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STATISTICAL PROCESS CONTROL IN WINE INDUSTRY USING CONTROL CARDS

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ABSTRACT: *This paper is based on the research of the technological process of automatic filling of bottles of wine in winery in Stip, Republic of Macedonia. The statistical process control using statistical control card is created. The results and recommendations for improving the process are discussed.*

Key words: *control card, stages, quality control, data processing.*

1. INTRODUCTION

Statistical methods are becoming more important factor in economic and social processes. This research aims to demonstrate the significance and importance of statistical methods and their application in the overall production process, and, also, to highlight the importance of applying statistical methods that affect making the right decisions and determining the timely and accurate results in companies.
The statistical methods enable monitoring of structural changes and the businesses that form the basis for market analysis and business decision-making, and it is a base for evaluation of basic macroeconomic indicators.
Statistical methods are one of the best ways to solve the paradox of the modern era, which means too much information and too little understanding (Bregar, 2003).
Statistical thinking and application of statistical methods in recent decades occupies an increasingly important role in managing companies.The task of leadership is to recognize the importance of the tools and methods of quality management and proper application, to achieve concrete improvements in performance.
Statistical process control (SPC) is a tool to monitoring processes in companies in order to ensure the achieved quality level, monitoring of deviations outside the control limits, the adoption and implementation of corrective measures. In the narrow sense, under SPC – methods it means the control process using statistical control cards and indices of ability to process.
Control card can be effectively applied with the support of computer equipment and related software. The control cards are determined variations in quality regarding the stability and ability of the production process in terms of the established control limits.
More commonly used control card variables (variables) are: - x (the average card, eng. *X-bar chart*, *average chart*), R card (card range, eng. *R chart*, *range chart*) and s card (card average deviation, eng. *s chart, standard deviation chart*).
Commonly used control cards for attributive features are: *p*, *np*, *c* and *u* card. *p* card (card of proportions, eng. *p chart, proportion chart*), *np* card (eng. *number of affected units chart*), *c* card (card of the number of differences, eng. *c chart, count chart*) and *u* card (card of average number of differences, per unit of products eng. *u chart, per unit*).
The control card must be installed in places where you can follow those quality characteristics that are essential to the use value of the product.

2. METHODOLOGY

The subject of our research is the process of automatic filling of bottles of wine in winery in Stip, Macedonia. It is made a statistical process control in manufacturing rechargeable wine in glass bottles of 1 liter, with the help of statistical control card. The period of observation of the production process is one month or 20 working days. For the defined sample is prepared table of measured values which is integrated in Microsoft Excel 2010 and statistical processing and construction of the control cards are making (table 1).

Appropriate methods of statistical process control or control cards can be used in four control points. ***First phase*** for the implementation of the control is in the process of sterilization of empty glass bottles. ***Second phase*** for statistical control is the work of dosing. Dosing fills empty wine bottles with a volume of 1 liter, and sets the request to investigate the matter of dosing, if the bottles are completely filled with the amount of 1 liter.

The *third phase* is to control the closing of the bottles, and to investigate and verify is the machine for closing properly and duly closed bottles with corks corresponding shut-bottles.

The *fourth phase* of statistical control is checking the work of machine for labels, if the label is printed correctly in the appropriate place, if all the data is correctly printed on the label, if the label is then printed and the quality and is there an option for quick detachment.

3. RESULTS AND DISCUSSION

The production process will be analyzed four control points: sterilizer, dosing, and machine for labels.

First it is controling the operation of the sterilizer, where checks on the accuracy of the work of the sterilizer. If sterilizer works properly, the number of microorganisms in glass bottle after leaving the sterilizer is equal to zero, or if the glass bottle containing a microorganism, then it will be considered that the bottle is defective. For this purpose, the controllers are taking each day from the random sample of 220 empty glass bottles that are processed in the sterilizer one month or 20 days (table 1).

