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Development and application of cataloging in structural design of freight car building

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Abstract
The paper presents features and results of cataloging of gondola carrying system throughout the application of this approach for face wall of one of the basic model of gondolas.
Key words: FREIGHT CARS, DESIGN, CATALOGING

Introduction

Railway transport plays an important role in the social and economic development of Ukraine, as the developed railway system is a precondition for national economic growth and increasing of its competitiveness. In connection with the Transport Strategy of Ukraine for the period until 2020, which was approved by the Cabinet of Ministers of Ukraine on October 20, 2010, requirements concerning improvement of transportation technology organization, modernization and building of infrastructure and renovation of rolling stock were put forward to the railway transport. Today the major part of the rolling stock of UZ falls on the freight cars park that combines universal, specialized and insulated ones.

Problem statement and result analysis of latest researches

In fact, for many years designing gondola body was an empirical process, which was based on gained operating experience expressed in the form of requirements or regulations [1,2]. There are works of freight cars structural design, taking into account their operating experience [3,4].

At present there is a gradual fundamental change in the theory and practice of gondola body structural design [4,5]. In the modern car building design process of gondola body provides two stages: automated design (AD) and automated parametric design (APD). AD is intended to form the visual information about the "arrangement" of construction: its constructive exterior and structural composition. APD serves to determine the dimensions of structural components, which meets the requirements of specifications of normative documents.

The aim of the article and statement of basic material

The aim of the article is to highlight certain features of cataloging in structural design of freight car building. As well as the allocation of its place in the modern methodology of transport engineering designs synthesis. It is presented an example of application of an electronic catalog of an assembly unit "Face wall of gondola" in the form of interactive electronic technical publication (IETP) in TG Builder software module.

System approach and methodology in automated freight cars body structural design can be represented by the following stages:

Stage 1 - decomposition and hierarchy;

Stage 2 - multi-stage and iteration;

Stage 3 - typification and unification.

Stage 1 – in the works [4,5] there designed block-hierarchical approaches for freight cars, which provide structuring and description of the design generally with the release of the abstract hierarchical levels and relevant internally layered constructional modules (blocks). Decomposition of the design object leads to decomposition of the design process - its submission as a set of simpler designing procedures of different hierarchical level. To solve the problems of automated body structural design it is necessary to have a wide range of models describing a body and components of its construction. It is significant that models may have a different structure and mathematical description and depend on the range of problems solved at the stage of design body to solve the tasks associated with gondola body structural design, one may define the following stages:

• Modeling of the shape and arrangement of the scheme of the designed body structure (geometric and constructive designing).

• Determination of the structural design and development of a mathematical model of the structure, according to the adopted structural design.

• Modeling of a "behavior" of the construction associated with the choice of set of mathematical relations, which connect some characteristics and design parameters.

The decision at APD is based on the optimization and search procedures. Model of decision is formalized representation of design problem in the form of mathematical programming problem limited in equations $H_j(\mathbf{X})$, inequalities $G_j(\mathbf{X})$ and boundary conditions:

$$F(X) \rightarrow Extr,$$
$$Hj\,(X) = 0,\ j = 1,\ldots,\ m;\ Gj\,(X) \geq 0,\ j = m + 1,\ldots,\ p;(x_i)_{min} \leq x_i \leq (x_i)_{max}, \qquad (1)$$

where X – the vector of search *n* variable design parameters;

F(X) – the target function in the search problem.

Designing problem solution is directly connected with the definition of minimum mass of the body. When designing of gondola body solution as target functions one may use: the cost of the body material, the construction cost of gondola and the economic effect of the operation of gondola for all its life cycle. The simplest target function in structure designing is the cost of the material that at fixed values of liquid limit of the material expresses its weight. The main limitations in determining the main elements of body are the requirements to provide strength and to prevent vibration of the body and components of its construction.

The process of body structural design provides: the creation of its overall structural arrangement and determination of its basic elements in the first approximation; decomposition of the body, development of structural arrangement of the individual structures and definition of the optimized elements; the synthesis of the whole system, assessing its quality and conformity with the specifications.

