

## EXPERIMENTAL COMPLEX FOR MATERIAL IMPACT STRENGTH RESEARCHES

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### Abstract

The objective has been stated to investigate the capability of materials and structures to withstand to impact loading. Computerized research complex has been developed and manufactured to carry out experiments on impact interaction of specimen with an accelerated to a certain velocity piercer. The complex includes „GANCHEN"-type thermogas ballistic gun for piercer accelerating, piercer velocimeter, ballistic pendulum for measurement of integral energy datum of piercer-specimen interaction, and „ODD" device for measurement of residual deformation of the specimen. The experiment progress control, gaging equipment sensor signal processing and obtained information data storage are accomplished at researches. The elaborated system and research techniques permit carrying out a series of comparative check tests of specimens of different metal-composite constructions.

Measurement of damages of a multilayer composite surface, the principal scheme of the thermal gas ballistic laboratory installation, basic and structural schemes of optical detector of deformations ODD-C, dependence of the optical gauge displacement, a screenshot of the developed software for the „ODD" device operation, the scheme of the contactless surface deformation damages scanning method, calculation algorithm of the scanned surface coordinates, appearance of the material samples after punching with a spherical piercer and computer representation of measurements of damaged zones, results of research of metal-plastic composites, increase of ability of samples to absorb the energy of the sphere, discrete character of deformation distribution are presented in the paper.

**Keywords:** impact loads, dynamic loads, residual deformation, composite materials, thermogas ballistic installation, deformation measurement device

### 1. Introduction

At the high level of technical equipment evolution the increasing attention is given to reliability of and construction usage safety maintenance while their development and operation. Besides more and more considerable requirements are exposed to specialized designs intended for protection. At the same time, despite of a high level of scrutiny in the statics, researches of not elastic deformation and destruction of materials, which are used in various branches, their strength and dependences of deformation characteristics on temperature and speed conditions of dynamical loads are scanty [1]. It causes actuality of this direction further researches development.

The problem of construction and material stability at impact loadings arises in many areas, starting with creation of protective designs and ending with constructing transport. Impact loading is a kind of dynamic loading, namely a pulse action at occurrence of a non-stationary strained deformed state in a volume of the loaded body that is quickly changing in time because of distribution of resilient-plastic and impact wave fronts and is transformed into a quasi-static or harmoniously changing state with the strain intensity reduction in time after the end of the transients. This question is actual one in aircraft because of the necessity of support of properties of technical and operational modern aviation equipment after collision with extraneous subjects and receptions of residual external deformations of construction members because of operation of aviation technical equipment in boundary modes or gradually accumulated residual deformations and because of transition to its on-condition maintenance. Bottom parts of fuselages, motor-

gondolas, chassis gondolas and of aerodynamic aircraft surfaces intensively interact with thrown out from under the wheels or entrapped with the air-gas streams of aviation engines while taking off and landing stones, extraneous objects, sand, dust etc. This problem is important for helicopters that are used at small heights and with unprepared take-off platforms, for high-speed on-ground vehicles, such as automobiles and locomotives, for estimation of deformations of automobile bodies after road accidents. The problem of impact strength research is especially actual one for composite materials which are widely used in designing of modern aviation technical equipment but are extremely sensitive to external damages [2].

To study the influence of the impact damage of a structural element on its load-carrying ability, it is necessary first of all to realize experiments which only are able to show the real material behaviour. Besides, an introduction of new materials put the demand of experimental confirmation of their theoretically predicted characteristics. It is necessary to note that this problem is complex and toilsome in both statics and especially in dynamics [3]. The influence of operational, repair, and technological damages on the construction work must also be considered. This equally concerns designs of isotropic and anisotropic materials.

The necessity of estimation of design properties and behaviour under action of external impact forces, which result in elastic or residual deformations depending on material structure and nature, and also the problem of comparison of deformation characteristics of different design variants at the stage of their material and the very design development cause an urgency of development of the research complex uniting opportunities of such impact interaction initiation and following definition and analyzing of reaction of material patterns to it, their characteristics.

## 2. Statement of problem

Installations for a high-speed flouncing with equipment for registration of rapid-transfer processes make the problem of a solid body impact consideration possible. For obtaining speeds up to 100 m/s installations with a falling cargo and its additional acceleration are used, speeds of 200-300 m/s are reached with pneumatic and powder installations [4, 5]. According to the body, accelerating principle the means for the high-speed flouncing can be classified into several classes. The type of the used device is chosen depending on the required speeds and the reasons of processability, adaptiveness to laboratory conditions, economic reasons.

According to the principle used for body acceleration, the high-speed tossing devices may be divided into categories:

- I. Gas-dynamic installations which accelerate piercers with a gas.
- II. Electrodynamic installations which accelerate piercers with forces emerging from current interactions or from magnetic fields action. There are contact and inductive electrodynamic installations.

According to the principle of energy supply to the work gas, there are three types of gas-dynamic installations:

- a) installations with mechanical compression with a plunger or blast wave,
- b) installations with electrical heating,
- c) installations with combustion.

The lacks of installations of different types are big dimensions; necessity of special means application that are needed from the point of view of the safety precautions, work with application of gunpowder and combustible light gases (hydrogen, oxygen) is especially dangerous; a high consumption level of the electric power for electrodynamic, cumulative etc. installations; expensiveness of the equipment [6].