It analyzes the bottles depending on their condition or value of the modality of the observed variables are correct glass bottles (without microorganisms) and defective glass bottles (which containing microorganisms). So it is attributive features that can be given two values and can be applied *p* control card. It examines whether it can regulate certain values of proportions of samples according to the normal distribution. Using Microsoft Excel 2010 it calculates the average value of the proportion $\bar{p}$, p_i - proportion of i-th sample, $\hat{\sigma}_p$ - estimation of standard error of proportions with n - sample size, CL-center line and control limits (ULC and LCL). It is construct *p* control card of defective empty glass bottles. The results of statistical data processing, as well as the table and graphical representation of data is given in Figure 1. The calculated parameters, the central line, upper and lower control limits for p control card are:

p-bar = 0,11818182 ; ULC = 0,18347604; LCL = 0,05288759

It is proceed to the construction of p control card that is displayed in Figure 1.

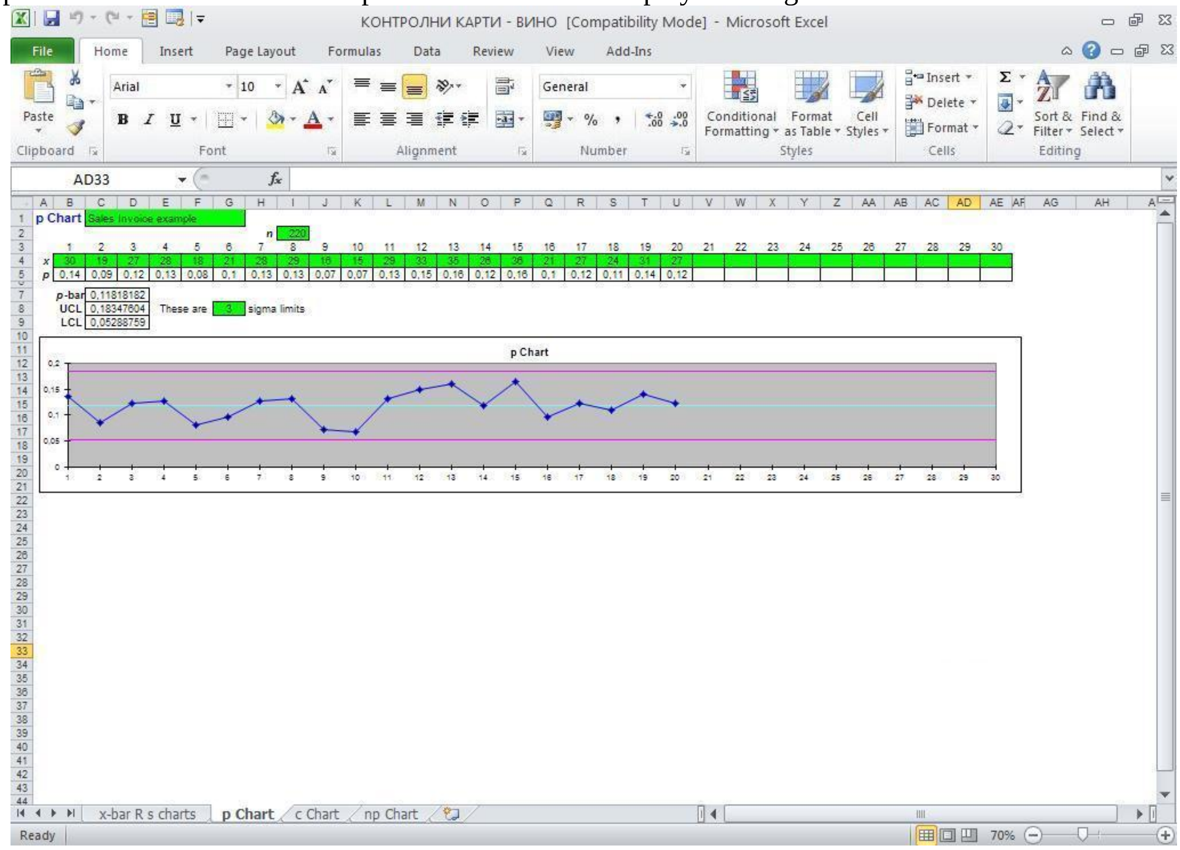

Figure 1: *P*-control card of defective empty glass bottles

The analysis of *p* control card, it is noted that the process is in a state of statistical control, or there is no need to take additional actions or adjustments to improve the functioning of the sterilizer.

