# Parameters and parametric series of a two-link road train of construction machinery

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**Abstract.** The work focuses on the development of a parametric series of any mechanical engineering products prior to identifying the entire nomenclature of parameters that characterise the various features of the product, systematising them into groups, defining a parameter that is viable for the purpose. In our case, where the objects of analysis are the parameters of a two-link wheeled train, it is advisable to consider some concepts and definitions related to the structural components of a wheeled vehicle, of which a road train is a special case. This is partly due to the fact that the lack of a unified interpretation of the concepts relating to products and assemblies of mechanical engineering products causes certain difficulties in classifying parameters according to the structural components of a complex system or machine. Parametrization makes it possible to work through the various basic design variants of a machine within a short period of time and to avoid possible errors.

## 1 Introduction

Transporting goods to hard-to-reach places is a pressing issue, even in today's world [1]. In the existing engineering infrastructure of operated construction and maintenance sites, new challenges arise for the transport of indivisible goods, requiring a redesign of the vehicle trajectory and a revision of the load capacity limitations [2].

A mathematical model shows the motion of a real object, but does not always represent some degree of its idealisation. One significant disadvantage of existing mathematical models of construction machinery turning kinematics is that they lack apparatus for determining the magnitude of the offset of the semitrailer trajectory relative to the trajectory of the prime mover directly in the process of solving the problem.

Addressing this shortcoming is the aim of this study.

A parametric decomposition must be carried out to determine the vehicle design level [3-5] and identify the required characteristics, criteria and design parameters to be analysed.

Ability to carry out design modifications for series or standardised equipment [4] not considered.

The diversity in the interpretation of technical terms in mechanical engineering has resulted from their development within a narrow departmental framework. In recent years,

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a number of research organisations have been working together to harmonise terms and concepts in the field of mechanical engineering in order to streamline terminology. This work is based on the study of functional and energy transformations, phenomena or processes in a set of products. There are different groups of concepts, for which, in some cases, the same terms are used. Different groups of concepts result from different approaches to the same object or phenomenon [5].

Any piece of mechanical engineering (machine, sub-assembly), which is essentially a mechanically linked system can be regarded as

a) In terms of its functions;
b) From an energy perspective;
c) In terms of the design process;
d) In terms of production technology;
e) In terms of production organisation.

There may be many other aspects.

In the theory of unification in the vast majority of cases the objects are considered in terms of production organisation, since the ultimate goal of unification can be considered specialisation, large-scale production and application of the aggregation method. In accordance with this concept, it is appropriate to consider the concepts and definitions for the products and the set of products that make up a wheeled machine, since it is the object of unification. Fig. 1 shows a structural diagram of a wheeled machine, which is a single, autonomous power system, functionally designed to perform a certain work. The connection of the structural components of the machine is carried out in a certain order, which corresponds to the general concept of the system. For this reason, even in a wheeled machine, the components that are combined to perform a specific task are referred to as a system [6].

GOST 2.101-2016 formulates the concept of a system as a set of products (and) parts of products connected mechanically, electrically, hydraulically or otherwise. For example, all parts, units and assemblies of a two-link wheeled train can be combined into systems, each of which performs the functions of drive, control, braking, regulation, etc. The system as a whole may not always be subject to unification [7-8].

However, the system parameters have a direct impact on the ability to unify individual sub-assemblies.

The theory of machines and mechanisms distinguishes between two types of machines:

1. Production machine.
2. Energy machine.

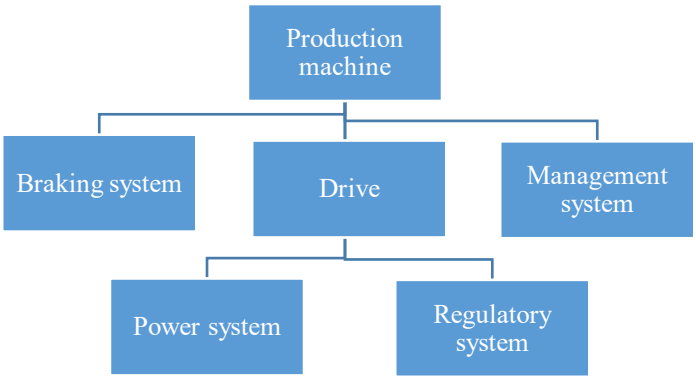


**Fig. 1.** A structural diagram of a wheeled machine, which is a single, autonomous power system, functionally designed to perform a certain work.

A characteristic feature of a production machine is the presence of an actuator, which is determined by its intended use. In the case of a vehicle designed for the transport of goods, for example, the body or platform is an actuator. In the case of a two-link or multi-link road train, the trailer or semi-trailer will be the actuating body [9].

A production machine consists of one or more functionally linked energy machines. A characteristic feature of an energy producing machine is the presence of operating elements that convert one type of energy into another; an internal combustion engine, which is the primary source of energy in a two-link train with active wheel drive, can be categorised as an energy producing machine [10].

In the same terms, a generator or induction motor built into the wheel of a road train is also an energy machine. It is important to note that a "machine" is a functional concept. In terms of production organisation, a "machine" has a very independent meaning and is, unlike a "system", a product of specialised production. In the set of machine parameters, it is possible to find the basic and main parameter that determines the possibility of unification, both within the machine itself and within the industry or several industries where it is used [11].

## 2 Parametric series

Among the structural components of machines, a set of parts called a mechanism is widespread.

The groups of basic parameters of wheeled vehicles have been considered in accordance with the structural diagram. The purpose of this paper is to propose a range of unified assemblies and systems for road trains of different payloads, the main objective of the analysis of the existing parameter nomenclature is to find the parameter by which the parametric series should be built. Obviously, for our purposes, this parameter will be fundamental.

