

OPTIMIZATION OF PARAMETRIC SERIES OF AUTOMOBILES, TRACTORS, AND SELF-PROPELLED CHASSIS BASED ON CONDITIONAL ENTROPY

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The modern development of mechanical engineering is characterized by a continuous increase in the diversity of machines and equipment. This trend is driven by growing requirements for functionality, energy efficiency, and operational performance. However, such diversity leads to increased complexity in production, maintenance, and operation. Therefore, one of the key tasks of standardization is to reduce the number of product types to a rational minimum while maintaining required performance characteristics.

The expansion of transport and agricultural machines significantly complicates standardisation, design, and rational selection under specific operating conditions. The presence of excessive modifications leads to increased production costs, difficulties in maintenance, and inefficient utilisation of technical resources. Therefore, the formation of parametric series with a minimal but sufficient number of models is an important scientific and practical problem. This paper proposes a method for constructing model series based on conditional entropy and similarity theory principles [1, 2].

The approach assumes that the first element of the series is considered as a prototype, while subsequent elements are treated as scaled models determined using scaling coefficients. This ensures preservation of relationships between geometric, kinematic, and dynamic parameters of machines, which is consistent with the principles of scale modelling in vehicle research [1]. The parametric series can be expressed as:

$$b_n = b_1(1 + q)^{n-1} \quad (1)$$

where b_1, b_n – the extreme elements of the series (the first and last);

n – number of elements of the series;

q – an increase in the conditional entropy of the object with respect to the main parameter b .

If, in constructing the dimensional series, the first and last elements (i.e., the values of the main parameter) are defined, then equation (1) yields the following

$$\sqrt[n-1]{\frac{b_n}{b_1}} = 1 + q \quad (2)$$

For a given parameter q , the number of elements of the series is determined as:

$$n = \frac{\ln \left| \frac{b_n}{b_1} \right|}{\ln |1+q|} + 1 \quad (3)$$

For the “Fendt” tractor model range, $b_1=26$ kW and $b_n=136$ kW. To determine the number of elements in the series n , the increment of the conditional entropy is evaluated based on the difference between the main parameters of the first two elements, b_1 and b_2 . This increment is $q=0.1538$. Using equation (3), the number of elements in the geometric series is obtained as $n=11.56$ (taken as $n=12$). According to the expression derived from equation (2))

$$q = \exp \left(\frac{\ln \left| \frac{b_n}{b_1} \right|}{n-1} \right) - 1 \quad (4)$$

for the specified value $n=12$, the refined value of the parameter is $q=0.1478$.

Table 1 shows the model series formed under the condition of a constant value of the conditional entropy of the main standardization parameter – the maximum effective engine power. The resulting series follows a geometric progression. This approach is proposed for the first time as a basis for the ranking of agricultural machinery.

Table 1 – Proposed tractor model range

Parameter	Tractor model number											
	1	2	3	4	5	6	7	8	9	10	11	12
N_{emax}, kW	26	30	34	39	45	52	59	68	78	90	103	136
$\Delta N_e = \Delta b_i, kW$	4	4	5	6	7	7	9	10	12	23	33	-

Therefore, it may be concluded that the application of conditional entropy in constructing model series of tractors and self-propelled chassis enables a reduction in the number of series elements. The principle of equal increments of the conditional entropy of the standardization parameter (in this case, the maximum effective engine power) allows the model series to be transformed from an arithmetic to a geometric progression. A comparison of the “Fendt” tractor model ranges presented in Tables 1 and 2 demonstrates a decrease in the number of elements from 19 to 12, corresponding to a reduction of 36.8 %.

As noted, reducing the tractor model range is beneficial not only for manufacturers but also for end users. For farmers, it is more practical to operate a smaller number of tractor models whose engine power covers the majority of agricultural tasks. The proposed method for constructing model series of tractors and self-propelled chassis based on a geometric progression provides an

opportunity to optimize equipment acquisition and reduce the costs associated with fleet renewal.

The results confirm that the use of conditional entropy ensures optimisation of model series structure, elimination of redundant elements, and improvement of design and manufacturing processes. The proposed method can be applied to automobiles, tractors, and self-propelled chassis due to similarity of physical principles governing their dynamics and interaction with supporting surfaces. This is supported by modern studies on self-propelled chassis performance and autonomous ground vehicles [4, 5]. The approach also enables integration of experimental and statistical data into the formation of model series, improving reliability of parameter selection and supporting multi-parameter optimisation.

References

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ANALYSIS OF INTERNATIONAL EXPERIENCE IN ASSESSING COMPLIANCE WITH SAFETY REQUIREMENTS OF CHANGES MADE TO THE DESIGN OF A VEHICLE, INCLUDING THOSE IN OPERATION

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During vehicle operation, owners often need to modify the design by making changes to the vehicle's structure.