Second place for statistical control is examining the work of dosing. Dosing is needed to fill sterilizated glass bottle with quantity exactly 1 liter. To examine the work of dosing the controllers every day, at random, are taken after 5 pre-filled glass bottles, and they measured the amount of content in each glass bottle, and the measured quantities, expressed in liters, and they recorded about 20 working days. Because variable that is observed (amount contained in glass bottle) is a continuous numerical variable in the analysis of the work of the dosing can use X, R, and s control card.

Based on these data are entered into a statistical program, are calculate average values, the range of variation and standard deviations of the sample. Using $A_{2,}$ D_3 and D_4 - tabular values, Shefhartov factors are calculated CL-center line and LCL - lower control limit and UCL-upper control limit of X, R and s control card.

The calculated parameters, the central line, upper and lower control limits for x, R, and s control cards are:

x-bar = 0,9505; ULC = 1,0759975; LCL = 0,8250025

R-bar = 0,2175; ULC = 0,4600125; LCL = 0

s-bar = 0,093507941; ULC = 0,195338089; LCL = 0

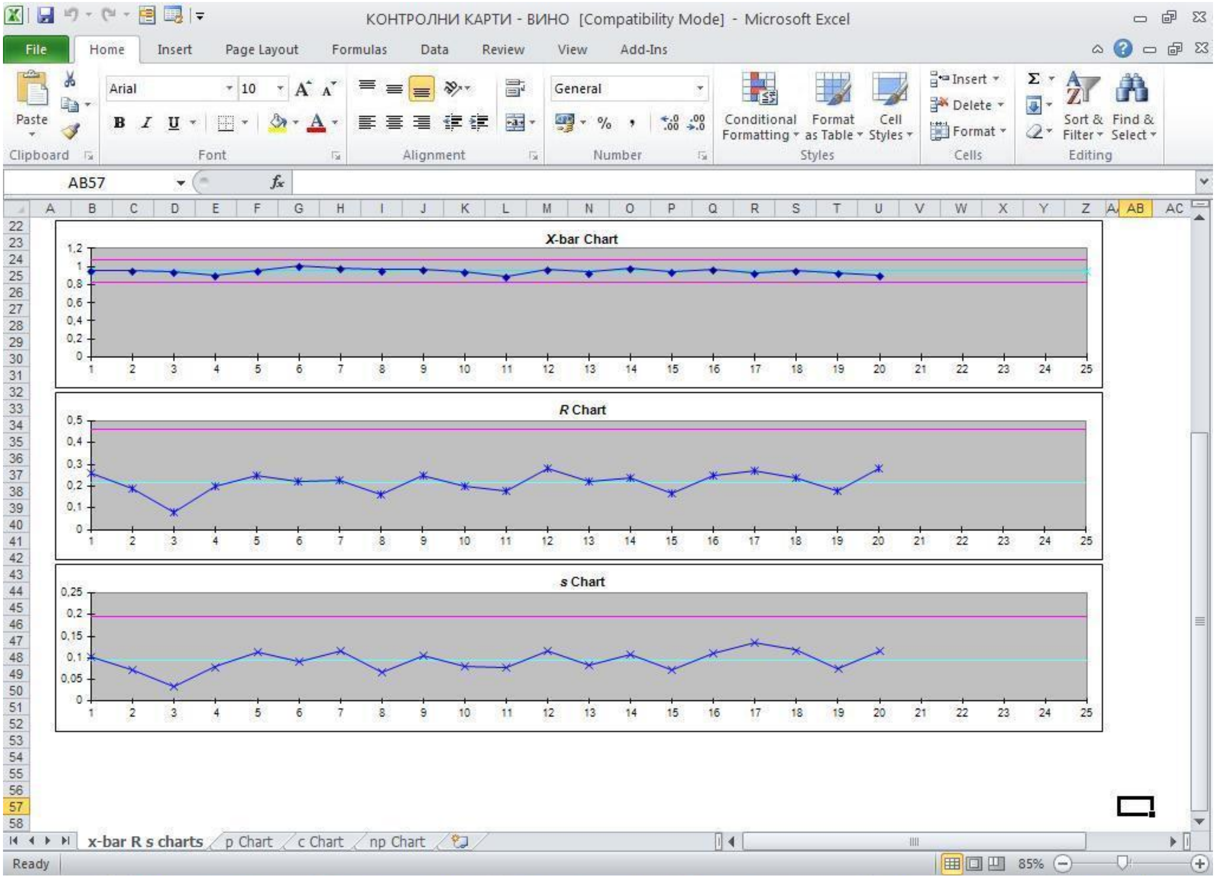

Figure 2: Quality control of dosing using ***x, R*** and ***s*** control cards

From the analysis of x and R and s controller card, it is noted that the process of working on the dosing of glass bottles is in a state of statistical control, or operation of the dosing is correct. The analysis of all three control cards is obvious that the set of basic criteria decision making are met, and concluded that the process is in a state of statistical control, or operation of the dosing is correct.

Third place is controlling the operation of closing the bottles. It checks whether the proper closing sets of bottle corks in a way that the bottle is sealed and disabled liquid spills. Daily checked after 220 bottles, so over 20 days total were processed and tested 4400 bottles. The quality control is used np-control card. The data obtained from measurements of the identified defective bottles with corks are processed.

The results of statistical data processing, as well as the table and graphical representation of data is given in Figure 3. The calculated parameters, the central line, upper and lower control limits for np-control card are:

