MODIFICATION OF "C"- CONTROL CARD

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ABSTRACT:

Standard C-kards show the total number of defects in a sample and, as such, they enable the following of the process and drawing of a conclusion if it is under control. However, the main imperative which is imposing is not to keep the process under control but to continually improve the quality system and tend to realize the production and delivery of products without defects. This is why this paper proposes modification of the C-card by which it is possible to have the insight into the number of established list of defects. It is possible to apply the Pareto analysis to these data for the purpose of establishing critical defects and determination of corrective activities necessary to be done for the purpose of decreasing the total number of defects and, consequently, of imroving the quality system.

Key words: *defects, C- card, Pareto analysis*

1. INTRODUCTION

Control cards are, essentially, special diagrams by which it is possible to follow the charge of a certain characteristic of a quality during a period of time. The sequence of sampling is entered on the abscissa, and the value of numerical or attributive characteristic of quality is entered on the ordinate. The middle line, that is the central tendency of the process and control limits, i.e. regulation points are drawn in such a formed diagram, and then real values of the characteristic of quality are, in the form of points (mutually connected by lines), entered for every individual sample.

According to the way of expressing the characteristic of quality, control cards can be divided as follows:

- Control cards for *numerical characteristics* in which the caracteristic of quality is established by measuring (X-card, $\bar{x}$ - card, R- card, σ- card).
- Control cards for *attributive characteristics* of quality where the evaluation is done attributively, that is according to the criterion: good-bad, right-wrong, goes-does not go, true-false, etc. (np-card, p- card, c- card, u- card).

Atributive characteristics of quality can be classified in two groups depending on whether the incompilance (walfunction) of the product or the number of defects noted on the product is stated. The following attributive control cards are used in practice:

- **p**- card for the percentage of incomplied units per sampling,
- **np**- card for the average number incomplied units per sampling,
- **u**- card for the percentage of defects per unit,
- **c**- card for the average number of defects per sampling.

2. CONTROL CARD FOR THE NUMBER OF DEFECTS (C-CARD)

In certain fields of industrial production (in textile industry, wood industry, paper industry, etc.), the control of defects is performed per unit of product (the number of defects per one roll), unit of length (the number of stains per 100 m' of the paper produced), unit of area (the number of surface defects per 100m^2 of the textile produced), etc. In these cases, the control card for the number of defects known as C-card is used for the control of the process. In metal processing industry, there are also a great number of similar cases:

- If the product is complex (automobile, engine, railway waggon, etc.), so that in the final control a certain number of defects are always found;
- In individual and small-serial production where it is necessary to have the control of critical characteristics of parts or products such as

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connections and joints realized by welding, riveting, soldering, glueing, etc.;

- Control of defects per unit of length or area as it is the case in wire, plates, etc.

The basic statistic parameter in this card is the total nuber of defects on one product or in a sample where the size of the sample is a constant (n=const.).

The observed process is said to be under control if, on the basis of the previous data, it can be foreseen how the phenomenon will change in the future, that is, if the limits within which the observed characteristic of quality will be found can be foreseen. However, the main imperative which is imposing is not to keep the process under control but to continually improve the process and tend to realize the production and delivery of products without defects.

3. PROPOSAL FOR MODIFICATION OF THE C-CARD

Standard C-cards allow only the following of the total number of defects per sample but do not offer the possibility of having the influence in the improvement of the process. Therefore, the next part, of the paper gives a proposal for modification of the C-card on the basic of which it is possible to have the insight into the number of the established list of defects; it also enable the application of the Pareto analysis to these data for the purpose of selecting critical defects and determination of corrective activities necessary to be done for the purpose of decreasing the total number of defects and, consequently, improving the quality system.

3.1 Procedure of Forming the Modified C-card

The procedure of forming the modified C-card consist of the following phases:

A/ identification of defects (errors), forming of the list of defects and classification into groups
B/ following of the number of defects in a specified period of time
C/ data procession
D/ calculation of the central line
E/ calculation of control limits
F/ graphical presentation of the number of defects in the sample
G/ analysis of the control card and estimation of the process stability
H/ graphical presentation of the frequency of defects
I/ Pareto analisis of defects per number of repetition
J/ Pareto analisis per costs that have arisen
K/ anticipation and implementation of corrective activities.

