Recent Activity in NDT in Belarus

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Abstract
The National Academy of Sciences of Belarus (NASB) coordinates basic and applied researches in the field of NDT in Belarus. Starting from 2011 State Program of Scientific Research "Technical Diagnostics" (2011-2015) accumulates research projects in this area. Most branches of national economy are interested in the realization of this Program. Various aspects of recent NDT activity in Belarus are briefly considered in the paper. The Institute of Applied Physics of NASB is the parent organization of the program "Technical Diagnostics". Some basic results of last applied researches in the field of various NDT methods in Belarus are presented in the paper.

Keywords: NDT researches, Belarus

Introduction
The government of Republic of Belarus pays specific attention for the development of researches in the field of non-destructive testing (NDT) and technical diagnostics (TD). Basic and applied researches are carried out in the field of NDT & TD in Belarus mainly in the frame of State Program of Scientific Researches "Technical Diagnostics" (2011-2015). The Institute of Applied Physics (IAPh) of National Academy of Sciences of Belarus, where the majority of known NDT methods are developed, is so called parent organization of this State Program. Many branches of the national economy are interested in the realization of the program.

The structure of these programs and main national research centers in the field of NDT & TD are briefly described in the paper. General characteristics of leading educational and certification centers, coordinating societies and structures are described as well. Practical technical diagnostic works in Belarus are carrying out by quality control departments of enterprises, and also by NDT laboratories (at present there are about 150 such laboratories in the country). The important organizational and coordinating role in the practical work in the field of NDT & TD plays The Belarusian Association on Nondestructive Testing and Technical Diagnostics being one of the member-founders of the European Federation for Non-Destructive Testing coordinates organizational activity and promotes an improvement in the quality, competitive ability, reliability and safety of production produced and exploited in Belarus.

An education of specialists in the field of NDT & TD in Belarus is carried out by 3 universities: Belarusian National Technical University in Minsk, Belarusian-Russian University in Mogilev and Belarusian State University of Transport in Gomel. There are two certification bodies of NDT personnel in Belarus, which work according to the widely used NDT methods (UT, PT, ET, RT, LT, MT, VT).

Recognized leading organizations in the field of NDT & TD in Belarus is the Institute of Applied Physics therefore the paper briefly describes recent results of applied researches obtained in this Institute.

Basic results obtained in the Institute of Applied Physics
New results of basic and applied researches were obtained in the IAPh in the field of mainly magnetic, ultrasonic, penetrant, microwave and X-rays methods.
The main priority of the republic industry development is mechanical engineering. Therefore for example nondestructive testing of basic machines parts including components of cylinder blocks of the diesel engines is very important activity direction. On the base of established regularities of subsurface ultrasonic wave propagation through multilayer mediums the equipment for ultrasonic flaw detection of wide types of the diesel engine pistons at different stages of the technological piston manufacturing was developed [1]. This ultrasonic equipment is successfully used at several engine plants in Russia and Belarus.

Investigation of the reversal magnetization of structurally inhomogeneous steel or iron products having defects of continuity results the development of effective method and the eddy current setup with complex superimposed transducers, which are used in automated systems for 100 % control of metallurgical defects on outer and inner surfaces of cylinder liners of diesel engines at the Minsk Engine Plant [2]. In this case increasing the reliability of control achieved by reducing the influence of interfering factors (structural inhomogeneities of the material, decarbonized layer, substantially rough test surface). Further improvement of the equipment comes in the direction of increasing the reliability and selectivity of detection of defects by the detuning from the influence of structural inhomogeneities, the detection of differently oriented defects and the development of equipment for non-contact control.

Substantial growth of high-duty cast iron application in mechanical engineering takes place in the world. Obviously the problem of reliable nondestructive cast grading with a presorting from a structure of gray cast iron is very important. Taking it into account the ultrasonic devices based on the analysis of the characteristics of distribution of ultrasonic waves depending on the cast structure defined by the form of graphite inclusions (spherical, lamellar and others) have been developed in the IAPH [3]. These devices are applied at some metallurgical and machine-building enterprises in Belarus. An improvement of the devices is now realizing to increase reliability enhancement and with the aim of control zone localization and possibility of ultrasonic evaluation at unilateral access.

Due to the actuality in Belarus of non-destructive testing and size measurement problems for complex geometry and bulky parts (castings, forgings, etc.) the IAPH is active in information technologies, namely in tomographic image reconstruction, based on the solution of indirect inverse problems, which appear under limited angle of observation, limited source energy and number of projections. Development of the theory for adaptive image reconstruction and new methods of images reconstruction from incomplete and noisy data in X-ray tomography are successfully carried out at the IAPH [4].

Developed in the IAPH the impulse magnetic method and the equipment for its realization are used at the iron-and-steel companies in CIS and Germany and are used for testing structure and mechanical characteristics of rolled steel, which speed in the production workflow is less than 5 m/s [5]. Evolution of the method includes increasing list of testing steels and control units (forging, procurements of metal-cutting tool etc) and increasing testing reliability by broadening quantity of informative parameters.

Practically important problem of ultrasonic measurement of hardened layer thickness of steel objects has been solved recently in the Institute [6]. Ultrasonic equipment for nondestructive control of hardened layers made by currents of high frequency, carburization and etc includes special ultrasonic probes with dot contact. This equipment is successfully applied at many industrial plants in Belarus.

