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Models Quality of Electronics Products

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Introduction

Complex electronics products (EP) are defined in technical documentation as an entire series of parameters, the values of which determine the level of product quality. Parameters can be differentiated according to their importance regarding the implementation of purpose functions. International standard ISO-2859-0 recommends to divide parameters into two – A, B – or three – A, B, C – classes (groups). Here A – most important or significant parameters, and B, C – secondary or less significant parameters. Such classification of parameters is convenient when analyzing problems of multi-parametric product quality control. When imitational modeling is applied, stochastic models of quality level are required for separate parameters, their groups and for entire product [1-5].

In companies which utilize modern technologies databases of manufactured production and technological processes are constantly maintained and complemented. Data is often read and input automatically. By using computer networks and database control and analysis systems, information can be transmitted in real-time and can be used in decision making processes at each intermediate or final stage of manufacture. Thus there is a possibility to use information not only from the current but also from the previous stages of manufacture. That can increase the quality of EP [6-18].

Models of control quality

Inter-operational control fragment is presented in Fig. 1, which involves two stages of continuous control K_1 and K_2 (in both stages EP are classified according to analogical decision rules) [6].

Analyzing double-level control schematics shown in Fig. 1, when MP is described as ℓ-dimensional parameter vector [1, 2], $i = 1 - \ell$.

Here $\omega_i, \theta_i, \tau_i$ – defective MP probabilities by i-th parameter before first level K_1, before and after second level K_2. These are accidental values with densities $f_i(\omega_i), g_i(\theta_i), h_i(\tau_i)$ and distribution functions $F_i(\omega_i)$, $G_i(\theta_i)$, $H_i(\tau_i)$. Respectively ω, θ, τ – analogical characteristics for product by all controlled ℓ parameters.

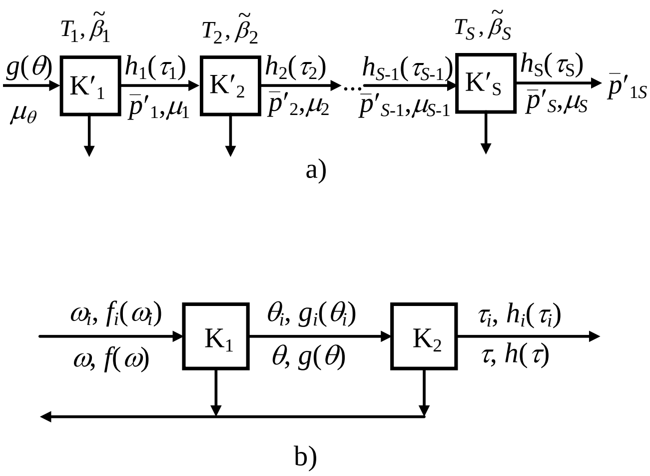

Fig. 1. Stochastic models of control quality: a – S stage; b – multi-parameter MP double level control

Analyzing double level control schematics shown in Fig. 2 [1], where electronics system is described as l-dimensional controlled parameters vector i=1-l

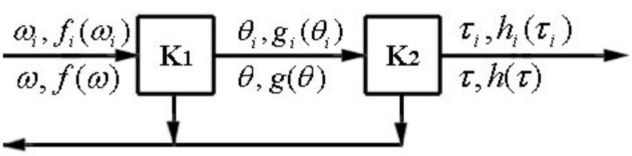

Fig. 2. Multiparameter electronics systems double level control and its probabilities characteristics.

In Fig. 2: ω_i, θ_i, τ_i – defected product probabilities by i-th parameter before first level K1, before and after second level K2. These values are accidental with densities $f_i(\omega_i)$, $g_i(\theta_i)$, $h_i(\tau_i)$ and distribution functions $F_i(\omega_i)$, $G_i(\theta_i)$, $H_i(\tau_i)$. Respectively ω, θ, τ – the analogical characteristics for product by all of the controlled l parameters. For the future analysis good electronics system probabilities by i-th parameter are needed:

