

5.2.6. GOST R 52889–2007 «NONDESTRUCTIVE TESTING. ACOUSTIC METHOD FOR TESTING TIGHTENING FORCE OF THREADED JOINTS. GENERAL REQUIREMENTS»

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In most cases of practical importance, objective evaluation of operability and safety of technical objects containing threaded joints is impossible without available trustworthy information on mechanical forces acting in the parts of joint.

Simplest devices for control of tightening force like torque-measuring wrench are suitable by no means always due to significant errors in results and the lack of objectivity during their application in order to ensure the given tightening force of joints in units of power plants, aviation, space equipment and other branches of industry.

In this connection, method of acoustic tensometry is used increasingly for the problems of testing tightening force of threaded joint [1, 2]. This method has no analogs among other methods for testing tension amount, since testing results do not depend on the value of friction coefficients in thread – μ_r and bearing end face – μ_{ef} during tightening, as well as on the yield of joint elements, which are not considered in calculations of the tension value.

As all acoustic methods of determination of stressed state, this methods is based on the acoustic-elastic effect representing the linear dependency of the propagation velocity of elastic ultrasonic (US) waves (longitudinal, shear, surface of Rayleigh waves) on stresses in material of tested part.

Basing on multi-year researches [1] and successful application of acoustic method and equipment for testing tightening force of threaded joints during production of liquid-fuel rocket engines in the OJSC «NPO Energomash named after academician V.P. Glushko» [2], the State Standard GOST R 52889–2007 «nondestructive acoustic testing. method for testing tightening force of threaded joints. General requirements» was elaborated.

Standard sets main requirements to the procedure of determination of forces and uniaxial mechanical tensile stresses caused by them that occur in the material of bolts or studs during tightening.

Standard covers bolts and studs with diameter of not less than 8 mm and with length-to-diameter ration of not more than 7 for diameters of up to 30 mm inclusively and not more than 10 for diameters of more than 30 mm. Requirements to the quality of blanks these parts are manufactured of are specified. It is stated that diameter of bolts and studs is not limited, while metal must not contain macro-defects detectable under nondestructive testing methods. Roughness parameter Ra of the stud or bolt end face must not exceed 2.5 μm . Standard prohibits the following to be presented on the surface of bolts and studs: grooves, indents, traces in the result of hardness testing, protrusions, flowed metal in the result of thread rolling, flanging of thread first turns, dents, as well as center holes for stud and bolts with diameter of less than 90 mm. Perpendicularity tolerance for end faces of bolts and studs in respect of thread axis must not exceed 0.05 mm for diameters within 8 to 16 mm and 0.1 mm – for diameters in excess of 16 mm. Parallelity tolerance for end faces of bolts and studs must not exceed 0.05 mm for diameters within 8 to 16 mm and 0.1 mm – for diameters in excess of 16 mm.

Standard provides requirements to used measurement means, selection of probes and procedure for accounting factors influencing accuracy of determination of tightening force. For testing, ultrasonic instruments can be used with absolute instrumental error of measurement of increment of the US oscillations propagation time $\Delta\tau \leq 0.03 \mu\text{s}$. Within the complete set of these instruments, it is permitted to use electro-acoustic probes (EAP) like piezoelectric or electromagnetic-acoustic ones that ensure emission and receipt of longitudinal US waves of frequency within 2.5 to 15 MHz with discreteness of not more than 2.5 MHz. There are also requirements stated to other EAP parameters.

For metrological support of US testing instruments, manufacturing of control or reference blocks is provided. Requirements to methodological support of measurement means contain measurement methods, characteristics of hardware and software, formulas for calculation of the tested parameter value by results of acoustic measurements, as well as required normative documents.

Calibration of measurement means and identification of calibration features of tested threaded joints is provided. They shall be carried out during setting up of the technological control process for instruments of specific type and threaded pieces of particular standard sizes. Calibration is performed at tensile-testing machines corresponding with requirements of GOST 28840 using attachment for securing threaded pieces in grips of a tensile-testing machine. Such attachment must simulate the design of elements of tested joint by the depth of engagement and length of the stretched part of threaded piece. It is permitted to carry out calibration at the metrologically attested specialized bench, which make it possible to perform loading of a threaded piece and simulates its operation within the real object.

Following assembling of joint, propagation time τ_0 of US oscillations in tested piece without load is measured. Then, in accordance with normative technical documentation, tightening to the given value in "MPa" or "N" is performed, value τ_i is measured, while desired value of mechanical stresses σ (MPa) or force Q (N) is determined from expressions under two options. Since for specific case $\tau_0\tau_i$, the following is valid initially:

$$\Delta\tau = \tau_i - \tau_0. \quad (1)$$

Option 1. Calibration results:

$$\Delta\tau = K_\sigma\sigma \text{ or } \Delta\tau = K_QQ, \quad (2)$$

where: K_σ – is calibration coefficient, $\mu\text{s}\cdot\text{MPa}^{-1}$; K_Q – is calibration coefficient, μsN^{-1} .

Option 2. Results of calculation in accordance with reference data [2]:

$$\Delta\tau = azz\tau_0\sigma \text{ or } \Delta\tau = azz\tau_0(Q/S_{cp}), \quad (3)$$

where: azz – acoustic-elastic coefficient of the US waves propagation time, MPa^{-1} ; S_{cp} – is an area of the cross section of a thread piece under GOST 24379.0–80 and GOST 1759.4–87, mm^2 .

Testing results are recorded in the instruction test sheet (ITS) or test protocol, which are executed under standards of enterprise testing is performed by. Testing results are stored until the end of the article operation term.

Method specified by the standard can be used during startup, repair works, in the process of operation at nuclear, hydraulic and thermal power plants, as well as in space machine building, oil-and-gas industry and other branches.

References:

1. **Bobrenko V.M.** Elaboration and creation of methods and tools for acoustic tensometry of detachable joints of aerospace vehicles. Abstract of doctorate thesis, M. – 2004.

2. **Nondestructive** Testing: Handbook: in 8 volumes/under general editorship of V.V. Klyuev. V. 4: in 3 books. Book 1. V.A. Anisimov et al. Acoustic tensometry. – M.; Mashinostroenie, 2006.