3.2 Table for Data Entering

In the table for data entering (Table 1), defects are denoted with small letters $g_1, g_2, \ldots g_j \ldots g_n$ and classified in "*s*" groups $G_1, G_2 \ldots G_s$. The frequency of repetition of the *i*-defect in the *j*-sample is denoted with f_{ij}. The total number of defects in the *j*-sample is denoted with C_j and calculated according to the formula:

$$C_j = \sum_{i=1}^{n} f_{ij}$$

Defects		The sequence of sampling									F_i
		1	2	3	.	.	j	.	.	m	
G_1	g_1	f_{11}	f_{12}	f_{13}	.	.	f_{1j}	.	.	f_{1m}	F_1
	g_2	f_{21}	f_{22}	f_{23}	.	.	f_{2j}	.	.	f_{2m}	F_2
	g_3	f_{31}	f_{32}	f_{33}	.	.	f_{3j}	.	.	f_{3m}	F_3
G_2	.	.	.	.			.			.	.
	.	.	.	.			.			.	.
		.	.	.			.			.	.
.	g_i	f_{i1}	f_{i2}	f_{i3}	.	.	f_{ij}	.	.	f_{im}	F_i
.		.	.	.			.			.	.
		.	.	.			.			.	.
.		.	.	.			.			.	.
	.	.	.	.			.			.	.
G_s	.	.	.	.			.			.	.
	g_n	f_{n1}	f_{n2}	f_{n3}	.	.	f_{nj}	.	.	f_{nm}	F_n
C_j		C_1	C_2	C_3	.	.	C_j	.	.	C_m	N

Table1: Survey of type and number of defects

The marginal frequencies F_i are obtained by adding all frequencies of the *i*-defect, i.e.:

$$F_i = \sum_{j=1}^{m} f_{ij}$$

The total number of defects in the observed period is:

$$N = \sum_{j=1}^{m} C_j = \sum_{i=1}^{n} F_i = \sum_{i=1}^{n} \sum_{j=1}^{m} f_{ij}$$

3.3 Basic Elements of the Proposed C-card

Basic parameters of the C-card are calculated in the following way:

A/ *Points which are entered in the control card*

Points which are entered in the control card represent the total number of defects in the *j*-sample, i.e. the marginal frequencies C_j.

B/ *Central line*

$$CL_c = \bar{c} = \frac{1}{m} \sum_{j=1}^{m} C_j$$

where $\bar{c}$ - the average number of defects per sample
m - the total number of samples
C_j - the total number of defects in the *j*-sample

C/ *Upper control limit*

$$GKG_c = \bar{c} + 3\sqrt{\bar{c}}$$

D/ *Lower control limit*

$$DKG_c = \bar{c} - 3\sqrt{\bar{c}}$$

It should be taken into account that in the case of a negative value for the lower control limit (*DKGc*), it is taken to be equal to zero (*DKGc=0*).

The presentation of the standard *C*-card which can be drawn on the basis of these data is shown in Figure 1.

j	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
C_j	12	9	18	15	7	13	5	10	16	8	12	15	7	10	6	11	4	8	6	11

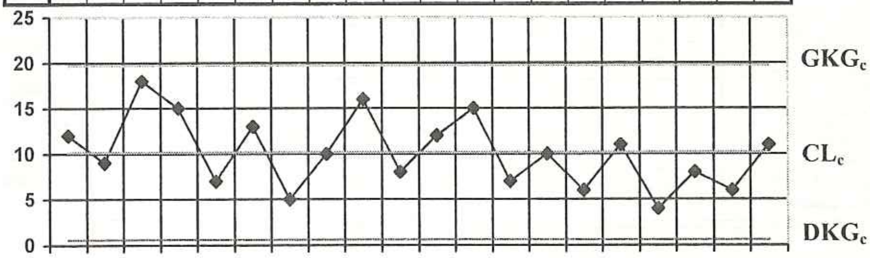


Figure 1: Presentation of the standard C- card

3.4 Analysis of Defects

The marginal frequencies F_i give the information about the number of each defect which can be graphically presented by column or bar charts (Figure 2.).

