DEVELOPMENT OF A PRODUCT DATA ENGINEERING AND MANAGEMENT WEB BASED APPLICATION

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The design process of a customized product involves a high volume of project data. This can be managed, for instance, with support of the Product Data Management systems. The present paper contributes to the development of an application in PDM environment, useable to analyze and configure of certain customized product components. The application design, unrolling a case study in industrial conditions and evaluation of the application performance are achieved.

Keywords: PDM, PLM, CAD, customized product, attributes, constructive configuration, technological validation, performance evaluation.

1. Introduction

Product Data Management, PDM, is a computer based system for the management and control of product design and manufacture [1], as part of Product Lifecycle Management, PLM, being primarily used by engineers [2].

It should be noted that PDM is an operational environment for development information infrastructure and cooperation [3].

Different product configuration approaches have been developed as, e.g., a configuration grammar design approach in CAD environment software [4].

All major Computer Aided Design software, CAD, is supported by a PDM or a PLM platform.

PDM is one of the most important elements of PLM environment because it can provide exactly the right information at exactly the right time and representing the collective know-how of a company [5].

PDM supports the product development process especially last two steps of the process, detail design and product validation [6].

Some of Product Data Management systems advantages are as follows [7]: PDM projects are the basis for creating an information - sharing environment; the desired effectiveness is achieved through the creation of distributed multi - disciplinary teams (supply chains) that work in a collaborative manner; the desired efficiency is achieved through the creation of a cost effective computing

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infrastructure that supports a distributed multi - disciplinary collaborative style of work; it creates an environment that automates management of work by integrating people, their tools, processes and information.

Modern PDM software offers a secure repository, version control for both minor changes and major revisions, accidentally overwriting data preventing, data reuse, improved value chain orchestration and also a greater visibility so users can make better business decisions [8, 9, 10].

The improvement of the collaboration within and outside organizations is possible with the html/ Java - based web user interfaces built in most PDM systems today [11].

Modern PDM systems advantages overrun the financial efforts and implementation difficulties, but in the case of customized products problems still occur: engineer - to order support by data reuse in order to further customize a preliminary configured product [12]; product parts testing in order to verify and correct technological solutions in conjunction with the existing manufacturing capabilities, etc.

Data reuse is achieved by the PDM systems through database searches that classify data by attributes as follows: supplier, supplier part number and supplier information management and user - defined attributes [13], but are limited in the most cases to standard components.

The use of tested and validated constructive solutions from other projects, as base for the new design, reduces the design time [14].

2. Objective and method of research

Advanced PDM systems offers more ways for users to access data by remote, no matter the location where they are.

PDM systems, especially those embedded in PLM systems, ensure technological validation of product parts by managing the workflow in conjunction with CAE tools and is mostly applicable in the case of CNC manufactured product parts.

In order to improve data reusability, database search possibilities can be extended from typical information managed by PDM systems to functional attributes, corresponding to previous product parts/ subassemblies, e.g.: unfolded lengths and widths; load capacity for structural elements; the temperature range for normal operation.

The reusability of manufacturing technology is an important task, so that a technological validation tool that regards the existing manufacturing capabilities should be developed in order to verify technological solutions.

By integrating constructive solutions configuration and technological validation tools into PDM applications, the time for generating and designing new customized constructive solutions can be minimized and development stages as tendering can be assisted and supported with results in product price optimization.

The objective of the present research is to develop a new Product Data Engineering and Management *Application* in PDM (Product Data Management) environment as design tool to support the analysis and configuration of certain customized product parts, operational in industrial conditions.

The research method has been structured with regard to the following reference elements: selection of the programming languages and models for the conceiving the application; defining the main structural components of the application, as well operating actions; unrolling a case study in real industrial conditions; evaluation of the application performance.

