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MATHEMATICAL SIMULATION OF POLLUTION INDEX

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Abstract: *Because the issue of environmental protection will always be a vital issue in a foundry, it is necessary for full and centralized sources of pollution. This work is devoted to a statistical analysis model of measurements to emissions of suspension powders.*
Key words: *Pollution index, dispersion, statistical processing, variance*

1. INTRODUCTION

In the operating processes from foundries environmental pollutants are emitted. By the nature of technology, but mainly because some foundries have no facilities to capture and neutralize pollutants or because existing tools do not work on greening at design parameters, metal powders, oxides various metals, anhydrous sulfur dioxide and sulfur trioxide, carbon oxides, etc. are emitted into the foundries atmosphere and then into environment. Natural agents like wind, rainfall, solar radiation, contribute to wide spread areas of gaseous and particulate pollutants (Rusu, 2002). Suspension powders with diameters less than 20 microns have similar behavior in the atmosphere like gas. These emissions have in the composition lead oxide, fluorides, sulphides, some oxides, cadmium, chromium, etc., which are toxic, (Voicu, 2002).

2. MATERIALS AND METHODS

For study it is chosen an iron foundry. Determinations are made relating to noxa in the form of suspension powders at source (emissions). It were taken samples of suspension powders by twelve working points denoted by P_i, the index i belongs to the interval (1, 12) : $\boldsymbol{P_1}$ - sandblast cleaning plant with SKB band type, $\boldsymbol{P_2}$ - I line formation, $\boldsymbol{P_3}$ - line formation mixture III SPAF, $\boldsymbol{P_4}$ - a polygonal mesh SPAF 1, $\boldsymbol{P_5}$ - a polygonal mesh SPAF 2, $\boldsymbol{P_6}$ - mechanical knock-out by vibration IV line, $\boldsymbol{P_7}$ - casting sandblast cleaning plant with shot, $\boldsymbol{P_8}$ - sixth line molding, $\boldsymbol{P_9}$ -iron foundry furnance, $\boldsymbol{P_{10}}$ - dryers for sand, $\boldsymbol{P_{11}}$ - sand preparation plant coated, $\boldsymbol{P_{12}}$ - modeling - collecting plant sawdust dust facility. The maximum permissible concentration (*CMA*) for particulate emissions to the atmosphere was established to 50 mg/m^3, (Baron et al., 1991).

3. THEORETICAL ASPECTS AND RESULTS

Measurements represent average instantaneous samples, short (30 minutes). Three samples were taken for each item of work fixing the average concentration of dust suspension, denoted by Cm. The results from the twelve working points are summarized in the form of pairs where the first number represents the average concentration of dust in suspension and the second index of pollution: (60.20;1,20), (7.14;0,14), (42.58;0,85), (142.06;2,84), (149.24;2,98), (116.78;2,33), (156.62;3,13), (114.68;2,29), (70.06;1,40), (161.42;3,22) (120.70;2,41) (76.16;1,52). Setting pollution index (Andrei & Stancu, 1995) was made after the relation

$$I_p = \frac{Cm}{C.M.A.} \tag{1}$$

It is presented a statistical model of the pollution index on the twelve technological lines mentioned above. We note that the model becomes efficient by increasing the number of technological lines.

By making use the data obtained by measurements and summarized in Table 1 can be formed a one-dimensional statistical series, frequency distribution, and continue. Data will be processed in order to characterize the statistical population, consisting of the twelve selected technological lines; chacaracteristic (X) is the index of pollution.

This requires knowledge of the variability in the series terms obtained by determining the parameters of variation, whereas the position parameters (mean and modal pollution index) capture only the central tendency of the series without being able to characterize the variability. Also, these scattering parameters reflect the degree of representativeness of index of pollution in the studied population. The twelve points will be spread over five working groups of index of pollution values. The results are shown in Table 1.

We obtain the relation

$$n = \sum_{i=1}^{k} n_i \tag{2}$$

where n is the total number of working points, k is the number of groups, $k < n$, and n_i is the frequent of group i. In this situation we have $n = 12$, $k = 5$, $i = \overline{1,5}$. Synthesizing all the pollution index variations in a single numerical expression is done through from the mean value, calculated from individual deviations of the five versions from their average. Thus, we obtain the absolute linear mean deviation, denoted by $\overline{a}$, by the formula

$$\overline{a} = \frac{1}{n}\sum_{i=1}^{k} \left| x_i - \overline{x} \right| n_i \tag{3}$$

where $x_i - \overline{x}$ are the individual deviations. It results the absolute linear mean deviation $\overline{a} = 0.83$.

To convert the variation range of the index of pollution into a discrete variable, this series being a continuous one, it will be calculated the midpoint of the range, the x_i values obtained from Table 1.

Characteristic (X)	n_i	x_i	$n_i x_i$
1	2	3	4
(0, 0.75]	1	0,37	0,37
(0.75, 1.5]	3	1,12	3,36
(1.5, 2.25]	1	1,87	1,87
(2.25, 3]	5	2,62	13,1
(3, 3.75]	2	3,37	6,74

Tab.1. Range of values for chacaracteristic (X)

We also deduce $\overline{x} = 2.12$ from the below formula.

$$\overline{x} = \frac{\sum_{i=1}^{k} x_i n_i}{\sum_{i=1}^{k} n_i} \quad (4)$$

The linear average deviation in absolute form given by (3) shows the degree of homogeneity of statistics population related to the average of pollution index. This parameter can be used to compare the homogeneity of this series with the series constructed in a different period during which any remediation technologies can be reviewed, aiming the comparative evolution of pollution indices at differet times.

