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THE CAPABILITY OF THE PROCESSES OF THERMAL ENERGY GENERATION -THE ANALYSIS OF THE PROCESS STABILITY

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Abstract: The capability of the generation and supplying process of the thermal energy represents one of the fundamental criterion referring to the achievement of quality and performance of the system. In the previous studies, it has been noticed that for an increasing trend of the performance the liability, with its components, the average time of proper functioning, durability, maintainability, security and generally safety in the system functioning are highly important. The performance of a production and distribution system of thermal energy needs to be evaluated. This is given by certain characteristics, especially important being those which represent exigencies of comfort, for example of the thermal one, and economic exigencies in exploitation, predominant being the fuel consumption and implicitly its cost. The achievement of a specified ambient temperature in terms of degree and maintenance in time for all users in the conditions of a humidity degree and a rate of ventilation equally specified, constitutes the essential indices of the system's capacity and implicitly of the production process and distribution of the product.

Key words: durability, maintainability, comfort, consumption, thermal energy.

1. INTRODUCTION

Before the introduction of the statistical control of thermal energy production a compatibility analysis is done which is supposed to establish if the set tolerances by specifications are compatible with the installations' capacity of satisfying these demands.

As in every production process, its quality characteristics are submitted to some influences having systematic and hazard or chance causes. Systematic causes generate a trend of systematic deviations from the specifications of the thermal agent characteristics (temperatures, specific fuel consumption, etc.). Among the systematic causes we can exemplify: the fuel (gaseous, liquid, solid) having different properties from the specified ones, the incomplete burning of the fuel according to the requirements due to the incorrect governing of the burning process, the failure of observing some functioning rules of the installation, the inappropriate feedback of the supply network, etc. Such deviances, having a determined and known trend, can be eliminated by the adjustments that the system is endowed with, for example in the case of a generation central, which can be connected to electronic recording means of the incorporated recording apparatuses and a display or a sensor system which operates both the recording and display by whose means direct commends could be transmitted to the mechanic, hydraulic and electrical components. In the case of a big generating system, the measuring means of the product's characteristics, the collection and display are done by a process computer, which may be endowed with a calculating program for data processing. By means of the computer, mechanical, hydraulic and electronic governing commends can be transmitted. In the governing system in all situations the supply network is also included, which is in contact to the end users who could have certain preferences which can be demanded to the system by means of an operator's center. Consequently, the correction of the systematic deviations can always be made.

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In subsidiary, the capacity presupposes also the use for the fulfillment of the mission of the quantity of fuel dimensioned by project and by the starting of the process.

The capability of the generation and supplying process of the thermal energy represents one of the fundamental criterion referring to the achievement of quality and performance of the system. In the previous studies, it has been noticed that for an increasing trend of the performance the liability, with its components, the average time of proper functioning, durability, maintainability, security and generally safety in the system functioning are highly important. Although between these and the process's capacity there are connections and interactions, their study and evaluation could be separated and the trends can be measured separately, their effects and amplitude on the performance, which at its turn constitutes perhaps the most significant component of the system's quality. In order to control the capacity of the generation and supplying process of the thermal energy, it needs to be controlled. Generally, the control of the process is statistically done and thus the capacity is statistically controlled.

2.THE ANALYSIS OF THE PROCESS STABILITY

The problem of the stability of the generation and distribution process of the fluid destined to heating is analyzed according to the parameters taken into consideration. The first of these parameters is the temperature of the fluid. According to the real demands and the profundity of the analysis different investigation programs can be considered:

1. The measurement of the temperature at the outlet. The measurements are done in a determined time period:

a) a number of days when the temperature is measured at a certain hour of the day;

b) a number of days when the temperature is measured several times a day at determined hours;

2. The measurement of the temperature in the distribution network, at selected points:

c) measurements of the water's temperature when entering the apartments and the common spaces respectively;

d) measurements of the water's temperature when entering the heated spaces, rooms with similar positions in apartments, the common spaces at established points.

3. Measurements of the temperature throughout a number of days and at established hours, in the central, on inlet respectively outlet, combined with measurements of the inner temperature in apartments, in similar rooms;

4. Combinations of measurements. One can establish measuring points, periods (hours, days), a number of measurements a day, etc. If it is the case, a certain component for consumers in the analysis period is included.

By the measurement of the temperatures a certain aspect of the process is highlighted, obviously very important for the creation of the ambient comfort, the establishment of the process being an essential condition.