$\xi_i = 1-\omega_i \quad \eta_i = 1-\theta_i \quad \kappa_i = 1-\tau_i$ – with accidental value densities:

$$\begin{aligned} &\ddot{\varphi}_i(\xi_i) = f_i(1-\xi_i), \\ &\varphi_i(\eta_i) = g_i(1-\eta_i), \\ &\dot{\varphi}_i(\kappa_i) = h_i(1-\kappa_i) \end{aligned} \tag{1}$$

and distribution formulas [2-4]:

$$\begin{cases} \ddot{\Phi}_i(\xi_i) = F_i(1-\xi_i), \Phi_i(\eta_i) = G_i(1-\eta_i), \\ \dot{\Phi}_i(\kappa_i) = H_i(1-\kappa_i). \end{cases} \tag{2}$$

Probability model analysis for EP

Let's assume that parameters of the system (Fig. 2) when using T-transformation are as defined: $\tilde{\beta}_1 = \tilde{\beta}_2 = 1/4; 1/10$ and $\mu_{\tau_1} = 0.1448$, with $\tilde{\beta}_2 = 1$, $\tilde{\beta}_1 = 0.1$; $(l=2)$, $\tilde{\beta}_i = 1/4$, $\tilde{\gamma}_i = 3/4$, $c_i = 3$; $a_i = 1$, $b_1 = 2$, $b_2 = 1$; $i = 1,2$;

$$\begin{cases} \overline{\mu}_{\tau_1} = 0.8552, \\ E\tau_1^2 = 0.04373, \\ \sigma_{\tau_1}^2 = E\tau_1^2 - \mu_{\tau_1}^2 = 0.02276. \end{cases} \tag{3}$$

Numerical characteristics for the second $i=2$ parameter coincide with [6] $i=1$ characteristics. When $i=1$, then $\mu_\tau = 1 - \overline{\mu}_{\tau_1}\overline{\mu}_{\tau_2} = 0.3867$; $\sigma_\tau^2 = 0.0606$; $\sigma_\tau = 0.2462$.

Densities after T transformation are:

$$\begin{cases} h_1(\tau_1) = \dfrac{8(1-\tau_1)}{(1+3\tau_1)^3}, \\ h_2(\tau_2) = \dfrac{4}{(1+3\tau_2)^2}, \\ h(\tau) = \dfrac{96(1-\tau)}{(7+9\tau)^3}\left\{\dfrac{41-9\tau}{7+9\tau}\ln\dfrac{(1-3\tau)^2}{1-\tau} - \right. \\ \left. -\left[\dfrac{8(7+9\tau)}{9(1-\tau)(1+3\tau)} - 3\tau + 11\right]\dfrac{1}{1+3\tau} + \dfrac{128}{9(1-\tau)} + 3 \right\}. \end{cases} \tag{4}$$

Since $\theta \sim Be(2,1)$ and $g(\theta) = 2\theta$ [1-3], then approximations $h_\Sigma(\tau)$ and $h_\sigma(\tau)$ of the density $h(\tau)$ coincide:

$$h_\sigma(\tau) \equiv h_\Sigma(\tau) = \frac{2\tau}{\tilde{\beta}^2(1+c\tau)^3}, \tag{5}$$

here $a_i = 1$, $b_1 = 2$, $b_2 = 1$, $\tilde{\beta}_i = 1/4$, and according to [6] $\tilde{\beta}$ is the solution for the equation:

$$\frac{1}{c}\left[\frac{2}{\tilde{\gamma}}\left(\frac{1}{\tilde{\gamma}}\ln\frac{1}{\tilde{\beta}} - 1\right) - 1\right] = \mu_\tau . \tag{6}$$

When $\mu_\tau = 0.3867$, $\tilde{\beta} = 0.2051$ ($\tilde{\gamma} = 0.7949$, $c = 3.8757$), we have

$$h_\sigma(\tau) = \frac{47.54\tau}{(1+3.876\tau)^3} . \tag{7}$$

If we assume $\tilde{\beta}_i = 0.1$, $\tilde{\gamma}_i = 0.9$, $c_i = 9$ ($a_i = 1$, $b_1 = 2$, $b_2 = 1$; $i = 1,2$), then we will have: $\mu_{\tau_1} = 0.0726$; $\overline{\mu}_{\tau_1} = 0.9274$; $\mu_{\tau_2} = 0.1732$; $\overline{\mu}_{\tau_2} = 0.8268$; $E\tau_1^2 = 0.01427$; $E\tau_2^2 = 0.07264$; $\sigma_{\tau_1}^2 = 0.00900$, $\sigma_{\tau_2}^2 = 0.04265$; $\sigma_{\tau_1} = 0.09487$; $\sigma_{\tau_2} = 0.2065$;

