JOURNAL OF ENGINEERING MANAGEMENT AND COMPETITIVENESS (JEMC)
VOL. 12, NO. 2, 2022, 142-150

ATTRIBUTIVE QUALITY OF PRODUCTS IN DECIBELS

DOI: 10.5937/JEMC2202142P

UDC: 621:005.6
Original Scientific Paper

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Paper received: 01.02.2022.; Paper accepted: 17.04.2022.

Traditional engineering can successfully define only the quality of measuring instruments and completed processes (*PCI* precision indices and *PPI* accuracy), while the quality of process results (semi-finished product, product, software, service) can only describe (good or bad quality, better or worse quality). In the modern consideration of quality, the quality of process results, today is defined by the number of decibels (dB), according to the discovery of the genius Japanese scientist Genichi Taguchi (1924 - 2012), pursuant to the Robust Technology Development Method. and standard ratio (*S/N*). Modern engineering considers the quality of process results, measuring instruments, and completing processes according to their quality characteristics (continuous, attributive). More often, continuous characteristics that can be more precisely defined are considered, while attribute characteristics can only be estimated. In this paper, four different types of process result quality with one attributive input variable are considered. After the calculations, the following results were achieved: in two classes with one type of error, poor quality results were obtained − 28.52, in two classes with two types of errors, the results obtained that the separation of A_2 is better than A_1 due to the difference of 7,532 dB, in the (*S/N*) ratio of the chemical reaction without side effects, the required results were obtained, in the methods of the ratio of the reaction rate of a chemical reaction with the side reactions, good quality results of 17.40 dB were obtained.

Keywords: Quality engineering; Quality of process results; Attributive characteristic.

INTRODUCTION

"Quality engineering" includes scientific principles and practices of quality assurance, as well as quality control of process results (semi-finished product, product, documentation, service). This term is newer and mainly refers to the chemical, construction, electrical and mechanical engineering. The history of quality has been created by many ingenious scientists discovering theoretical laws and well-known practitioners of innovative knowledge.

In the 17th century, the first scientists-inventors appeared (1711. De Moivre, 1713. Bernoully J, 1724. Bernoulli D, 1724. Laplace) with discoveries of probability and distributions of probabilities. Theoretical statistical discoveries were made in the 18th century (1805. Legendre, 1807. Gauss, 1854. Boole, 1857. Poisson, 1869. and Galton, 1880. Chebyshev). Most discoveries in the field of quality control were made in the 19th century (1900. Markov and Pearson, 1904. Spearman, 1905. Rayleigh, 1908. Gosset, 1912. Pareto, 1922. Fisher, 1924. Shewhart, 1928. Deming, 1929. Kolmogorov, 1938. Kendall, 1939 Weibull, 1941. Cochran, 1945. Wilcoxson, 1947. Bartlett, Mann, Whitney, and Dantzig, 1950. Mahalanobis, 1952. Anderson and Darling, 1953. Anscombe, 1962. Tukey and Johnson, 1964. Watson, 1964. Box, 1965. Shapiro, 1971. Cook, 1990. Yates). Finally, in the late 20th century, the latest theoretical and practical discoveries in the field of quality management were made (Smith, 1998; Taguchi, Subir, & Shin, 1999). These last two discoveries led to the emergence of Smith's new "Six Sigma System" and new "Taguchi Methods" of quality engineering. The inventor from New York Ing. William B. Smith, Jr. (1929 - 1993), "father of the Six Sigma system". He was educated at the

ISSN 2217-8147 (Online)

Available online at http://www.tfzr.uns.ac.rs/jemc

University of Minnesota (now known as the Carlson School of Management) and after nearly 35 years of work in engineering and quality assurance, he joined Motorola. There he was vice president and senior manager at Land Mobile and founded Motorola University and the Six-Sigma Institute. By implementing the Six Sigma system, Motorola had already saved more than $ 15 million in 2005. The six sigma system is a new way of improving the business of organizations, in the processes of designing, implementing, and delivering process results, by applying new theoretical discoveries and practical experiences. This system is based on the practical idea of W. B. Smith (1929-1993) that processes with a scatter size (σ), which have only a tolerance width of ± 6σ, have at least 3.4 losses per million realizations. This has led to a significant increase in the quality of the process results in the world, as an extension of the manufacturing tolerances concerning the size of the scattering has been achieved.