Another indicator of the degree of concentration characterizing individual values, related to the pollution index (central value) is variance or total dispersion which is denoted by $\sigma^2(x)$ and is calculated by the below relation.

$$\sigma^2(x) = \frac{1}{n}\sum_{i=1}^{k} (x_i - \overline{x})^2 n_i \quad (5)$$

The calculation of the variance, according to relation (5) following data from Table 1 leads to $\sigma^2(x) = 0.87$. A very important property of the variance is Koning's theorem which gives dependence between the variance calculated related to the average pollution index and that calculated related to a constant c. We obtain

$$\sigma^2(c) = \sigma^2(x) + (\overline{x} - c)^2 \quad (6)$$

An important parameter of dispersion (variation) is also the standard deviation or mean square deviation, denoted by σ and calculated by the formula

$$\sigma = \sqrt{\sigma^2(x)} = \sqrt{\frac{1}{n}\sum_{i=1}^{k} (x_i - \overline{x})^2 n_i} \quad (7)$$

Thus, according to calculations we obtain $\sigma = 0.93$. The standard deviation reflects also variants deviation from the mean deviation of pollution index, but standard deviation is more synthetic, with a greater complexity degree. An index relevant to the homogeneity of the series is the coefficient of variation, calculated below

$$c_v = \frac{\overline{a}}{\overline{x}} \cdot 100 \quad (8)$$

It is also used in checking the representativeness of average pollution index. Generally, a series is accepted as homogeneous when the coefficient of variation does not exceed 30% and is more homogeneous while the value is far smaller then 30%. Based on the values already calculated the coefficient of variation will be $c_v = 39.31\%$.

Position and the variation parameters presented so far serve to build an asymmetry coefficient, which characterize the shape of the series. Thus, is calculated the Pearson's empirically coefficient (*c.a.p*) who gives us the opportunity to assess frequency curve without actually sketch it.

$$c.a.p = \frac{\overline{x} - x_M}{\sigma} \quad (9)$$

where x_M is modal pollution index, determined by the parabolic approximation and calculated by the formula

$$x_M = x_i^{\inf} + \delta_M \frac{\Delta_1}{\Delta_1 + \Delta_2} \quad (10)$$

where $x_i^{\inf}$ is the minimum modal limit (which has the highest frequency),

$$\delta_M = x_i^{\sup} - x_i^{\inf}, \quad \Delta_1 = n_i - n_{i-1}, \quad \Delta_2 = n_i - n_{i+1}$$

and n_i is the absolute frequency of the modal interval. If

(a) *c.a.p* < 0, there is a right asymmetry;
(b) *c.a.p* > 0, there is a left asymmetry;
(c) *c.a.p*=0, symmetry.

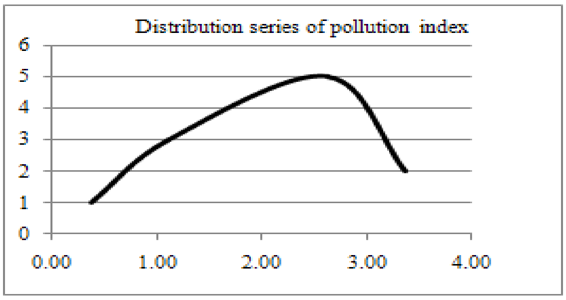

Fig. 1. Right asymmetry

In our case $x_M = 2.67$ and because $c.a.p = -0.59$ there is a right asymmetry.

Graphic representation of sequence distribution (Fig. 2) confirms those determined by calculation, observing the right asymmetry.

4. CONCLUSIONS

The obtained linear average deviation shows that the pollution index of technological lines deviate upwards or downwards from the average pollution index $\overline{x}$, on average, with 0.83. The standard deviation has a higher value than the average linear deviation, but it is more real, this indicator is the most sensitive indicator of dispersion. Therefore, we can say that the pollution indices of technological lines deviate from the average index in more or less, on average, with 0.93. The founded value for the coefficient of variation $c_v = 39.31\%$ shows that the series is not homogeneous at all.

From these results we deduce the necessary of the modernization of technological lines, research and studies addressing the design and development of new equipment for clean technologies with superior parameters to those existing parameters and their implementation in foundry production processes. It also requires the development of economic and financial mechanisms in order to optimize costs for reducing pollution in those lines which recorded large deviations from the average index of pollution.

5. REFERENCES

Andrei, T.; Stancu, S. (1995). *Statistics. Theory and applications*, All Publishing House, ISBN 973-571-108-7, Bucharest.

Baron, T.; Biji, E. & Tovissi, L. (1991). *Theoretical statistics and economic*, Didactic and Pedagogic Publishing House, Bucharest.

Rusu, T. (2002). *Industrial Environment*, Mediamira Publishing House, Cluj-Napoca.

Voicu, V. (2002). *Combating pollutants in industry*, Technical Publishing House, Bucharest.

*** Order 462/1993 of the Ministry of Waters, Forests and Environmental Protection.

*** Air in the protected areas. 12574-87 SR quality conditions.

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