The Method of Manufacturing Nonmetallic Test-Blocks on Different Sensitivity Classes

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Abstract. Nowadays in our modern world there is a vital question of quality control of details made from nonmetallic materials due to their wide spreading. Nondestructive penetrant testing is effective, and in some cases it is the only possible method of accidents prevention at high-risk sites. A brief review of check sample necessary for quality evaluation of penetrant materials is considered. There was offered a way of making agents for quality of penetrant materials testing according to different liquid penetrant testing sensibility classes.

1. Introduction

Nondestructive testing and technical diagnostic are an industry around the world, an essential part of manufacturing and operation of technical appliances: thousands of specialists provide daily screening test of nonconforming components at manufacturing and timely detection of dangerous cracks on technical equipment in operation, first of all cracks which are dangerous for life, health and environment (safety).

The most effective method for nondestructive testing of large areas is capillary, especially that with complex geometry and in case of mass production. Penetrant testing is good because it allows detecting a fault at the initiatory stage of manufacturing and at all stages of product life cycle. Liquid penetrant inspection technology is comparatively simple and does not need difficult and expensive equipment.

Nowadays on Russian market there is a great diversity of penetrant materials for different application conditions, with different behavior on single-type defects and quality-price ratio.

Material quality is assessed according to flaw-detection efficiency of different types and dimensions.

Properties of penetrant, cleaner and developer are tested together with complex testing of penetrant materials at conditions close to developing conditions on real details.

Sensibility, working efficiency and quality comparison of penetrant material sets are assessed with the help of check samples with fine cracks and test-panels.
Sample diversity used in different countries is almost similar. Samples are defective details with natural cracks or plates, disks and other products with intentional cracks. Samples organized as plates with brittle metallic, galvanic or chemical cover or with the surface hardened with chemical and thermal processing – nitrogen hardening are widely used. Cracks are formed with the help of samples deformation by bending or stretching, or punch pressing in with cylindrical or spherical form of contact surface. Obtained cracks characteristics such as opening width, length and depth, which as a rule is equal to the thickness of nitration case, are measured and put down into certificate [1–7].

Unsatisfactory features of such samples are cracks in nitration case which appear in uncertain areas with indefinite distribution density on a unit of surface of check sample, their number and distance between them is not defined. Also manufacturing possibility of a sample containing defects with definite regularity of opening width and depth from imposed load is excluded. Instability of charge in a sample causes variable depth and opening width of cracks along their length. Sample bending during its charge leads to curves (as it has permanent deformation) and that in its turn leads to free change of opening width of cracks along their length. Besides, quality testing of cavity defects cleaning from polymerizing remaining residues, frequently used penetrant materials, is difficult in check samples described above; there is no possibility of physical processes visualization occurring at liquid penetrant testing technology. As capillary methods allow diagnosing products made from any materials including glass, ceramics, plastic materials, it would be necessary to have check samples free from discontinuity described above.

2. Versions of the nonmetallic test-blocks for penetrant testing

Nowadays there is information about nonmetallic check samples with given characteristics of defects [4]. Such samples are simple and cheap in manufacturing, defects are received with given characteristics, there is no corrosion of material at sample cleaning, and penetrant materials residues remained in defect cavity are easily replaced. One more circumstance allows to do sample cleaning qualitatively which in its turn prolongs their operational lifetime.

There is one more problem at penetrant materials testing connected with the necessity of using two check samples (check and reference) with cracks of similar characteristics and almost similar dimensions on each sensibility class. But now there are check samples with one crack on the market. Therefore, according to GOST 18442-80 [8] it is necessary to have minimum six check samples on three most important sensibility classes.

The way of nonmetallic check samples manufacturing offered by the authors allows to implement defects on three capillary testing sensibility classes on one sample.

The following components are necessary for manufacturing: plate with sprayed metal coating (thickness of a layer about 1 μm), silver leaf (brass leaf) and foil, thickness 7 – 20 μm. The main technological stages are as follows.

Slots of similar depth are cut perpendicular to the basement on two opposite sides of rectangular form. Slots are necessary for placement foil in them, preliminary covered with a thin coating of epoxy adhesive, as shown in [9, 10].

Flat foils are set into slots of a form and a form is filled with epoxy adhesive for the lower part of foil strings to be put into adhesive for 1 – 2 mm, and the upper parts are left without being filled with adhesive.