In 1957, the Japanese scientist Dr. Genichi Taguchi (1929 - 1993) discovered new methods of designing experiments by designing the smallest number of experiments with orthogonal rows (Design of Experiments). Then, in 1972, he set the magnitude/deviation ratio, which enabled the first value definition of the quality of process results (S / N Ratio) in decibels (dB). Afterwards, in 1981, he established the border function of realization of quality inline production (On-line Quality), and in 1982 the function of realization of quality in serial production (Off-line Quality). In 1984, he proposed a special design of process result parameters (Parameter Design), and a little later in 1984 a special design of process result tolerances (Tolerance Design). In 1986, Taguchi proposed a new way of considering quality in the special science of quality engineering, in the design, production, and delivery of process results (Quality Engineering). Then, in 1992, he laid the foundations for a new outstanding approach to Robust Technology Development. Subsequently, in 1994, he defined Taguchi Methods with 3 criteria: Nominal is the best, Smaller is better, and Larger is better. Finally, in 2002, he developed a special quality review strategy (Mahalanobis-Taguchi Strategy).

The business of organizations, in order to fully satisfy customers, stakeholders, and employees, largely depend on the achieved quality of process results, which is discussed in detail in Quality Engineering. The quality of process results is the level to which a set of quality characteristics effectively meets planned requirements and tasks. Quality engineering is a way of approaching anticipation or prevention of problems that may occur in the market, after the customer sells and uses the product in different circumstances and applied conditions, during the projected life of the product.

The quality of process results (semi-finished product, product, documentation, service) is characterized by its quality characteristics. Quality and reliability are the probability according to which the result of a process can perform its function, ie a set of characteristic quantities: Availability, Reliability, Security, Confidentiality, Integrity, and Maintenance.

The traditional understanding of quality takes into account the quality of process results, the quality of measuring systems, or the quality of completed processes. The quality of measuring systems and completed processes can be defined by a standardized (ISO 8258) Process Precision Index (*PCI*, *Cp*) or Process Accuracy Index (*PPI*, *Pp*). Unfortunately, the quality of process results can only be described in terms of attributes (there is or there is no quality, good or bad quality, better or worse quality, etc.).

Modern understanding of the quality of process results includes defining quality in decibels [dB], according to the findings of Japanese scientist Genichi Taguchi (1924-2012), whose methods cover the following main areas:

1. System design with Quality Loss Function (QLF) and Offline Quality Control (System design with Quality Loss Function (QLF) and Offline Quality Control (Logothetis, & Wynn, 1989; Nair, 1992; Taguchi, 1986, 1995),
2. Parametric design robust technology development and standard (S/N) ratio (Taguchi, 1984; Taguchi & Hiroshi, 1994; Taguchi, 1992; Taguchi & Rajesh, 2002; Taguchi et al., 2000, 2005; Taguchi et al., 2004; Wu & Hamada, 2002).
3. Tolerance design with criteria: Nominal is-best, Less-is-better, and More-better is better (Taguchi et al., 2005),
4. Design of experiments (DoE) with an orthogonal sequence of plans and multilevel experiments (Atkinson et al., 2007; Box, & Draper, 2007; Hardin & Sloane 1993; Moen et al., 1991).

The standard magnitude/variability ratio (signal-to-noise ratio, *S/N*) establishes the appropriate input quantity (*S*) and variability (*N*) ratio, which Taguchi used for applications in the communications industry, is to check the sound quality. Starting from the fact that the radio receives a signal or voice wave emitted from broadcast stations and converts it into sound, voice is the input quantity (signal), the received voice wave is the output signal (response), where input is mixed in space with output variability signal (noise). Thus, sound quality is expressed by the ratio of the input signal and variability in decibels [dB], and of course the higher the (*S/N*) ratio, the better the quality.

