

Conference Paper

Development of a Universal Locomotive Frame Using System Engineering Methods

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Abstract

The article presents the practice of using systems engineering methods in the development of a universal locomotive frame. The work is aimed at developing the optimal design of the locomotive frame, which will simplify the production process of the unit and save on design and technological preparation of production. The advantages of applying a systematic approach to working with requirements, identifying the required functions and forming the structural structure of the product are described.

Keywords: locomotive, frame, life cycle, systems engineering, requirement, function, design.

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1. Introduction

Today in the Russian industry there is a strong deterioration of railway equipment: locomotives, wagons, track equipment. The constant obsolescence of technology poses the issue of updating the park before industrial enterprises. Tighter requirements for the technical condition of rolling stock only exacerbates this problem. In this regard, there is an increased demand for new types of equipment on the market, including locomotives. However, each industrial enterprise has its own requirements for this type of equipment, which differ in:

- 1) required power,
- 2) operating conditions,
- 3) the level of service and repair,
- 4) the load level of equipment per shift.

At the same time, the customer wants to get a locomotive with the best indicators of fuel efficiency, inexpensive, cheap to operate and repair, modern working conditions of the locomotive crew. All this leads to the creation of different types of locomotives for specific consumer conditions. But on the other hand, the equipment manufacturer must make a profit, and the development of a new locomotive leads to time and material costs for:

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- 1) Design development,
- 2) Technological preparation of production,
- 3) Assembly of the prototype,
- 4) Trial operation,
- 5) Establishment of serial production.

In this context, the following problem arises for the locomotive manufacturer: how to satisfy the maximum number of customers at the lowest cost. To solve this problem, the modular design of locomotives was adopted, where by replacing a number of modules you can get a locomotive of different characteristics, for a specific customer. However, to reduce the cost of production, it is necessary to develop a universal platform - the locomotive frame. The first two modular locomotives TEMG1 and TEM10 were developed with different types of engines - gas piston and diesel. How to ensure the placement of different equipment on the same platform? To solve this problem, I applied the methods of system engineering, in order to identify the necessary requirements for both types of locomotives, identify the functions performed and construct the necessary structural elements.

2. Results and Discussions

The studied literature suggests, first of all, to consider the system as a black box. At this stage, the object being developed is not presented in the form of a structure, but in the form of an abstract object to which the requirements are presented in order to satisfy the needs of stakeholders [1]. In this process, I used a sub-discipline of systems engineering-requirements engineering. First of all, the stakeholders of the developed product are determined. These are the customers of the locomotive, the manufacturer and the owner. The next step is to develop a list of requirements for the product being developed. Each stakeholder has its own requirements: the customer's requirements are spelled out in the terms of reference and GOST, the manufacturer's requirements relate to the limitations of the production site, and the owner makes demands for economic efficiency. For this product, two lists-one is formed for the locomotive TEMG1, and the second-for the locomotive TEM10. A mandatory step in requirements engineering is to verify the consistency of requirements. In addition to the directly contradictory requirements, I have identified the same requirements, which turned out to be the majority [2].

After imposing the external requirements of stakeholders on the system, we work with the system as a "white box" and describe the functions of the system necessary to

meet the requirements [3]. As a result of this process, we get two functional structures of the product. In them, I described the functions that should be implemented in the finished product [4]. Comparing these structures, I came to the conclusion that each product has a small number of unique functions that need to be provided in the design.

The next step was to draw up two design schemes for each frame, in which one or more functions are performed by different structural elements. Some elements were taken from previous frame designs, some became unique. The result of the previous work was the development of the matrix function-design, which clearly shows what design elements can be used in a universal platform and meet the General requirements. All unique elements for each of the frames were placed in separate nodes. Common design elements are assembled in a single Assembly unit, so that in the future it was possible to borrow this node without modification. There are such structural elements that are represented on both locomotives, but are used only on one, since they are not necessary on the other.

Thus, having carried out detailed work with requirements and having described system functionally I could carry out development of a uniform platform for two locomotives. It allowed to provide a high degree of unification, increase of tactfulness of production and reduction of expenses for design and technological preparation at production of new types of equipment. In the future, it will also allow in the shortest possible time to develop a locomotive for the special requirements of the new customer. Thanks to the modular layout of the locomotive and preliminary study of the requirements and functions of the system, we were able to create a universal platform, where without changes in the crew part, you can get a locomotive with completely different traction characteristics.

3. Conclusion

The greatest economic effect is brought by reduction of time for design and technological preparation. To date, the study of the frame structure of the new locomotive takes an average of 1 year to 1.5 years. At the same time, at different stages in the development involved engineers-calculators, economic services, as well as design engineers, working on the design of the surrounding units of the locomotive. Today, the universal platform is used in three projects, and it is planned to use it in six projects. Technological training is carried out on average for 6-9 months, by 2-3 process engineers. In addition to the obvious benefits, one of the stakeholders (business owner) gets a competitive

advantage in the market, as it has the ability to close new market needs faster than its competitors.

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