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Laboratory Model of a Contactless Device for Measuring Diameter of Objects with Circular Cross-section Objects

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Abstract: *The laboratory model of a device for non-contact control of the diameter of objects with round cross-section size is realized by a laser beam, opto-mechanical parts photoreceiver and specializes electronics. Opto-mechanical system scans the laser beam in order to obtain a laser plane. The use of a scanning laser beam and a laser plane in this method to determine the diameter of objects with round cross-sections leads to results, which are independent neither on the refraction index of the material nor on the position of the object in the scanning area. This result is obtained owing to used method to process of registered impulses.*

Accurate of the laboratory model on determines of diameter on object with round cross-section is ± 2 μm. *It is possible to determine on elliptical of cross-section of investigated object as use some laser plane, whose are located under define angle and exactly so much photoreceiver.*

Keywords: *non-contact control, laser beam, opto-mechanical system.*

Introduction

Circular reference features such as drilled holes are located in an area of a part such as a cylinder head, the surface of which is laser scanned to obtain scan data. The scan data provides height values of the part. Differences in height values are used to determine the points on scan lines, which are boundary points of the circular holes. A first algorithm is used to estimate the contour and radius of each hole. A second algorithm provides a correction factor for the radius of each hole. The circular reference features are used for registering the partrelative to a reference datum. Methods are provided that allow the accurate determination of the location of such reference features to within

0.01mm from the scan data. The method may be utilized to create modified scan data to machine the part. The method may be utilized iteratively from different views of the part to obtain data, which represents the part. Also, the method may be utilized iteratively on similar parts to detect minor differences between the parts [1].

The regularity of the section along the length of the optical fibers determines the quality of the product in the process of drawing out optical fibers [2]. The measurement of the fiber diameter must be done on-line with the process of drawing out the fibers; also this measurement must be contactless and with a sufficient preciseness [3]. In addition it is necessary that the mode of measuring must be independent on the sort of the material, i. e. on the refraction coefficient of the light. These requirements imposed the need to design a laboratory model of a device for a contactless measuring the diameter with round cross-sections. The achieved preciseness is comparable with the preciseness of devices from this class. The difference in this new device is the usage of a laser diode and the mode of processing the registered impulses.

SLB Dia. Measuring System is non-contact measuring device that is used to measure on-line outside diameter of optical fibers for quality control on production lines [4]. It features an Anritsu exclusive tuning fork receiprocating scanning system using a laser beam. This eliminates error due to the wobbing of optical fibers and improves the accuracy to measure the outside diameter of optical fibers manufactured at high speed. The device has folow specifications: measuring range: (0.1–1) mm, measuring area ϕ2mm, light sourse – laser diode λ = 670 nm and 1m.W max output power.

Description of the opto-mechanical system

A laser radiation, obtained from a laser diode is colliming by the specialeze optical system [5]. A rotating hexagonal prism scans the monochromatic and coherent radiation from a semiconductor laser diode till it is transformed in a quasi-laser plane [6] (Fig. 1).

The rotation speed of the prism is kept within the range of 800÷1000 r.p.m. by a synchronous ac motor. The ac voltage to feed the motor is provided by a quartz-stabilized generator. The generator exactly fixes a high frequency, which is reduced down to 50 Hz

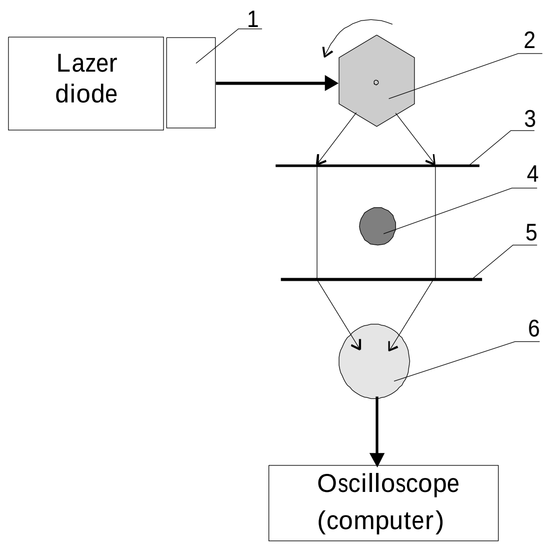

Fig. 1.
1 – collimating optical system;
2 – scanning prism; 3 – objective I;
4 – target object; 5 – objective II;
6 – photoreceiver

by a frequency divider. An analog filter transforms the rectangular impulses in sinusoid oscillations the amplitude of which is amplified by a voltage amplifier; a 220 V power amplifier (220V, 50 Hz) sets the necessary for the electric motor current. When the scanning of the radiation is over then a proper illuminated optics collimates it till the energy is evenly distributed in the zone of the measured object