It is customary to identify the main parameter of a component or machine as the main parameter. In some countries, e.g., in Germany, the main parameters are general parameters.

The concept of a main parameter has a definite meaning. For example, in the field of standardisation, the main operational, design or technological parameter which is distinguished from all other parameters by its stability, regardless of technical improvements in the product of mechanical engineering, is taken as the main parameter. For motor vehicles and articulated trains, this parameter is usually considered to be the payload. It must be borne in mind, however, that the purposes for which it is used must be taken into account when defining the main parameter. For example, for the user, the vehicle's payload is a fundamental parameter and is selected according to the operating conditions, road limitations and intensity of use [12-15].

For the manufacturer, the vehicle's payload no longer plays a leading role.

In this case, the parameter that most fully expresses the design features of the component or vehicle as a whole, the technology of production, its organisation and methods of.

The unification of wheeled vehicles should be based on one of the main parameters - the load on the drive axle.

A standard parametric range of drive axle loads to be developed based on the requirements of specialised production technology and the required payload classes (for vehicles), depending on the vehicle wheel configuration and gross weight.

Based on the parametric series of axle loads, a series of basic parameters for assemblies and sub-assemblies can be developed and, once the design has been determined, a size

series can be developed.

A parameter series is a limited set of numerical values of the same dimension that define a basic technological or operational characteristic of a product [16].

A limited set refers to the establishment of a numerical value of the parameters within a given range. The following concept of parametric series has been proposed: "A parametric series is a set of parameter values constructed in a certain range on the basis of an accepted grading system".

## 3 Results

Parameter series are generally defined on the basis of a system of preferred numbers. The system of preferred numbers is the theoretical basis for the systematic construction of numerical values of parameters defining the technical characteristic of products or their main properties. The parameters to be standardised in this way can be different: payload capacity of a vehicle (road train), axle load, internal combustion engine power, etc.

However, it should be stressed that the parametric series, especially for the parameters of transport and construction and road vehicles, should be established in accordance with the requirements of the national economy. The application of preferred numbers in this case makes it possible to establish a rational and economically feasible gradation of values of parameters of the series, as well as to harmonise the main interrelated parameters for a variety of product types within different branches of the national economy. The latter is of particular interest at the present time when it comes to matching the following parameters: vehicle (vehicle-train) carrying capacity, gross weight and axle load.

The main parameter in the vehicle parameter series is the axle load, since the relative unit values of cost, capacity and operating costs are the most constant.

When determining the optimum parameter series of machines, a series with a uniform programme distribution between machines with different wheel loads is taken as a starting point. By varying the programme, the feasibility of changing the initial series in the direction of reducing or densifying the number of members is analysed.

The economic evaluation criterion for constructing a machine parameter series is the weighted average annual present value P, which is calculated from the original and modified series.

Presented costs P are determined by machine manufacturing and operating costs.

The manufacturing costs for the original series are defined in relation to the unit of axle load rarefaction of the series leads to an increase in the production programme of the individual machine sizes that make up the rad.

A change in the series production of individual sizes will cause the cost of machining the sizes of the machines in the series to decrease with an increase in the programme or increase with a decrease in the programme.

By changing the programme, we determine the weighted average manufacturing costs for each row, respectively. The manufacturing costs are calculated without the cost of materials, because with the unification in most cases the cost of materials increases, and the cost of manufacturing decreases. Material costs are assumed to be 40% of the wholesale price of the machine [17-34].

Manufacturing costs as a function of programme changes are determined by the following formula:

$$\frac{C_1}{C_2} = \left(\frac{N_2}{N_1}\right)^z$$

where $C_1$ and $C_2$ - the costs of making machines before and after row thickening;

$N_1$ and $N_2$ the machine production programme of the same ranges;

*Z*- an indicator of the extent to which the cost of machining varies by programme.

The Z-value is determined on the basis of the relationship between the production and processing costs of machines in the most recent accounting year of production and those of the previous few years.

Let us find the value:

$$Z = \log\frac{C_1}{C_2} / \log\frac{N_2}{N_1}$$

Several *Z* values are calculated and their arithmetic mean is taken. In the methodology, the value of degree *Z* is taken as 0.3

The operating costs per 15.000 km run are determined according to the following formula:

$$P = \frac{15000}{P_f + P_{cm} + P_{maint} + P_A}$$

where *C*- running costs in operation, $P_A$- depreciation charge,

$P_f$ – fuel costs, $P_{\text{cm}}$- Lubricants costs, $P_{maint}$- maintenance costs.

The ready-to-use costs for each parameter series are determined using the weighted average present value formula:

$$C = E(C + M) + EL_c$$

where *C* – weighted average cost of production; *M*- weighted average cost of materials; $EL_c$- weighted average cost of operation.

The maximum annual savings when comparing the weighted average present value of the original series and the sparse series determines the optimum unification option:

$$P_{orig} - P_c = EL_{max}$$

where $P_{orig}$ – the annual present value of the original parameter series, $P_c$ – annual present value of the sparse parametric series, $EL_{\max}$- maximum annual savings.

There are several types of parameters in the various stages of machine construction. In the design stage of a machine, for example, parameters are often distinguished into initial and design parameters. Initial parameters are the starting point for the design of a component or machine as a whole.

## 4 Conclusion

The optimum decision when selecting the frequency of a parametric series can be made on the basis of a feasibility study, taking into account the factors involved in the manufacture and operation of the machines. The feasibility study for a parametric series begins with the establishment of its limits, whereby the main criterion for the justification of the limits is a sufficiently large product programme of boundary dimensions to allow for their efficient centralised production.

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