Multi-criteria optimization of quality and reliability providing processes of electronic devices

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Abstract **This paper describes the method of electronic devices manufacturing optimization by technical and economic criteria.**
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The process of manufacturing electronic devices is characterized by multi-step structures. Each step is intended for realization of the set task, namely formation of products set properties including obtaining appropriate parameters of quality and reliability. In the process of manufacturing the flows of defects are formed that are compressed as a result of technological operations and rarefied when carrying out control operations. The flow of defects determines products quality level, which causes the flow of failures during the operation time. Research into correlation links between them allows you to set a quantitative relationship for concrete steps of manufacturing.

The final step is characterized by a system of reflections:

$$\begin{aligned}
&\varepsilon_{n,1} : \omega^{\partial}_{n,1}(t) \to \omega_{n,1}(t);\\
&\varepsilon_{n,2} : \omega^{\partial}_{n,2}(t) \to \omega_{n,2}(t);\\
&\cdots\cdots\cdots\cdots\\
&\varepsilon_{n,n} : \omega^{\partial}_{n,n}(t) \to \omega_{n,n}(t),
\end{aligned} \qquad (1)$$

where: $\varepsilon_{n,i}(t) = \dfrac{\omega_{n,i}(t)}{\omega^{\partial}_{n,i}(\tau)}$ is the coefficient of manufacturing defects flow conversion $\omega^{\partial}_{n,i}(\tau)$ in to the failure flow $\omega_{n,i}(t)$.

Here and below: τ is the time in units accepted to assess the duration of a technological series of products;

T is the time in units accepted to assess the duration of products operation time;

n is the number of steps of technological processes, $i=\overline{1,n}$ is the number of quality parameters. The functional efficiency of the complete process estimated by the probability to fulfill the assignment $P_{в3.n}$ in the form of recurrent functions:

$$P_{в3.n}=P(P_{пр.n.i};\ \omega^{\partial}_{n,i}(\tau);\ \omega_{n,i}),\ i=\overline{1,n}, \qquad (2)$$

where $P_{в3.n.i}$ is the probability of manufacturing defects pass from the n-th step of the process for i-th quality parameter.

The economic effectiveness of the process is estimated by the total costs C_Σ on the formation of quality parameters at every step, quality control and warranty service of products at the customer site:

$$C_\Sigma = C_1 + C_2 + \ldots C_n. \qquad (3)$$

In the complex effectiveness assessment of the processes of providing products quality and reliability by means of two criteria - probability of the assignment $P_{в3.n}$ and total production costs C_Σ, each of them can be a major. Thus, there are two main variants for the process optimization task. The first one is considered as a direct task to provide of a given value of the main criterion - probability of the assignment $P_{в3.n}$ with minimal production costs C_Σ:

$$\begin{aligned}
&P_{в3.n} \geq P_{в3.n.зад}\\
&C_\Sigma \to \min\\
&C_1 \in G_{C_1}\\
&C_2 \in G_{C_2}\\
&\cdots\cdots\\
&C_n \in G_{C_n},
\end{aligned} \qquad (4)$$

where $P_{в3.зад}$ is the set value of probability of the task fulfillment;

G_{C_i}, $i=\overline{1,n}$ is the range of acceptable variables C_i.

The second variant is the task of providing acceptable value of the main criterion - the total production cost C_Σ at the maximum attained value of $P_{в3.n}$. This inverse task is given on:

$$\begin{aligned}
&C_\Sigma \leq C_{\Sigma доп}\\
&P_{в3.n} \to \max\\
&P_{в3.n,1} \in G_{P_{в3.n.1}}\\
&P_{в3.n,2} \in G_{P_{в3.n.2}}\\
&\cdots\cdots\cdots\\
&P_{в3.n,n} \in G_{P_{в3.n.n}}
\end{aligned} \qquad (5)$$

where $C_{\Sigma доп}$ is the acceptable value of total costs; $G_{P_{в3.n.i}}$, $i=\overline{1,n}$ is the range acceptable variables $P_{в3.n.i}$.

The proposed approach to the pass-through probabilistic modeling and optimization of process of providing products quality and reliability by technical and economic criteria, without limitations on the complexity of the structures and physical nature of the processes. The developed mathematical apparatus with using the universal criteria of quality is suitable for improvement of manufacturing of a wide-class technical objects, performing decomposition procedures and complex systems synthesis, solving the task of their complex optimization.