We aimed for solving the task of a laboratory ballistic installation creation at avoidance of the stated lacks. The rated velocities are velocities up to 1000 m/s, taking place at impact loadings of transport equipment, and based on a principle of thermodynamic gas expansion processing at chemical reaction of burning with eduction of the energy used for piercer racing.

### 3. Development of the experimental complex for material impact strength researches

Because of necessity of construction properties and behaviour estimation under action of high-speed impact loadings and comparison of corresponding characteristics of materials and different variants of execution of constructions at the stage of their material development or engineering of the complete design, specially for carrying out of experiments on research of impact durability of monolayer materials or materials of complex composite structure and constructions of them, computerized research complex is developed and produced. It serves for carrying out experiments on impact interaction of specimen with an accelerated to a certain velocity piercer. The complex includes "GANCHEN"-type thermogas ballistic gun for piercer accelerating, piercer velocimeter, ballistic pendulum for measurement of integral energy datum of piercer-specimen interaction, and "ODD" device for measurement of residual deformation of the specimen. The experiment progress control, gauging equipment sensor signal processing and obtained information data storage are accomplished at researches. The elaborated system and research techniques permitted carrying out a series of comparative check tests of specimens of different metal-composite constructions.

Impact strength researches are strictly regulated with numerous state and international standards. Among them are European standards CEN, Germany police administration's standard DIN 52290. They were considered at development of the research equipment. The scheme of the carried out measurements of damages of multilayered composite surfaces with impact speeds of 300 and 450 m/s is shown in Fig. 1a. Examples of graphic representation of the measurement results obtained with help of the elaborated installation are shown in Fig. 1b, c.

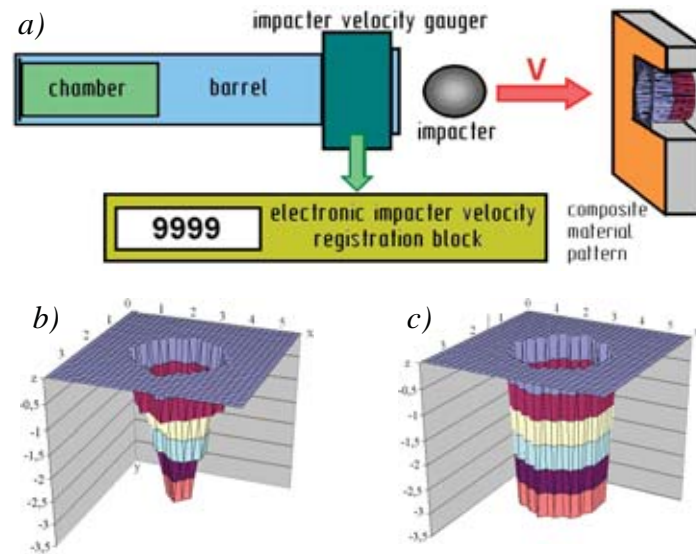


Fig. 1. Measurement of damages of a multilayer composite surface: a) the scheme of the tests; b, c) graphic results representation for speeds of 300 and 450 m/s accordingly

The used method essence is as follows. The researched samples are punched with a piercer as obstacles. Energy characteristics of the impact process are defined with the ballistic pendulum on which the investigated samples are fixed. It receives an impact pulse while punching which causes the pendulum deviation of size  $S$  from the equilibrium position that may be used for calculation of the power absorbed by the sample during its deformations and fracture [7, 8]. Such calculation is based on the energy balance equation:

$$E = \frac{m}{2} \left[ 2V_0^2 \cdot \frac{S}{S_1} - V_0^2 \left( \frac{S}{S_1} \right)^2 \right] = \frac{mV_0^2}{2} \left[ 2 \frac{S}{S_1} \left( 1 - \frac{S}{2S_1} \right) \right], \quad (1)$$

where:

$m$  - piercer weight,  
 $V_0$  - collision speed,  
 $S_1$  - pendulum position,  
 $S_1 < S$ .

Laboratory installation „GANCHEN”, which principal scheme is presented in Fig. 2, consists of a thermal gas ballistic accelerator – the flouncing device 2 for the piercer 5 racing, the piercer velocity measuring set 3, the ballistic pendulum 4 for estimation of the impact interaction energy characteristics and computer 1 for the process of experiment controlling, processing of measuring equipment sensor signals and saving of the received information.

Advantages of such the installation are compactness, simplicity of work and control remotability, modular structure that makes possible not only replacement of the deteriorated units, but also experimentation with usage of different types of igniters, membranes, barrels, power supply units of different capacity.

The principal scheme of the developed and made flouncing device is given in Fig. 3. Its main elements are established on the basis 5 working chamber 1 maintaining pressures up to 60 MPa, unit 2 of a replaceable calibrated membrane serving for providing of achievement of the necessary pressure in the working chamber 1 and for directing the gas stream at its destruction in the cavity of the barrel 3, and also the electric ignition unit 9, the compressor working gas supply unit 6, the control unit 4, the unit of hydraulic automatics 7, the installation’s work is provided with the power supply unit 8.