The obtained quasi-laser plane strikes across the section of the investigated object. A part of the laser beam energy meets the investigated object and the other part hits the photoreceiver. The portion that has met the investigated object is partially absorbed, it is refracted and a part of it crosses the object. After the radiation has crossed the investigation zone it meets another optical system, which focuses the laser radiation on a pin-photoreceiver. As a result the photoreceiver registers an electric impulse with a definite form. The detection of the ellipticity is done by several laser planes, which are tilted under definite angles. The laser planes are focused by optical systems on the photoreceivers.

Registration and processing of the information

The semiconductor laser diode beam is scanned; after that it meets the investigated object. A part of the monochromatic coherent light, which has crossed the object, reaches the photoreceiver. The photoreceiver itself resides on a micrometric coordinate table, which allows the precise set-up in the focal plane of the second objective. The photoreceiver outputs an electric impulse, which is amplified, transformed by an ADC and it is passed to the input of a computer where it is written and processed. The

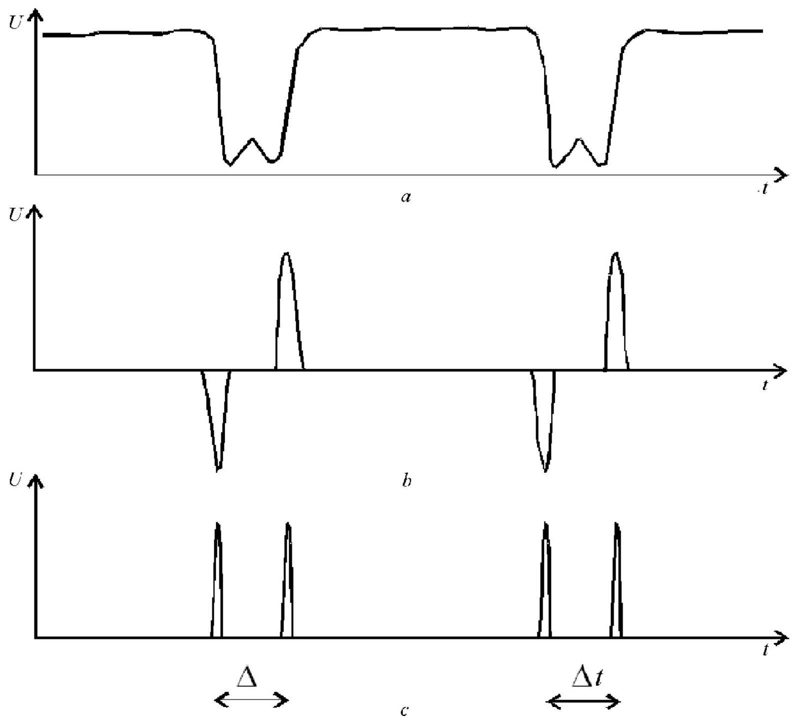

Fig. 2

receiving system guarantees an optimal speed of the photoreceiver sensitivity for the laser diode wave (λ=675nm). An oscilloscope or a computer visualizes the electric signal on the output of the photoreceiver also.

The obtained time diagrams for determining the diameter size of the investigated object are shown in Fig. 2*a*. The differentiated diagrams are transformed to Fig. 2*b* and after their inversion and digital processing by a compararator we have fig. 2*c*. The last figure (Fig. 2*c*) shows that between two registered impulses after the process of differentiation a time interval Δt is obtained. This time interval corresponds to Δt and it is directly proportional to the diameter of the investigated object *d*, i. e. $\Delta t \approx d$ and this is the idea itself of the laboratory model to measure the diameters of objects with round cross-section. The laboratory model allows determining the ellipticity of the diameter of the investigated object, too. This is achieved if we use several laser planes tilted under different angles and a number of photoreceivers, which is the same as the number of the laser planes.

