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Application of System Engineering Methods in Management of Locomotive Design Processes

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Abstract

In the presented article designing of a product is offered to consider as set of typical processes. Examples of processes occurring in the organization for possible optimization of resource costs and ensuring rhythmicity are given. The information environment of the product developer as the main participant of typical processes is described, and the approach on effective change of the developed in the organization of processes is offered. The key importance is given to the processes of forming the task for the development of the product and the subsequent analysis of the dynamics of change in the target indicators at each iteration of improving the standard processes.

Keywords: product, process, design, stakeholder, developer, knowledge, stag, rhythmicity.

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1. Introduction

Enterprises engaged in the production of goods for successful development in the modern market must be guided by the rapid changes in demand under the influence of digital technologies. New products need to emerge quickly, with high quality and low cost of ownership. Performance of the put requirements probably at the expense of change of the relation to a design stage of a product. Now there are the tools of designing, allowing not only to simulate properties of the future product, but also to carry out virtual simulations of possible scenarios of work. The use of digital technologies allows to exclude expensive errors before the execution of works at the stages of manufacturing, testing, operation and repairs. However, application of modern tools without change of methodologies and approaches to the organisation of processes of designing will not allow to receive high-grade effect. Specialists from various scientific disciplines participate in the design of complex products. Formation of the necessary degree and sequence of interaction of all stakeholders of the design will allow to strengthen the positive emergenic effect.

2. Results and Discussions

It is offered to consider processes occurring in designing on an example of the engineering organisation which is engaged in designing of locomotives. Fig. 1 shows the main design stages determined on the basis of the state standard 15.902-2014 on the system of development and production of railway rolling stock [1].

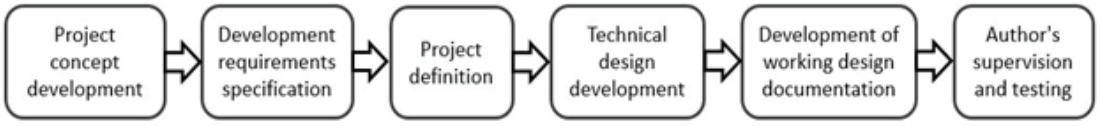

Figure 1: Design stages

It should be noted that the mentioned state standard does not regulate the processes taking place within the engineering organization at each stage. In an organization that is already operating through direct communication with all stakeholders, it is possible to identify the actual processes, their sequence, artifacts and performers. Building of logical interrelations between the revealed processes allows to look at designing, as on uniform functioning system [2]. Unification of processes will allow to simplify representation about system of designing. Identification and subsequent control of coordination processes between stakeholders will reduce the probability of occurrence, typical for the design, of errors in interaction.

If you have a good idea of how the design system works, you can perform analysis and identify processes that need to be simplified or eliminated. For example, after assembly of a pilot series of products for working technologists the technological charts are developed and the requirement for the design documentation disappears. Development of technological charts by technologists is possible without design documentation in the presence of a digital model of the product with the necessary annotation. Thus, exclusion of processes of working out of the design documentation, its check, the coordination and the statement becomes possible. There is a simplification of process of entering of changes in a design of a product at the expense of absence of necessity of updating of the design documentation. The use of electronic paper, augmented reality and numerically controlled machine tools in the production of electronic paper will make it possible to abandon paper-based media. In this scenario, the duration of the actual information transfer process will change from a few weeks to seconds.

With a description of the process sequence, it is possible to conduct a rhythmic analysis and minimize the uneven distribution of work among designers. Violation of the rhythmicity may cause errors caused by the reason of premature termination of not

sufficiently developed process or parallel launch of the next process. In both cases, there is a risk of increasing the duration of the entire design phase due to cyclical feedback. Presence of cyclic links can be considered as creation of dynamically changed task on target system development. As an example it is offered to analyze a situation when one of developers, without waiting for reception of the necessary information from the second developer, starts release of the design documentation. As a result, there may be a situation when the first developer, when finishing his work, learns from the second that it is necessary to make changes and repeatedly returns to the initial stage of product design. One possible way to keep the rhythm of the processes running is to assign priority to the processes. Give higher priority to processes that affect the performance of other stakeholders.

An essential variable in planning the duration of design processes is the experience of developers. To understand the essence of the issue, it is proposed to consider Fig. 2, which represents the developer's information environment. Let's assume that the developer, who does not have the necessary experience, starts designing the product.

