4.1.20. MAGNETIC MEASURING SYSTEM (MMS), SPECIAL FEATURES OF THE DESIGN OF ITS TRANSDUCER ANT ITS METROLOGY SUPPORT

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Magnetization curve, magnetic hysteresis loop and their parameters (initial and maximum magnetic permeabilities, residual magnetic induction, coercive force, rectangularity coefficient and others) are the main characteristics of ferromagnetic materials and articles at magnetic measuring and in non-destructive testing.

Last time serious attention is given to design of new automatic measuring means of magnetic characteristics of magnetic soft materials using the means of computation engineering. In the paper the new system for measurement of magnetic characteristics (MMC) of soft magnetic materials in quasi-static mode is described, the special features of the transducer construction, metrology support and application for non-destructive testing and magnetic measurement are done.

The system MMC ensures reading of magnetization curve and magnetic hysteresis loops of ferromagnetic materials at major and minor cycles of alternating magnetization in quasi-static mode in closed (at rings) and open circuits. On the magnetization curve and hysteresis loop the main (maximum value of magnetizing field H_m, maximum magnetic permeability μ_m, coercive force H_c, maximum B_m and residual B_r magnetic induction) and additional (differential magnetic permeability μ_{Hc} at field, equal to H_c; magnetic inductions B_{Hc} and B_{2Hc} at fields H_c and $2H_c$ accordingly) magnetic parameters. The system has convenience to determine the static value of coercive force with the aid of extrapolation of the speed of the rise of the magnetization reversal field for zero.

Maximum amplitude of the magnetization reversal field is 40 kA/m, the frequency is 0.05–0.5 Hz, the measuring region of magnetic induction is 0.015–2.5 T. The main reduced error of measurement the magnetic field strength and magnetic induction don't exceed 2%.

The construction principle of the system MMC is based on the method of continuous induction, that is characterized by well effectiveness and by possibility to select the optimum speed of alternating magnetization for every of the specimens under test. The system constructively includes transducer, magnetization unit, measuring unit, PC and printer.

The transducer of the system includes the magnetizing and the measuring coils.

The magnetizing system includes many-turns solenoid, two identical compensation windings, located above the solenoid near its end faces, connected with it in series-aiding, two additional compensation windings, arranged above the solenoid symmetrical relative its centre and connected with it and with the first two compensation windings in series-aiding or in series-inverse (dependent on the real field configuration). The decrease of the field along the axis of the solenoid near its end faces is compensated by the field of ring windings, and its inhomogeneity in the centre is compensated by the additional ring windings. At adjustment the compensation windings can move along the solenoid axis, what ensures in the working zone of the transducer ±120 mm long relative the centre the inhomogeneity less than 0.5%.

For compensation the field of solenoid at measuring the magnetic induction of the specimen under test and for comparison it with the standard the transducer has two working zones. The central part of every of them embraces the appropriate measuring coil. The measuring coils are connected between them in series-inverse and are 10 mm long.

The magnetizing unit includes the driving generator, power amplifier and the reference resistor and generates the line current of sawtooth form having maximum amplitude of 5.4 A and frequency of 0.05–0.5 Hz.

The measuring unit includes integrator, channel of measuring the strength of the alternating field, channel induction measuring, the control unit and unit of data processing.

The channel of measuring the magnetization field is made as standard one, which measures the current through the magnetizing system and conversions its value in the value of the magnetization reversal field.

The channel of measurement the magnetic induction is designed on the base of analog integrator, the control and the compensation of the error of transformation of which is executed using the PC. The special feature of the system MMC is the decrease of the measuring error because the automatic account of the shift of the channel of the magnetic induction up to and after the measurement on the specimen and the introduction of the appropriate correction in their results [1]. It allows at the frequency of magnetization reversal of 0.05 Hz to decrease the drift of the measuring channel up to 0.4%.

The PC controls the processes of magnetization reversal and of measurement through the port USB. Apart from the control it ensures the collection and store of data, the plotting the hysteresis loops and the output of the data to printer.

Metrology support of the system MMC includes its certification on the value and the frequency of the magnetization reversal field and on the value of the measured magnetic induction.

The certification of the system on the value of the magnetization reversal field consists in determination using the high precision Tesla meter of the K_H constant of the magnetizing unit, introduction of this value in the storage, in measurement of the current value I through the magnetizing unit on the value of voltage from the reference resistor and in determination the value H of the magnetization reversal field using the equation $H = K_H I$. The frequency of the magnetization reversal field is measured by the frequency meter on the voltage from the reference resistor.

The certification of the channel of magnetic induction measurement is curried out using the standard of mutual inductance, one of windings of what is connected in series with the magnetizing system of the transducer, and the second winding is connected to the input of the channel under test. As the system measures not magnetic induction, but the magnetic flow (at connecting the standard of mutual inductance it is equal to LI, where L is the value of mutual inductance of the standard), then to determination the value of magnetic induction, generating this flow in the working zone of the transducer, the received value must be divided by the cross section and the number of turns of the measuring winding, the values of which are stored in PC. Therefore the conversion of the value of the flow in the value of appropriate magnetic induction is executed automatically. The certification for the magnetic induction is executed at several frequencies and maximum values of the magnetization reversal fields within the measuring range. Express test of the system is carried out using the special specimen having the prescribed cross section with the predetermined magnetic properties.

Apart from the direct measurement of the magnetic characteristics of the specimens under test the system MMC is used for the determination of the magnetic characteristics of articles, what on one can execute the magnetic testing of their mechanical properties. Using the system MMC one can investigate the scope for multiple regression analysis and for direct use in the tasks of multiparameter non-destructive testing. Very promising is the use of the system MMC for determination of the thickness of the hardened layers of the ferromagnetic articles on the change of the configuration of the magnetic hysteresis loop.

References:

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