$\mu_\tau = 0.2332$, $\sigma_\tau^2 = 0.04322$; $\sigma_\tau = 0.2079$. In this case we will have:

$$\begin{cases} h_1(\tau_1) = \dfrac{20(1-\tau_1)}{(1+9\tau_1)^3}, \\ h_2(\tau_2) = \dfrac{10}{(1+9\tau_2)^2}, \\ h(\tau) = \dfrac{1.8(1-\tau)}{(1.9+8.1\tau)^3}\left\{\dfrac{28.1-8.1\tau}{1.9+8.1\tau}\ln\dfrac{(1+9\tau)^2}{1-\tau} - \right. \\ -21 + \dfrac{61.73}{1-\tau} - \dfrac{1}{1+9\tau} \times \\ \left.\left[(29-9\tau) + \dfrac{6.173(1.9+8.1\tau)}{(1-\tau)(1+9\tau)}\right]\right\}. \end{cases} \quad (8)$$

A separate case is when

$$h_\sigma(\tau) = \frac{362.3\tau}{(1+12.46\tau)^3}, \quad (9)$$

when $a_i = 1$, $b_1 = 2$, $b_2 = 1$, $\tilde{\beta}_i = 0.1$, $\tilde{\beta} = 0.0743$, $c = 12.46$, $\mu_\tau = 0.2332$; $\tilde{\beta}_1 = 0.1$, $\tilde{\beta}_2 = 1$, $\mu_{\tau_2} = \mu_2 = 0.5$; $\sigma_{\tau_2}^2 = \sigma_2^2 = 1/12$; $h_2(\tau_2) = g_2(\theta_2) = 1$; $\mu_\tau = 1 - \overline{\mu}_{\tau_1}\overline{\mu}_{\tau_2} = 0.5363$; then we will have that $\sigma_\tau^2 = \sigma_{\tau_1}^2\overline{\mu}_2^2 + \sigma_2^2(\overline{\mu}_{\tau_1}^2 + \sigma_{\tau_1}^2) = 0.09492$; $\sigma_\tau = 0.3081$, and

$$h(\tau) = \frac{10}{9}\left[1 - \frac{1}{(1+9\tau)^2}\right], \quad (10)$$

Table 1. Values of densities when $l = 2$, $h(0) = f(0) = 0$, case a: $a_i = b_i = 1$, $a^* = \dfrac{15}{7}$, $b^* = \dfrac{5}{7}$; case b: $a_i = 1$, $b_1 = 2$, $b_2 = 1$, $a = 2$, $b = 1$

Case a: $\tilde{\beta}_1 = 1/4$, $\tilde{\beta}_2 = 1/3$; $h(1) = f(1) = \infty$										
τ; ω	0.01	0.05	0.1	0.2	0.4	0.6	0.8	0.9	0.95	0.99
$h(\tau)$	0.115	0.484	0.792	1.102	1.194	1.082	0.957	0.921	0.930	0.987
$h_\Sigma(\tau)$	0.173	0.651	0.955	1.143	1.081	0.971	0.939	1.001	1.106	1.424
$h_\sigma(\tau)$	0.115	0.633	0.970	1.173	1.077	0.939	0.896	0.975	1.126	1.708
$f(\omega)$	0.0008	0.0046	0.010	0.025	0.085	0.248	0.892	2.267	4.651	14.65
$f_\Sigma(\omega)$	0.0005	0.0027	0.006	0.016	0.062	0.218	0.973	2.696	5.402	13.34
$f_\sigma(\omega)$	0.0003	0.0018	0.005	0.014	0.058	0.217	0.999	2.724	5.298	12.76
Case b: $\tilde{\beta}_1 = \tilde{\beta}_2 = 1/4$; $h_\Sigma(\tau) \equiv h_\sigma(\tau)$										
τ	0.01	0.02	0.05	0.1	0.2	0.4	0.6	0.8	0.9	1
$h(\tau)$	0,295	0,552	1,175	1,604	1,763	1,275	0,812	0,508	0,401	0,313
$h_\sigma(\tau)$	0,424	0,760	1,398	1,780	1,700	1,147	0,776	0,552	0,473	0,416
Case b: $\tilde{\beta}_1 = \tilde{\beta}_2 = 0.1$; $h_\Sigma(\tau) \equiv h_\sigma(\tau)$										
τ	0.01	0.02	0.05	0.1	0.2	0.4	0.6	0.8	0.9	1
$h(\tau)$	1,960	2,615	3,729	3,389	1,986	0,725	1/3	0,181	0,140	0,116
$h_\sigma(\tau)$	2,547	3,717	4,238	3,198	1,702	0,676	0,357	0,220	0,179	0,149
Case b: $\tilde{\beta}_1 = 0.1$, $\tilde{\beta}_2 = 1$; $h_\Sigma(\tau) \equiv h_\sigma(\tau)$										
τ	0.01	0.02	0.05	0.1	0.2	0.4	0.6	0.8	0.9	1
$h(\tau)$	0,176	0,313	0,583	0,803	0,969	1,059	1,084	1,095	1,098	1,100
$h_\sigma(\tau)$	0,085	0,165	0,376	0,645	0,972	1,182	1,157	1,062	1,007	0,952