Attributive characteristics are often used for data collection and analysis, but from a quality engineering point of view, they are not good quality characteristics. Such characteristics do not have much information, so the calculations are inefficient and there is an interaction between the input values (control factors). The classified data here contain 0 and 1 and e.g. The number of defaults can be expressed by 1, and without defaults by 0. The result calculated from a mixture of defects and without defects looks like a continuous variable but is actually calculated from data 0 and 1. Even in the case of chemical reactions, the result is part of the substance which reacted within the whole substance, in units of molecules or atoms.

Attributive characteristics are very widely used for data collection and analysis, but from the point of view of quality engineering, they are not quality characteristics. Not much information can be collected by using only such characteristics, so the study would be ineffective and there would be an interaction between control factors.

METHODOLOGY

There is the following methodology to avoid such interactions:

a) avoid data 0-1,
b) when data with continuous variables cannot be measured due to lack of technology or other reasons, try to provide more than two classes, such as good, normal, and bad, or large, medium, and small, the more levels are classified, the more information is revealed, in this way, the trend of changing the control factor can be noticed and somewhat inaccurate conclusions can be avoided,
c) the best strategy is to use a function-based (*S/N*) ratio.

This assessment of product quality attributes features includes:

– two classes with one type of error,
– two classes with two types of errors,
– (*S/N*) the ratio of Chemical Reactions without Side Reactions.
– Reaction Speed ratio methods of Chemical Reaction with Side Reactions.

TWO CLASSES WITH ONE TYPE OF ERROR

The use of 0-1 data will reveal the interactions among control factors. Interaction is synonymous with inaudibility, and inconsistency. and inrepability. In two production processes, the fraction is defective in the production of the component, indicated by p= 0,10.

For example, we measured separately Three Measuring Blocks (countermeasures) to obtain the component, denoted by p= 0.10. Three counter-actions were taken separately to achieve the following outcomes:

A: material, A_1: current material (B_1C_1); p= 0.10, A_2: new material (B_1C_1); p= 0.02 ,
B: machine, B_1: current machine (A_1C_1); p= 0.10, B_2: new machine (A_1C_1); p= 0.04 ,
C: method, C_1: current method (A_1B_1); p= 0.10, C_2: new method (A_1B_1); p= 0.02

Such a method is called the *one-factor-at-a-time approach*. If arithmetic activity is assumed, the fraction defective under $A_2B_2C_2$ is calculated as:

$$p = 0.10 + (0.02 - 0.10) + \\ +(0.04 - (0.10) + (0.02 - 0.10) = -0.12 \,. \tag{1}$$

A negative fraction is unrealistic. To avoid such a problem it is recommended that one used the omega transformation, Following are the results of a test: y_1, values are either 0 or 1. Assume that 0 or 1 are good and defective products, respectively.

Letting the defective fraction be p, and the ratio (*S/N*) is calculated, so the data are decomposed and the total variation is (Taguchi, & Rajesh, 2002; Taguchi et al., 2004):

$$p = \frac{y_1+y_2+...+y_n}{n};$$
$$S_T = {y_1}^2 + {y_2}^2 + ... + {y_n}^2 = np. \quad (2)$$

The result of the signal (S_P) is calculated as a variation (p), so since equation (p) is a linear equation, (L) its variation is denoted by (S_P), where (D) is the number of units of equation (p):

$$S_p = \frac{L^2}{D};$$
$$D = \left(\frac{1}{n}\right)^2 + \left(\frac{1}{n}\right)^2 + ... + \left(\frac{1}{n}\right)^2 =$$
$$= n\left(\frac{1}{n}\right)^2 = \frac{1}{n}. \quad (3)$$