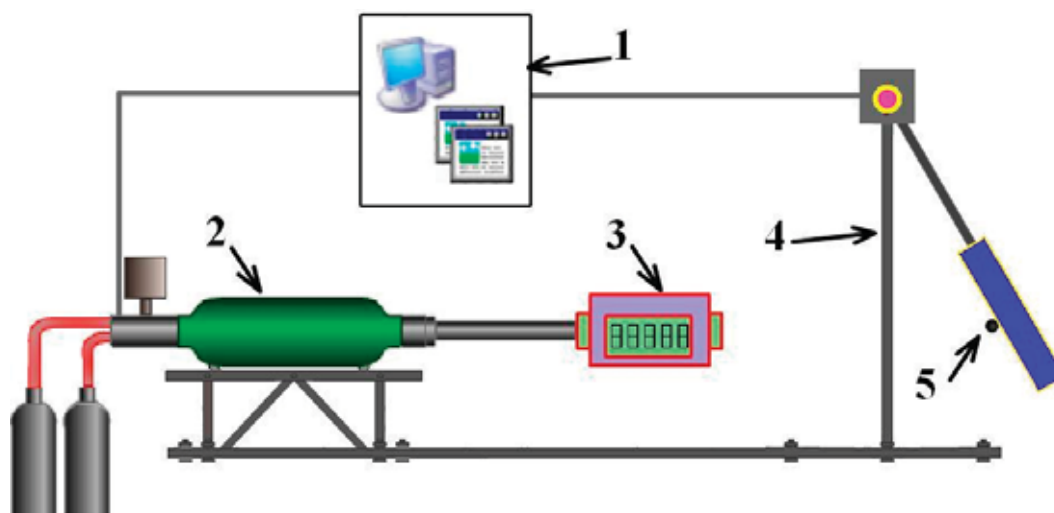


Fig. 2. The principal scheme of the thermal gas ballistic laboratory installation „GANCHEN”: 1 – computer, 2 – flouncing device, 3 – piercer velocity measuring set, 4 – ballistic pendulum, 5 – piercer

The action principle of the developed thermogasdynamic flouncing device in the structure of the research ballistic installation „GANCHEN” is as follows. At guidance of the control unit 4 and with help of the working gas supply unit 6, the chamber 1 is filled with working gas at a certain pressure. The ignition system (the unit 9) creates the electric spark discharge on a specially developed lengthened electrode located directly in the chamber 1. It initiates the chemical reaction of burning (explosion) accompanied with a temperature and pressure increase that results in destruction of the membrane and accelerating of the piercer in the barrel 3. A butane-air mixture is used as the working gas in the constructed installation. The electric ignition unit 9 provides a voltage of 25-30 kV for the spark creation. Power supply is affected from a network (220 V). The power supply unit 8 transforms the alternating current to direct current with voltage of 27 V for work of the hydraulic automatics unit 7, the electric ignition unit 9 and particularly for the control unit 4. A special working chamber internal surface form is designed for receiving a cumulative

effect and thus considerable increase of the installation effectiveness. Several safety levels are incorporated in the working gas supply system design, which are duplication of the gas access overlapping cranes, the fulfilled gas release system for the case of unforeseen pressure increase and others. The unit 7 provides control remotability and consequently safety of work with the installation.

The designed speed received with the help of the described flouncing device at the barrel length of 0.5 m is 541 m/s, at the barrel length of 1 m is 724 m/s. Accordingly kinetic energy of a steel piercer of 10 mm diameter constitutes 4.8 kJ and 8.6 kJ.

A feature of the ballistic pendulum of an original design for a complex integrated estimation of interaction of the piercer with samples of a researched material is use of self-centering bearings in the suspension bracket and of a fast-response electronic optical relocation gauge. These enterprises minimize friction losses and raise measurement responsivity and precision essentially. The obtained for the first time results give possibility to estimate the destruction processes of each layer of the researched multilayered composite construction with integral parameters and, that is the main, to separate destructions of every layer. Elaborated computer support programs for installation operation enable calculation of the pendulum deviation speed and acceleration dependences on time with a high precision. The gauge, which is used in the device, is able to define pendulum deviations of 0.01 mm, its polling with the computer program soft is executed with frequency of 1 ms, accuracy of the deviation speed measurement is 1 m/s of the deviation acceleration – 147 m/s<sup>2</sup>. Precision may be increased with usage of gauges having matrixes of greater dimension or with polling frequency increase.

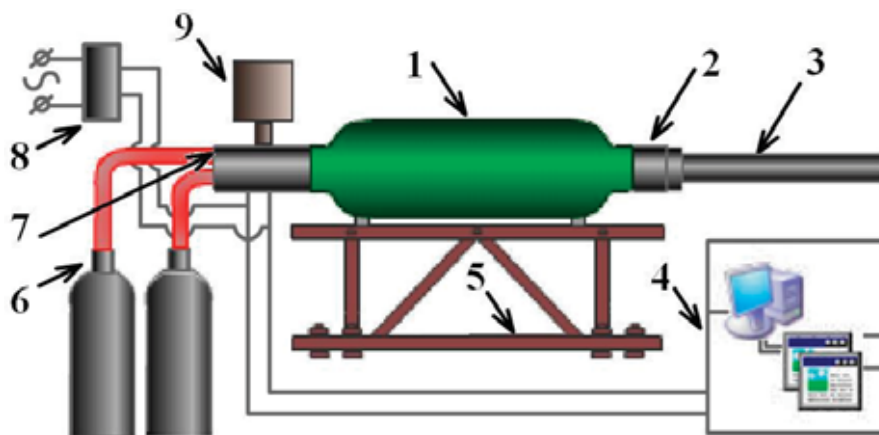


Fig. 3. The principal scheme of the flouncing device of the thermal gas ballistic laboratory installation „GANCHEN”:  
 1 – working chamber, 2 – replaceable calibrated membrane unit, 3 – barrel, 4 – control unit, 5 – basis,  
 6 – working gas supply unit, 7 – hydraulic automatics unit, 8 – power supply unit, 9 – electric ignition unit

The experiment may be carried out according to two procedures. In the first case, the piercer has a fixed velocity and the level of the remainder deformation or destruction after the impact is determined for each material of the researched ones. While using the second technique a number of velocities in order of their augmentation with a certain step is given to the piercer in the consecutive series of experiments, the critical velocity causing a previously defined degree of the material destruction is fixed.

