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# THE INFLUENCE OF EQUIPMENT RELIABILITY ON THE STABILITY OF MANUFACTURING OPERATIONS AND EFFICIENCY OF AUTOMATED PRODUCTION SYSTEMS

The influence of equipment reliability on stability of manufacturing operations and efficiency of automated production systems in the furniture industry is analized. The modern methods of determining reliability to meet the challenges of improving the functioning of the automated industrial systems furniture factories. Reliability of equipment has a significant impact on the stability of the process and on the actual performance of automated lines. Reduced reliability leads to a significant reduction in the actual performance automated lines and reduce the stability of manufacturing operations. Improve the reliability of the automated industrial systems using expedient development schemes equipment layout, structural and parametric optimization, redundancy and structural simulation.

**Keywords:** reliability of equipment, parameter stability, technological indexes of efficiency, automated production systems, imitation design, structurally and parametric optimization, reservations.

Study features furniture production process shows that it is constantly influenced by various random factors. Therefore, the length transactions furniture production values are random because they depend on such random influences: size-quality characteristics of raw materials, safety equipment, process organization [1-19]. Furniture parts are characterized by size and physical properties that accept different values in a certain range of changes. Between these values there is no definite constant communication parameters of raw materials have properties of random variables. Elements cycle time manufacturing operations in furniture production include the working pace, duration and idle stroke cycle time losses. Loss of time outside working cycle created especially unreliable technology, shortcomings in the organization of labor and other factors of external influence. To restore the normal functioning of the machine process requires some time. Time spent on the restoration of normal equipment operation intervals increase the duration of release and reduce the actual performance machines. Thus, the operation of the machines there is a consistent alternating two different periods – periods of continuity and recovery periods working condition of the machine. Uptime machine technique called time operating time $\mathbf{t_н}$, and its operability during recovery – recovery time $\mathbf{t_в}$.

The relationship between these parameters determines the level of technical equipment and the efficiency of its use in production. It is estimated fate uptime $\mathbf{t_н}$ or coefficient of readiness. The coefficient of readiness $\boldsymbol{K_г}$ availability index is a comprehensive measure of the reliability and sets the expectation of the time of normal operation of the automated line:

$$K_Г = t_н/(t_н + t_в) \qquad (1)$$

Significantly affect the efficiency of automated production systems in furniture manufacture reliable technical equipment, production equipment, means of control. Unreliable technology, shortcomings in the organization of work, factors outside influence causing loss of time operation of process equipment. Reliability of equipment entails considerable influence on the stability of manufacturing operations and efficiency of automated production systems. According to a number of studies [1, 2] expectancy distributed manufacturing operations by Erlang distribution, used to describe the process operations furniture production:

$$F(t) = p\{\tau < t\} = 1 - e^{-K\cdot\mu\cdot t} \cdot \sum_{i=1}^{k=1} \frac{(K\cdot\mu\cdot t)^i}{i!}, \qquad (2)$$

where: ***F (t)*** – distribution function of the time intervals; p{τ<t} – the probability that the duration of the operation will be less than a certain value ***t***; $\mu$ – intensity operations; **K** – Erlang parameter that describes the technological stability operations. Erlang parameter defined as the ratio to the square of the average duration of the operation to its variance:

$$K = t^2/D(t) \qquad (3)$$

Depending on the size of the dispersion parameter K may take different values ranging from 1 to $\infty$. At **K=1** when the variance of length transactions equal to its average value, we get the distribution to describe purely random processes. In the absence of dispersion when the duration of the operation constant parameter K infinitely large ($K \to \infty$). Because of this property allows Erlang distribution to describe a wide range of manufacturing operations length with varying degrees of unevenness from a purely accidental to a permanent, inclusive. Dispersion interval release describes stability technology determined by the formula

$$D(t_{IB}) = \frac{\overline{t_H} - \overline{t_Ц}}{\overline{t_H}}\left(D_Ц + \overline{t_Ц}^2\right) + \frac{\overline{t_Ц}}{\overline{t_H}}\left[D_Ц + D_B + \left(\overline{t_Ц} + \overline{t_B}\right)^2\right] - \left(\frac{\overline{t_Ц}}{K_Г}\right)^2 == D_Ц + \frac{\overline{t_Ц}}{\overline{tн}}\left[D_B + \overline{t_B}^2\left(1 - \frac{\overline{t_Ц}}{\overline{t_H}}\right)\right]., \qquad (4)$$

where $\mathbf{D_ц}$, $\mathbf{D_в}$ – variance cycle; $\mathbf{t_ц}$ – cycle of technological operations.