Stage 2 - multi-stage process and iteration of body design provides an iterative type of designing, when one or more stages of designing can be repeated. For example, in case of a negative design decision or non-compliance of gondola parameter to specification requirements one has to return to a previous step and repeat the design process. The most frequent iterative type of

designing is in the design of complex objects in the form of gondola.

There is a multi-stage of the process of gondola body structural design in the form of structural and logical diagram in the Figure1. The components of a vector definition engineering are: the cost of materials, the cost of gondola body, the generally and local strength requirements expressed in terms of allowable voltage safety factor, $X(x_1,\ldots,x_m)$ – a vector of optimization of system variables, or vector of sought characteristics of gondola body; where $(x_i)_{min} \leq x_i \leq (x_i)_{max}$, $i = 1,\ldots,m$, $(x_i)_{min}$ are minimum and $(x_i)_{max}$ – are maximum allowed value of optimizing variables.

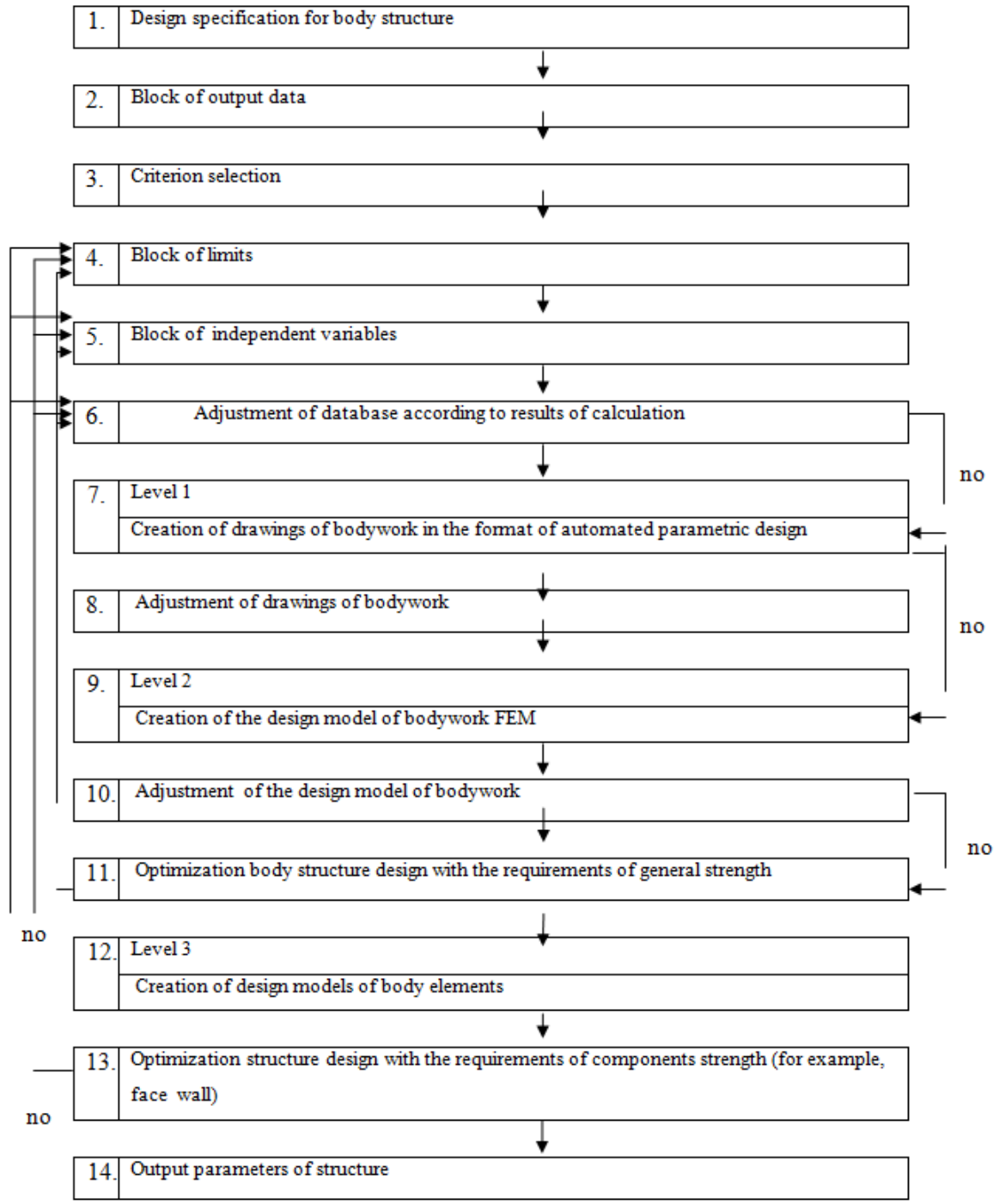

Figure 1. Structural and logical scheme of the bodywork gondola design process

Improvement of the efficiency and quality is closely related to its computerization. Currently tools for support of initial stages of design with the status of techniques and standards of conceptual

design in the development of CAD grow rapidly. Among them functional, infological and behavioral design techniques, which confirmed by IDEF standards, are the most popular.

The technique of structural analysis Structured Analysis Design Technology (IDEFO standard) is focused on building of functional models of management system of production, business and so on which are then analyzed by various experts and used in the design of structural systems and simulation models. Behavioral modeling (IDEF2, IDEF3 standards) is based on building of simulation models of complex systems with the use of queuing theory, Petri nets and finite-state machines. The methods of data-driven design (IDEF1, IDEF1X standards) are oriented to support engineering databases creation on the basis of ER-models (essence - connection). The main result of application of these techniques, and some others, is saving of time spent on conversion of descriptions and data formats, which are used at various stages and in various tasks of design. [6,7]. Traditional expert systems are configured to solve a narrow variety of specific problems in terms of knowledge in KB so **Stage 3** - typification and unification – is the most relevant in the first three stages of design with the creation of constructive catalogs, which provide known engineering solutions of elements of bodies design.

The question of repeated multiple use of engineering knowledge in different design processes have been developed in a new direction, called Design Reuse (DR). This is research area with the development of computer systems, including databases of engineering solution and methods of effective information use in the design process. The main problem of DR is the lack of information structuring methodology which reflects the experience of available engineering for reuse in the design processes. Thus both successful and unsuccessful solutions [8] are of great interest. Figure 2 shows the proposed structure of DR-system and its place in the design process of the gondola body. These materials show that the demand for information about known engineering solutions is the most relevant in the first three stages of design.

In the work [7] there noted that contemporary problems of computer support of design processes are

1) creation of product data models to ensure their smart use in computer systems;

2) engineering of system of design methodology, allowing to arrange application of automated procedures;

3) building strategic design systems that , unlike ordinary CAD, can handle all available data and choose actions;

4) development and construction of electronic design data catalogs (e-catalog), which allow easily and quickly receive accurate data on the structure and machinery parts.