In both cases, the piercer velocity is measured with a device communicated with the computer and transmitting the data on its values for usage in the further calculations. Usually at the velocity definition (for small distances the piercer movement may be considered as approximately rectilinear and parallel to the installation axis) the principle of fixing of moments of the beginning and the end of a certain way passage by the piercer is used. This distance is the base of the measuring instrument [6]. Distinction of different types of measuring instruments consists in the way of registration of the moments of passage of these two points. As a rule, such the registration



is based on connection or disconnection of contacts of electric or photoelectric circuits. For providing a reliable operation of the measuring instrument a scheme with disconnection because of a physical destruction of wire contacts and an original timer device are applied in its design. The measuring instrument provides precision of 0.09% at piercer velocity of 541 m/s and 0.12% at piercer velocity of 724 m/s if the base of the measuring instrument is 0.15 m.

Carried out tests of the thermal gas ballistic installation of the type „GANCHEN” proved principal functionality of the proposed construction with use of the chemical gas intermixture combustion energy for giving acceleration to the piercer and with utilization of original constructions of multielement combustion chamber unit, removable barrel of the thread type with a diaphragm element, electronic ignition unit with a specially designed igniter with elongated electrodes.

For an operative complex qualitative and quantitative estimation of macro and micromechanical damages of material surfaces with calculation of both the damage geometry and complex integrated parameters of deformation destruction a special device was created and patented [9]. Analysis of existing methods of residual deformation estimation of the material shows expediency of development of contact and contactless methods of surface deformation definition for different investigation conditions.

For realization of the contact method a special device – the optical detector of deformations ODD-C (Optical Deformation Detector – Contact) was developed and manufactured [10], which realizes scanning of the deformed and not deformed surface regions with a sensitive probe while for its displacement calculation an optical movement-defining system is used in the developed device.

The contactless method is realized with a modification of the optical detector of deformations ODD-L (Optical Deformation Detector – Laser) in which the principle of the measured surface scanning with a laser beam is used with the following surface points coordinates definition by the analysis of the corresponding image received with a photosensitive matrix or at the analysis of curvatures of a grid image projected with laser onto the researched construction surface.

Basic and structural schemes of the optical detector of deformations ODD-C are shown in Fig. 4. Probe movement defining precision reaches 0.01 mm.

The device design is defined with the selected scanning trajectory. Several trajectories were analyzed including circular-trajectory scanning, screw-trajectory scanning, etc. Line-by-line scanning technique was selected. It permits to considerably simplify kinematics of the scanning element movement, reduces probability of operator's crude errors due to incorrect setting of the step between lines, and permits to automate linear longitudinal and transversal movement using special guide frame, which is included in device kit. The required step value is set in the accomplishing software.

Carried out tests show that from the point of view of the received scanning precision, the simplicity of device design, and operational convenience the selected row-wise linear scanning technique is preferable as compared to spherical or rectangular scanning. In selected approach, the surface profile data are obtained in cylindrical coordinate system and then converted to conventional Cartesian one. Thus longitudinal probe movement along the scanning guide is concerned as the X coordinate and the surface material deformation is calculated through probe rotation round the scanning guide (Y coordinate). The scanning line shift is performed via the guide movement in the direction perpendicular to guide axis (Z coordinate).

Moving together with the probe along the scanning guide, optical scanning system unit transfers the data about its longitudinal and rotational movement to the data acquisition and processing system. Thus in the realized device, the X and Y coordinates are entered automatically, while the Z coordinate is entered manually.

The device consists of a guide which initial position sets the accepted coordinate system, and mobile element, which structurally unites the probe providing its longitudinal and rotary

displacement relative to guide, and optical probe movement definition system. The core of the optical probe movement definition system is image-analyzing processor with built-in light signal receiver. The surface under the gauge is lighted with a light-emitting diode, which is regulated by the control unit. The LED highlights a surface site through a system of its light focusing lenses. The light reflected from the surface is focused by objective on a photosensitive matrix.

The image analyzing processor compares consecutive images, which are square matrixes of pixels of different brightness, and calculates on their distinctions the probe movements along the guide and around it transferring the corresponding information to DAS.

