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Processing method of results of thermo vision assessments of the high-voltage equipment

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Abstract— In work thermo grams of the high-voltage power, equipment is investigated. For leaving from subjectivity in the analysis of thermo grams during Thermo vision researchers of the power equipment of objects of power it is offered to use thermo graphic information functions. The method of the analysis is realized by means of the mathematical MathCad environment. As a criterion for evaluation of the technical condition of the power equipment the deficiency coefficient is used.

Keywords: teplogramma, thermo graphic information functions (TIF), temperature matrix analysis technique, nondestructive control, deficiency coefficient.

I. INTRODUCTION

Modern trends in the development of the industry and production dictate the need for high requirements to a reliability of the equipment. In Russia, more than 40% of the power equipment operated on objects of power has developed the resource. Only harmonious and interconnected work of all elements of a uniform power complex ensures the safety of work of power objects [1]. In this regard, more and more actual are questions connected with a reliability of work of power objects (The Federal law from 7/21/1997 N 116-FZ (an edition from 7/13/2015) "About the industrial safety of hazardous production facilities") [2, 3].

The necessary level of operational reliability of the power equipment can be supported, applying methods and means of nondestructive control [4]. Today one of the perspective directions of development of a highly effective system of technical diagnostics in power is an introduction of devices of infrared equipment. Timely carrying out Thermovision inspection of the power equipment allows to reveal the defects arising in him at early stages, to predict their development [5,6]. However, there is a problem when the analysis of results of Thermovision inspection of the equipment is influenced by subjective factors [7]. All elements of the working power equipment have a certain temperature. The equipment elements having defects differ on temperature from normally functioning elements. Thermovision research allows to see thermal radiation and to receive the thermal image (Heat Map) of the object where to a certain value of temperature there corresponds a certain color.

For leaving from subjectivity in the analysis Heat Map, various power objects of power received during thermovision research, it is offered to develop a technique of the computer analysis Heat Map. It is offered to use a technique of the analysis of the thermo graphic information functions (TIF). The analysis Heat Map is conducted in a mathematical MathCAD environment. Means of MathCAD drawing turns into the matrix [8] consisting of numbers from 0 to 255. To number 0 there corresponds the pixel with the minimum brightness and to number 255 – with the maximum brightness. As, on a Heat Map distribution of the temperature field of the studied object is visible, compliance between values of the received matrix and temperature in the corresponding point of the studied object has been established. That is, a transformation of a matrix of a brightness of a teplogramma with values from 0 to 255 in a matrix of distribution of temperatures on an object surface with values from t_{min} to t_{max} is executed. Three thermo grams of one object (fig. 1) received at different times carrying out scheduled works have been subjected to the analysis. The document of processing of the first thermo gram (A) is given in the MathCAD software product is presented below.

ORIGIN= 1 - establish counting of indexes from 1 (by default from 0)

A= READGB (Fig1 (A)) - reading the color image from the file.

We receive a matrix A

m = rows (A) = 356 the number of rows of the matrix A

n= cols (A) = 1728, A_{min}= min (A) = 0 A_{max}= max(A) = 255

N1 = A_{max} - A_{min} + 1=256

Converting of a matrix of brightness (with values from 0 to 255) in a matrix of temperatures (with values from tmin to tmax):

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$t1max = 42$, $t1min = 30$, $h1 = \frac{t_{1max} - t_{1min}}{N_1} = 0.047$ K1 = 1..N1+1

$$t1_{k1} = t1_{min} + h1.(k1 - 1)$$

i = 1..N1 +1 , x_i = i- 1

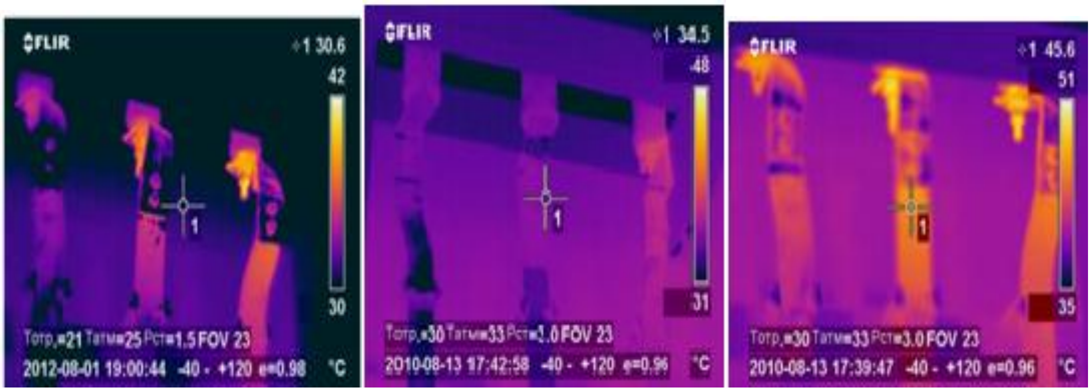
At (m,n,M) = for i ϵ 1..m

for j ϵ 1..n

for k ϵ 1..N1+1

s ← k-1

$A1_{i,j} \leftarrow t1_k$ if $M_{i,j}$=s.