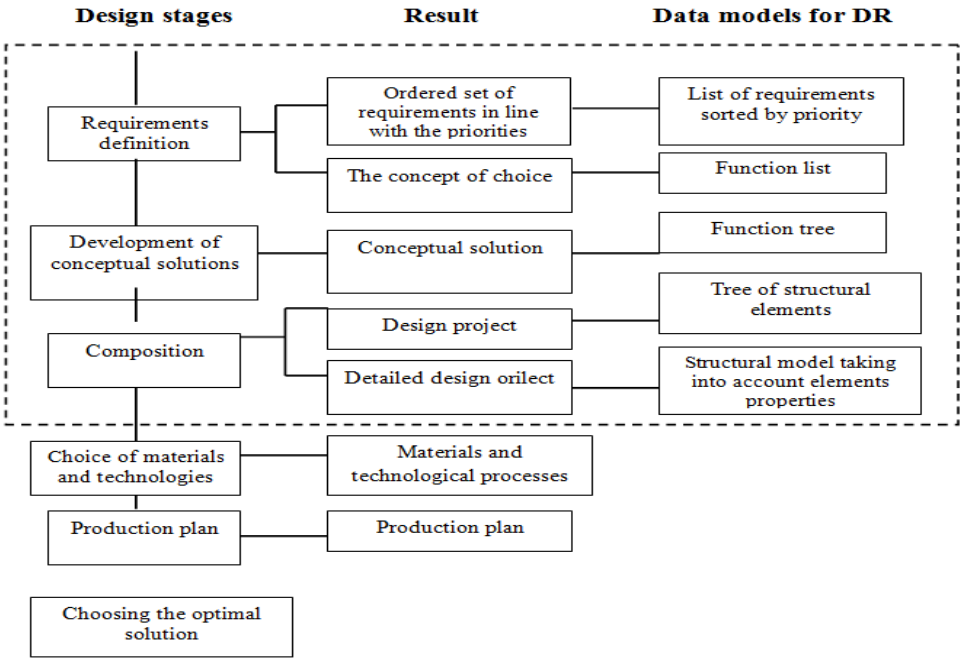

Figure 2. The structure of DR-system of design process of the gondola body

The next stage of the research is to build a tree of structural elements of face wall in the form of electronic design catalogs of wall elements.

Let us distinguish the following main stages in the development of catalogs:

Stage 1. Preparation of initial data, which describes wall composition and structure. At this stage an informative part of the catalog is determined. It shows basic identification data on the wall.

Stage 2. Reconciliation of an informative part with customers, determining a list of items and cataloging them in order to obtain data for logistical support. At this point there was made a list, which identifies the supplies with data on their cataloging.

Stage 3. Electronic and paper publication forming for users of documentation.

Electronic catalogs involve the following: compactedness, high-speed information retrieval, powerful capabilities, convenience and visibility in work, as well as computer programs. An example of an illustrated electronic catalog of assembly unit "Face wall of gondola" in the form of interactive electronic technical publications (IETP) is shown in the Figure 3 and Figure 4. The catalog is developed in the software module TG Builder – it is a system of automated preparation of supporting documentation in electronic and paper forms to complex products, its review is carried out in the TG Browser module.