By adding (p) and (D) to equation (S_P), the error variation (S_e) is calculated by subtracting (S_P) from (S_T), so the ratio of (S/N) digital data is calculated as the ratio of signal variation to error variation in decibel units (dB), and (p = 0.0014) used in omega transformations:

$$S_P = \frac{p^2}{\frac{1}{n}} = np^2 = S_m;$$
$$S_e = S_T - S_P = np - np^2 = np(1-p), \quad (4)$$

$$S/N = 10 \log \frac{S_P}{Se} = 10 \log \frac{np^2}{np(1-p)} =$$
$$= 10 \log \frac{p}{1-p} = -10 \log\left(\frac{1}{p} - p\right). \quad (5)$$

Using the omega transformation, the omega value of each state is calculated and for the current state (T), condition $A_2B_2C_2$ is estimated to:

$$A_1B_1C_1(p = 0.10);\ \eta = -10 \log\left(\frac{1}{p} - p\right) =$$
$$= -10 \log\left(\frac{1}{0.10} - 1\right) = -9.54,$$

$$A_2B_1C_1(p = 0.02);\ \eta = -10 \log\left(\frac{1}{p} - p\right) =$$
$$= -10 \log\left(\frac{1}{0.02} - 1\right) = -16.90,$$

$$A_2B_2C_1(p = 0.04);\ \eta = -10 \log\left(\frac{1}{p} - p\right) =$$
$$= -10 \log\left(\frac{1}{0.04} - 1\right) = -13.80,$$

$$A_1B_1C_2(p = 0.02);\ \eta = -10 \log\left(\frac{1}{p} - p\right) =$$
$$= -10 \log\left(\frac{1}{0.02} - 1\right) = -16.90.$$

Assume that the current condition is T, the state of $A_2B_2C_2$ is estimated as follows:

$$S/N = -10 \log\left(\frac{1}{p} - p\right) = T + (A_2 - T) + (B_2 - T) +$$
$$+ (C_2 - T) = A_2 + B_2 + C_2 - 2T =$$
$$= A_2 + B_2 + C_2 - 2T = -16.90 - 13.80 - 16.90 -$$
$$- 2(-9.54) = -28.52,\ p = 0.0014.$$

Obtained results showed that these processes are not of good quality (S/N= − 28.52), due to all negative values (S/N) of the relationship, but it is still a slightly better process with existing material, machine, and method, which is the least negative S/N = − 9.54 (Taguchi, 1962; Wu, & Hamada, 2002; Wadsworth, 1997).

TWO CLASSES WITH TWO TYPES OF ERROR

To explain this case, a copper smelting process is used as an example. From copper ore (copper sulfide), metal copper is extracted to produce crude copper. It is desirable that all copper in the ore is included in the crude copper and to include all non-copper materials in the slag (waste). Actually, some impurities are included in the crude copper, and some copper is included in the slag. For example, Table 1. shows the input/output in the copper smelting process. In the table there are two types of faults: p, part of the copper included in the slag, and $q = 1-p$, is the fraction of the impurities included in the product. From Table 2., two types of mistakes: p, a fraction of copper included in the slag, and q, the fraction of impurities included in crude copper ingot, p is the fraction of copper mistakenly included in the slag, and ($1-p$) is called <u>*yield*</u>, is the fraction of noncopper materials included in the product. Both fractions are calculated by the fraction in weight, are calculated as follows:

$$p = \frac{Bp^*}{A(1-q^*) + Bp^*};\ q = \frac{Aq^*}{Aq^* + B(1-p^*)}. \quad (6)$$

Table 1: Input and output values of the smelting

Input	Output		Total
	Product	Slag	
Cooper	$A(1-q*)$	$Bp*$	$A(1-q*)Bp*$
Noncooper	$Aq*$	$B(1-p*)$	$Aq*B(1-p*)$
Total	A	B	A+B

Table 2: Input and output values with p and q

Input values	Output values		Total
	Product	Slag	
Cooper	$1-p$	p	1
Noncooper	q	$1-q$	1
Total	$1-p+q$	$p+1-q$	2

To compare p and q, when the furnace temperature is high, more copper melts into the product, therefore p decreases. However, at the same time, no more copper materials melt into the product, which increases (q). The factor, which decreases p but increases q is called the *tuning factor*. The tuning factor does not improve the process separation function of the process. A good separation function is to reduce both p and q simultaneously.

