17th World Conference on Nondestructive Testing, 25-28 Oct 2008, Shanghai, China

Stress Testing is a New NDT Type in the Russian Standard GOST R 52330-2005 and International Standard ISO-9712.

Anatoly DUBOV, Sergey KOLOKOLNIKOV

Energodiagnostika Co. Ltd.

Office 12, Yubileiny prospect 8, Reutov, Moscow region 143965, Russia

Tel:+7-495-723-83-22 Fax: +7-498-661-61-35

E-mail: mail@energodiagnostika.ru Web:http://www.energodiagnostika.com

Abstract

The modern diagnostics of structural materials state, having a large number of various physical methods and means at its disposal, already does not limit itself to the tasks of defect detection, but is more widely used to determine mechanical characteristics of metals applying methods of residual and internal operating stresses measurement.

The topic of "Strain Testing" is nowadays relevant both for quality inspection of machine-building products and in operation at equipment life assessment.

All leading world diagnostic centers are now occupied with the problem of mechanical stress measurement in operated structures for the purpose of their state assessment.

Such active development of this direction of non-destructive testing and engineering diagnostics was taken into account in the latest edition (2005) of the International Standard ISO 9712 "Non-Destructive Testing. Qualification and Certification of Personnel", which introduced the new type of inspection – "Strain Testing" along with conventional methods.

GOST R 52330-2005 "Non-destructive testing. Stress-strained state tests on industrial objects and transport. General requirements" was put into effect in 2005 in Russia.

This standard specifies general requirements to application of methods and means of industrial and transport objects' stress-strained state (SSS) non-destructive testing at life assessment of machine-building products, equipment and structures.

Keywords: non-destructive testing, metal magnetic memory, residual life assessment, stress concentration, stress-strained state.

1. Introduction

Modern diagnostics of equipment and structures state, possessing a large arsenal of various physical methods and means, already does not limit itself to flaw detection problems. It is more and more widely used at solution of problems of materials' actual mechanical characteristics determination.

In connection with this circumstance methods of engineering diagnostics combining fracture mechanics, physical metallurgy and non-destructive testing occupy the foreground. Such methods incorporate, first of all, methods of stress-strained state (SSS) control.

The topic of "Strain Testing" is nowadays relevant both for quality inspection of machine-building products and in operation at equipment life assessment.

All leading world diagnostic centers are now occupied with the problem of mechanical stress measurement in operated structures for the purpose of their state assessment.

At present, in addition to the well-known methods (Determination of Residual Stresses by the Hole-Drilling, Strain-Gage Method, etc.), works are carried out on standardization of new technologies of stress measurement, for example: X-ray Diffraction (prEN 15305 Non-destructive Testing - Test Method for Residual Stress analysis by X-ray Diffraction) and neutron diffraction (CEN ISO/TS 21432:2005/prAC Non-destructive testing - Standards test method for determining residual stresses by neutron diffraction (ISO 21432:2005)) methods.

Three parts of the new ISO Standard on the Metal Magnetic Memory method are published (ISO 24497-1:2007 (E) Non-Destructive testing – Metal magnetic memory – Part 1: Vocabulary, ISO 24497-2:2007 (E) Non-Destructive testing – Metal magnetic memory – Part 2: General Requirements, ISO 24497-3:2007 (E) Non-Destructive testing – Metal magnetic memory – Part 3: Inspection of welded joints). This unique method, along with defects detection, allows assessing the Inspection Object's SSS.

Such active development of this direction of non-destructive testing and engineering diagnostics was taken into account in the latest edition (2005) of the International Standard ISO 9712 "Non-Destructive Testing. Qualification and Certification of Personnel", which introduced the new type of inspection – "Strain Testing" along with conventional methods.

In Russia in 2005 the Russian Society for Non-Destructive Testing and Technical Diagnostics (RSNDTD) approved the "System of voluntary personnel certification in the file of non-destructive testing and diagnostics" where "Strain testing" is included in the list of NDT methods.

2. Problems of metrology and personnel training at inspection of equipment's stress-strained state

Till date effectiveness of various stress control methods and means remains low at their application directly on equipment.

The analysis of capabilities of the known methods of stresses and strains inspection in the base metal and welded joints of equipment and structures allow naming their essential drawbacks:

- unsuitability for inspection of long pipelines and large products, equipment and vessels;
- impossibility to use most of methods in the plastic strain area;
- variation of metal structure is not considered;
- impossibility of deep metal layers assessment for most inspection methods;
- the need to make graduated diagrams based on tests of preliminarily prepared specimens, which, as a rule, do not reflect the actual energy state of equipment;
- the need for inspection surface and Inspection Objects preparation (dressing, active magnetization, sensors adhesion, etc.);
- complexity of testing sensors location determination relative to the direction of the action of maximum stresses and strains determining the structure reliability.

Thus, the above-listed drawbacks of well-known SSS inspection methods are determined by these methods' physics and are regular.

The lack of metrological basis for materials' SSS characteristics measurement means certification and calibration (till date there are no unified standards and specimens in Russian and other countries) leads to ambiguity of requirements and wrong methodical approach towards the developed inspection means.

Besides, at present not a single country of the world has programs and centers for specialists training in equipment's and structures' SSS non-destructive testing. There are no standards specifying general requirements to methods and means of stresses and strains NDT in structures.