Some new interesting and perspective results are obtained in the field of penetrant testing. The technology and equipment for carrying out an electrochemical machining of welds and other objects with a high surface roughness in field conditions are developed. The technology is intended for preparation of parts for dye and fluorescent penetrant testing after preliminary abrasive machining of surfaces. Using the electrochemical machining by means of the developed devices provides complete removal of background fluorescence in developer layer,
considerably increases detectability of defects that allows carrying out high-quality fluorescent penetrant testing of objects with a high surface roughness. Special means for product family sensitivity control are worked out the last years in the Institute. Computerized system with corresponding software and original test panels enable reliable quantitative evaluation of penetrant sensitivity level [7, 8].

Much attention is focused in the IAPh on technical diagnostics problems of electrical machines (such as power transformers, generators, electromotor etc). The research of a nature of electromagnetic processes in electrical machines was carried out, the influence of the insulation defects on transitions processes in windings was studied, and the regularities of heterogeneous reversal magnetization of electrical steels and of electric machines cores were established. The following devices for diagnostics of electric machines and equipments are worked out in the IAPh and successfully used at many industrial enterprises in Belarus: the devices for noncontact measuring higher-voltage equipment leakage, for diagnostics of power transformers under operating conditions and repair, for diagnostics of dc machines, for adjustment and diagnostics of compensation installations of reactive power in power lines and other electrical power equipment, for a control of shorts in windings, for measuring magnetic properties such as magnetic loss and magnetic induction in electric steel [9, 10].

One of the most perspective branches for nondestructive testing application nowadays represents the building branch where high investment activity is predicted. In this field the Institute carried out a series of new researches.

Based on the established relationship between the parameters of contact interaction of rigid indenter with building materials (concrete, asphalt concrete, brick, etc.) and their strength characteristics the technique of contact-dynamic testing of strength of materials is worked out in the IAPh. The technique is based on the relationship between dynamic hardness and strength. Contact-dynamic devices for measuring the strength of concrete and asphalt concrete were developed [11]. For the first time the dynamic indentation method is proposed as a new direction for studying and testing of fracture toughness of composite and polymer materials [12]. A device for contact-dynamic testing of mechanical properties of steel constructions was developed, which, unlike the well-known, provides a control of hardness and tensile strength with the detuning from the influence of surface roughness and stiffness of constructions, thus extending the applicability range of the device under control of non-rigid (thin-walled) metal constructions.

Novel microwave methods of reconstructive analysis of structure of inhomogeneous dielectric media are being developed. Advanced subsurface radar instrument for detection of voids, faults, inclusions in concrete walls, floors and house footings and visualization of their internal structure, as well as detection of faults in road clothes and detection of versatile objects in the ground has been developed. New effective techniques of enhancing radar resolution for the layer-by-layer visualization of structures in civil engineering have been proposed and verified. A microwave moisture meter for concrete and other building materials and aggregates is being developed.

The wide-range magnetic thickness gauges for testing of protective coatings (nickel, chrome, paint, varnish, and polymeric (including fireproof)) on steel are worked out at the Institute [13].

The last years more and more consideration is given to the development of the systems for diagnostics and structure health monitoring (SHM) of potentially hazardous industrial, civil, power and other objects. The IAPh conducts basic and applied researches including mathematical principles and algorithms, software, sensors, communication devices, signal processing of multi-sensor information for condition SHM systems development of civil engineering and unique buildings and constructions. They are realized in several SHM systems in Belarus as well as in some objects of OAO “Gazprom” (Russia). Several technical
techniques are developed to predict residual lifetime of potentially hazardous industrial objects and technical equipment at petrochemical enterprises. The research is continuing in the direction of technical policy development for diagnosis techniques, SHM systems and prognosis of residual life algorithms.

The devices for contact-dynamic control of physical and mechanical properties of special materials, such as PTFE and carbon plastics have been worked out as well.

The physical model and algorithms for calculation of multi-elements sources of permanent magnetic fields based on hard and soft magnetic materials are developed, that made possible working out of the two-ring magnetic system for clearing pigs of long-distance pipelines of big diameter (1400 mm) [14]. An efficiency of pipelines clearing of ferromagnetic technological dust of this system exceeds in 5-6 times the known and used earlier analogues. Some applied researches are conducted for the aerospace industry as well. Special magnetic thickness gauges for testing protective coatings of rocket engines (thick (up to 1000 microns) nickel coatings, coatings made from weak-magnetic metal ceramics, two-layer (nickel under chrome) coatings), and the measures of coating thickness were worked out in the IAPh.

More detail information about the institute is available at web site http://iaph.bas-net.by.

Directions of basic and applied activity of other research NDT centers in Belarus

Basic and applied researches in the field of NDT are conducted in some other Institutes of National Academy of Sciences of Belarus and at several Belarusian universities

Various new methods of vibration monitoring of mechanical drives are working out in the United Institute of Machine Building, Belarusian State University and Belarusian State University of Informatics and Electronics. Basic and applied researches in the field of laser control of chemical composition of materials are conducting in the Institute of Physics, thermal NDT methods – in the Institute of Heat- and Mass Transfer. New perspective results are obtained in the field of magnetic-tape and visual methods in Belarusian-Russian University.

Some problems in the field of X-ray microscopy and microwave methods are solved in the Research Institute of Applied Physical Problems. Basic and applied researches are carrying out in Belarusian National Technical University to develop new optical and electro-potential methods, methods and means for the estimation of residual resource of industrial objects. In Vitebsk State Technological University has been developed new capacitive method for nondestructive determination of structure and properties of polymeric materials.

References