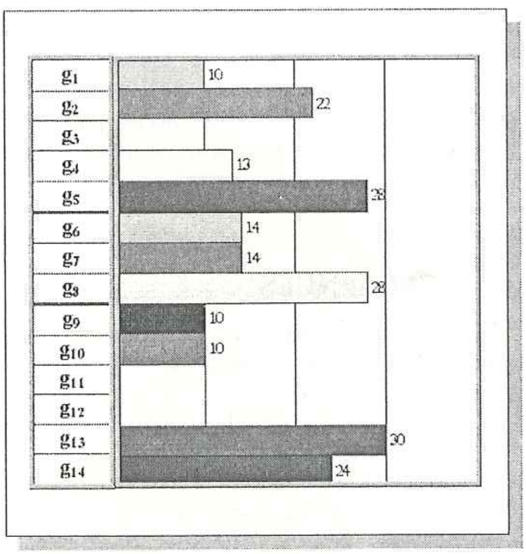


Figure 2: Survey of the number of defects

By further analysis it is possible to sort defects according to their number, i.e. according to the percentage share and draw a Pareto chart (Figure 3.) in which the fields A ,B and C are defined.

- Group A covers the defects that make about 75% of all defects,
- Group B covers the defects that make about 20% of all defects,
- Group C covers the defects whose share in the total number of defects is only about 5%.

If the data about the costs which arise due to the occurrence of defects are available, it is desirable to do the Pareto analysis by the costs arisen in order to note which defects have caused the greatest costs. Then, corrective activities for the defects that have caused the greatest cost (Group A) are foreseen in order to reduce or eliminate them. Also, a framework estimation of necessary investments and an analysis of corrective activities by priorities are given.

