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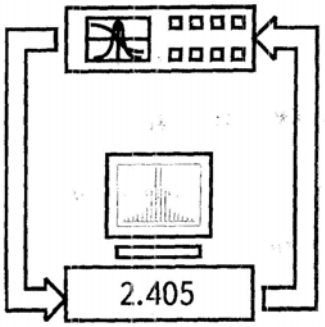
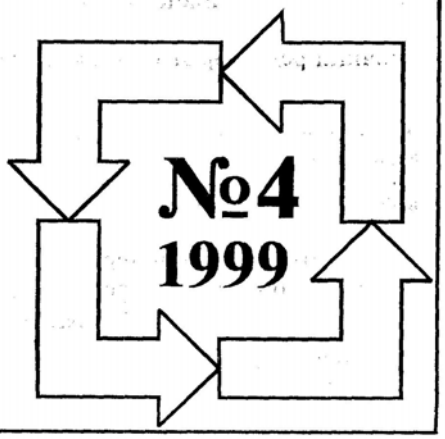
Вимірювальна та обчислювальна техніка в технологічних процесах



МІЖНАРОДНИЙ НАУКОВО-ТЕХНІЧНИЙ ЖУРНАЛ

ВИМІРЮВАЛЬНА ТА ОБЧИСЛЮВАЛЬНА ТЕХНІКА В ТЕХНОЛОГІЧНИХ ПРОЦЕСАХ



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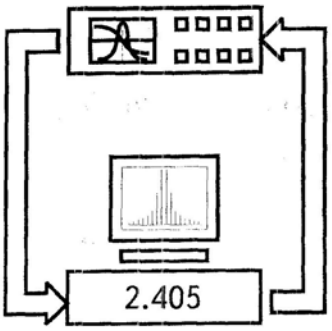
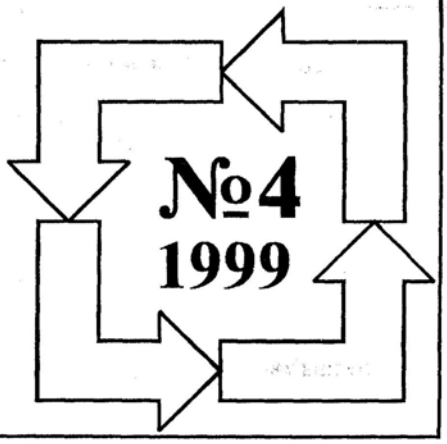


INTERNATIONAL SCIENTIFIC-TECHNICAL MAGAZINE

MEASURING AND COMPUTING DEVICES IN TECHNOLOGICAL PROCESSES



KHMELNITSKY

б) знаходження коефіцієнтів відбиття згідно формули:

$$R(N)=\frac{I^{N}_{вим.}}{I^{N}_{ПВО}}, \qquad (6)$$

де $I^{N}_{вим.}$, $I^{N}_{ПВО}$ - значення струму N-ї фотокомірки в режимі вимірювання і в режимі повного внутрішнього відбиття відповідно ;

в) проведення згладжування функції коефіцієнта відбиття в районі критичного кута;

г) знаходження критичного кута, що відповідає показнику заломлення контрольованого середовища, з використанням методу екстраполяції.

Результати обчислень критичного кута наглядно представлені на рис.2.

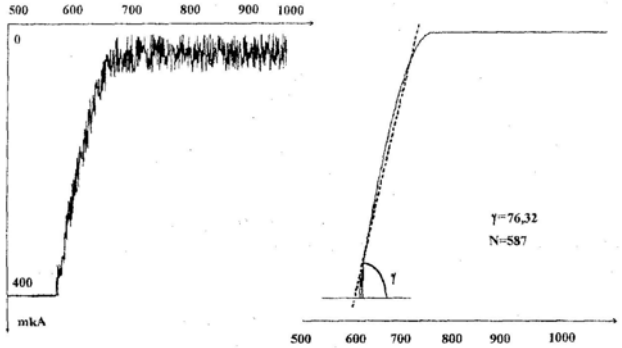


Рис. 2. Результати обчислення критичного кута:
а) вихідні дані БЕФП; б) результати виконання методики

Дослідження показали, що сумарна систематична похибка рефрактометра, обумовлена неточністю калібрування, неоднорідністю приймальної площадки фотокомірки, нестабільністю джерела випромінювання, не перевищує 0,02%. При цьому знаходження критичного кута безпосередньо не пов'язано з номером фотокомірки, а з результатами обчислень, згідно запропонованої методики, що дозволяє суттєво зменшити похибку кроку дискретизації БЕФП. Загальна похибка вимірювань показника заломлення складає 0,1%. Діапазон вимірювання безпосередньо пов'язаний з габаритними розмірами фотолінійки і становить 1.33..1.48, градуювальна характеристика рефрактометра лінійна у всьому діапазоні, чутливість знаходиться на рівні 10^{-5} відн. одиниць показника заломлення.

