … 10/7 and polishing by the tool from elements EP1-10x5 Aquvapol on a based CeO_2 (tabl. 1), were established in the optical grinding-polishing machine and in static conditions were estimated on reflective ability. Increase of reflexion index in process of roughness decrease is established (fig. 2).

Table 1. Parameters *Ra*, *Rz* and *R*max of a surface roughness

Parameter of surface roughness K8 optical glass (μm)	Processing operation (tool characteristic)			
	Grinding (ASM 40/28)	Grinding (ASM 20/14)	Grinding (ASM 10/7)	Polishing (CeO_2)
Ra	0.07	0.05	0.02	0.01
*R*z	0.45	0.18	0.10	0.05
*R*max	0.85	0.46	0.29	0.07

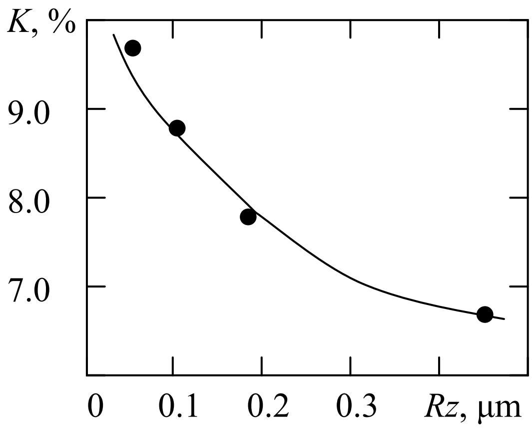

Fig. 2. Dependence of an index of reflexion on a surface roughness

As the standard the polished surface processed on classical technology on polishing tools, consisting of pellet Fujimi Kenmazai (Japan) was used. The index of reflexion of the standard was defined with the spectrometer Specord M80 (Carl Zeiss, Germany): $K = 10.2$ %.

In situ the control of a roughness of a flat surface of a detail from glass by reflectometric method was spent by a method directly in the course of polishing. An initial roughness of sample Ra = 0.02 μm. With increase in time of polishing the index of reflexion of a processed surface increases (fig. 3), that speaks about roughness reduction. This time dependence not linear, and is represented periodic function. Similar dependence at in situ ellipsometry method measurements in the course of glass polishing is received in work [1, 4]. Periodic changes of an index of reflexion speak occurrence and removal from a processed surface of a deposit from slime and wear particles. On fig. 4 the kind of a surface of a working layer of the tool after polishing of the sample from glass within 10 minutes is resulted.