np –bar = 14,75; ULC = 26,2717; LCL = 3,22828; These are 3 sigma limits

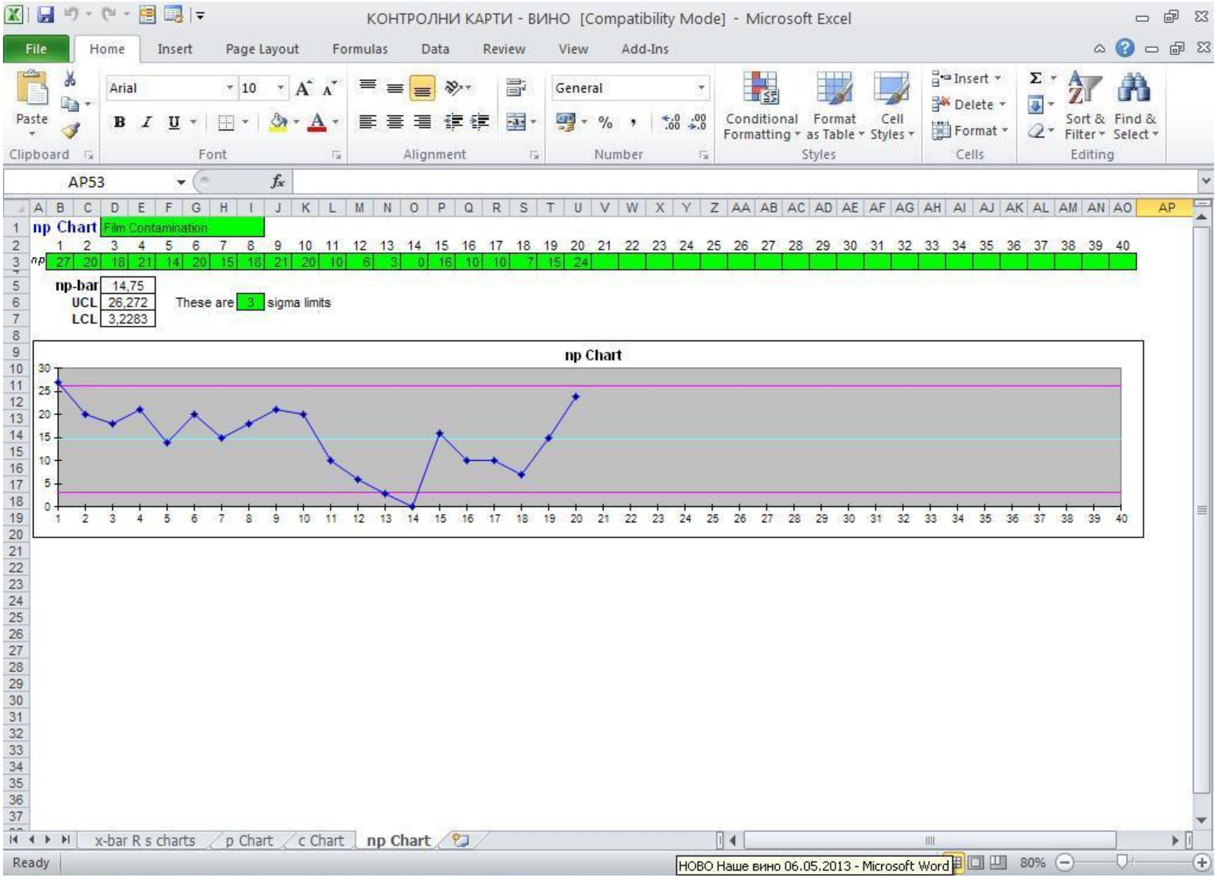

Figure 3: Control the quality of work by closing the ***np*** control card

From the *np*-control card is conclude that the first condition is not filled because the number of defective corks is three, so the first day is above the upper control limit and the 13 and 14 working day number is located underneath the lower critical control limits, and conclude that the process is not in a state of statistical control. It is therefore necessary to examine the work of closing the blunt and to make adjustments to the device.

Fourth place for control is correctness of work of machine for labels. It checks whether the labels are placed in a particular place, after discharge from the labels of bottles line to peel, and proper numeric code printed on each bottle. These requirements are descriptive (attributive) changing the characteristics of the irregularity of work of machine for labels. Variable irregularity of work machine for labels can have five modes as follows: machine for labels meets all the following conditions, machine for labels not meet a requirement, it meets two conditions did not meet the three conditions, and does not meet any requirement.

Because of the types of features and the number of modes which is greater than two, in the control of working of machine for labels will use *c-control card*. Every working day from the line on machine for labels are taken 220 bottles and are controling over the 20 working days, for order to control and check the accuracy of labeling.

The calculated parameters, the central line, upper and lower control limits for c-control card are:

c –bar = 16,65; ULC = 28,8913; LCL = 4,40868; These are 3 sigma limits

With the analysis of the *c* - control card is determined that the first condition is filled, or even three individual values are outside the control limits, which means that the process is not in a state of statistical control, i.e. it is necessary to further investigate the matter of working of machine for labels and to take certain corrective measures (Figure 4).