(A) (B) (C)

Fig. 1. Thermograms of object

(A) – The first thermo gram of object, (B) - the second thermo gram of object, (C) – the third thermo gram of object

Statistical processing of matrixes of temperature has given the opportunity to receive function of the distribution of temperature (TIF) [9]. We define optimum number of intervals of change of temperature:

N= round (1+3,323.1n(m.n)) = 45.

$$nA\_red = \frac{hist(x, A\_red)}{m.n}$$ - Relative frequency of values x in matrixes A_red (fig.2).

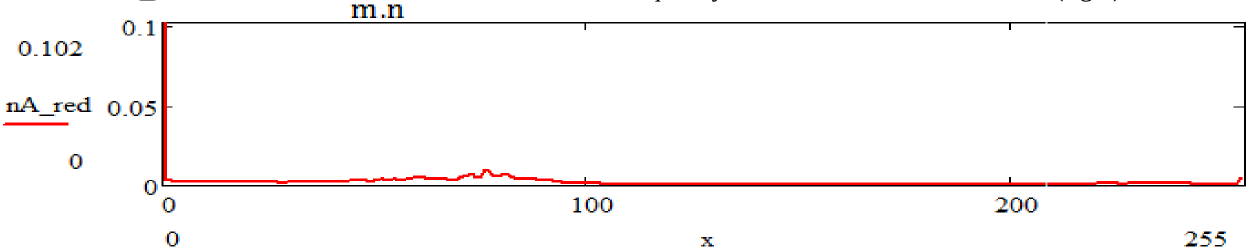


Fig.2. TIF red

$$nA\_green = \frac{hist(x, A\_green)}{m.n}$$ - relative frequency of values x in Matrices of A_green (fig. 3).

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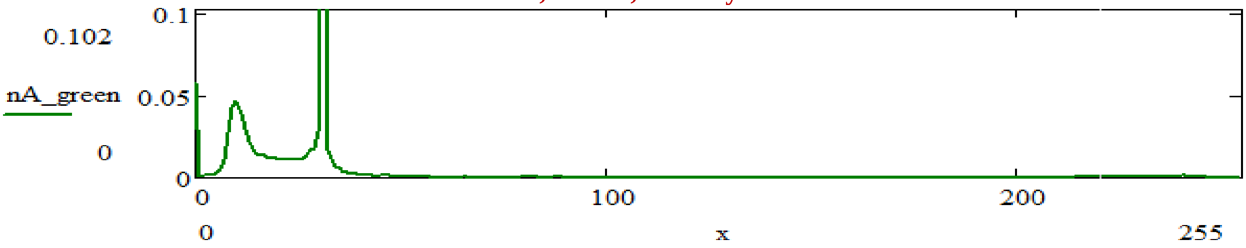

Fig 3. TIF green

$$nA\_blue = \frac{hist(x, A\_blue)}{m.n}$$ - Relative frequency of values x in matrices of A_blue (fig. 4).

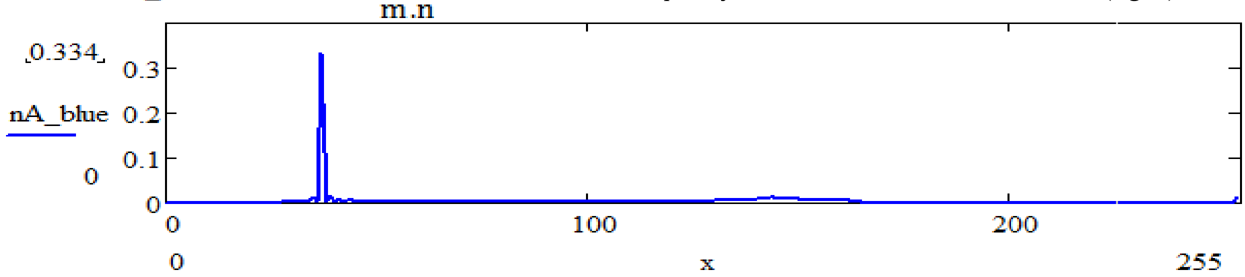

Fig 4. TIF blue

$$nA\_ob = \frac{hist(x, A)}{m.n}$$ - relative frequency of values x in a matrix A (fig. 5).

