УДК 620.179.14

DEVELOPMENT OF TEST SPECIMENS FOR FERROMAGNETIC OBJECT FLAW DETECTION WITH A MAGNETIC FIELD VIEWING FILM

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The Department of Physical Methods of Control of the Belarusian-Russian University have developed a magnetic testing method that allows detecting defects in ferromagnetic objects by means of a magnetic field viewing film that reveals the presence of indication patterns of the defects.

So far, theoretical and experimental foundations of the quantitative assessment of parameters and the depth of defects by computer processing of images of their indicator patterns on the film have been developed, and technical facilities and methods for magnetic testing of parts and products have been elaborated.

A significant disadvantage of this method is absence of test specimens which can be used for testing: to determine the presence of flaws, to identify and find parameters and the depth of flaws in test specimens under specified conditions (magnetization mode, angle of observation, the way the film is placed with respect to the magnetizing device) for external and internal defects. This will provide high sensitivity and reliability of testing. Therefore, the development of test specimens for flaw detection in ferromagnetic objects by means of a magnetic field viewing film is an important and urgent task.

Service life of the machinery depends on the quality of manufacture, accuracy of non-destructive testing and prompt repair of defective parts. Flaws appear throughout the entire life cycle of a product. They can appear at the stage of preparation of a workpiece (casting, forging or rolling defects); at the manufacturing stage (treatment flaws, hardening defects), at the stage of operation (fatigue cracks, brittle and elastic failures). Timely detection of defects in objects significantly reduces the number of breakdowns and emergency situations.

There are a number of nondestructive testing (NDT) methods, such as optical, acoustic (ultrasonic), radiation, thermal, electrical, eddy current, magnetic, penetrant testing. These methods have some advantages and disadvantages. All NDT methods, except radiation testing, require that careful mechanical cleaning of the surfaces under test should be performed. Radiation methods have low efficiency, require an access to the backside of an object and fail to detect thin cracks and poor welding fusion. In addition, they are rather

expensive. Magnetic, eddy current and electrical methods make it possible to test the surface and the subsurface.

The method of magnetic field viewing film is used to test ferromagnetic cast, welded and non-welded objects; it allows detecting surface and subsurface defects, such as cracks, porosity, slag inclusions, poor welding fusion.

This method is simple and highly efficient; it does not require preliminary surface cleaning. The main condition required for testing is the presence of a magnetic film, which allows visualizing the magnetic field over a large area of the object. Besides, this method is not subject to influence of interfering factors and is sensitive to both the tangential and normal components of the magnetic field. The correspondence between the indication patterns of defects on the film and types of discontinuities has been established.

The magnetic film consists of a non-magnetic base with tiny gel capsules. The capsules contain elongated nickel particles. These particles reflect light in different ways. The film is usually made in light colors with particles oriented parallel to its surface, and in dark colors with particles oriented perpendicular to it. If the film is placed in a magnetic field, the nickel particles begin to align tangentially to the magnetic field lines. In this way, we can observe the indication pattern of the object under test.

To obtain high-quality records of the defect leakage field, the magnetic film must not have any mechanical defects, such as tears, perforations, delamination or traces of remanent magnetization.

The following tools are used for testing: a magnetic field viewing film, a magnetizing device, a source of current, auxiliary testing tools, test specimens to determine the magnetization mode and the sensitivity of the testing method.

This method is based on registration of indication patterns of flaws on the magnetic field viewing film placed on the surface of a magnetized object. It makes it possible to detect defects in the product and to establish the depth and dimensions of flaws by distribution of the coefficient of diffuse reflection of light from the film. As a result, it leads to increased efficiency and reliability of testing.

The distribution of the light reflection coefficient for a flat surface defect has a pronounced symmetric maximum and two minimum values on both sides. As the depth of the discontinuity increases, the maximum increment of the diffuse reflection coefficient becomes greater in the defect zone. The limits of the area of satisfactory detection of flaws in the product depend on the magnetization mode, the size of the flaw, the distance between the poles of the electromagnet and the location of the electromagnet and the film, i.e. whether the electromagnet and the film are placed on the same or on different sides of the wall of the object. The maximum value of the increment of the diffuse reflection coefficient during flaw

detection in ferromagnetic objects correlates with the depth of the defect on the outer and inner surface of the object wall and the diameter of the internal defect; the distance between its minimum values correlates with the depth of the internal defect, which allows us to determine the depth of flat defects on the outer and inner surface as well as their diameters and depths.

A test specimen is a specifically manufactured product with characteristic flaws for determining the quality of the materials under test. The defects must be of different types, have different parameters, be located at different depths, etc.

Test specimens are made for each wall thickness and steel grade and represent a part of the tested product manufactured by using the same technology as that used for the products subject to magnetic testing. Some faulty products of an enterprise can be used as test specimens.

In our research, the test specimen is a bar made of St3 steel with artificially created cylindrical defects located at different depths. When the specimen is magnetized, indication patterns of defects can be observed on the magnetic film. These patterns are recorded with a digital camera. Then the images are digitized and processed using computer-based processing techniques. Graphs of the dependence of the diffuse reflection coefficient on the film in the defect zone are created. Further, these graphs can be used to determine the depths of the defects in the objects of control.

The location and the limits of defective areas must be marked on the surface of the test specimen with paint, and the type and size of the defects must be indicated as well.

Each test specimen must be tested and accepted by a commission consisting of senior engineering and technical personnel and the head of the quality control unit.

Test specimens and photos of indication patterns of defects must be stored at the inspection office together with the certificate of acceptance of the test specimen by the commission.

The magnetic field viewing film is used for flaw detection of ferromagnetic objects, such as cast products, pipe bends, drilling equipment, screws of river and sea vessels, beams of load-bearing structures, car parts, etc.

The method of magnetic field viewing film has a number of advantages: simplicity of testing, high informativeness and efficiency, low cost, etc.

Currently, this method is used at automotive plants to check the vehicle identification numbers. The only disadvantage of the method is the lack of test specimens.