Рефрактометр такого типу забезпечує можливість дослідження малих об'ємів рідин, допускає зміну діапазону вимірювання, є надійним у роботі, а наявність мікропроцесорного блока з стандартним інтерфейсом забезпечує зв'язок з ПЕОМ, може використовуватися як в лабораторних, так і в промислових умовах, а також може бути виготовлений і в проточному виконанні для неперервних вимірювань.

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A LASER ACOUSTOOPTICAL SYSTEM FOR TECHNOLOGICAL PROCESSES DIAGNOSTICS OF THE PRECISION DETAILES PROCESSING

1 INTRODUCTION

The problem of the automated production process of materials quality increase is urgent at a modern condition of an industry, when there is a constant reduction of workplaces at preservation of the equipment. Danger of occurrence of infringement production processing in this case grows. The quality of technological process is determined by conformity of the current condition of the equipment, tool and detail to the given parameters in the engineering specifications, and the quality management of technological process is carried out by diagnostics the arising instabilities. For a case of machining to

the instability concern: the critical deterioration cutting tool, breakage, constraint of the tool in a body of processable preparation (for the drilling process), emergencies of the equipment, when is broken a normal course of the production processing. Discrepancy of parameters the given sizes in this case is observed. The achievement of the machining stable quality is possible only at use of systems of the analysis of the current condition of the cutting tool. The systems of threshold regulation only for quantity manufacture are most distributed. Therefore the development of such system of a condition of the production process for the automated individual manufacture is expedient.

The functions of quality surveillance of process carry out control and measuring of a sensor's subsystem, the principle of which action on definition of a condition of the cutting tool is based. One of the basic requirements to quality of such subsystems is the opportunity of their coordination with system of the CNC-machine tool for creation of the automated monitoring systems for the production process.

2 A DIAGNOSTICS METHOD OF THE CUTTING TOOL EMERGENCIES

Most sensitive to the instability of the process of machining are the physical phenomena natural image arising at cutting materials (the acoustic emission (AE), the vibration, the electromotive force (EMF) of the cutting process. The changes of the signals parameters identifying these phenomena, characterize changes occurring in a cutting zone, condition of CNC-machine tools, the edge of the cutting tool, the roughness of a work detail [1, 2].

Processing the information about cutting process of acting from the primary converters, is usually carried out through electronic systems. So, for example, definition of connection frequency of dependences of the acoustic and power (force) factors allows to supervise quality of a processable surface during deep drilling on depth of the deformed layer at production process. The analysis of spectral structure of AE - signals of the cutting process allows to supervise quality of process on the form parameter at the turning processing. The electronic monitoring systems and diagnostics of a condition of the cutting process are known which carry out the analysis of a cutting process condition the basis of the device of the Fourier transform. Realization of such systems however is hardware - technical is rather difficult.

For measurement of precision quality parameters of usually use the noncontact methods of definition of the cutting edge deterioration, roughnesses, form of a work detail surface by optoelectric devices. The action principle of such devices, for example, on the reflectometrical methods of measurements in industrial quality surveillance, on use of of a light dispersion effect flow by a controllable surface, which the angular distribution depends of a roughness parameters, is based. The devices of a such optical method of measurement allow to achieve the errors by 1 - 5 microns. One of the exactest methods of measurement is a diffractional method of measurement of the cutting tool wear. An error of measurements of the gauge no more than 1 micron. The errors up to 0,6A° provide of the laser interferometrical system. However all listed systems have restrictions only for fair processing without application of cooling liquids.

Thus, on the basis of the carried out analysis it is possible to conclude, that the known monitoring systems of a condition of the production process have restrictions, and in conditions of the automated manufacture allow to supervise of the quality process of the details processing only for quantity manufacture.

These lacks are eliminated by the new universal laser acoustooptical hybrid system of a machining process condition on the basis of the optical analysis of the Fourier spectrum of the dynamics signals in a cutting zone. The operations of the Fourier transform are carried out in a mode of real time and consequently are most applied for the automated monitoring systems of quality by production process, in particular, for group management of CNC-machine tools.

For mathematical modeling of the developed system in work the dependences of hardware function of the processor on entrance signals of the dynamics cutting process, parameters of the optical system are analysed. The dependences are considered which define physical transformations of an electrical signal to optical analogue for the subsequent processing at the Raman-Nath diffraction.