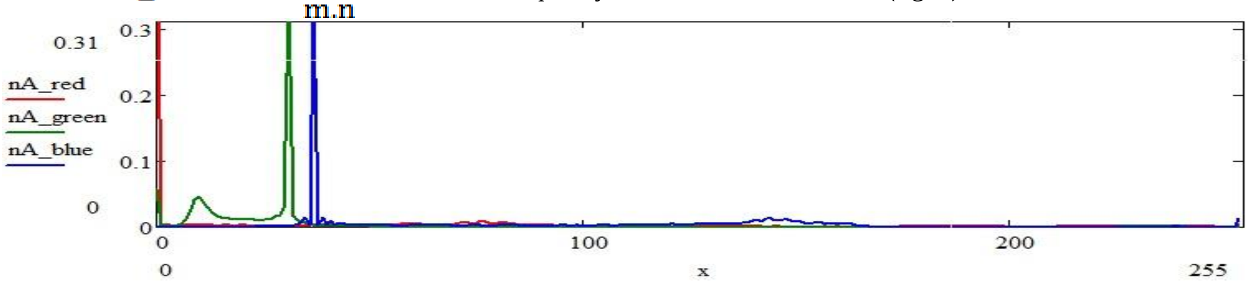

Fig. 5 the overall TIF of the surveyed object (the thermo gram A)

The following two thermo grams are processed according to the same scheme. Results of processing are presented in fig. 6 and 7.

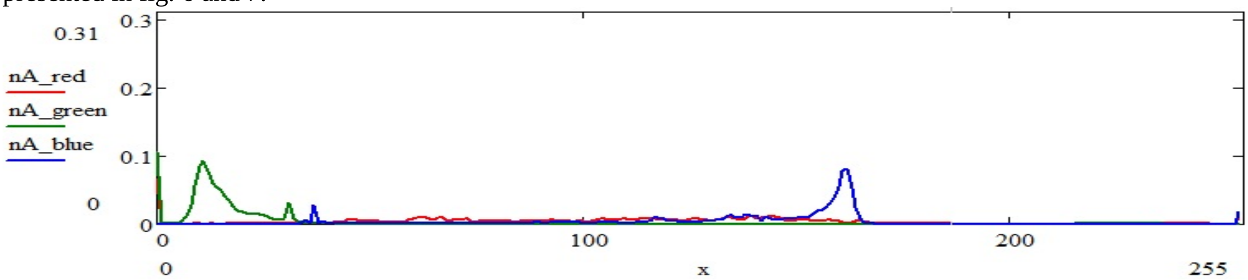

Fig. 6 the overall TIF of the surveyed object (the thermo gram B)

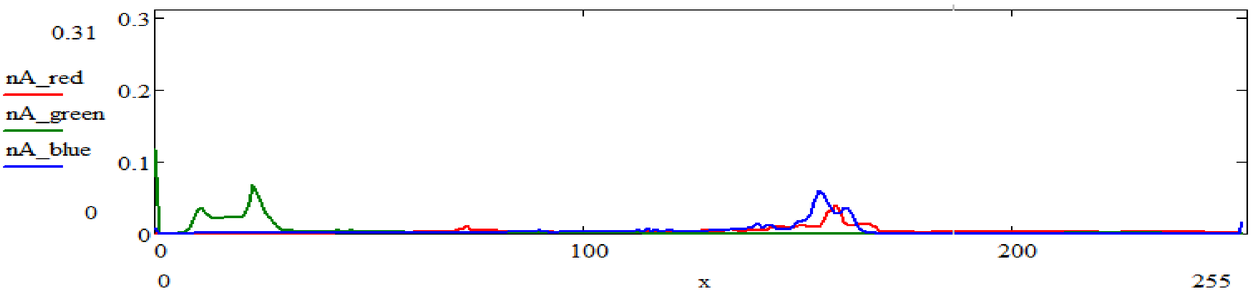

Fig. 7 the overall TIF of the surveyed object (the thermo gram C)

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The graphs distribution of the relative frequency of registration of different temperatures on the thermogram of the object. By way of illustration in fig. 8 shows the displacement TIF of three Heat Map to higher temperatures. The assessment of degree of development of local defect is made according to tab. 1

