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On The Choice of an Algorithm for Optimizing the Parameters of Spring Flashing of Rail Crews

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Indicators of the quality of functioning of the rail crew with given mass and, as m_i well as geometric characteristics, are completely determined by the parameters of its spring suspension − spring stiffness J_i and attenuation coefficients of $æ_i$ β_i vibration dampers. When choosing these parameters, it should be borne in mind that they have an ambiguous effect on the dynamic properties of the crews and, consequently, on their quality indicators. On the one hand, an increase in the coefficient attenuation reduces the amplitudes of the coordinate and improves the safety factor of the structural deflection of the springs. On the other hand, such a decrease leads to an increase in active forces in spring suspension and, especially, accelerations in the resonant region, which worsens such quality indicators u_i (where $i = 1,\ 2,\ ...,\ n$) as maximum body accelerations and dynamic overload coefficients.

Therefore, the problem of choosing the parameters of spring suspension can be considered as the task of finding a compromise between two contradictory effects − a decrease in some quality indicators and an increase in others. To find such a compromise, it is best to use methods of optimization of technical systems. Such methods are based on finding the minimum of a certain ***objective function*** $\ddot{O}$ that describes analytically the purpose of the procedure being performed.

At the same time, the most reasonable would be the objective function in the form of a minimum of total costs for the production and operation of the rail crew. However, due to the complexity of this approach, objective functions are used in practice in $\ddot{O}$ the form of linear and nonlinear combinations of quality indicators taken with different weight coefficients. Such combinations are called additive if the individual indicators are summed up and ***multiplicative*** if the individual measures are multiplied.

With this approach, there may be some arbitrariness in the choice of weight coefficients and the incorrectness of the solution of the problem due to the presence of functional dependencies between individual quality indicators. Free from these shortcomings are the target functions in the form of a function $\ddot{o}_1$ of total permissible losses and in the form of the total intensity of emissions of quality indicators beyond their permissible values $\ddot{o}_2$, the use of which to solve the problems of optimizing the parameters of spring suspension will be considered below.

However, in our experience, the best results are obtained by the methods of the deformable Nelder–Mead polyhedron [2, 4] and random search [1, 3]. Since the goal of optimization was formulated as the need to find a compromise between the contradictory consequences of changing the parameters of the system, the optimization problem can be reduced to the following algorithm.

At the first stage, the minimization of each particular quality criterion (where u_i), i.e., the selection of a set of parameters is carried out $i = 1,\ 2,\ ...,\ n$ so as to ensure the minimum of each particular criterion. At the same time, the values of all other indicators are recorded. As a result of this procedure, a dimensional set of parameters will be obtained, $\left[æ_j, \beta_j\right]$ where l − l the number of minimized quality indicators. Usually, when solving such a problem, a limited number of optimized quality criteria are selected, for example, the maximum acceleration of the body at its various points ($i = 1,\ 2,\ ...$) and the coefficients of dynamic overloads at various stages of its suspension ($j = 1,\ 2,$). Other quality indicators, such as the safety factor of the structural deflection of the springs, the stability of the body from overturning, the stability of the wheel against derailment, smoothness, etc., are transferred to the category of restrictions.

At the second stage, the objective function is minimized $\ddot{O}_1$ in the form of a function of total permissible losses, which describes the conditions of the trade-off:

$$Ц_1 = \sqrt{\frac{1}{l}\sum_{i=1}^{l}\left(\frac{u_i - u_i^*}{\left[u_i\right] - u_i^*}\right)^2}, \qquad (1)$$

where u_i are the values of the partial quality criterion that will be found at the second stage, as a result of minimizing this objective function;

$\left[u_i\right]$ - normative values of particular quality criteria;

u_i^* - minimum values of particular criteria found at the first stage of optimization.

The numerator of the root expression in (1) determines the deviation of the optimal value of the quality indicator from its possible minimum value. This suggests that it is impossible to realize the minimum value of all quality indicators u_i^* by selecting the parameters, $\left[æ_j, \beta_j\right]$ but it is necessary to degrade these values to u_i^* the value of u_i, but so that the sum of relative deteriorations $\frac{u_i - u_i^*}{\left[u_i\right] - u_i^*}$ would be minimal.

Graphically, this procedure can be visually interpreted for two quality indicators u_1 and. Let us u_2 set aside on the plane in the form of separate points the entire set of values and, obtained as a result of solving the first stage of optimization (Fig. 1). It should be borne in mind that each point on this plane corresponds to certain $\left[u_1, u_2\right]$ values u_1 and u_2. $æ_j$ Suppose that the set of such values took the form of the figure shown in this figure. β_j

Let us select the "best" points from the resulting set so that at these points the objective function (1) is minimal. These points, as well as the points, will lie on the line. At any other point, the u_i^* magnitudes AB and, u_1 and hence the corresponding value of function (1) will be greater than for any point lying u_2 on the line . The set of points lying on the line AB AB, which includes points with the minimum values of quality indicators u_i^*, as well as all other points at which the value of the objective function $\ddot{O}_1$ is less than at u_i^*, is called ***the "negotiation" Pareto set*** and it is said that ***"the optimal parameters of the system are on the Pareto negotiation set"***.

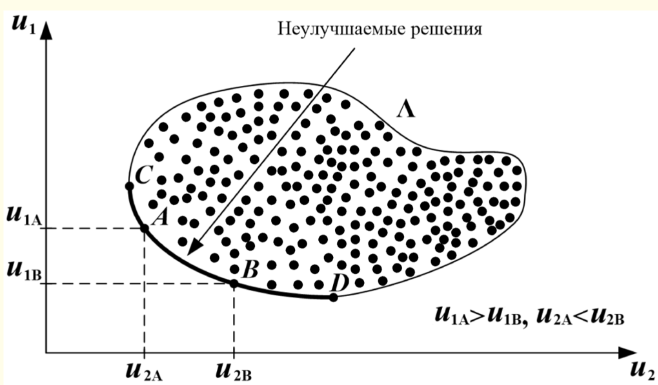

Figure 1: On the definition of the Paretic set of improvables solutions to the optimization problem.

Thus, the point at which the value of the objective function (1) will be minimal lies on the line AB. This point, which determines the optimal solution of the problem, corresponds to a certain set of parameters of spring suspension, $\left[æ_j, \beta_j\right]$ in which the value of the objective function is $\ddot{O}_1$ minimal on the Pareto set. The use of such an algorithm ensures the unambiguousness of the solution of the problem of multicriteria optimization.

References

1. Rasstrigin LA. "Random search in optimization problems". Riga: Zinatne (1965): 584.
2. Savoskin AN and Akishin AA. Application of the target function of MPC emission intensity to optimize the parameters of spring suspension of rolling stock. Interdisciplinary Institute “Science and Education”. Monthly scientific journal. Ekaterinburg 5 (2014): 94-98.
3. Sobol IM and Statnik RB. "LP-search and problems of optimal design". Problems of random search 1: collection of Riga (1972): 117-135.
4. Himmelblau D. "Applied nonlinear programming". D. Himmelblau. M.: Mir (1975): 534.

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