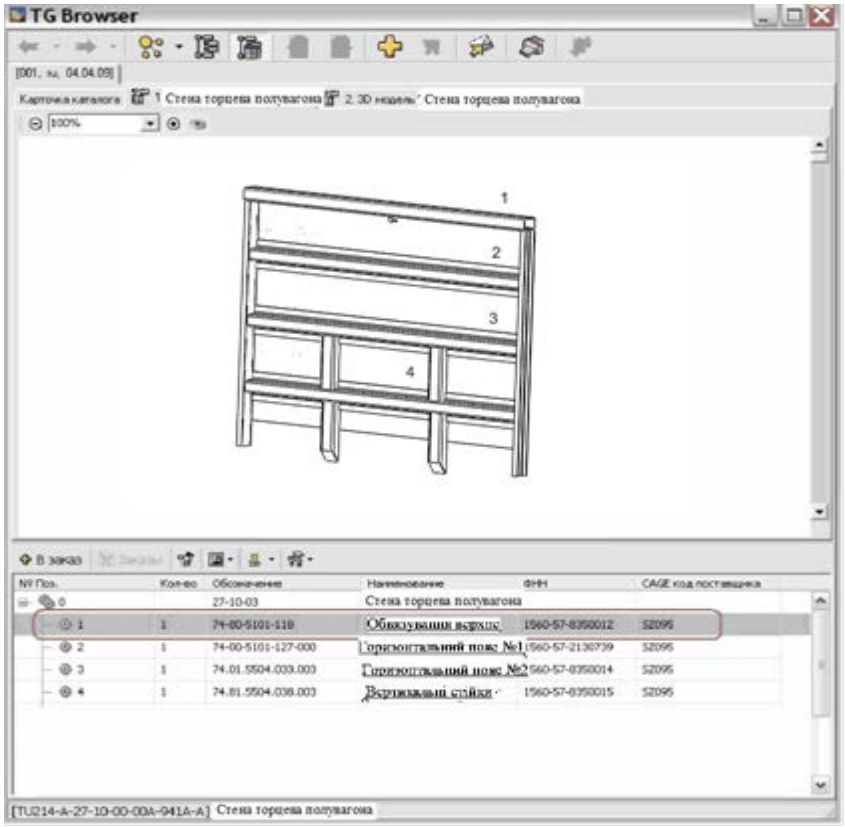

Figure 3. Interactive publication of a component of tree of structural elements of gondola body – face wall.

3D models allow visualizing the process of knocking down the body and the contents of its parts. They also show the assembly process into larger units and the final product. In the viewer It is planned a high-speed products retrieval in catalogs on their name, designation and code (Figure 4).

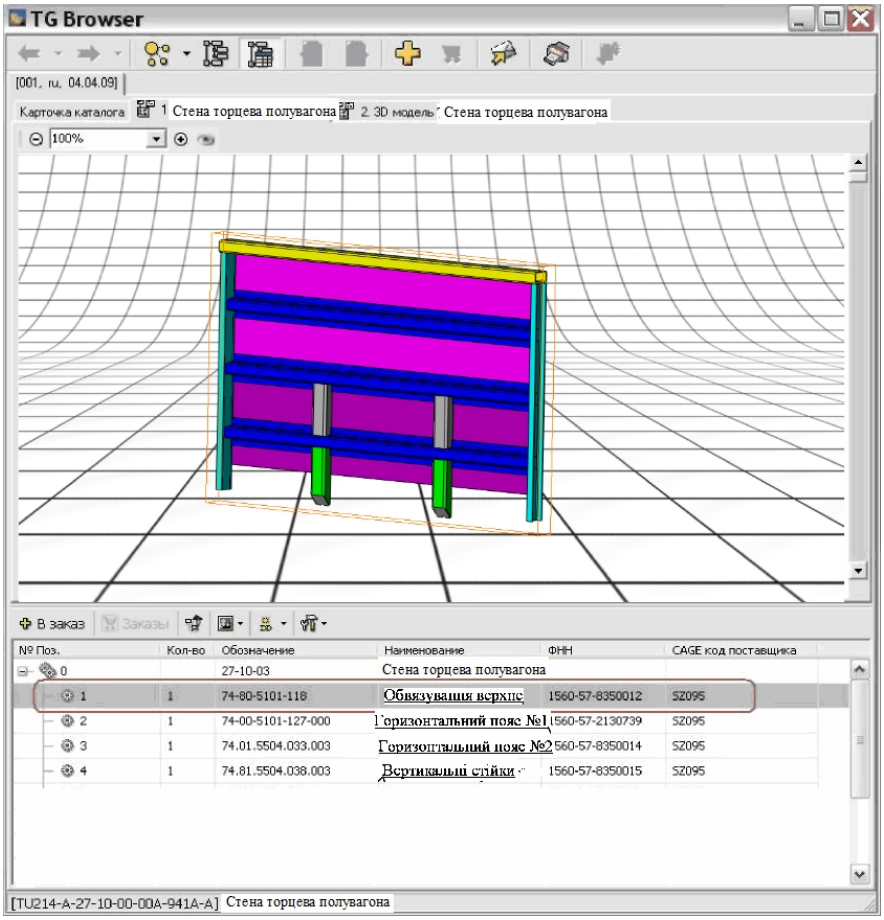

Figure 4. Catalog of 3D model of face wall

Conclusions and recommendations for future use

The results of research presented in the paper confirm the practicability of application of cataloging in freight cars design. The above mentioned confirms development of electronic catalog of an assembly unit "Face wall of gondola" in the form of interactive electronic technical publication (IETP).

Electronic catalogs have a great potential in the design process of freight cars. Their advantages include: easy-to-use and an informative value.

This approach can be applied for the railway transport and other means of transport engineering.

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