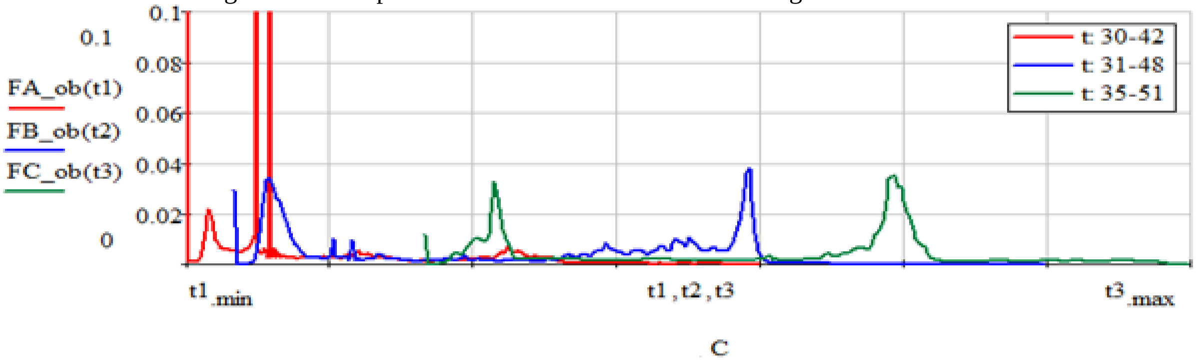

Fig. 8 The offset TIF of three Heat Map

Table 1. Assessment of technical condition of object

Assessment of technical condition	Norm	Norm with deviations	Norm with considerable deviations	a degraded	The preemergency
$K_{дис}$	До 1,2	1,2-1,4	1,4-1,6	1,6-2	Более 2

As criterion for an assessment of power of the dissipative phenomena in the power equipment we use the coefficient of deficiency [10] determined by a ratio.

$$K_{dis} = \frac{P_2 - P_1}{P_1} \qquad (1)$$

Here P_i - power levels of dissipation. Dissipation power for each color of all three Heat Map was calculated.

where $P_1 = \int_{t_1}^{t_2} F_1(t).t\ dt$ $P_2 = \int_{t_1}^{t_2} F_2(t).t\ dt$

In the environment of MathCAD this calculation looks so: calculation of coefficients of deficiency - Red color:

$$P1 = \int_{t1_{min}}^{t1_{max}} FA\_red(t).t\,dt = 1.126$$

$$P2 = \int_{t2_{min}}^{t2_{max}} FA\_red(t).t\,dt = 2.442$$

$$P3 = \int_{t3_{min}}^{t3_{max}} FA\_red(t).t\,dt = 2.836$$

$$K12\_red = \frac{P2-P1}{P1} = 1.169,\ K13\_red = \frac{P3-P1}{P1} = 1.519,\ K23\_red = \frac{P3-P2}{P2} = 0.162.$$

Calculation of coefficients of deficiency - Green color:

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$$P1 = \int_{t1_{min}}^{t1_{max}} FA\_geen(t).t\, dt = 1.453$$

$$P2 = \int_{t2_{min}}^{t2_{max}} FA\_green(t).\tau\, dt = 2.092$$

$$P3 = \int_{t3_{min}}^{t3_{max}} FA\_green(t).t\, dt = 2.299$$

K12_green = $\frac{P2-P1}{P1}$ = 0.44 , K13_red = $\frac{P3-P1}{P1}$ = 0.583 , K23_red = $\frac{P3-P2}{P2}$ = 0.099

Calculation of coefficients of deficiency - Blue color:

$$P1 = \int_{t1_{min}}^{t1_{max}} FA\_blue(t).t\, dt = 1.601$$

$$P2 = \int_{t2_{min}}^{t2_{max}} FA\_blue(t).t\, dt = 2.691$$

$$P3 = \int_{t3_{min}}^{t3_{max}} FA\_blue(t).t\, dt = 2.697$$

K12_blue = $\frac{P2-P1}{P1}$ = 0.681 , K13_red = $\frac{P3-P1}{P1}$ = 0.685 , K23_red = $\frac{P3-P2}{P2}$ = 2.327.

Calculation of the overall coefficient of deficiency:

$$P1 = \int_{t1_{min}}^{t1_{max}} FA\_ob(t).t\, dt = 1.393$$

$$P2 = \int_{t2_{min}}^{t2_{max}} FA\_ob(t).t\, dt = 2.408$$

$$P3 = \int_{t3_{min}}^{t3_{max}} FA\_ob(t).t\, dt = 2.611$$

K12_blue = $\frac{P2-P1}{P1}$ = 0.729, K13_red = $\frac{P3-P1}{P1}$ = 0.874, K23_red = $\frac{P3-P2}{P2}$ = 0.084.

The assessment of the technical condition of thermal conditions is made on coefficient level K_{dis} according to table 1. The coefficient of deficiency of K13_red=1.532 meets standard with considerable deviations, to the coefficient of deficiency of K23_red = 2.327 corresponds to a precritical condition. All other coefficients are normal.

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II. CONCLUSION

Distribution of temperatures on a surface of objects bears information of the following character: about an existence of the distributed sources of a thermal emission, system effectiveness of cooling, existence of local temperature anomalies which are caused by the latent defect of thermal character. From subjectivity in the analysis of the thermograms received during thermovision research of various power objects of power, it is offered to develop a technique of the computer analysis of thermograms for leaving. It is offered to use a technique of the analysis of thermographic information functions. The method of the analysis is realized by means of the mathematical MathCAD environment. The approbation of a method is carried out in the analysis of thermograms of real objects of power. As a criterion for evaluation of the technical condition of the transformer the deficiency coefficient is used.

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