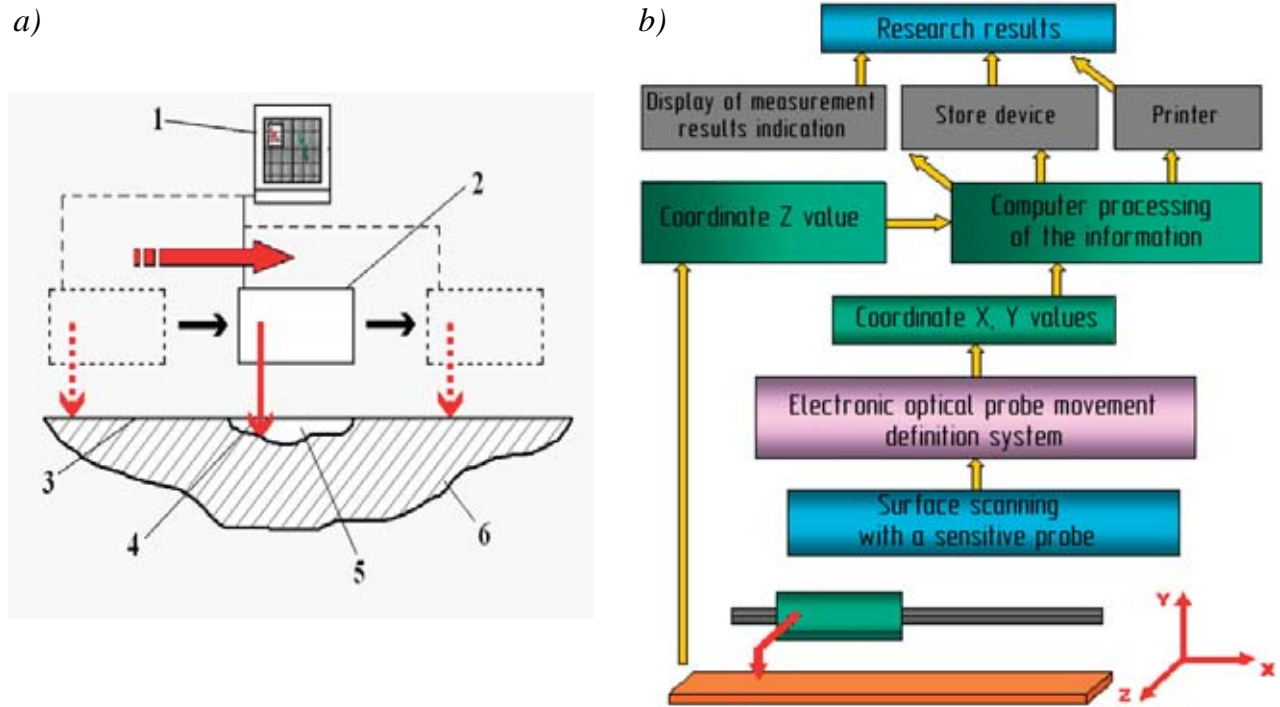


Fig. 4. Basic (a) and structural (b) schemes of optical detector of deformations ODD-C: 1 – computer, 2 – optical probe movement defining system, 3 – undistorted surface region, 4 – scanning probe, 5 – distorted surface zone, 6 – region of a constructive element with damages

The probe relocations along the design surface and thus its coordinates are calculated from the values of the probe displacements relatively the scanning guide as shown in Fig. 5. X coordinates of optical gauge position and of the scanned surface point are the same. Coordinate Z0 of the scanning guide axis is directly set by the operator. The MM' arch value, which represents the Y coordinate and is transferred by the optical movement gauge processor to the DAS, gives the angle  $\varphi$  of the gauge rotation round the O axis:

$$\varphi = MM' / OM, \quad (2)$$

where:

OM = r - the guide radius.

Considering that the system of the optical gauge and the probe is rigid, the angle  $\angle MOM'$  of the gauge rotation round the O guide axis is equal to the angle  $\angle AOA'$  of the probe tip (touching the scanned surface in the point A) rotation along the arch AmA'. At known radius of its rotation OA = R the basis of the isosceles triangle  $\Delta AOA'$  with the basis angle  $\varphi$  is expressed as:

$$AA' = 2 \cdot R \cdot \sin(\varphi/2). \quad (3)$$

The valid scanned surface point coordinates are calculated as projections of the AA' disalignment on Y and Z-axes. Special software (Fig. 6a) is developed for the device usage with the operational system Microsoft Windows for operative indication of the scanning process on the display and the data of probe movement logging with the purpose of their further processing. The probe trajectory deviation from rectilinear one may be observed in different scales. Coordinates X and Y are displayed on the display in digital and graphic forms. Their values enable calculation of the deformed material surface area, the deformation dents volume and building of their three-dimensional image, the definition of areas of maximal and minimal deformations, whence it is possible to build conclusions about the material characteristics and to analyze possible ways of its structure optimization.

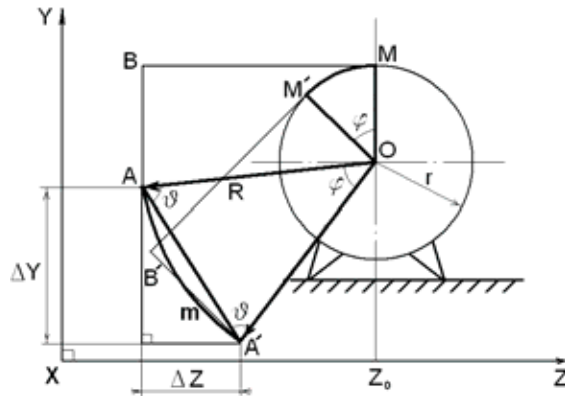


Fig. 5. Dependence of the optical gauge displacement from the scanned surface point coordinates