The method of the resolution increase of the optoelectronic hybrid by differentiation of a Fourier -image of an input signal in work [3] is stated. The differentiation is carried out at illumination of the modulator aperture by Gaussian beams, the intensity distribution of which to the first transverse Hermite-Gaussian modes.

In work the new mathematical determining model of functioning at the approximation of stationary casual processes are received. It is caused by that on a background the slowly current technological process of cutting suffices the registration of separate realizations of an electrical non-stationary casual signal is carried out. The mathematical models are constructed in view of the statistical characteristics of the dynamics cutting signals. It allows to apply them to definition of a condition of the cutting tool during machining.

3 PRINCIPLE OF THE CIRCUIT CREATION OF THE LASER DIAGNOSTICS SYSTEM

The creation methods of the laser acoustooptical hybrid systems of a condition of the process of machining materials on CNC-machine tools are developed:

1. Registration of vibrations on the cutting tool surface by a reflectometrical method with the subsequent processing amplitude-frequency-phase distributions of the light fields in a output

plane of the optical system. These methods are used basically for turning processing.

2. Formation and analysis of a mutual power spectrum of vibration, acoustical emission and electromotive force signals of cutting process. They are used at different kinds of machining.

3. The construction of laser acoustooptical hybrid systems, which is based on the Mach-Cender modified interferometer, allows to supervise jamming of the tool during drilling, milling on the basis of definition of the mutual spectral characteristics of the cutting tool and detail dynamic subsystem vibrating signals.

4. Analysis of a mutual spectrum of superficial and volume acoustic fluctuations of the cutting tool by Mach-Cender modified interferometer.

5. Creation the multichannel acoustooptical systems of the spectral and correlation analysis of the dynamical signals for the monitoring of the group CNC-machine tools, the processing CNC-centres.

The circuit of the laser acoustooptical hybrid systems for a turning processing condition on application of the developed combined method of the resolution increase of the system by a combination of the balance modulation of an electrical signal and illumination of the input modulator by laser radiation containing maximum transverse Hermite-Gaussian modes for the reliability increase of the results is based.

The dynamic signals describing the current condition of production process, act in the optical and electronic system of processing as electrical signals from primary converters established in CNC-machine tools system on minimal distance from of a cutting zone.

The transformation of electrical signals in optical system of this laser hybrid system of a spectrum is carried out by the acoustooptical modulator (AOM) of light fields working in a mode the Raman-Nath diffractionor Bragg diffraction, which allows to the form of an output optical system a Fourier spectrum of a researched electrical signal. So, the device [5, 6] contains optical system, in which is established diffractional AOM, on which input through electronic system of registration and transformation consisting of the filters, amplifier, the researched signal acts. As changes of the amplitude-frequency-phase distributions parameters of the light fields on an optical systems output of this laser hybrid system of a spectrum will correspond to changes diffraction of an input electrical signal parameters, the application of such optical and electronic systems for the analysis of dynamic signals of the cutting process is quite expedient.

Advantages of systems in comparison with electronic systems are speed at processing signals with application of the Fourier device in the real time scale. It raises productivity of the quality surveillance process, thus reducing the cost price of the diagnostics system and quality surveillance.

In conditions of the flexible industrial systems development, of the productivity productions there is a necessity of group management of the CNC-machine tools. The decision of a task of management of group of metalcutting machine tools is difficult for carrying out with the help of multichannel electronic control systems, as the systems of the signals processing are extremely difficult in manufacture, are expensive and do not provide high efficiencies at realization of process of the spectral analysis of signals. Use of the multichannel acoustooptical devices will supply parallel processing of dynamics signals of the cutting process registration, acting through separate electronic channels, from each machine tool separately. It will allow to lift productivity of quality surveillance in conditions of deserted technology. The generalized circuit of the laser device for the control of the production processing dynamic processes (Fig. 1) contains the diffractional AOM as devices of the input and transformation electrical signals.

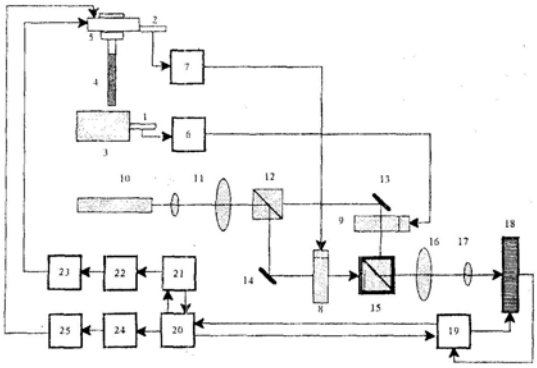

Figure 1. The block-circuit of the laser controller of the processing of materials: 1, 2 - primary sensors, 3 - processable detail, 4 - spindle, 5 - cutting tool, 6, 7 - amplifiers, 8, 9 - AOM, 10 - laser, 11 - collimator, 12 - light-divide cuba, 13, 14 - mirror, 15 - light-divide cuba with a photochromium covering, 16 - Fourier-lens, 17 - lens, 18 - matrix CCD-element, 19 - feed block of the photoreceiver, 20, 22, 24 - interfaces, 21- processors, 23, 25 - machine tool working heads