Table 1 (Continued). Values of densities when $l=2$, $h(0)=f(0)=0$, case a: $a_i=b_i=1$, $a^*=\frac{15}{7}$, $b^*=\frac{5}{7}$; case b: $a_i=1$, $b_1=2$, $b_2=1$, $a=2$, $b=1$

Density $h(\tau)$ maximum value h_M at the mode point $\tau=\tau_M$									
Case	1			2, $\tilde{\beta}_i=1/4$		2, $\tilde{\beta}_i=0.1$		2, $\tilde{\beta}_1=0.1$, $\tilde{\beta}_2=1$	
Approximation*)	–	„ σ “	„ Σ “	–	„ σ “≡„ Σ “	–	„ σ “≡„ Σ “	–	„ σ “≡„ Σ “
τ_M	0,342	0,226	0,239	0,172	0,129	0,060	0,040	–	0,454
$h_M=h(\tau_M)$	1,204	1,179	1,152	1,779	1,817	3,773	4,308	–	1,188

*) Approximation „ σ “, when $h(\tau)\to h_\sigma(\tau)$, and „ Σ “, when $h(\tau)\to h_\Sigma(\tau)$.

A very important case is when $a_i=1$, $b_1=2$, $b_2=1$, $\tilde{\beta}_1=0.1$, $\tilde{\beta}_2=1$, $\tilde{\beta}=0.0476$, $c=1.1$. Then

$$h_\theta(\tau)=\frac{8.823\tau}{(1+1.1\tau)^3}. \qquad (11)$$

Values of densities and their approximations are given in Table 1 and graphical representations of the densities are given in Fig. 3–7.

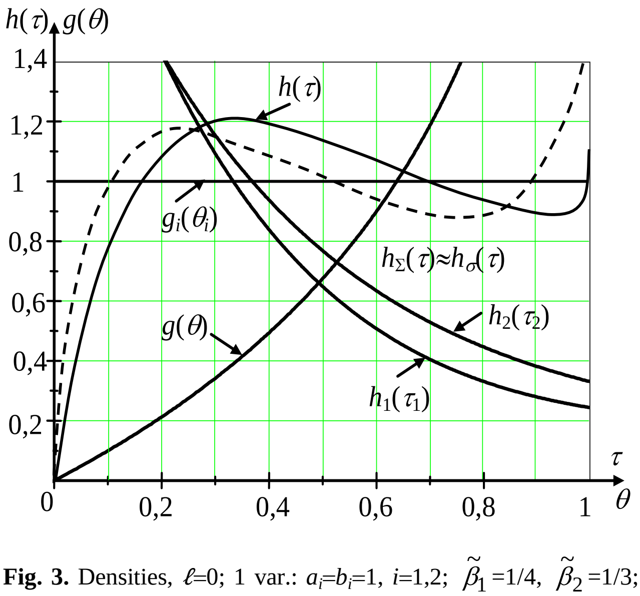

Fig. 3. Densities, ℓ=0; 1 var.: $a_i=b_i=1$, i=1,2; $\tilde{\beta}_1$=1/4, $\tilde{\beta}_2$=1/3; T, - - - - - approximated density