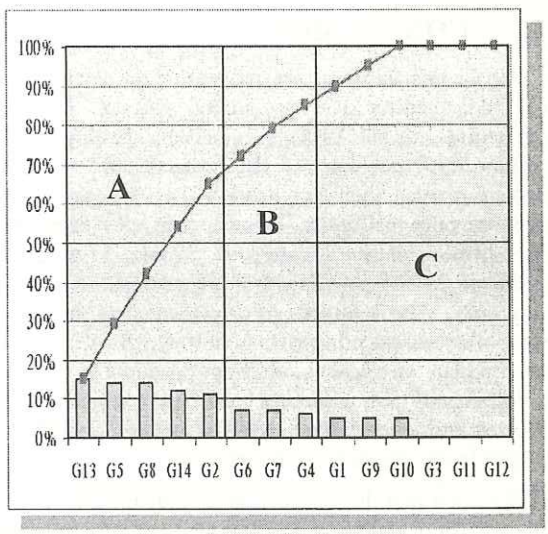


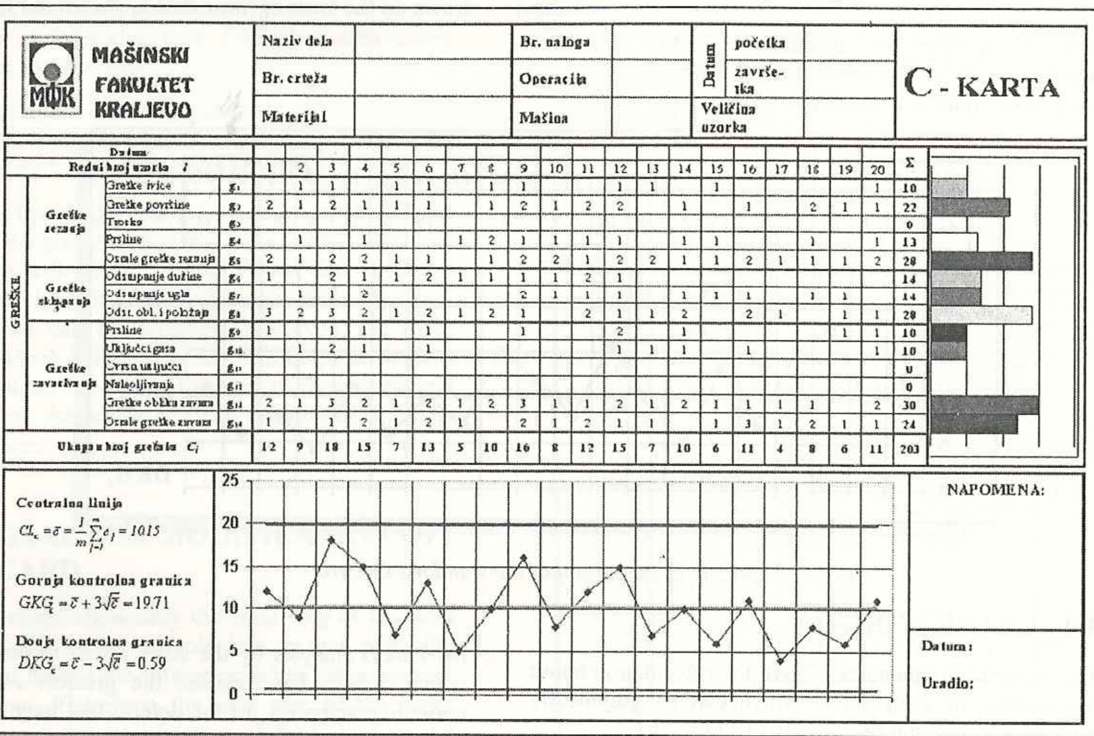
Figure 3: Pareto chart

Figure 4 presents the modified C-card by which defects that arise in the process of making a welded structure of a tool machine have been followed. All defects are classified in three groups according to JUS CT3.013, 014, 020 and 022:

- cutting defects
- assembly deffects (defects of shape and position) and

- welding defects,

and denoted with $g_1, g_2 \ldots g_{14}$.



				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Σ
Datum																								
Redni broj uzorka i				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Σ
GREŠKE	Greške rezanja	Greške ivice	g_1		1	1		1	1		1	1			1	1		1					1	10
		Greške površine	g_2	2	1	2	1	1	1		1	2	1	2	2		1		1		2	1	1	22
		Troska	g_3																					0
		Prsline	g_4		1		1			1	2	1	1	1	1		1	1			1		1	13
		Ostale greške rezanja	g_5	2	1	2	2	1	1		1	2	2	1	2	2	1	1	2	1	1	1	2	28
	Greške sklapanja	Odstupanje dužine	g_6	1		2	1	1	2	1	1	1	1	2	1									14
		Odstupanje ugla	g_7		1	1	2					2	1	1	1		1	1	1		1	1		14
		Odst. obl. i položaja	g_8	3	2	3	2	1	2	1	2	1		2	1	1	2		2	1		1	1	28
	Greške zavarivanja	Prsline	g_9	1		1	1		1			1			2		1					1	1	10
		Uključci gasa	g_{10}		1	2	1		1						1	1	1		1				1	10
		Čvrsti uključci	g_{11}																					0
		Nalepljivanja	g_{12}																					0
		Greške oblika zavara	g_{13}	2	1	3	2	1	2	1	2	3	1	1	2	1	2	1	1	1	1		2	30
		Ostale greške zavara	g_{14}	1		1	2	1	2	1		2	1	2	1	1		1	3	1	2	1	1	24
Ukupan broj grešaka C_i				12	9	18	15	7	13	5	10	16	8	12	15	7	10	6	11	4	8	6	11	203

Figure 4: Presentation of the proposed C- cart

4. CONCLUSION

Control cards are very applicable tools for determination of the capability of a production process. Althought attributive control cards give a considerably weaker insight into the state of the process than numerical control cards, their application is very useful and economically justifiable. This paper gives a proposal of modification of the C-card with the aim to point to a great number of new data that are possible to obtain in this way. The analysis of obtained data offers the possibility of selecting parameters which influence the occurrence of defects during production and the possibility of eliminating the parameters which have the greatest influence, which would result in a considerably higher level of quality of the product.

It is certain that the application of statistical methods in the control of production process is necessary both from the aspect of reduction of costs of quality and from the aspect of constant following of the process stability. The enterprises which want to reduce their costs of quality and improve the quality of their products must permanently work on the improvement of their quality systems, and it does not require only writing of procedures and determination of working processes but also constant innovation of tools and methods for quality improvement of the working procedure.

5. REFERENCES

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