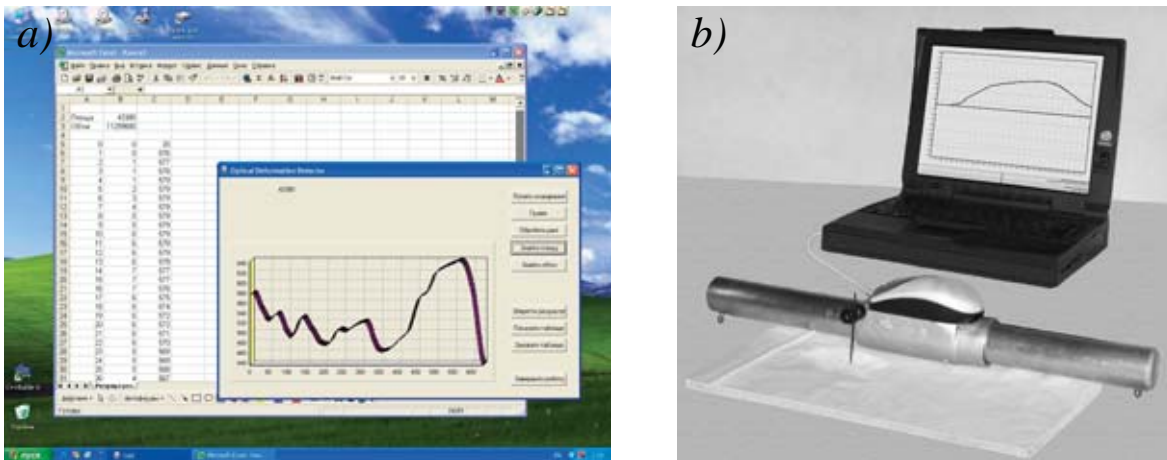


Fig. 6. A screenshot of the developed software for the „ODD” device operation (a) and a variant of the device implementation (b)

The optimum distance between the optical system of focusing the LED light lenses and the guide surface for the used gauge types should be in the range from 2 up to 2.5 mm, which is provided by the device design. For these gauges, the maximal speed of the probe movement relative to the guide is 1 m/s that are comfortable for the operator. Acceptable scanning acceleration for avoiding of truncation errors is 150 m/s<sup>2</sup>. The device connection with computer (Fig. 6b) is wireless for serviceability rise.

The functioning of the ODD-L device for contactless deformation damage scanning principle consists in scanning of the measured surface with a laser beam with the following definition of its point coordinates analyzing the images received from a photosensitive matrix. The scheme of its work is shown in Fig. 7.

The developed device includes optical system, which consists of a positioning unit of the laser radiator 8, which projects the laser beam 7 onto the scanned surface 3 with deformation damages 6



through a translucent mirror 2, and the photosensitive matrix 9, which receives the data about the beam 5 reflected from the translucent mirror 2 and the beam 4 reflected from the scanned surface 3 and transfers it to computer 1 for processing and analysis.

Calculation algorithm of the scanned surface coordinates is illustrated in Fig. 8a. The plane of the translucent mirror is concerned an Oxy plane of Cartesian coordinate system Oxyz. Beam AK is positioned on the scanned surface laser beam, which reflects from the translucent glass in point B and from the scanned surface in point K.

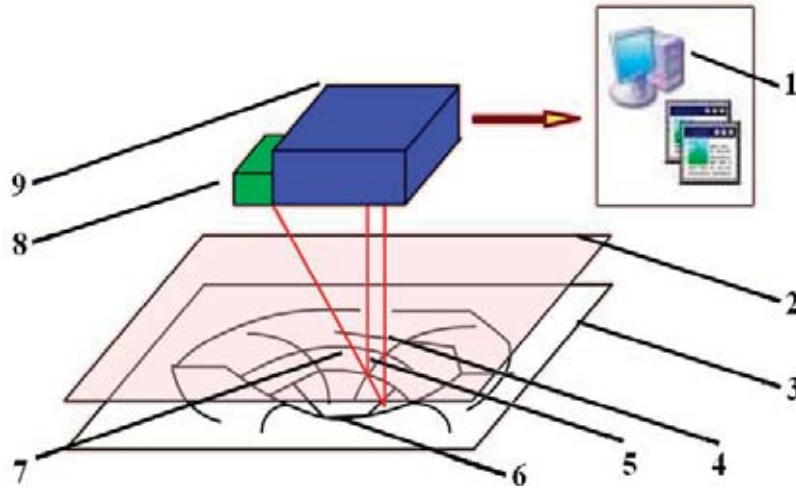


Fig. 7. The scheme of the contactless surface deformation damages scanning method

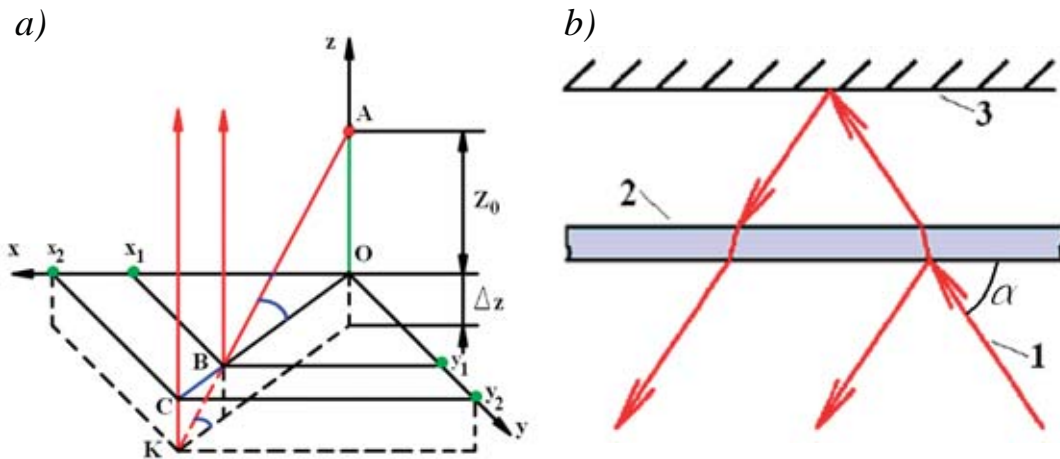


Fig. 8. Calculation algorithm of the scanned surface coordinates at application of the contactless device for design deformation damages definition (a) and the scheme of the laser beam passage through the translucent glass (b)