From the point of view of the "economical comfort" the achievement of a stable process especially concerning the fuel consumption is desirable. In this sense the fuel consumption (for example the gas if it is a gas central) is measured. The daily consumption over an established period of time can be measured or the hourly consumption for certain periods of the day, which is more realistic if the variations of the environment characteristics are taken into consideration.

It needs to be mentioned that the capacity of the process can be analyzed taking into consideration the achieved temperatures or the fuel consumption simultaneously or commonly.

In each of the mentioned cases or in other possible cases, by measurement values are recorded, for example of the temperature, which forms a series, increasingly ordered. Given x_i, i=1, 2, 3, 4,...n, these values of the variable x, namely $x_1<x_2<x_3\ldots<x_i\ldots<x_n$ and $k_1, k_2 . k_3, \ldots k_n$, the absolute frequencies of the values x_i or $f_1, f_2, f_3, \ldots f_n$ relative frequencies, where :

$$f_1=\frac{k_1}{N}, f_2=\frac{k_2}{N}, f_3=, \frac{k_3}{N} \ldots\ldots f_i=\frac{k_i}{N} \ldots, f_n=\frac{k_n}{N} \tag{1}$$

where N is the total number of measured values.

A correspondence is established between x_i,(i=1,2,3,…n) and f_i,(i=1,2,3,……n)

$$\begin{pmatrix} x_1 x_2 x_3 \ldots x_i \ldots x_n \\ k_1 k_2 k_3 \ldots k_i \ldots k_n \end{pmatrix} \rightarrow \begin{pmatrix} x_1 x_2 x_3 \ldots x_i \ldots x_n \\ f_1 f_2 f_3 \ldots f_i \ldots f_n \end{pmatrix} \tag{2}$$

which is the empirical distribution (of frequency), of the recordings and which obviously is of a statistic nature. For the static distribution resulted from measurements (recordings and more generally observations) the main statistic indices are established [2]:

1. of localization;
2. of diffusion.

1. The static indices of localization are the mean, the median and the mode.

The arithmetical mean:

$$\bar{x}=\sum_{i=1}^{n} f_i x_i \tag{3}$$

The median (m_e) is equal to the value of the central term with the indices $\frac{n-1}{n}$, namely:

$$m_e=x_{\frac{n-1}{2}}, \text{if n is uneven} \tag{4}$$

$$m_e=\frac{1}{2}(x_{\frac{n}{2}}+x_{\frac{n+1}{2}}), \text{ if n is even} \tag{5}$$

The mode m_o is x value with the highest frequency.

2. The static indices of diffusion are:

1. dispersion:

$$s^2 = \frac{1}{n-1}\sum_{i=1}^{n} f_i (x_i - \bar{x})^2 \text{, the standard deviation respectively } s = \sqrt{s^2} \quad (6)$$

For higher values of n, instead of n-1, n can be used

For the population (particularly at every point and every moment), the mean also called mathematical hope is represented by μ or M(x) or m, and dispersion is represented by D(x) or σ^2, square mean deviation is σ. In static reasoning the distinction between the population's indices and those of the sample, the latter representing approximations of reality with a certain degree of confidence. Thus for a number of samples n_e the mean of the population is equal to the mean of the samples, and the square mean deviation:

$$\sigma = \frac{s}{\sqrt{n_e}} \quad (7)$$

2. amplitude;

$$R = x_{max} - x_{min} \quad (8)$$

3. variation coefficient:

$$C_v = \frac{\sigma}{\bar{x}} \quad (9)$$

Case study:

It refers to a rehabilitated block of flats where the following have been achieved [4]:

- Thermal isolation;
- The replacement of wood carpentry with PVC profiles;
- The insulation of the terrace,
- The centralized heating system has been replaced with an individual system;

The block has 4 floors P+4E and two flights of stairs with 30 apartments with 2 and 3 rooms.

On putting in function after the rehabilitation with a new heating system tests have taken place among which the measurement of the achieved temperatures. Form the recording of temperatures the values of two sets which observed the behavior type of the heating system have been kept. The temperature measurement has been effected in 36 points, apartment rooms, common spaces. The temperatures have been measured simultaneously at the same hour, with identical measuring means, which have been previously checked. The 36 measuring points have been grouped in twos; the result that is kept is the mean, for every measurement 18 values. The reading and recording have been done over a period of 10 days, with the inhabited apartments but by taking up a self-supervision regime.

The establishment of the tolerance field has been based on some general normative indications, the most frequently mentioned, namely:

a) the insurance of a minimal temperature of 17-18 ˚C;

b) the achievement of a maximum temperature of 25-26 ˚C.

it has been appreciated that between these boundaries a tolerance field can be established, the inferior and superior boundaries being able to fluctuate. For example, it has been considered: T_i = 18˚C, T_s = 25˚C, the variations of these boundaries being able to be up to 1˚C.