Results

The elaborated laboratory model was applied to investigate the diameters of glass fibers and glass tubes. The accuracy for objects with round cross-sections was ± 2 μm. This method does not depend on the refraction coefficient of the investigated material and the dimensions do not depend on the location of the object in the scanned zone. The ellipticity of the diameter of the object was determined using three laser diodes under angles of 120^o and three photoreceivers.

Conclusions

The laboratory model of the device for a contactless control of objects with round cross-sections (glass fibers, tubes, etc.) is realized by a laser beam, an opto-mechanical section, a photoreceiver and specialized electronics to proceed with the obtained data. A proper optical system scans the laser beam; after that the beam passes through the investigated object and it hits the receiving system. The developed receiving system ensures an optimal speed as a function of the photoreceiver sensitivity. The laser diode type determines the photoreceiver type.

The opto-mechanical section scans the laser beam so as to get a laser plane. This laser plane strikes across a section of the investigated object. A part of the laser beam energy meets the investigated object and the other part hits the photoreceiver. The portion that has met the investigated object is partially absorbed, it is refracted and a part of it crosses the object. The result of all this is the registration of an electric impulse with a definite form on the photoreceiver. The diameter of the investigated object is specified by the impulse parameters, namely the plateau width and the change of the steep slopes of the fronts.

The use of a scanning laser beam and a laser plane in this method to determine the diameter of objects with round cross-sections leads to results, which are independent neither on the refraction index of the material nor on the position of the object in the scanning area. The registered total energy is sufficient in spite of the absorption and the refraction for different materials and it does not influence the results. The proper optical system focusizes the laser planes on the photoreceivers. This method does not operate with an upper boundary of the measurement scale and this is a corollary from the chosen method of registering the measurement result.

The preciseness to determine the diameter of objects with round cross-sections is ±2μm.

The laboratory model allows the determination of the object diameter ellipticity. This can be done with several laser planes, which are tilted under definite angles and a number of photoreceivers, which is the same as the number of the laser planes.

R e f e r e n c e s

1. Patent No 5,481,483 with 2 claims, issued 01/02/1996, Non-contact method of obtaining dimensional information about an object for comparing similar objects.
2. A g r a v a l, G. P. Nonlinear Fiber Opticss. New York, Academic Press, 1989.
3. F o m i c h e v a, I. A. Optical Connection. Moscow, Radio i svjaz, 1984 (in Russian).
4. Prospects of Anritsu Corporation. Tokyo, 2002.
5. B o r i s s o v a, D., M. D i m i t r o v, S t. D i n o e v. Optical system to convert the laser radiation from a TOLD 9230(F) diode. Working papers – Institute of Information Technologies – BAS, 1996, No 21B.
6. C h e s h a n k o v L., S t. D i n o e v, S t. B a c h v a r o v, D. B o r i s s o v a. Transmission stations for rotation-formed lazer surfaces. – Problems of Engineering Cybernetics and Robotics, **45**, 1996, 27-32.

Лабораторен модел на уред за безконтактно измерване диаметъра на обекти с кръгло сечение

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(Р е з ю м е)

Лабораторният модел на уреда за безконтактен контрол на диаметъра на обекти с кръгло сечение (стъклени нишки, тръби и др.), е реализиран с помощта на лазерен лъч, оптико-механична част, фотоприемник и специализирана електроника за обработване на получените данни. С помощта на оптико-механичната система се сканира лазерният лъч така, че да се получи лазерна равнина. Използвайки скениращ лазерен лъч (лазерна равнина) за определяне диаметъра на обекти с кръгло сечение, получените резултати не зависят от коефициента на пречупване на материала на изследвания обект и не зависят от положението в зоната на сканиране. При този метод практически отсъства горна граница на диапазона на измерване вследствие избрания начин за отчитане на резултата от измерването.

Точността на определяне на диаметъра е ± 2 μm. Лабораторният модел дава възможност за определяне и на елиптичността на диаметъра на изследвания обект.