

CURRENT PROBLEMS OF METROLOGICAL ASSURANCE IN THE FIELD OF MEASUREMENTS OF COATING THICKNESS.

Elena Bryukhovetskaya

Abstract: The article covers thickness gauges types with their metrological and technical characteristics as well as the problems of metrological assurance in the field of coating quality control in industry. General solutions for ensuring the uniformity of measurements and traceability of units of thickness are represented.

Keywords: nondestructive testing, coating thickness, reproduction and transfer of unit, metrological assurance, thickness testers, verification, calibration, thickness gauges.

In terms of present improvements in aerospace, military, nuclear industries and due to increasing requirements to coatings the necessity of complex quality control of coatings, including uniformity of measurements of geometric electromagnetic and mechanic characteristics, appears.

According to the document [1] the coating is one or more layers of a material, raised on the coated surface. There are different types of layers used to achieve characteristics required: metal, non-metal, plastic, composite, etc.

The general parameters of the layer can be described by the following characteristics represented in documents: geometrical, physical, mechanical, optical and so on.

Thickness control in industrial shops performs with the thickness testers based on different principles (magnetic, eddy-current, acoustic, roentgen, etc.). It's necessary to use thickness gauges with the same characteristics in the measuring range as the measuring item for calibration or verification of testers. There are different types of thickness gauges passed the approval procedure:

1. MTP – real thickness gauges are:
 - MP on MO – magnetic layer on the magnetic base;

- MP on NTO – magnetic layer on the non-magnetic conductive base;
- NTP on MO – non-magnetic conductive layer on the magnetic base;
- NTP on NTO – non-magnetic conductive layer on the non-magnetic conductive base;
- 2. ITP – coating thickness imitators.

Thickness gauges included into the Russian state registry up to date are given in the table 1.

There are following parameters to be measured along the thickness gauge calibration: coating thickness, coating flatness, base flatness, parallelism of the base planes, base roughness, deviation of the coating thickness, coating roughness.

The general view of the thickness gauges is given in figures 1 and 2

In D.I. Mendeleev Institute for Metrology (VNIIM) approval tests, verification and calibration of thickness gauges take place. Work standards and references traceable to the National primary standard of the unit of length – meter GET 2-2010 are used [3]. The first echelon standard of the unit of length – meter in the range 10-6–1100 mm [4] is also in use with the following metrological characteristics:

Table 1. Base materials, coatings and coating thickness

Thickness gauges	Material		Thickness range, μm
	Coating	Base	
MP on MO	Nickel	Structural steel	5-100
MP on NTO	Nickel	Brass, copper alloy	5-100
NTP on MO	Chrome, copper, zinc, cadmium, tin, copper+chrome, nickel+chrome, tin+ bismuth	Structural steel	5-200
NTP on NTO	tin+bismuth, chrome, copper, silver, aurum	Brass, copper alloy, titanium alloy, aluminum alloy	5-200
ITP	Quartz glass, polyethylene, polytetrafluoroethylene, organic glass	Magnetic, non-magnetic	10-120000

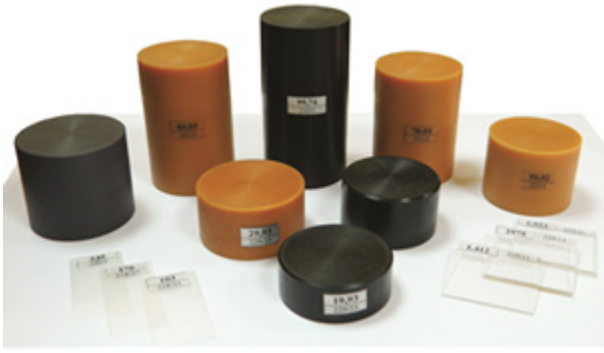


Figure 1 – Coating thickness imitators



Figure 2 – Thickness gauges

- measuring range (10–6–1100) mm;
 - resolution 0.001 μm ;
 - measurement uncertainty ... $\pm(0,05+0,5L) \mu\text{m}$,
- where L – is the length measured.