It is obvious that under small values of $\tilde{\beta}_i$ ($\tilde{\beta}_i \le 1/8$) the maximal value of density $h_\sigma(\tau)$ approximated for T transformation is $h_{M\sigma}=h_\sigma(\tau_{M\sigma})$ at the mode point $\tau=\tau_{M\sigma}$ and it is higher than the maximal value of the density $h(\tau)$ which equals $h_M=h(\tau_M)$ at the mode point $\tau=\tau_M$, since we use $\tilde{\beta}=const$ for approximation even though the real $\tilde{\beta}$ value varies from $\tilde{\beta}(0)=1/2(\tilde{\beta}_1+\tilde{\beta}_2)$, when $\tau=0$, to $\tilde{\beta}(1)=\tilde{\beta}_1\tilde{\beta}_2$, when $\tau=1$. In order to equalize the maximums of both densities the higher value of $\tilde{\beta}$ should be applied: $\tilde{\beta}^*>\tilde{\beta}$, since under small τ values the real value of $\tilde{\beta}$ increases [8-18].

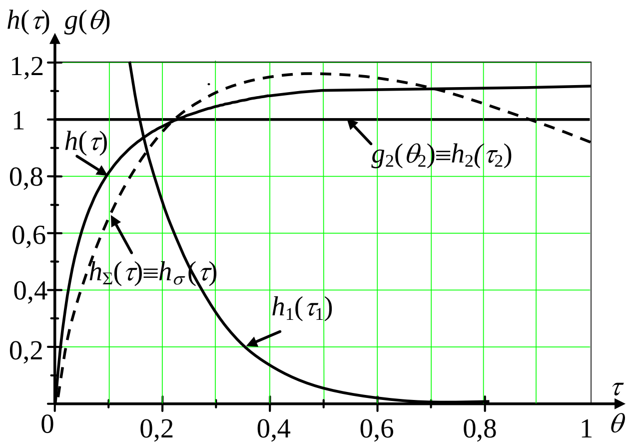

Fig. 4. Densities, ℓ=2; 2 var.: a_i=1, b_1=2, b_2=1; $\tilde{\beta}_1$=0,1, $\tilde{\beta}_2$=1; T

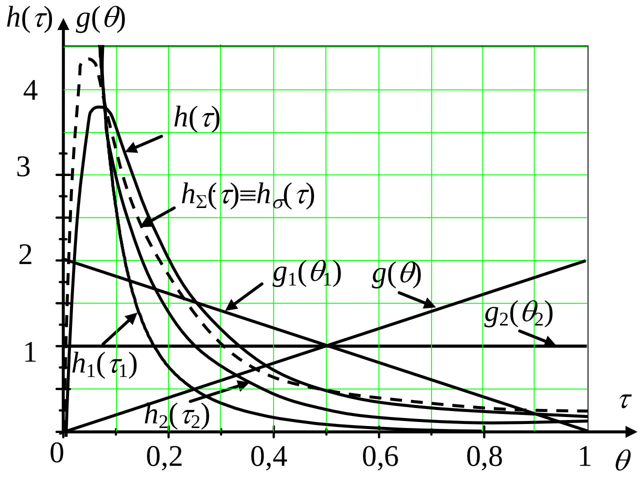

Fig. 5. Densities, ℓ=2; 2 var.: a_i=1, b_1=2, b_2=1; $\tilde{\beta}_1=\tilde{\beta}_2$=0,1, T

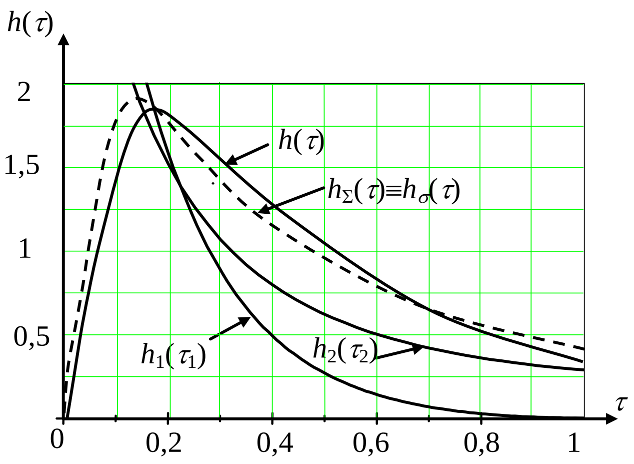

Fig. 6. Densities, ℓ=2; 2 var.: a_i=1, b_1=2, b_2=1; $\tilde{\beta}_1 = \tilde{\beta}_2$ =1/4; T

