USING OF CHOSEN METHODS OF STATISTIC PROCESS CONTROL FOR ESTIMATION OF VISCOSITY RESULTS OF ACRYLIC PAINTS

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Summary: The chapter presents practical use of certain methods of Statistic Process Control in building industry in relation to viscosity results of acrylic paints. It presents the use of control charts, indices of process capacity and statistical parameters for evaluating production process of acrylic paints in the tested plant.

INTRODUCTION

The subject of researches is a plant from construction industry. It produces acrylic, silicone and silicate paints as well as acrylic, silicone and silicate plasters and primers. Each paint should be characterized with specific properties: adequate gloss and covering level, high resistance to abrasion and the highest breathability. In the tested plant each newly produced paint, before it is sent to the client, undergoes detailed tests. After a sample has been taken, the plant laboratory checks its weight, viscosity and pH. Such measured values are compared with model ones and recorded. When paint positively passes through the first stage of tests its grindability, gloss, covering and breathability are checked. Only after all tests have been carried out can the paint be poured into buckets and sent to clients. In the case of producing paints that are already present on the market the plant checks only their viscosity level, weight and pH.

THE ESTIMATION OF STABILITY AND CAPACITY OF VISCOSITY RESULTS

In order to analyze paint production process in the tested plant 28 viscosity tests of a new product – acrylic paint of increased gloss have been performed. Paint viscosity can be determined by measuring shearing forces that occur in the paint when it is being tested. Adequate paint viscosity causes that when paint is being applied it does not drip from the brush and its application is easy and smooth. Pain viscosity is measured with devices called viscometers. In the tested plant measurements were carried out with one day intervals (24 hours). Each measurement was carried out on three paint samples. Viscosity was measured on spindle 5, its seed being 20 [rpm].
Basic statistical parameters, i.e. average, median, standard deviation, skewness and kurtosis were taken into account when evaluating viscosity of acrylic paints. Results were presented in a table 1.

Table 1. Descriptive parameters of data set

Parameter	Symbol	Value
lot size	n	84
minimum value	min	17977
maximal value	max	18311
range	R	334
average	$\bar{x}$	18142,99
standard deviation	s	122,82
skewness	SK	-0,03
kurtosis	KU	-1,62

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Average viscosity of tested acrylic paints was 18143 [mPas] and average diversity +/- 122,82 [mPas] around the average value. The value of skewness coefficient (SK) less than 0 indicates left-side asymmetry of results distribution, and the value of concentration coefficient (KU) defines that the analyzed distribution is more flat than in the case of a standard curve.

Basing on three-elements samples a Shewhart control chart of average value and range has been created in order to evaluate stability of results in a statistical sense [1÷5] - results are presented in figure 1.

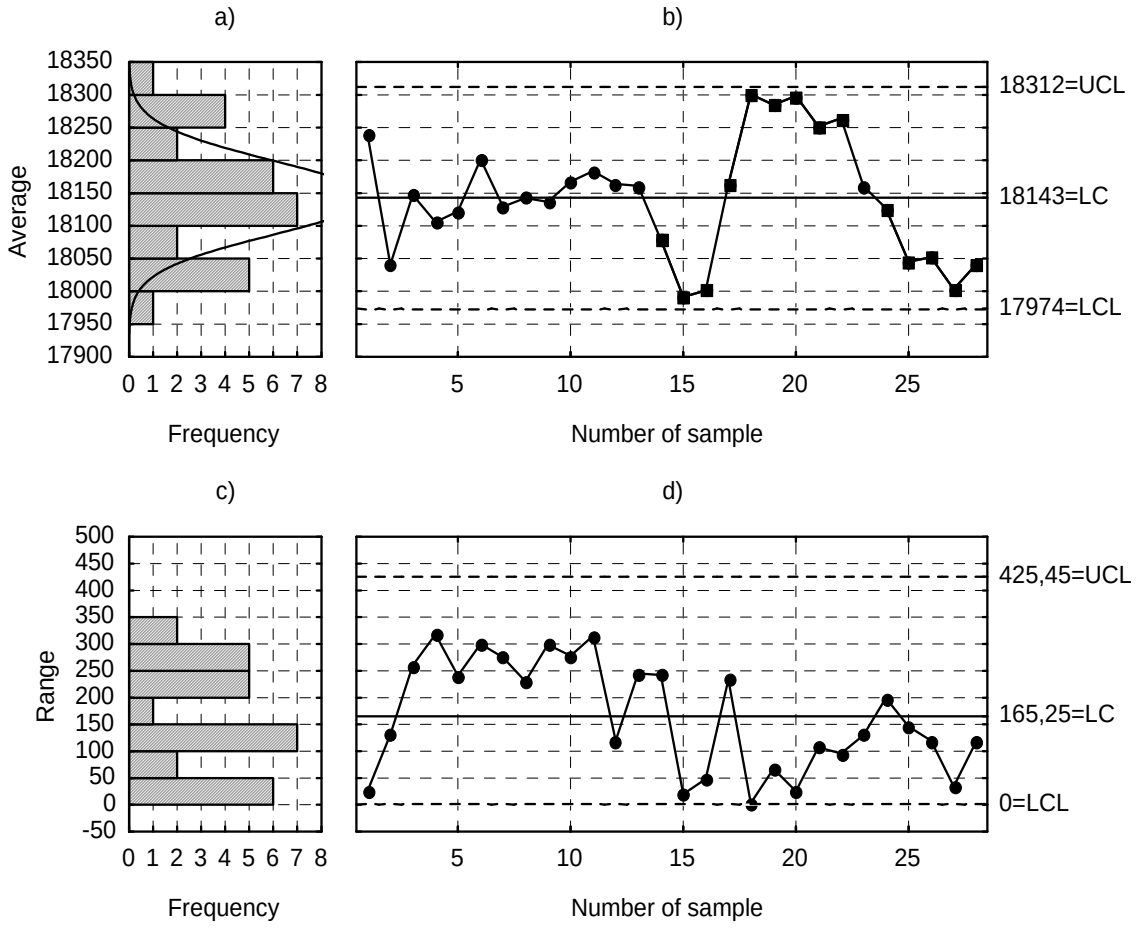

Fig. 1. Diagrams of control charts: a) histogram of averages, b) chart $\bar{x}$, c) histogram of ranges, d) chart R.