The Amplitude $R = t_{max} - t_{min} = x_{max} - x_{min}$, was of 4,6˚C. The recorded temperatures were noted by x.

For the statistic processing [1], 18 subintervals have been considered (which by chance are equal to half of the measuring points). The proceeding of the calculations is in Table 1.

The size of the interval has been considered 0,2 ˚C with deviations at extremities, for the intervals 2 respectively 16, 18, each having a unique value that was read, these were given higher values in order to be able to include all the recordings with non-null values. It is mentioned that these deviations form the value 0,2 do not significantly change the results. These are also reflected in the central values of the same intervals, the 3rd column of the table used for the orderly carrying out of the operations. In the 4th column there are the interval frequencies, namely the number of measured values which fall into every sub-interval.

In the 6th column the measured deviations from the mean were listed, $\bar{x}$, namely $x_k - \bar{x}$, and in the 7th column have been listed the multiplications between the square value of the deviations and the interval frequencies. Then, the dispersion has been calculated:
The variation coefficient being relatively small is a further indication that the system can be included in the category of the statically stable systems. Actually, possible corrections for the system to be statistically rigorous, stable and precise can be made by identifying the spaces that generate the deviations, which in practice and at the same system, in time, can be even higher. But the checking form the initial stage evidence a satisfying process.

Tab. 1 Results and calculations

№	Intervals	Centered values of interval	Frequency of appearance in interval	Product between centered value and interval frequency	Deviations $\bar{x} = 21{,}85$, $(x_k - \bar{x})$	Square of the deviation $(x_k - \bar{x})^2$	$n_k((x_k - \bar{x})^2$
1	2	3	4	5	6	7	8
1	20,1-20,3	20,2	2	40,4	-1,65	2,7225	5,445
2	20,3-20,5	20,4	4	81,6	-1,45	2,1025	8,41
3	20,5-20,7	20,6	4	82,4	-1,25	1,5625	6,25
4	20,7-20,9	20,8	8	166,4	-1,05	1,1025	8,82
5	20,9-21,1	21,0	9	189,0	-0,85	0,7225	6,5025
6	21,1-21,3	21,2	10	212,0	-0,65	0,4225	4,225
7	21,3-21,5	21,4	14	299,5	-0,45	0,2025	2,835
8	21,5-21,7	21,6	19	410,4	-0,25	0,0225	1,1875
9	21,7-21,9	21,8	22	479,6	-0,05	0,0025	0,055
10	21,9-22,1	22,0	23	506,0	+0,15	0,0225	0,5175
11	22,1-22,3	22,2	20	444	+0,35	0,1225	2,45
12	22,3-22,5	22,4	15	336	+0,55	0,3025	4,5375
13	22,5-22,7	22,6	11	248,6	+0,75	0,5625	6,1875
14	22,7-22,9	22,8	5	114,0	+0,95	0,9025	4,5125
15	22,9-23,1	23,0	7	161,0	+1,15	1,3225	9,2575
16	23,1-23,3	23,2	4	92,8	+1,35	1,8225	7,29
17	23,3-23,5	23,4	2	46,8	+1,55	2,4025	4,805
18	23,5-23,7	23,6	1	23,6	+1,75	3,0625	3,0625
				$\sum = 3934{,}2$			$\sum = 36{,}35$

R=23,7-20,1=3,6

$\bar{x} = 21{,}85^\circ C$

$D = \sigma^2 = 0{,}4997$

$\sigma = 0{,}69$

$C_V = 0{,}316$

3. CONCLUSIONS

For measuring it can be considered that the process is governed, the deviations between the mean and TC :

$$\frac{21{,}85 - 21{,}5}{21{,}5} = 0{,}016 \quad (10)$$

Thus in the admissible field
Similarly from both measurements it results that the process is precise:

$$T = T_s - T_i = 25\text{-}18 = 7^\circ C \quad (11)$$

The capacity indices C:

$$C = \frac{T}{6\sigma} = \frac{7}{4{,}16} = 1{,}68 \quad (12)$$

The C_{ps} and C_{pi} values are calculated:

$$C_{pi} = \frac{\bar{x} - T_i}{3\sigma} = \frac{21{,}85 - 18}{2{,}08} = 1{,}85\,; C_{ps} = \frac{T_s - \bar{x}}{3\sigma} = \frac{25 - 21{,}85}{2{,}08} = 1{,}51 \quad (13)$$

The practical results above were obtained after several governing actions and corrections of the installation.

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