To find control factors that can reduce p and q together, it is important to evaluate the function after adjusting p and q on the same basis. For example, if you want to know which level of control factor, A_1 and A_2, there is a better separation of functions. Assume that p and q values for A_1 and A_2 are p_1, q_1, and p_2. q_2 respectively. According to the earlier, (p_1+q_1) with (p_2+q_2). cannot be compared Consequently, the data must be transformed in such a way that the comparison can be carried out on the same basis.

For this purpose, the standard ratio (*S/N*) is used, which is calculated after tuning, to get to the point where ($p = q$). This fraction is denoted by (p_0) and the standard ratio (*S/N*) is calculated as:

$$p_0=\frac{1}{1+\sqrt{\left(\frac{1}{p}-1\right)\left(\frac{1}{q}-1\right)}};$$

$$S/N=10\log\frac{(1-2p_0)^2}{4p_0(1-p_0)}. \quad (7)$$

For example, the aim was to separate *A* from the mixture of *A* and *B*. The separating functions of the two conditions were compared. Table 3. shows hypothetical results after separation. To calculate the standard (*S/N*) ratio, the results in the table are converted into fractions to obtain Table 4.

Table 3: Results of the experiment after separations

Separations	Input	Product	Slag	Total
A_1	A	1.025	3.975	5.000
	B	38.975	156.025	195.000
	Total	40.000	160.000	200.000
A_2	A	1.018	3.782	4.800
	B	38.982	256.218	195.200
	Total	40.000	160.000	200.000

Table 4: Results in a fraction

Separations	Input	Product	Slag	Total
A_1	A	0.20500	0.79500	1.00000
	B	0.19987	0.80013	1.00000
	Total	0.40487	1.59513	2.00000
A_2	A	0.21208	0.78792	1.00000
	B	0.19970	0.80030	1.00000
	Total	0.41178	1.58822	2.00000

Condition A_l and conditions A_1 and A_2 are:

$$p=\frac{3975}{5000}=0.79500\ ;\ q=\frac{3875}{195.000}=0.19987\ ,$$

$$p_0=\frac{1}{1+\sqrt{\left(\frac{1}{p}-1\right)\left(\frac{1}{q}-1\right)}}=\frac{1}{1+\sqrt{\left(\frac{1}{0.795}-1\right)\left(\frac{1}{0.19987}-1\right)}}=$$
$$=0.496602\ ,$$

$$S/N(A_1)=10\log\frac{(1-2p)^2}{4p_0(1-p_0)}=$$
$$=10\log\frac{[1-2\cdot 0.49602]^2}{4\cdot 0.49602(1-0.49602)}=-41.981\ dB\ .$$

$$S/N(A_2)=-34.449\ dB.$$

The obtained results showed that the separation of A_2 is better than the separation of A_1 due to the difference:

$$A_2-A_1=-34.449-(-41.981)=7.532\ dB.$$

(*S/N*) OF CHEMICAL REACTION WITHOUT SIDE REACTIONS

The nature of the function of a chemical reaction is to change the combining condition of molecules or atoms. In most cases, it is impossible to measure the behavior of individual molecules or atoms. Instead, only the unit, such as yield, can measure the behavior of an entire group. The yield used in chemical reactions sounds like a continuous variable, but it is a fraction of the number of molecules or atoms.