The cards $\bar{x}$ and R there are no points beyond control limits, which may indicate stability of viscosity results. After verification of the basic test, i.e. samples beyond control limits, it has been also checked whether non-random sequences of points appear on the control chart. Configuration tests have been used for this purpose (also called AT&T tests). Results of AT&T tests application were presented in a table 2.

Table 2. Configuration tests for $\bar{x}$ – R chart

Zones A/B/C: 3,000/2,000/1,000 *Sigma	Configuration tests $\bar{x}$, R chart	
	from sample	to sample
9 on the same side of central line	OK	OK
6 in growing/ decreasing trend	OK	OK
14 up and down alternately	OK	OK
2 of 3 in zone A or further	14	16
	17	19
	20	22
4 of 5 in zone B or further	17	21
	24	28
15 in zone C	OK	OK
8 out of zone C	OK	OK

Configuration tests have been presented on the control chart (fig.1). Suspicious sequences of points are shown on the chart with a continuous line and a different shape of points marker. Configuration test allows to determine that the insofar course of the process is not correct – it shows us that from some point we have kind of too many low and too many high values of properties. This suggests a shift of the average.

In relation to lack of stability results pertaining to viscosity of acrylic paint to evaluation of a process capacity, process performance indices P_p and P_{pk} have been used, since using indices C_p and C_{pk} for the course of an instable process significantly inflates its capacity. In the analyzed process the nominal value of viscosity at the level of 18000 [mPas] with a tolerance of +/- 1000 [mPas] has been assumed. Comparing such gained results with the assumed tolerances is presented in the histogram visible in figure 2.

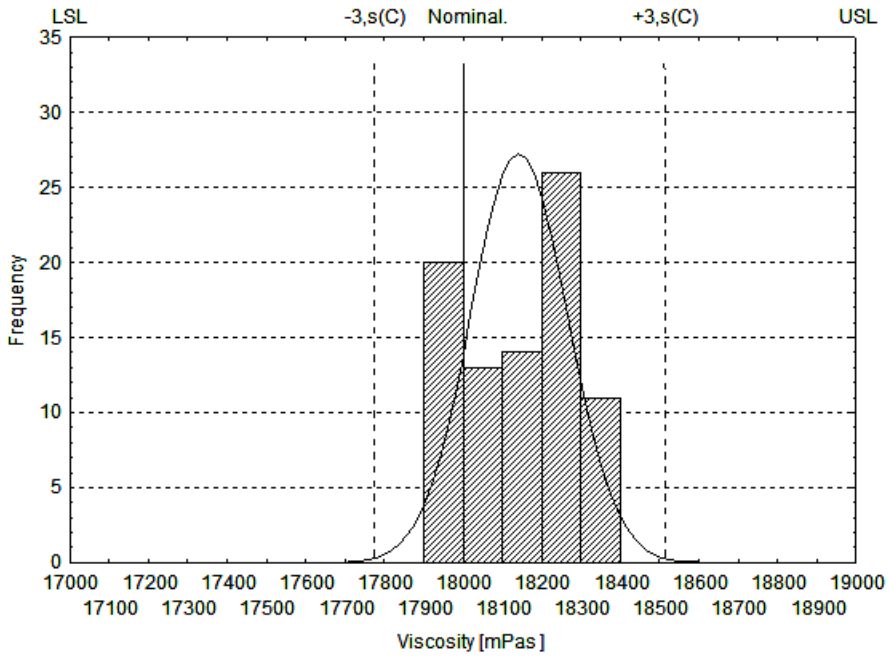

Fig. 2. Research of capacity results of viscosity of acrylic paints.

Complete results of the analysis were presented in a table 3.

Table. 3. Results of the analysis of process capacity

Lower limit of specification	17000
Nominal specification	18000
Upper limit of specification	19000
P_P (Index of performance)	2,71
P_R (Fraction of performance)	0,37
P_{PK} (Index of process performance)	2,33
P_{PL} (Lower index of performance)	3,10
P_{PU} (Upper index of performance)	2,33

The calculated process index P_p is 2,71, which means that the process diversity is more than twice as little as the assumed tolerance limits. The value of the index P_{pk} shows that the process is shifted towards values greater than nominal. The process must be affected in such a way as to shift the average value to the nominal one.

CONCLUSION

Use of certain methods of statistical process control for evaluating results of acrylic paints viscosity made it possible to obtain a lot of valuable information concerning the process. Control charts showed a phenomenon of process irregularity (configuration test) while capacity indices provided information about high process capacity to comply with client's demands. Therefore the process is potentially capable but it is shifted towards the upper tolerance. In the analyzed case the process must be affected in such a way that its average value is covered with the assumed nominal (centre of tolerance field). However, actions meant to decrease the process diversity do not need to be taken.

In order not to put the process out of adjustment one should implement a detailed control during the paint production process and precisely dose certain components when the paint is being produced. In the laboratory one needs to pay greater attention to the fact whether the paint is adequately refrigerated before its viscosity is measured and whether it is free of air bubbles, which could cause inadequate measurements and therefore process irregularity.

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