At known values of the distance between the laser radiator and the translucent glass AO and coordinates of reflection points B and K, namely  $(x_1; y_1)$  and  $(x_2; y_2)$ , determined by the system of analysis of the images of the photosensitive matrix, the software calculates the distance CK of the scanned surface point from the zero plane Oxy, i.e. its third coordinate  $z_2$  at known coordinates  $(x_2; y_2)$ :

$$z_2 = CK = \left[ \sin \left( \arctg \left( \frac{y_2}{x_2} \right) \right) \right]^{-1} \cdot (x_2 - x_1) \cdot \operatorname{tg} \angle ABO = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \cdot \operatorname{tg} \angle ABO. \quad (4)$$

The usage of the described method requires taking into account the erroneous image approximation because of the light beam 1 refraction while passage through the translucent glass 2 and before reflection from the scanned surfaces 3 (Fig. 8b).

The calculation of  $z_2$  coordinate accounting for the correction for refraction in the translucent glass is given in the expression:

$$z = \left( \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} + h \cdot (\text{ctg}\alpha - \text{ctg}\beta) \right) \cdot \text{tg}\angle\alpha, \quad (5)$$

where:

- $h$  - the translucent glass thickness,
- $\alpha = \angle ABO$  - the angle of the falling laser beam,
- $\beta$  - the angle of the falling refracted laser beam.

Precision of definition of the surface coordinates depends on the created laser beam quality, the matrix sensitivity, computer algorithm of the data processing, etc. In the realized device the received precision is  $1280 \times 1024 \times 1024$  points. However, a feature of the device is that scanning may be executed not only in the visible light, but also in infrared one, that enables using of more stable infrared laser radiators and corresponding measurement quality increase.

#### 4. Measurements of deformations of structural components

The developed installation and research techniques allowed to carry out a series of tests of structured PCV film samples on expediency of their usage as damping layers of multilayered metal-composite designs for vehicle surface protection. The 7-layer composite material consists of crimped carbon fabric of sateen texture with epoxy cohesiver and filled with styrene foam in the crimps. A metal sphere was expelled from the barrel with high-pressure heated gases in the carried out tests. The spherical piercer speed selection was made by batching of the working medium amount in the flouncing device chamber. Test of samples were carried out according to standards for CEN protection class SG1. Appearance of the material samples after punching with a sphere is shown in Fig. 9. Measurements of the surface deformation damages of the composite material samples were carried out using developed device „ODD” for complex macro and micro mechanical surface damages estimation with calculation of both the damage geometry, such as the hit area, volumetric characteristics of the damages, and complex integral parameters of the design deformation fracture. The received results allowed constructing computer models of zones damaged with the spherical piercer (Fig. 9). It is perspective in the directions of protection of surfaces of such vehicles as planes, helicopters, automobiles, trains, boats and yachts, in the directions of light armouring and engineering of protection systems.

Executed examinations of multilayered metal- and cement-plastic composite materials allowed considering them in accordance to the energetic destruction theory [8]. The experiment results give the directions of association searching of the relative initial kinetic energy of the impacting objects that dissipates in the area of elastic deforming because of the imperfect pressure and that transforms into potential energy of the new relative position of the structure material units at their link corruption in the area of plastic deforming on their velocities, impact wave spreading velocity in their materials and also their inner structure.

Processing of the measurement results allowed making a conclusion concerning prospects of structured polyvinylchloride films use as damping layers of multilayered metal-composite designs for vehicle surface protection. Fig. 10a shows the increase of constructive element surface ability to absorb the energy of the spherical piercer depending on the number of the structured polyvinylchloride film layers. As could be seen, two film layers, superimposed onto the metal-plastic composite basis, increase the carrier property of the impact zone in one and a half time.

The further increase of the number of layers does not result in essential increase of the material carrier property due to physical processes of deformation destruction propagation in the damaged zone. The speeds of deformation propagation in the impact zone in the researched range of speeds

of spherical piercers correspond to the full realization and an optimum interrelation of the impact zone carrier property increase due to the increase of the construction material volume, which perceives these loadings.