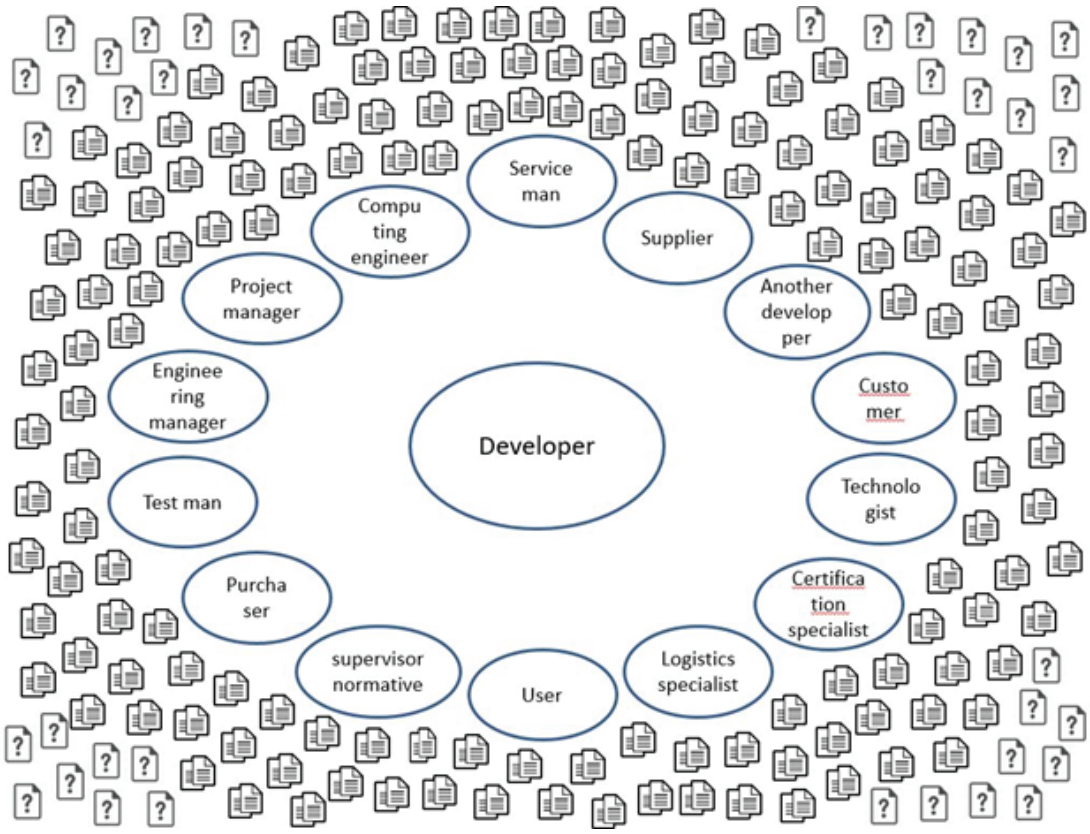

Figure 2: Developer Information Environment

At various stages of the design process, it interacts with a variety of stakeholders. Each stakeholder, guided by his or her own knowledge, presents his or her own unique

image of the future product. In addition, there is knowledge that stakeholders do not have, but that is necessary for successful design. The task of the developer at the initial stage is to collect all the necessary knowledge for the work. The less experience the developer has, the more knowledge needs to be gathered. In order to collect knowledge, the developer usually begins to seek help from his or her supervisor or other more experienced colleagues, spending the total time. If the developer will often ask his colleagues for help, he will be directed to search for information in documents that are sources of knowledge. At this point in time, the developer is left alone with a huge amount of knowledge accumulated by any generation, and spends a significant part of his time searching for the necessary knowledge. There is a high probability of occurrence of a design error caused by ignorance or acceptance of false knowledge. Errors may be detected at the stages of checks, but checkers often do not know exactly what exactly is being checked.

In an engineering organization dealing with relatively similar tasks, there is a sense in introducing an additional process of forming a task for the developer on the node under development. The task may include the requirements of stakeholders to the node of decomposition requirements for the product, restrictions, information on analogues, lists of necessary artifacts, relationships, processes and other information for reflection. Thus, the developer will work with a relatively small but sufficient amount of knowledge and understand the check criteria while designing. Checkers will perform compliance checks on the job, spending less time and skipping fewer errors.

In conclusion it is necessary to notice that perfection of typical processes of designing can proceed long with performance of set iterations, but thus it is important to carry out the analysis of dynamics of changes of target indicators of efficiency. In the described model of designing it is possible to allocate three basic target indicators: duration of all stage of designing; quantity of the used resources expressed in man-hours; the quality defined by quantity of cycles of returning to processes which have been earlier completed. Availability of a system for collecting feedback from stakeholders will also allow you to assess the success of the design process management.

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