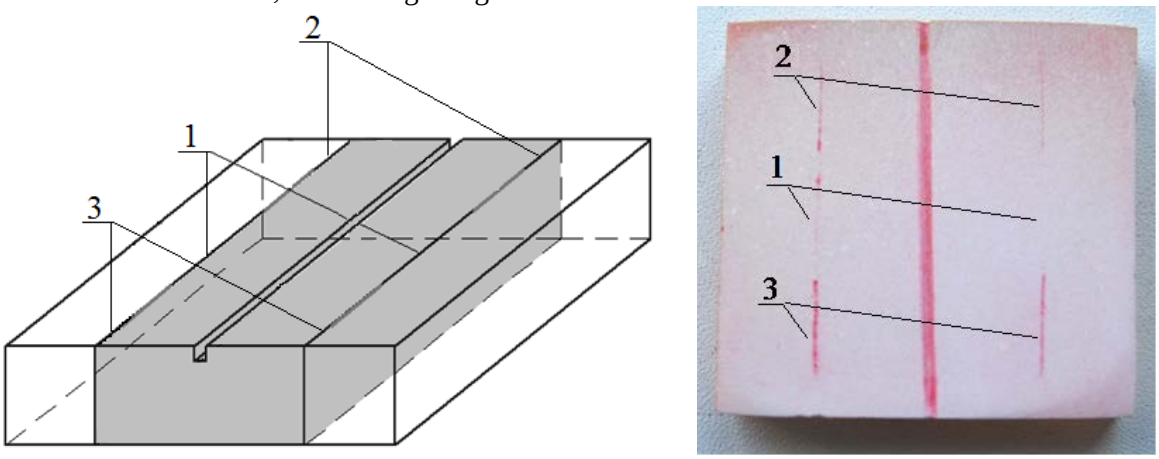
After full consolidation of epoxy adhesive an obtained block is taken out of a form. After that mechanical processing (grinding, polishing) of the surface is done. As a processed sample is almost transparent, there is a possibility of width testing of remained lower parts of foil strings, and finally the depth of a defect will be tested.

After obtaining the required characteristics (necessary roughness of surface, the width of remaining lower parts of foil strings), etching of foil with ferric chloride solution is done.

Use of back surface allows obtaining high quality working surface as more bubbles formed at epoxy adhesive manufacturing are remained on sample facial surface. Also ultrasonic bath is used to decrease a number of bubbles formed during tar being mixed with hardener.

Obtained cracks are tested for width opening.

Check sample made in accordance with the given technology allows assessing the ability of flaw detective materials to defects detection, and slotting realization in the middle of a panel – to compare the sets with one another, as showing in figure 1.



a) b)

Figure 1 Nonmetal test panel with cracks (1, 2, 3) according to I, II, III sensitivity classes: a) Schematic, b) Image of test-panel after comparing two penetrant material sets.

3. Summary

Thus, variants of sample realization for penetrant nondestructive testing from nonmetals that are under consideration allow:

- placing some defects (cracks) with given characteristics (width opening, length, depth) on one sample. For example, one crack with opening on I sensitivity class, i.e. less than 1 μm, another – with opening on II class, i.e. from 1 to 10 μm, the third – with opening on III class, i.e. from 10 to 1000 μm and so on;
- decreasing the necessary number of samples on different sensitivity classes needed for users;
- realizing and using a test – a panel as a universally applicable check sample as the defects are done with standard characteristics (on different sensitivity classes);
- increasing resource of using every sample as: in this case there is no filling of cracks cavity with oxidizing products and samples of oxygen concentration of metal; samples are done from almost transparent material (epoxy adhesive) and it is easy to follow the quality of samples washing (or its absence) after each use from residues of applied penetrant materials which could not be done with samples from metals.

References

[1] William J. M (2004) Patent US 6729175 B2
[2] ISO 3452-3:2013 (2013) Nondestructive testing Penetrant testing Part 3: Reference test blocks
[3] James R. Alburger (1975) Patent US 3791198 A
[4] Frank J. Vicki, Setsuo Shimizu (1986) Surface penetrant inspection test piece having varying thickness plating US 4610157 A
[5] William J. Martin (2001) Patent US 6311538 B1
[6] Paul Dunnwald (2011) Patent Non-destructive liquid penetrant inspection process integrity verification test panel WO 2011097146 A1
[7] ISO 3452-1:2013 (2013) Non-destructive testing Penetrant testing Part 1: General principles

[8] GOST 18442-80, Nondestructive testing, Capillary methods. General Requirements (Moscow, Publish House of Standards)
[9] Kalinichenko N P, Kalinichenko A N, Lobanova I S and Borisov S S (2013) Methods for the manufacture of nonmetallic reference specimens for liquid penetrant inspection *Russian Journal of Nondestructive testing* **49**(11) 668–672 doi 10.1134/S1061830913110041
[10] Kalinichenko N P, Kalinichenko A N, Lobanova I S, Popova A Yu and Borisov S S (2014) Manufacturing technology and an investigation of samples for testing instruments for the capillary nondestructive testing of nonmetals *Measurement Techniques* **57**(5) 484–488 doi 10.1007/s11018-014-0485-1