The lack of understanding of the physical essence of this or that non-destructive testing (NDT) physical method, used for experimental determination of stress-strained state (SSS) parameters and materials' characteristics, leads to wrong interpretation of measurement results and to common mistake in objects' residual life determination.

Unfortunately, currently the theoretical basis is insufficiently developed as well for objective comparison of SSS inspection methods effectiveness and determination of boundary conditions and scope of their application. A uniform theoretical basis developed based on modern scientific achievements in the field of fracture mechanics, material engineering, solid-state physics may become a basis for resolution of contradictions occurring nowadays at practical implementation of various methods and means of materials' SSS inspection.

Based on many years' experimental and theoretical investigations, we made an attempt to develop such a uniform theoretical basis for comparison [4].

GOST R 52330-2005 "Non-destructive testing. Stress-strained state tests on industrial objects and transport. General requirements" was put into effect in 2005 in Russia.

This standard specifies general requirements to application of methods and means of industrial and transport objects' stress-strained state (SSS) non-destructive testing at life assessment of machine-building products, equipment and structures. The standard covers products and equipment made of steel and alloys, cast iron and other structural materials without limitation by size and thickness, including welded joints. The principal requirement of this standard to the applied methods and means of products' stress-strained state NDT consists in determination of SCZs – the sources of damages development – in them.

A SCZ – stress concentration zone – is a local zone of a product, in which large strain occurred compared to the average strain across the entire product's volume. At the micro level formation of local SCZs is determined by non-uniformity of dislocation clusters, first of all along grain boundaries.

For new machine-building products SCZs are determined by structural inhomogeneity and manufacturing technology, and in operational conditions – by the action of working loads.

SCZs may vary from fractions of micron (product's micro volume) to sizes comparable to those of the product itself (macro volume). It is practically impossible to detect such SCZs by calculation methods. Currently this is possible only with NDT means.

Energodiagnostika Co. Ltd. specialists first prepared the new National Standard on the above-indicated theme, and it has no analogues in Russia and abroad. This Standard was presented by the Russian delegation as a draft ISO International Standard at the Annual Assembly of the International Institute of Welding in Quebec (Canada) in September 2006.

With introduction of the new NDT type – "Stress Testing" in the new edition of ISO Standard 9712 it is required to solve the problem of specialists training in this direction.

A Program for specialists training in "SSS Inspection" was developed in 2006 on the initiative of the Scientific-Training Center "Quality" with involvement of specialists of Energodiagnostika Co. Ltd. and a number of other expert organizations and diagnostic companies.

Table 1 shows the list of topics included in this Program. At present this Program, upon agreement with Rostechnadzor (Russian Technical Supervision Body) and SIU “RISCOM”, is in the process of approval at personnel training of expert organizations and diagnostic companies.

Table 1. Basic sections of the program of specialists training in the field of NDT under the topic “SSS Inspection”.

No.	Topic Name	Hours
1	Study of the “Provision about the order of technical devices, equipment and constructions safe operation period prolongation at hazardous industrial objects” (GD 03-484-02)	4
2	Problems of ageing equipment residual life assessment.	2
3	Analysis of IO state based on technical documentation (operational, repair, design). Analysis of equipment failures by units and reasons. Reliability criteria.	4
4	Study of the “Methodical guideline for residual life determination of potentially dangerous objects under control of Rostechnadzor” (GD 09-102-95). Study of branch GDs on life assessment.	6
5	Study of standards on engineering diagnostics GOST 27.004-85 and safety GOST 27.002-89.	4
6	Basics of fracture mechanics. Energy criteria.	10
7	GOST R 52330-2005. Non-destructive testing. Stress-strained state tests on industrial objects and transport. General requirements.	4
8	Methods and instruments for stress-strained state (SSS) inspection. Theory and practice.	10
9	The procedure of SSS and metal’s mechanical properties inspection methods and flaw detection methods application at life assessment.	8
10.	Drawing up of expert conclusions at equipment life assessment.	4
11.	Laboratory classes. Sitting for a practical examination in methods of SSS inspection, mechanical properties investigation and flaw detection methods.	16
12.	Examinations.	8
	TOTAL:	80

References

[1] Vlasov V.T., Dubov A.A. Analysis of reasons for materials' stress-strained state (SSS) diagnostic means low effectiveness. Stress-strained state inspection of industrial equipment and metal structures at residual life assessment // International Workshop. Contributions Digest under edition of TC-132 Coordinating Council Chairman Professor Dubov A.A., Moscow, Energodiagnostika Co. Ltd., 2005, pp. 8-22.

[2] Dubov A.A. Metrological problems of equipment stress-strained state assessment and ways of their solution based on the metal magnetic memory method. Stress-strained state inspection of industrial equipment and metal structures at residual life assessment // International Workshop. Contributions Digest under edition of TC-132 Coordinating Council Chairman Professor Dubov A.A., Moscow, Energodiagnostika Co. Ltd., 2005, pp. 23-31.

[3] IIW-Document **V-1219-02**. Dubov A.A., Demin E.A., Milyaev A.I., Steklov O.I. The Experience of Gas Pipelines Stress Strain State Control with Usage of the Metal Magnetic Memory Method as Compared to Conventional Methods and stress Control Means.

[4] Vlasov V.T., Dubov A.A. Physical theory of the "Strain-failure" process, Part I. Physical criteria of metal's limiting states. Moscow: ZAO "TISSO", 2007, 517 p.