Thus dependence (4) defines the dispersion length interval output for specific parameters cycle time, equipment uptime and recovery time its operability. With equipment reliability theory we know that the average time between failure $\mathbf{t_н}$ and recovery time $\mathbf{t_в}$ linked by (1). Therefore, the variance range of output can be expressed in terms of availability factor:

$$D_{IB} = D_Ц + \frac{\overline{t_Ц}}{\overline{t_H}}\left[D_B + \left(1 - \frac{\overline{t_Ц}}{\overline{t_H}}\right)\left(K_Г^{-1} - 1\right)^2 \overline{t_H}^2\right], \qquad (5)$$

Parameter Erlang $\mathbf{K_{iв}}$ production interval is calculated using the ratio

$$K_{IB} = \frac{\overline{t_{IB}}^2}{D_{IB}} = \frac{\overline{t_Ц}^2 / K_Г^2}{D_Ц + \overline{t_Ц}^2\left(\frac{1}{K_Г} - 1\right)^2\left(2\frac{\overline{t_H}}{\overline{t_Ц}} - 1\right)} == \left[\frac{K_Г^2}{K_Ц} + \left(2\frac{\overline{t_H}}{\overline{t_Ц}} - 1\right)\left(1 - K_Г\right)^2\right]^{-1}. \qquad (6)$$

Stability of technological operations is determined by the Erlang $\mathbf{K_ц}$ cycle time and depends on the readiness coefficient $\mathbf{K_г}$ machines. Only perfect machine ($\mathbf{K_г}$ =1) parameter $\mathbf{K_{iв}}$ remains at its value for the duration of the cycle $\mathbf{K_ц}$. Parameter Stability $\mathbf{K_ц}$ cycle shows a strong influence on the reliability of machines allowed only in the range of $\mathbf{K_ц}$=1 to $\mathbf{K_ц}$=2. This limits availability factor quite high ($\mathbf{K_г}$=0.90-0.98).

To ensure this reliability in terms of furniture production difficult. Further growth cycle stability parameter $\mathbf{K_ц}$ has little effect on the permissible reliability of the machine. Thus appears essential primary stability ordering cycle time. More intensive and broader range of acceptable reliability affects the relative length of time of use.

Completed simulations using statistical research and analysis of the literature [1, 2], allows to formulate the following conclusions: Reliability technological equipment creates a significant impact on the stability of manufacturing operations and efficiency of automated production systems in furniture production. Reduce the reliability of equipment leads to a significant increase in the dispersion intervals output. The results of simulation modeling confirms that the average duration of intervals of output is determined by the mean time rate of technological operations and readiness of the machine.

The solution to these problems, along with other technical and organizational measures will significantly improve the reliability of automated production systems.

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## Вплив надійності обладнання на стабільність технологічних операцій та ефективність функціонування автоматизованих виробничих систем

Аналізується вплив надійності обладнання на стабільність технологічних операцій та ефективність функціонування автоматизованих виробничих систем у меблевому виробництві.

Розглядаються сучасні методи визначення надійності для вирішення завдань підвищення ефективності функціонування автоматизованих виробничих систем на меблевих підприємствах. Надійність обладнання має значний вплив на стабільність процесів та фактичну продуктивність автоматизованих ліній. Зниження надійності зумовлює значне зниження фактичної продуктивності автоматизованих ліній і зниження стабільності технологічних операцій.

Підвищувати надійність автоматизованих виробничих систем доцільно за допомогою розроблення схем компонування обладнання, структурно-параметричної оптимізації, структурного резервування та імітаційного моделювання.

**Ключові слова:** надійність обладнання, параметр стабільності, технологічні показники ефективності, автоматизовані виробничі системи, імітаційне моделювання, структурно-параметрична оптимізація, резервування.