For the experiment, when $a = 2$, $b = 1$, mode $\tau_{M\sigma} = \frac{1}{2} c$ [1], and $h_{M\sigma} = 8/\left(27\tilde{\beta}\tilde{\gamma}\right)$, when $\tilde{\gamma} = 1 - \tilde{\beta}$, $c = \tilde{\gamma} / \tilde{\beta}$. Maximums of densities $h(\tau)$ and $h_\sigma(\tau)$ coincide when $\tilde{\beta}^* = \frac{1}{2} - \sqrt{\frac{1}{4} - \frac{8}{27 h_M}}$. When $\tilde{\beta}_i = 0.1$, we have $h_M = 3.773$ under $\tau_M = 0.06$, $\tilde{\beta} = 0.0743$ and $\tilde{\beta}^* = 0.086$. Then the corrected density $h_\sigma(\tau) \to h_\sigma^*(\tau)$ is $h_\sigma^*(\tau) = \frac{271\tau}{(1 + 10.64\tau)^3}$ with mode $\tau_{M\sigma}^* = 0.047$ and $h_{M\sigma}^* = h_M = 3.773$. However in the interval $\tau_M < \tau < 1$ with $h_\sigma^*(\tau)$ the approximation worsens and $h_\sigma^*(1) = 0.172$. Multiparametric ES is widely discussed in [5].

Conclusions

Obviously double and triple parameter electronics systems exact and approximated densities models for engineering purposes are quite similar. In that case, it is better to use approximated densities $h_\varepsilon(\tau)$ or $h_\delta(\tau)$ and $f_\varepsilon(\omega)$, $f_\delta(\omega)$ in multiparameter electronics system quality control modeling, to avoid complicated integration process to find $h(\tau)$ or $f(\omega)$ and guarantee enough precision for engineering calculations (modeling).

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This publication is about continuous between-operational control main probabilities characteristics modelling techniques for multilevel EP, when separate independent parameters defect level probabilities distributions are set (known) in chosen control schematics place. Denied EP streams go back to production process for regeneration and classification rules, in different control levels, are similar. Made EP defect level probability density direct and reverse transformations models by separate parameter levels densities transformations. Offered to use approximated models instead of whole EP defect level probabilities density transformed models because of complicated process of integration and models get more simple expressions. Ill. 6, bibl. 18 (in English; abstracts in English, Russian and Lithuanian).

Д. Эйдукас, Р. Кальнюс. Модели контроля электронных изделий // Электроника и электротехника. – Каунас: Технология, 2010. – № 2(98). – С. 29–34.

Предложена методика моделирования основных вероятностных характеристик системы сплошного контроля мехатронных изделий, когда заданы (известны) вероятностные распределения уровней дефектности по отдельным независимым параметрам в нужной точке схемы контроля. Потоки забракованных изделий возвращаются в процесс производства для регенерации, а правила классификации изделий на отдельных ступенях контроля одинаковы при наличии существенных ошибок классификации по отдельным параметрам. Представлены расчётные модели основных вероятностных числовых характеристик (математическое ожидание и дисперсия), когда отдельные параметры описываются бета распределением. Ил. 6, библ. 18 (на английском языке; рефераты на английском, русском и литовском яз.).

D. Eidukas, R. Kalnius. Elektroninių gaminių kontrolės modeliai // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2010. – Nr. 2(98). – P. 29–34.

Pateikta daugiaparametrių EP ištisinės tarpoperacinės kontrolės pagrindinių tikimybinių charakteristikų modeliavimo metodika, kai atskirų nepriklausomų parametrų defektingumo lygių tikimybių skirstiniai yra duoti (žinomi) pasirinktoje kontrolės schemos vietoje. Išbrokuotų EP srautai grąžinami į gamybos procesą regeneruoti, o klasifikavimo taisyklės atskirose kontrolės pakopose analogiškos, esant nepaneigtinoms EP klasifikavimo pirmos ir antros rūšies klaidoms pagal atskirus parametrus (geras brokuojamas arba blogas pripažįstamas geru). Pasiūlyta vietoj tikslių visos EP defektingumo lygio tikimybių tankio transformuotų modelių taikyti aproksimuotus modelius, kuriems sudaryti nereikalinga sudėtinga integravimo procedūra, o patys modeliai įgauna gerokai paprastesnę išraišką. Il. 6, bibl. 18 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).