The calculation of correlation dependences of signals with application of correlation dependences of signals with application of recording optical environments (for example, the photochromium materials) allows to abstract from concrete conditions of processing connected to modes of cutting, geometry of the tool and preparation, physical and chemical parameters of the pair "tool - detail" materials, rigidity of the equipment.

The simultaneous analysis of the mutual spectrum and correlation characteristics of signals describing the current quality of processing, for example, of the AE and EMF of the cutting process, allows to increase reliability of definition of the cutting tool emergencies and, as a consequence, of a processable detail quality. Thus in a target plane of the device optical system the mutual power spectrum of signals reflecting a picture of dynamic processes in a cutting zone is formed. It will raise reliability of formation of managing teams on change in modes of cutting, entering of correction into process of the production

processing, or on stop of the CNC-machine tools in case of revealed emergency situations, To preliminary of a emergency situation, computing device of the processor connected to the working head of the CNC-machine tool. It will allow to expand functionalities of monitoring systems of the quality processing of the precision details with use of various kinds tool, processable materials, types of metalcutting machine tools.

As the redistribution of fields of a pressure in a material of preparation is entailed by the waves distributions of the elastic deformation on a cutting tool surface, the spectral characteristics of the superficial acoustic waves it is possible as to determine through the optical and electronic hybrid processors. So, the effective measurement system of a roughness of a detail surface at the acoustooptical interactions phenomenon of the laser radiation at a running acoustic pulse can be constructed.

The analysis of the spectral making signals in a range of frequencies more than 1 GHz is carried out. However the fluctuations of the laser radiation power can negatively influence at the optical system characteristics and as a whole on reliability of the control, therefore is necessary stabilization of the radiation power. Thus it is possible to combine a method of the analysis of superficial waves with the simultaneous analysis of volumetric acoustic waves. It raises productivity of the controllable processes, as the condition of the cutting tool on macro- and micro-levels is estimated, but has restrictions, characteristic for direct optical methods of measurement.

The check of serviceability of the new laser hybrid system was carried out by preliminary realization of the tests of the cutting tool durability on the turning CNC-machine tool. The durability characteristic of a casual signal of the vibrations are determined.

The histogramms of the relative density distribution of probability show increase variance of the amplitude of a signal depending on a degree of process of the tool wear are constructed. The analysis of the approximation histogramms of the density probability of amplitudes of an input signal of vibrations shows concurrence with the histogramms, constructed as a result of statistical processing of meanings of the video signal amplitudes of this laser hybrid system.

On the basis of the carried out researches the algorithms of the this laser acoustooptical system functioning are developed which allow to determine the current condition of process on an example of turning processing in view of the statistical characteristics of the dynamics signals of cutting process, that is advantage in conditions of the flexible manufacture in comparison with known methods, when diagnostics will be carried out on threshold meanings of the signals. The developed algorithms allow to determine stages of the cutting tool work conditions, stable deterioration, critical deterioration, breakage of the tool.

The research of errors of definition of a degree of the cutting tool deterioration has shown reliability of the analysis of a condition of machining by the developed analyzer. As the size of a relative error does not fall outside the limits 3 % from rating value of deterioration at 10 series of experiments the suitability of use of the laser analyzer in conditions of the automated manufacture is proved.

4 CONCLUSION

On the basis of the adduced results of the research it is possible to make the following conclusion:

1. The construction methods of the laser acoustooptical hybrid system circuits for the condition definition of the machining process condition for the flexible without the work interruption of the automated equipment are created. That allows to increase the work productivity of the technological machining equipment.

2. The methods of the resolution increase of the laser acoustooptical hybrid system for diagnostics of a condition of process of machining, which allows to increase accuracy of the analysis of the input electrical signals are developed.

3. The developed laser hybrid analyzer on a basis the acoustooptical interactions allows to carry out the multiparametrical analysis of the dynamic signals by application of the optical system of the spectral Fourier-analysis, the statistical analysis methods for definition of the cutting technological process emergencies. In comparison with the electronic systems of processing of the information by the laser acoustooptical system allows to reduce time of the processing of the spectrum and correlation characteristics of analyzed signals, raises work reliability of the module.

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