The basic function of a chemical reaction is to change the combining state of molecules or atoms. When substances *A* and *B* react to form material *C*, *A* and *B* collide and the molecules of *A* gradually decrease. In this case, it is ideal that reaction speed is proportional to the concentration of A": (A + B $\Rightarrow$ C). This is an example of classifying attribute data, for process characteristics without side reactions.

If the initial amount of the main raw material $A= Y_0$, and the amount at time $T= Y$, the proportion of the number of changes in time $T= Y/Y_0$ then the reaction rate is obtained with a reduced amount, which is differentiated by time:

$$\frac{d\frac{Y}{Y_0}}{dT} = \beta\left(\frac{1-Y}{Y_0}\right). \quad (8)$$

and from this equation arises:

$$\frac{Y}{Y_0} = 1 - e^{-\beta T}, \quad (9)$$

Previously shown amount in parentheses on the right gives the concentration (A), so as:

$$p_0 = 1 - \frac{Y}{Y_0}\,;\ p_0 = e^{-\beta T}\ , \quad (10)$$

The ideal zero-point proportional function is obtained by substituting ($-\ln p_0 = y$) in the last function, so the ideal zero-proportional function is obtained:

$$p_0 = e^{-\beta T}\ , -\ln p_0 = \beta \mathrm{T}\ , -\ln p_0 = y\ . \quad (11)$$

For example let (T) be the signal factor and the remaining fractions at different times (p_1, p_2,..., p_k) according to the table in Table 5. and also the ideal proportional relationship between other fractions and time.

Table 5: The remaining fractions at different times

Time	T_1	T_2		T_k
Fraction of remaining main raw material	p_1	p_2	...	p
$\ln\frac{1}{P_0}$	y_1	y_2	...	y_k

From the results in a table the variation of y_1, y_2,..., y_k is decomposed as follows - Total variations are broken down into variations due to generic function and variations caused by deviation from a generic function:

$$S_T = y_1^2, y_2^2, \ldots, y_k^2\ ,\ (f = k). \quad (12)$$

The proportional term of the variation, the linear equation, the effective divisor, and the variations of the error are shown in Table 6:

$$S_\beta = \frac{L^2}{\gamma},\ (f = 1);$$
$$L = y_1T_1 + y_1T_1 + \ldots + y_1T_1;$$
$$\gamma = T_1^2 + T_2^2 + \ldots T_k^2\ ;$$
$$S_e = S_T - S_\beta\ , (f = k-1)\ . \quad (13)$$

Table 6: ANOVA table for chemical reaction

Source	f	S	V	$E(V)$
β	1	S_β	...	$\sigma^2 + \gamma\beta^2$
e	$k-1$	V_e	...	σ^2
Total	k			

Relationship (S/N), and sensitivity assessment (S) are:

$$S/N = 10\log\frac{\frac{1}{\gamma}(S_e - V_e)}{V_e}\ ;$$
$$\eta \Rightarrow 10\log\frac{\beta^2}{\sigma^2}\ ;$$
$$S = 10\log\left(S_\beta - V_e\right);\ S \Rightarrow 10\log\beta^2\ . \quad (14)$$

REACTION SPEED RATIO METHODS OF CHEMICAL REACTION WITH SIDE REACTIONS

In chemical reactions, noise factors are not included in the experiment because of the cost increase. When there are side reactions, the reaction speed of side-reacted products (β_2), may be considered as noise, therefore, its (S/N) ratio is written as:

$$S/N = \frac{\beta_1^2}{\beta_2^2}\ . \quad (15)$$

In order to maximize the total reaction speed (β_1), denoted by (h_1), it is calculated using a larger-the-better characteristic. We also want to minimize the side-reacting speed (β_2), denoted by (h_2). The (S/N) ratio of (β_2) is calculated using a smaller-the-better characteristic. The two (S/N) ratios are added together to obtain the overall (S/N) ratio, denoted by (h), and also in the decibel scale:

$$S/N = S/N_1 + S/N_2\ ;\ S/N = 10\log\frac{\beta_1^2}{\beta_2^2}\ . \quad (16)$$

