1.4.20. INVESTIGATION OF RELATIVE SENSITIVITY X-RAY TELEVISION SYSTEMS ON THE BASIS OF HIGH-SENSITIVITY CCD-CAMERAS AND X-RAY MONOCRYSTAL SCREENS

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X-ray television systems (XRTS) are widely applied to non-destructive testing of materials and products quality in the industry. Such systems have some advantages relative X-radiography concerning productivity and cost of the control, and also over an opportunity of the control of objects both in a statics, and in dynamics. XRTS on the basis of x-ray screens and high-sensitivity CCD-cameras characterised by simplicity of design, have low cost and can effectively be applied to the nondestructive control of mobile objects, providing relative sensitivity of the control 1.7 – 2.5% in a wide range of steel depth. The further improvement of relative sensitivity of control XRTS is possible due to operation of a CCD-matrixes in a mode of adjustable duration of images accumulation.

Results of experimental researches new developed computerized XRTS on the basis of the monocrystal x-ray screen from material Cs (Tl) with diameter 200 mm and the television camera on matrix ICX429ALL SONY corporation of a format 1/2" and amount of active light sensors 752 × 582 are considered in the report . The camera has an opportunity of operation as in the broadcast standard of image decomposition (625 lines, 25 frames per sec, scanning interlaced), and in a mode of adjustable duration of accumulation of images on a CCD-matrix (duration of accumulation up to 2048 frames, a frame interval 40 ms). The camera is equipped by zoom lens Computar T4Z2813 with a relative hole 1 : 1.3 and a focal length 2.8 – 12 mm. For input of images in a computer the high-speed device of input through interface USB 2.0 which provides an opportunity of supervision and record of images on a computer in real time (a frame frequency of 50 Hz, aspect ratio 720 × 576) is used. There is also an opportunity of record in a computer of separate video frames with high resolution in a format 1440 × 1152. Control of all modes of the television camera (duration of accumulation on a CCD-matrix, a gain of a video path, a black level, etc.) is carried out with a computer through interface RS-232.

For control objects X-ray device EKSTRAVOLT-350 of production of TESTRON corporation was used. Welded steel plates with depth 10, 20 and 30 mm was used for control. Distance between the anode of a X-ray tube and the screen was 350 mm.

Results of experimental researches XRTS are presented in the table. In the table are specified: accelerating voltage of a X-ray tube (U_a), an anode current of a X-ray tube (I_a), depth of controllable object (H), amount of frames of accumulation CCD-cameras (N_k). The amount of frames of accumulation N_k = 1 corresponds to the broadcast standard of image decomposition. Results of measurement of relative sensitivity of the control are presented by numbers of the smaller depth of the revealed groove and the smaller diameter of the revealed wire with defining the types of corresponding penetrameters sensitivity (Fe-1, Fe-2 or Fe-3). Values of sensitivity of the control on groove (K_g) and wire (K_w) to penetrameters are also included in the table.

Apparently from the table, for depth H = 10 mm at N_k =1 relative sensitivity is K_g = = 1.67% and K_w = 2.5% at U_a = 160 kV. At reduction of an anode voltage up to U_a = = 100 kV grooves and a wire are not detected (item 4 of the table). However accumulation on CCD-matrix N_k = 64 of frames provides the same sensitivity, as at U_a = 160 kV. Accumulation also N_k = 16 at U_a = 150 kV improves sensitivity K_w from 3.2 up to 2.5%. The images received after accumulation (item 2 and item 5 tab.) are better because of absence noise on them.

The table

№	U_a, kV	I_a, mA	H, mm	N_k	Groove penetrameter		Wire penetrameter	
					№ groove and type of the penetrameter	K_g, %	№ wire and type of the penetrameter	K_w, %
1	150	10	10	1	5 Fe-1	1.67	2 Fe-2	3.2
2	150	10	10	16	5 Fe-1	1.67	3 Fe-2	2.5
3	160	10	10	1	5 Fe-1	1.67	3 Fe-2	2.5
4	100	10	10	1	–	–	–	–
5	100	10	10	64	5 Fe-1	1.67	3 Fe-2	2.5
6	200	10	20	1	6 Fe-2 2 Fe-1	2.1 2.27	4 Fe-3	3.15
7	240	8	20	1	6 Fe-2 3 Fe-1	2.1 1.8	4 Fe-3	3.15
8	240	8	20	16	4 Fe-1	1.36	5 Fe-3	2.5
9	140	10	20	32	3 Fe-1	1.8	5 Fe-3	2.5
10	260	8	30	1	6 Fe-2	1.47	3 Fe-3	2.67
11	300	6	30	1	6 Fe-2	1.47	3 Fe-3	2.67
12	300	6	30	16	6 Fe-2 2 Fe-1	1.47 1.56	4 Fe-3	2.1
13	200	10	30	64	3 Fe-1	1.25	5 Fe-3	1.67

For depth of steel H = 20 mm the best relative sensitivity of the control at N_k = 1 was K_g = 1.8% and K_w = 3.15% at U_a = 240 kV (item 7 of the table). Accumulation N_k = = 16 at the same anode voltage improves sensitivity of control K_g from 1.8% up to 1.36% and K_w from 3.15% up to 2.5%. Decrease anode voltage up to U_a = 140 kV at N_k = 1 leads to sharp impairment of sensitivity (grooves and a wire of penetrameters did not come to light). However, accumulation on CCD-matrix N_k = 32 of frames improves sensitivity of the control sizes which are achieved at U_a = 240 kV (item 9 of the table).

Similar law is observed also for depth H = 30 mm. Sensitivity of the control at N_k = = 1 provided K_g = 1.47% and K_w = 2.67% at U_a = 300 kV. Accumulation on CCD-matrix N_k = 16 of frames improves sensitivity K_g 2.67% up to 2.1%. And at decrease in an anode voltage up to U_a = 200 kV accumulation N_k = 64 of frames allows to achieve sensitivity of control K_g = 1.25% and K_w = 1.67% (item 13 of the table) that surpasses the sensitivity received at an anode voltage at U_a = 300 kV.

Thus, application of a mode of adjustable duration of accumulation of images on the CCD-matrix allows to improve relative sensitivity XRTS, to increase quality of received images due to elimination of noise and to reduce necessary power of an exposition doze of X-ray radiation on its entrance.

Operation of CCD-matrixes XRTS in a mode of adjustable duration of accumulation of images allows to apply effectively also small-sized pulse X-ray devices and to realize the control over field conditions and remote places. So, for example, at operation XRTS with pulse device MIRA-2D sensitivity of the control of 2.5% has been achieved at control there were depth of 10 mm and accumulation on a CCD-matrix of 256 frames.