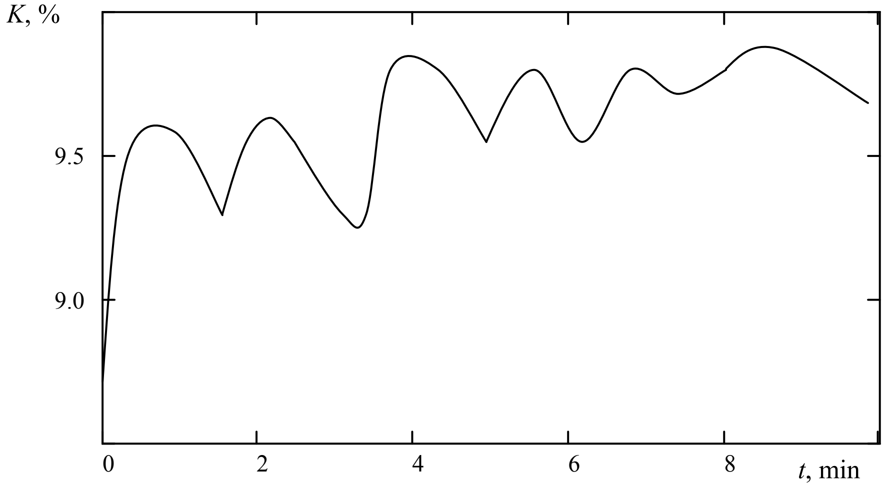

Fig. 3. Dependence of an index of reflexion on polishing time

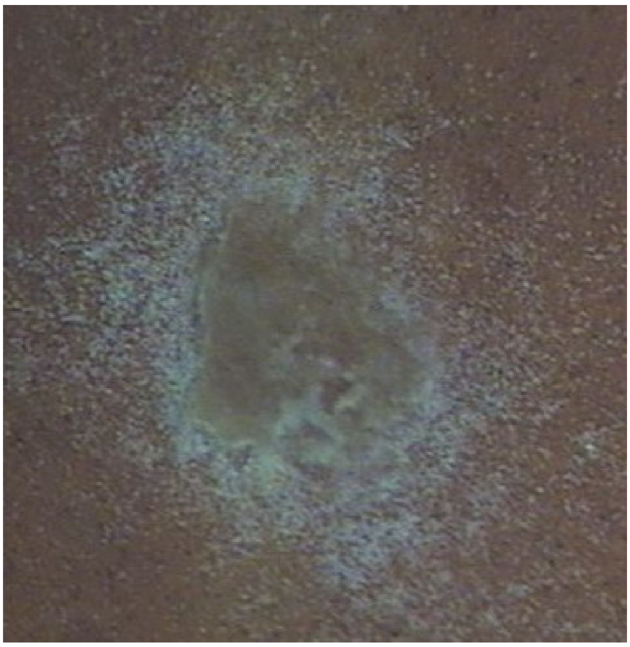

Fig. 4. Deposit from slime and wear particles on a surface of the polishing tool

Particles of slime glass and wear of the tool settle down on a surface of a working layer of a polishing element non-uniformly. They are localised in the form of a deposit in which concentration of particles increases from edge to the centre. In the particle centre are localised in the form of a continuous fragment in the sizes 200 – 250 microns round which small groups and separate particles are located. As the result of researches on index of reflexion of processed material in case of polishing and researches on condition of surface of the tool it is determined that their periodical changes are connected with process of deposit formation.

Conclusions

We have developed a system and methods for the measurement of reflection coefficients of polished surfaces. This work has demonstrated a theoretical possibility of and created prerequisites for the development of an express method for tentative assessment of polished surface roughness. A sufficient body of experimental data have been obtained and a basis has been generated to study the dependence of scattering and reflection coefficients of polished surfaces on the surface roughness.

As the result of researches on index of reflexion of processed material in case of polishing and researches on condition of surface of the tool it is determined that their periodical changes are connected with process of deposit formation. Dependencies of index of reflexion of the processed material on time of polishing are obtained experimentally and approximated by periodical functions.

Possibility of active quality assurance of precision surfaces in the course of processing is shown.

Prospects of the further researches are defined by necessity of active quality assurance of processing of precision surfaces of details of optical and optical-electronic devices, workings out of a technique of its realisation and practical application under production conditions.

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IN SITU КОНТРОЛЬ ШЕРОХОВАТОСТИ ПРИ ФИНИШНОЙ ОБРАБОТКЕ НЕМЕТАЛЛИЧЕСКИХ МАТЕРИАЛОВ

Описана схема установки для мониторинга поверхности в процессе полирования, осуществляемого при помощи оптических методов. Отношение интенсивности луча, отраженного от поверхности, к интенсивности падающего луча позволяет оценивать коэффициент отражения

света in situ. Установлено, что в процессе уменьшения шероховатости поверхности ее коэффициент отражения увеличивается.
Ключевые слова: прецизионная поверхность, *in situ* контроль качества, шероховатость.

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IN SITU КОНТРОЛЬ ШОРСТКОСТІ ПРИ ФІНІШНІЙ ОБРОБЦІ НЕМЕТАЛЕВИХ МАТЕРІАЛІВ
Описано схему обладнання для моніторингу поверхні в процесі полірування, що здійснюється за допомогою оптичних методів. Відношення інтенсивності променю, що відбивається від поверхні, до інтенсивності падаючого променю дозволяє оцінити коефіцієнт відбивання in situ. Встановлено, що в процесі зменшення шорсткості поверхні її коефіцієнт відбивання збільшується.
Ключові слова: надточна поверхня, *in situ* контроль якості, шорсткість.

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ПАНДАННА ЗОНА РІЗАЛЬНОГО ІНСТРУМЕНТА І ДЕТАЛІ (Частина 1)

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Панданна зона різального інструмента і деталі є зоною, у якій відбуваються процеси руйнування надлишкової маси та процеси торкання деталі вимірювальними інструментами. Визначення поняття панданної зони інструмента є суто авторське дослідження. Метою роботи є обґрунтування явища виникнення панданної зони типових різальних інструментів у металообробці. Оскільки інструмент виконує низку специфічних рухів у просторі, він має просторовий об'єм відповідно траєкторії руху, форма та параметри якого повинні відповідати технологічним задачам формотворення деталі. Якщо не виконуються ці умови, то верстат або не виконує свої технологічні завдання, або це призводить до аварійної ситуації. У підсумку необхідно зауважити, що наразі наведений опис панданної зони не враховує дефекти шорсткості, геометрії та ексцентриситету інструмента, оскільки неможливо передбачити ці параметри заздалегідь. Тому, у подальшому необхідно провести дослідження панданної зони елементарних технологічних об'єктів, які мають чіткий математичний опис своєї геометрії.
Ключові слова: верстат, інструмент, панданна зона.

Вступ

Зона, у якій періодично присутня маса різального інструмента і деталі, є дуже важливим параметром у процесі металообробки. Саме у цій зоні відбуваються процеси руйнації надлишкової маси та процеси торкання вимірювальними інструментами. Отже, форма панданної зони буде визначати точність отриманого виробу. Різальний інструмент, як засіб отримання деталей необхідної