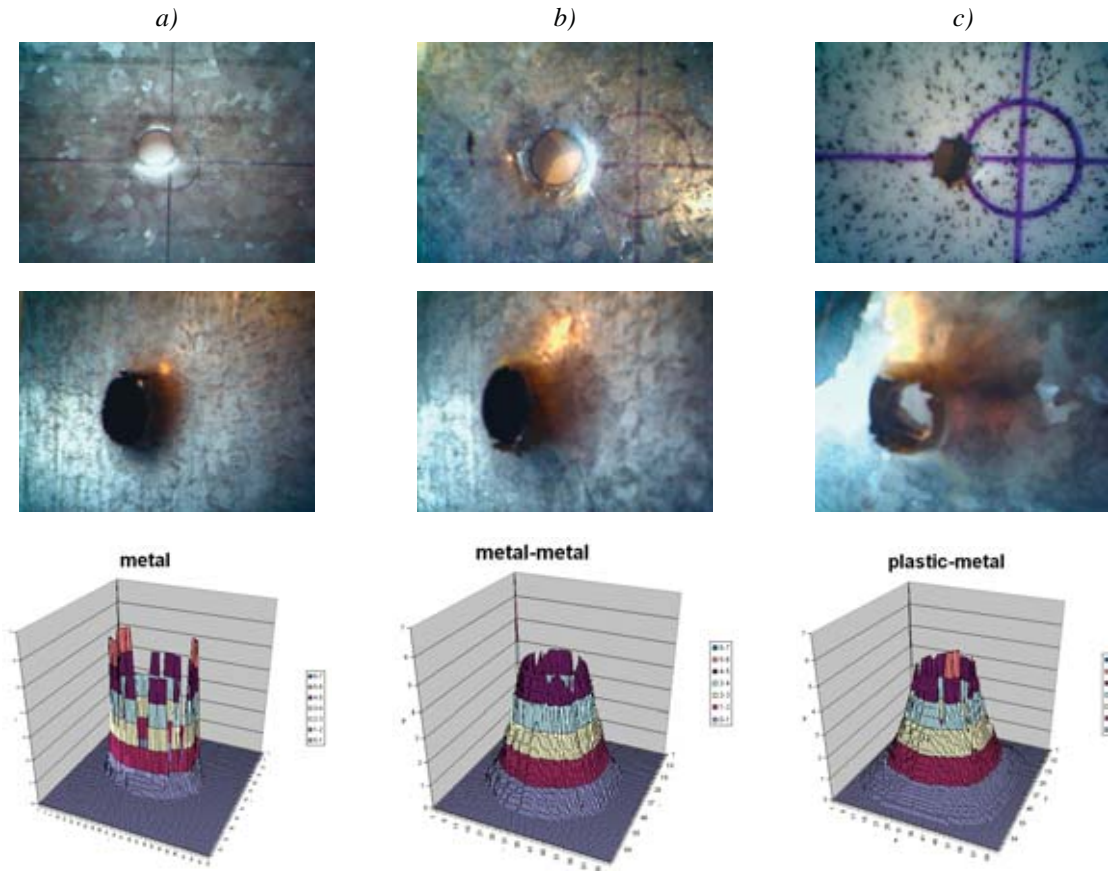


Fig. 9. Appearance of the material samples after punching with a spherical piercer and computer representation of measurements of damaged zones: a) reference metal plate, b) metal-composite sample, c) metal-plastic composite sample

Apparently from Fig. 10, b computer processing of the deformed surface zone in the very hit area and of nearby deformation zones allowed to show the discrete character of deformation distribution in local zones, which confirms the discrete character of destruction at ultra speed loadings according to the energetic approach.

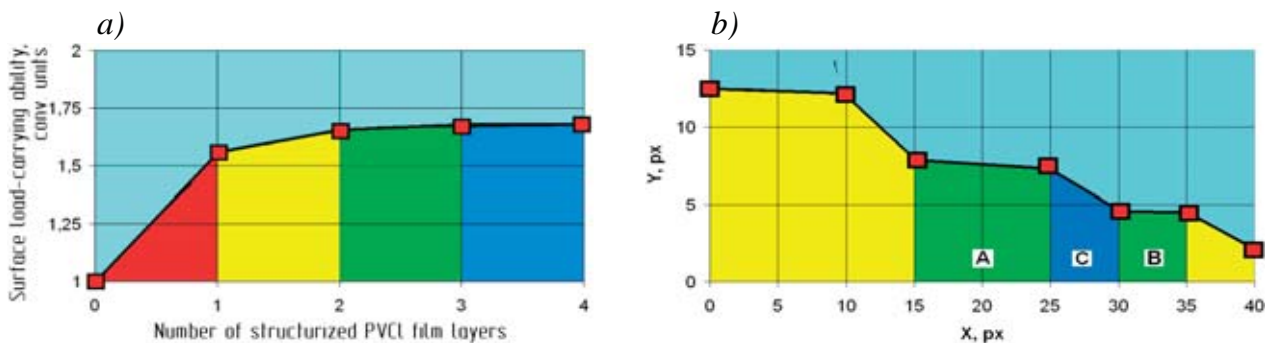


Fig. 10. Results of research of metal-plastic composites: a) increase of ability of samples to absorb the energy of the sphere, b) discrete character of deformation distribution

According to our assumptions, the zones marked as A and B correspond to an increase of the design ability to resist the residual deformations origination during punching of the first and the second film layers with a sphere. The C zone corresponds to the spherical piercer passage of the

layer between the films when loading is fully transferred to the design material that causes occurrence of residual deformations.

Obtained results gave an opportunity to state the next aims and directions of the material destruction researches at micro and molecular level using high nanotechnologies.

## 5. Conclusions

For properties of constructions and behaviour estimation under the action of high-speed impact loadings and comparison of corresponding characteristics of materials and different constructions' execution variants at the stage of their material development or engineering of the complete design, specially for carrying out of experiments on research of shock durability of monolayer materials or materials of complex composite structure and constructions of them, laboratory research ballistic installation "GANCHEN" is developed and produced.

The developed installation enabled carrying out a series of researches of materials and designs on their stability at impact damages. Thus, confirmations of discrete surface destruction and deformation nature at ultraspeed loadings were received that opens directions of investigation of new composite materials with increased impact-proof properties and creation of new-type composite materials for light metal-plastic armour protection.

A new variant of the developed installation with improved diaphragm element unit and more functional pendulum set is being manufactured. It has modular easy sectional construction for heightening of operational characteristics of the elaborated research installation.

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