This is called the speed ratio method, and a sample of the data collection is also shown in Table 7:

$$\beta_{11} = \frac{y_{11}}{T_1}, \beta_{12} = \frac{y_{12}}{T_2}, \ldots, \beta_{1k} = \frac{y_{1k}}{T_k};$$
$$\beta_{21} = \frac{y_{21}}{T_1}, \beta_{22} = \frac{y_{22}}{T_2}, \ldots, \beta_{2k} = \frac{2k}{T_k}\ . \quad (17)$$

Table 7: Data collection for the speed ratio method

Time	T_1	T_2		T_k
M_1	y_{11}	y_{12}	…	y_{1k}
M_2	y_{21}	y_{22}	…	y_{2k}
M_1	β_{11}	β_{12}	…	β_{1k}
M_2	β_{21}	β_{22}	…	β_{2k}

(*S/N*) ratio of (M_1), (*S/N*) ratio of (M_1), and (*S/N*) ratio of the speed ratio method is:

$$\frac{S}{N_1}=-10\log\frac{1}{k}\left(\frac{1}{\beta_{11}^2}+\frac{1}{\beta_{12}^2}+\ldots+\frac{1}{\beta_{1k}^2}\right);$$
$$S/N_2=-10\log\frac{1}{k}\left(\beta_{11}^2+\beta_{22}^2+\ldots+\beta_{2k}^2\right), \qquad (18)$$

$$S/N=S/N_1+S/N_2\,. \qquad (19)$$

Since the generic function of reactions is defined, *B* is estimated from the of M_l and M_2 in Table 9:

$$y=\beta T;\; y=\ln\frac{1}{p};\; \beta=\frac{y}{T}; \qquad (20)$$

The values of β estimated under M_1 are larger-the-better, and the ones under M_2 are smaller-the-better. Therefore, the larger-than-better (S/N_1) ratio is calculated from the former β_1 values, and the smaller-the-better (*S/N*) ratio, (S/N_2) ratio, is calculated from the latter β_2 values. The (*S/N*) ratio of the operating window using the speed ratio method is calculated by:

$$S/N=S/N_1+S/N_2\,. \qquad (21)$$

Table 8. shows the estimates of β_1 (under M_1) and β_1 (under M_2). From table (S/N_1) and (S/N_2) are calculated:

$$\frac{S}{N_1}=-10\,log\frac{1}{10}\left(\frac{1}{\beta_{11}^2}+\frac{1}{\beta_{12}^2}+..+\frac{1}{\beta_{1\,10}^2}\right)-10\,log\frac{1}{10}\left(\frac{1}{0.275^2}+\frac{1}{0.0318^2}+\cdots+\frac{1}{0.2477^2}\right)=$$
$$=-25.17\text{ dB},$$

$$\frac{S}{N_2}=-10\,log\frac{1}{10}\left(\beta_{21}^2+\beta_{21}^2+\cdots+\beta_{1\,10}^2\right)=-10\,log\frac{1}{10}\left(0^2+0.0018^2+\cdots+0.0086^2\right)=$$
$$=42.57\text{ dB},$$

$$S/N=S/N_1+S/N_1=-25.17+42.57=17.40\text{ dB}.$$

The results obtained using the speed ratio method showed that this process has a good quality, due to all the positive values of the ratio (*S/N*) = 17.40 dB.

Table 8: Estimates of proportional constant

	Time $[h]$									
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
M_1: β_1	0.0275	0.0318	0.0803	0.1204	0.1731	0.2085	0.2237	0.2289	0.2342	2.4770
M_1: β_2	0.0000	0.0018	0.0033	0.0051	0.0086	0.0106	0.0107	0.0101	0.0093	0.0086

CONCLUSIONS

In traditional engineering, only the quality of measuring instruments and the quality of completed processes (*PCI* precision and accuracy indices, *PPI*) can be successfully defined, while the quality of process results (semi-finished product, product, software, service) can only be described as good orpoor quality/ better or worse quality). In modern consideration of quality, the quality of process results is now defined by the number of decibels (dB), according to the discovery of Japanese scientist Genichi Taguchi, using the Robust Technology Development Method and Standard Ratio (*S/N*).

