

1.1.35. PULSED MAGNETIC MULTIPARAMETER ANALYZER IMA-M

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Pulsed magnetic method of testing of mechanical properties of rolled products and articles from ferromagnetic steels and the devices for its realization are used in many metallurgical and machine-building plants for the sampling testing (devices type IMA) and for testing in the production flow (devices type IMPOC) [1, 2]. It consists in local magnetization of the article under test by the inhomogeneous pulsed magnetic field of solenoid or of system of solenoids with the given amplitude in one direction and in measurement of the gradient ∇H_{rn} of the normal component of the residual magnetization field after the termination of the magnetization cycle. But the devices type IMA are not able to test the articles from the medium-carbon and alloyed steels, that are undertaken to the hardening with the following tempering in the temperature region from 350 up to 600°C. This is caused by that the measured using the devices gradient ∇H_{rn} has not the unambiguous dependence on the tempering temperature of such articles.

For the quality testing of the medium-temperature and high-temperature tempering of the articles from the upgraded steels in the IAPH of Belarus was designed the pulsed magnetic multiparameter analyzer IMA-M. Its distinguish consists in [3] that the magnetization is realized by five series of pulses with the changing from one pulse to the next pulse amplitude with the permanent step. The amplitude in the first series rises with the step ΔH_p from zero up to the maximum value of H_{ps} , in the second series the amplitude decreases from H_{ps} up to zero, in the third series the field direction is reversed and the amplitude rises from zero up to given value of $H_{upi} = i\Delta H_u$ (where i is the number of steps), in the fourth series the amplitude decreases from H_{upi} up to zero, in the fifth series the direction of the field is reversed to the initial and the amplitude rises from zero up to H_{us} . The number of pulses in every series does not exceed 10, and their duration is not longer than 3,5 ms. During the magnetization process are to be measured the next values of the gradient ∇H_{rn} of the residual magnetization field strength: ∇H_{rnm} – the maximum value in the process of magnetization by the first series of pulses, ∇H_{rms} – after the termination of the first series, ∇H_{rn0} – after the termination of the second series, ∇H_{rnp} – after the termination of the third series, ∇H_{rn0i} – after the termination of the fourth series and ∇H_{rnm} – the maximum value in the process of magnetization by the fifth series.

The hardness or the tempering temperature of the articles under test determines one on the equation of the multiple correlation.

The analyzer IMA-M consists: transducer 1, including the magnetizing solenoid 1-1 and incorporated in it the ferroprobe-gradientmeter 1-2, the channel of pulses generation 2, including the step-up transformer 2-1, the communication condenser 2-2, the bridge rectifier 2-3, the charge switch 2-4, the detector 2-5 of the charging current, the store condenser 2-6, the detector 2-7 of voltage and the discharging switch 2-8, the measuring channel 3, including the separating condenser 3-1, the amplifier 3-2, the detector 3-3 of the compensation current, the band filter 3-4, the programming amplifier 3-5, the synchronous detector 3-6, the restrictive amplifier 3-7, the integrators 3-8 and 3-9, the control unit 4, including the microcontroller 4-1, the output on the USB-port 4-2 for the connection with the PC, the liquid-crystal display 4-3, the push button 4-4 and the power source 5.

At positioning the transducer of the analyzer on the surface of the article under test and pressing the keystroke START the channel 2 generates the sequence of pulses according to the mode, entered in the microcontroller from the control buttons or from the PC. The current pulses, going through the magnetizing solenoid, locally magnetize the article. In the analyzer the compensation circuit of measurement of the electromotive force of the second harmonic of the ferroprobe-gradientmeter is realized. The value of the compensation current, flowing through the measuring winding of the ferroprobe-gradientmeter is proportional to the gradient of the normal component of residual magnetization field strength after the next magnetizing pulse.

In according with the selected mode the microcontroller determines the values of ∇H_{rms} , ∇H_{rms} , ∇H_{rm0} , $\nabla H_{rm\pi}$, ∇H_{rm0i} и $\nabla H_{rm\pi i}$ and puts them out to the display or to the PC. In the analyzer is provided the possibility for conversion the measured data into the values of hardness for the each particular article.

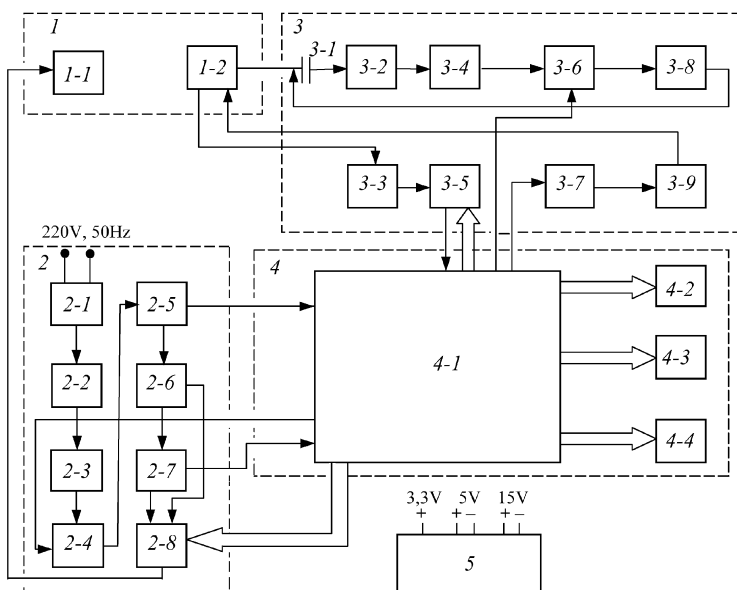


Fig. Function scheme of the analyzer IMA-M

Main technical performance data of the analyzer IMA-M

- maximum amplitude of the magnetizing field on the end face of the solenoid $H_{ms} = (5.2; 5.9; 6.5; 7.2; 7.8) \times 10^5$ A/m with the error of $\pm 5\%$;
- the step of change of the pulse amplitude $\Delta H_{ms} = (1/9 H_{ms} \pm 5\%)$ A/m;
- the range of the measurement of the gradient $\nabla H_{rm} \pm (1 - 180) \cdot 10^3$ A/m²;
- the relative measuring error is not more than $\pm [5 + 0.07(1.5 \cdot 10^5 / \nabla H_{rm} - 1)] \%$;
- the duration of single measurement is not more than 30 s.

The analyzer IMA-M is effectively used at the testing of hardness of medium-carbon steels after hardening and following high-temperature tempering.

References:

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