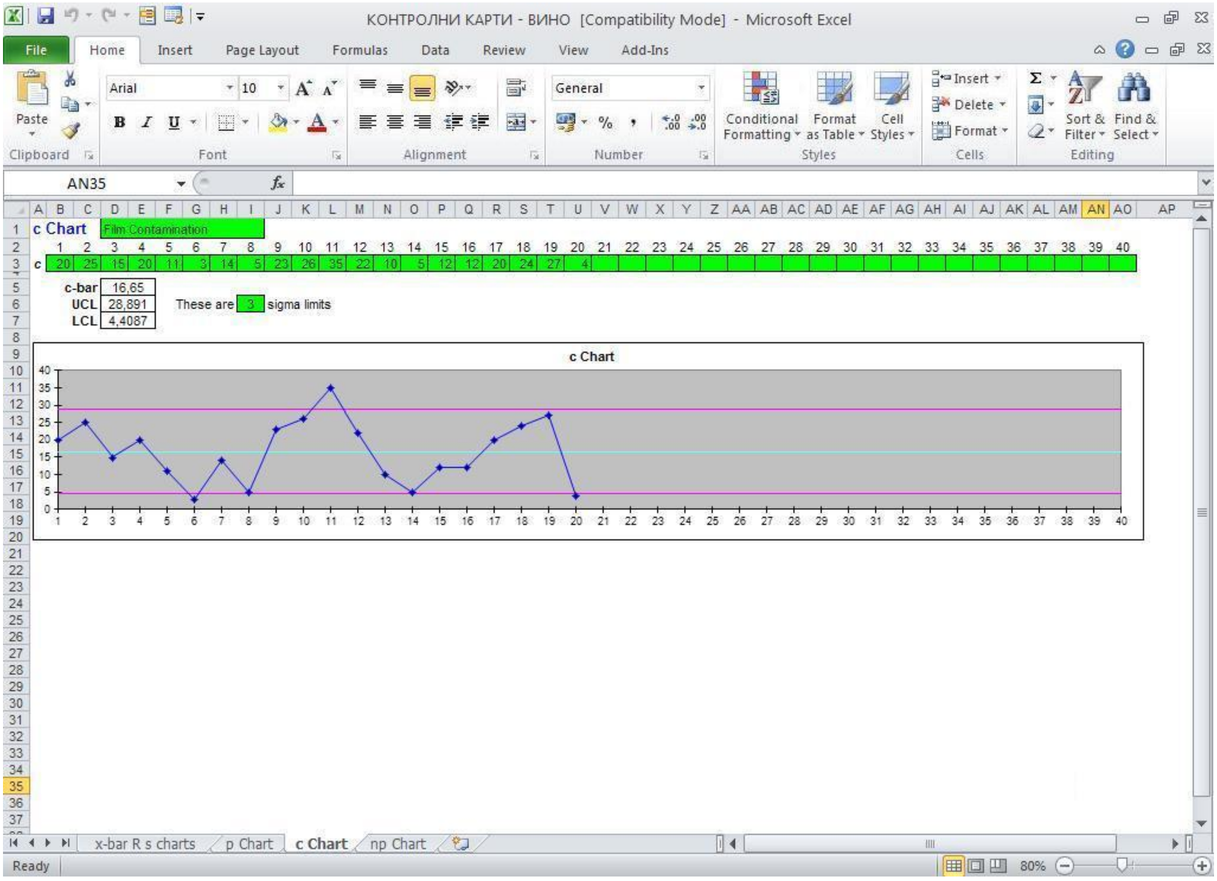

Figure 4: Control the quality of work of machine for labels using ***c*** control card

Table 1: Data analysis of the process of making wine using a control card

Working days / serial no. of sample	Machine for sterilizering		Machine for dosing					Machine for locking		Machine for labels	
	Sample Size	Number of defective bottles	Measuring 1	Measuring 2	Measuring 3	Measuring 4	Measuring 5	Sample Size	Number of defective corks	Sample Size	defective labels
1	220	30	1,03	0,80	1,06	0,94	0,94	220	27	220	20
2	220	19	0,96	0,94	1,01	0,85	1,04	220	20	220	25
3	220	27	0,92	0,95	1,00	0,94	0,92	220	18	220	15
4	220	28	0,94	0,89	1,02	0,82	0,85	220	21	220	20
5	220	18	1,05	0,83	0,85	0,97	1,08	220	24	220	11
6	220	21	1,07	1,05	1,06	1,02	0,85	220	20	220	3
7	220	28	1,09	1,05	0,86	0,86	1,02	220	15	220	14
8	220	29	0,95	1,02	1,04	0,92	0,88	220	18	220	5
9	220	16	1,06	0,90	0,95	1,10	0,85	220	21	220	23
10	220	15	0,87	0,92	1,07	0,96	0,88	220	20	220	26
11	220	29	1,03	0,86	0,88	0,85	0,85	220	10	220	35
12	220	33	1,07	0,95	0,90	0,82	1,10	220	6	220	22
13	220	35	0,92	0,99	1,04	0,91	0,82	220	3	220	10
14	220	26	1,04	1,04	0,86	0,88	1,10	220	0	220	4
15	220	36	0,90	0,98	1,01	0,84	1,00	220	16	220	12
16	220	21	1,03	0,80	1,05	1,05	0,92	220	10	220	12
17	220	27	1,07	0,84	1,09	0,85	0,82	220	10	220	20
18	220	24	0,87	0,85	0,90	1,08	1,09	220	7	220	24
19	220	31	0,86	0,85	0,95	1,03	0,95	220	15	220	27
20	220	27	0,90	0,85	0,82	0,88	1,10	220	24	220	3

4. CONCLUSION

Control cards have a great importance in quality control as one of the methods of statistical process control. With the control cards are observed if the process is in a state of statistical control, whether in the process there are special reasons for variation, and whether variations fall within the given control limits.

Using control cards allows controlling the process of filling the bottles. Through analysis of the control card detect some weaknesses in the production process, and it can certainly assist managers in making decisions.

It is necessary to carry out continuous quality improvement of the products and / or services and the ability of the process.

Every company strives to continuously improve the quality, and that means meeting the needs and expectations of customers by reducing the variability of all processes.

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