A lot of testers have no metrological assurance, for example, the ones measuring double and multi layers.

The research of ability to use non-contact methods of thickness gauges measurements based on Fizeau interferometer in the range from 0.5 μm up to 10 mm is now in progress.

Reference documents analysis [5] shows that more than twenty types of metal used as the coating. Some are used very wide (chrome, zinc, nickel) and some are not. There are more than thirty types of forged metals, over ten conversion materials (non-metal, non-organic) – oxides, phosphates, about twenty types of composite materials.

VNIIM performed approval procedures for two types of thickness gauges, more than ten types of thickness testers, some traceability schedules in the field of measuring the coating thickness are developed.

Calibration and verification experience shows that a lot of thickness gauges are produced with the technological process violation and don't meet metrological characteristics declared.

The production process can be divided into three stages: base production, coating process, fine processing of the coating to achieve required characteristics.

The base processing should provide structure stability, hardness, conductivity, magnetic parameters, roughness and flatness required. The coating should provide stability of thickness and mechanical characteristics.

Cavities, micro hardness, electrical and magnetic conductivity affect the thickness measurements

results but are not controlled during the gauge calibration [6].

It is necessary to take mechanical, geometrical, physical and some other parameters into account to provide the coating characteristics required.

There is the State traceability schedule for the coating thickness measuring instruments in the range from 1 to 20000 μm [7]. The unit of length is transferred from the set of higher precision with no traceability to GET 2-2010. It also does not cover the entire types of thickness gauges and testers. The document needs to be reviewed.

To solve the problems appeared in the units transfer along the calibration and verification it is necessary to do the following:

- to set the requirements for coatings to characterize their quality,
- to set the requirements to the characteristics to be controlled,
- to create the documents to determine the parameters of the thickness gauges production process, including the control at every step,
- to determine calibration and verification procedures,
- to perform type approval procedures,
- to create and implement metrological control of chemical and geometrical parameters of coatings.

Non-destructive coating control is the multiple problem, affecting the items quality.

References

- [1] GOST 9.008-82 «Edinaja sistema zaschity ot korrozii i starenija (ESZKS). Pokrytija metallicheskie i nemetallicheskie neorga-nicheskie. Terminy i opredelenija».
- [2] <http://www.fundmetrology.ru>.

[3] **Aleksandrov V.S., Zaharenko Ju.G., Kononova N.A., Lejbengardt G.I., Fedorin V.L., Chekirda K.V.** Gosudarstvennyj pervichnyj `etalon edinitsy dliny – metra G`ET 2-2010. *Izmeritel'naja tehnika* 6, 2012, 3-7 s.

[4] **Zaharenko Ju.G., Kononova N.A., Moskalev A.A.** Izmerenie geometricheskikh parametrov rez'bovyh kalibrov, *Izmeritel'naja tehnika* 2, 2016, 24-27 s.

[5] **Potapov A.I., Sjas'ko V.A.** Nerazrushajuschie metody i sredstva kontrolja tolschiny pokrytij i izdelij. SPb, *Gumanistka*, 2009, 904 s.

[6] **Gogolinskij K.V., Sjas'ko V.A.** Metody i sredstva kontrolja mehanicheskikh svojstv mikro- i nanometrovych pokrytij i modifitsirovannyh pri-

poverhnostnyh sloev. *V mire nerazrushajuschego kontrolja*, 3(61), 2016, s.43-48.

[7] R 50.2.006-2001 GSI. Gosudarstvennaja poverochnaja shema dlja sredstv izmerenij tolschiny pokrytij v diapazone ot 1 do 20000 μm . M. *Izdatel'stvo standartov*. 2001.

Information about the author

Elena Bryukhovetskaya,

SPbGITMO(TU), aser engineering and laser technologies (2001), D.I. Mendelejev Institute for Metrology VNIIM, researcher.

Web address: <http://www.vniim.ru>,

e-mail: e.b.bruhovetskay@vniim.ru