The standard (*S/N*) ratio (signal-to-noise ratio, *S/N*) establishes the appropriate ratio of the values of input quantity (*S*) and variability (*N*), which Taguchi used for application in the communications industry, to check the quality of sound waves. Starting from the fact that the radio receives a signal or a wave of voice that is broadcast from broadcast stations and converts it into sound, the voice is the input quantity (signal), and the received voice is the output signal (response). The input is mixed in space with the variability of the output signal (noise), so the sound quality is expressed by the ratio of the value of the input signal and the variability in decibels [dB]. This paper considers the application of four different types of evaluation of the quality of process results, with one input value and continuous characteristics.

After the performed calculations, the following results were achieved:

– in two classes with one type of error, the obtained results showed that these processes are not of good quality ($S/N = -28.52$), due to all negative values (S/N) of the relationship, but it is still a slightly better process with existing material, machine, and method, which is the least negative $S/N = -9.54$.
– in two classes with two types of errors, the obtained results showed that the separation of A_2 is better than the separation of A_1 due to the difference: $A_2 - A_1 = -34.449 - (-41.981) = 7.532\ dB$.
– in (S/N) ratio of Chemical Reaction without Side Reactions, relationship (S/N), and sensitivity assessment (S) are:

$$S/N = 10 \log \frac{\frac{1}{\gamma}(S_e - V_e)}{V_e} ;$$
$$\eta \Rightarrow 10 \log \frac{\beta^2}{\sigma^2} ;$$
$$S = 10 \log \left(S_\beta - V_e\right) ;$$
$$S \Rightarrow 10 \log \beta^2 .$$

– in Reaction Speed ratio methods of Chemical Reaction with Side Reactions, the results obtained using the speed ratio method showed that this process has good quality, due to all the positive values of the ratio (S/N) = 17.40 dB.

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ATRIBUTIVAN KVALITET PROIZVODA U DECIBELIMA

Nažalost, tradicionalno inženjerstvo može uspešno definisati samo kvalitet mernih instrumenata i kvalitet završenih procesa, indeksima preciznosti i tačnosti *PCI* i *PPI*, a kvalitet rezultata procesa (poluproizvod, proizvod, dokumentacija, usluga) može samo opisati (dobar ili loš kvalitet, bolji ili lošiji kvalitet, itd.). U savremenom razmatranju kvalitet rezultata procesa se definiše brojem decibela (dB), prema otkriću genijalnog japanskog naučnika Genichi Taguchi (1924 - 2012), uz Robust Technology Development Method i sa standardnim oodnosom S/N. Savremeno inženjerstvo razmatra kvalitete mernih instrumenata, završenih procesa i rezultata procesa prema njihovim kontinualnim i atributivnim karakteristikama kvaliteta. Naravno češće se razmatraju kontinualne karakteristike koje se mogu preciznije definisati jer se atributivne karakteristike mogu samo proceniti. U ovom radu se razmatraju četiri različita tipa kivaliteta rezultata procesa, s jednom atributivnom ulaznom promenljivom. Proračunom su postignuti su sledeći rezultati: kod dveju klasa sa jednom vrstom greške dobijen je loš kvalitet (– 28.52 dB), kod dveju klasa sa dve vrste grešaka dobijeno je da je odvajanje A_2 bolje od A_1 zbog razlika od 7.532 dB, kod hemijske reakcije bez nuspojava dobijeni su traženi rezultati i u metodama odnosa brzine hemijske reakcije sa sporednim reakcijama, dobijen je dobar kvalitet od 17.40 dB.

Ključne reči: Inženjering kvaliteta; Kvalitet rezultata procesa; Atributna karakteristika.