3. General conceive and operating elements of a web based product data engineering and management application

Let PDEM.A01 be the considered new Product Data Engineering and Management *Application.*

Reference basis for PDEM.A01 conceive

It has been chosen as PDEM.A01 to be web based, so that this has the specific advantages - no dependence of an operating system, no need of installation and configuration on the user workstations, etc. PDEM.A01 is accessible by using common preinstalled web browsers, offering mobility and easy maintenance.

PDEM.A01 is designed mainly based on PHP and JavaScript programming languages. To allow the interconnection of independent software parts, data encapsulation and abstraction, maintenance, an *Object oriented programming* model is used [15, 16] in conjunction with MySQL database management system. The *user interfaces* are created based on principles of an *Event User-Interface Pattern* [17], in order to allow association of events and detail instances of data.

The main components of the PDEM.A01 are PDEM.A01 interface, and the sections PDEM.A01.S1, PDEM.A01.S2, PDEM.A01.S3.

Relevant elements on PDEM.A01 components and associated operating actions are as follows, noting that the data specific engineering and management are interactively performed by a certain product developer.

PDEM.A01 interface

In relation to the research objective and reference basis, the PDEM.A01 interface is structured as presented in Fig. 1.

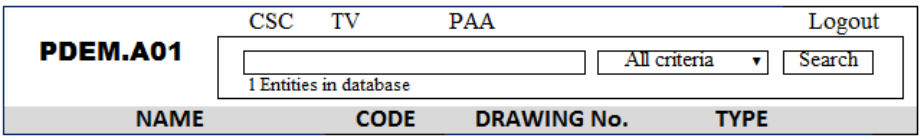

Fig. 1. PDEM.A01interface structure

PDEM.A01.S1 section

PDEM.A01.S1 section is dedicated to analysis, selection and reuse of product data for development of new products/ parts.

The PDEM.A01.S1 section has the operational title of "Constructive Solutions Configuration", *CSC*.

The configurator algorithm matches the closest data from the MySQL database by using SELECT, WHERE or LIMIT clauses as well as SWICH and CASE statements and returns the appropriate values from the filtered results set.

Let A (name & code) be the new part to be configured, and the "Selection criteria" - the entrance main attributes defining this part, i.e., Attribute 1, Attribute 2, …, Attribute m, and V/E[A1(A)], V/E[A2(A)], …, V/E[Am(A)] - their correspondent values/ expressions, as presented in Fig. 2.

By "Configure" *action*, one or more "Results"/ possible solutions could be identified, in the application database, and consecutively displayed, PS1, PS2, …, PSn, in the order of constructive similarity level to the A part, as presented in Fig. 2.

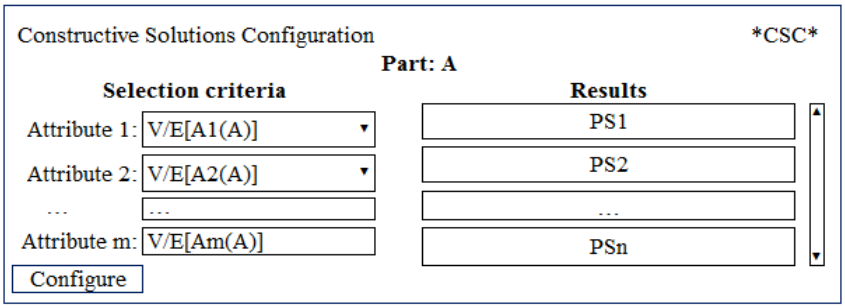

Fig. 2. Case of part/ selection criteria for which there are results/ possible solutions

The principal attributes, secondary attributes and attachments associated to the most appropriate solution, PS1 part, are displayed as presented in Fig. 3, where "…" is the value/ expression/ notation of the considered attribute or attachment, after case.

According to the entrance selection criteria and the attributes of the PS1 part, the principal and secondary attributes of the A part are further completed as presented in Fig. 4, where "…" is the value/ expression of the considered attribute, after case.

Further, the attachments - 3D model, native drawing, etc. - of the PS1 part are downloaded, the 3D model is changed with respect to the A part attributes, and the result is *saved* as 3D model of the A part.

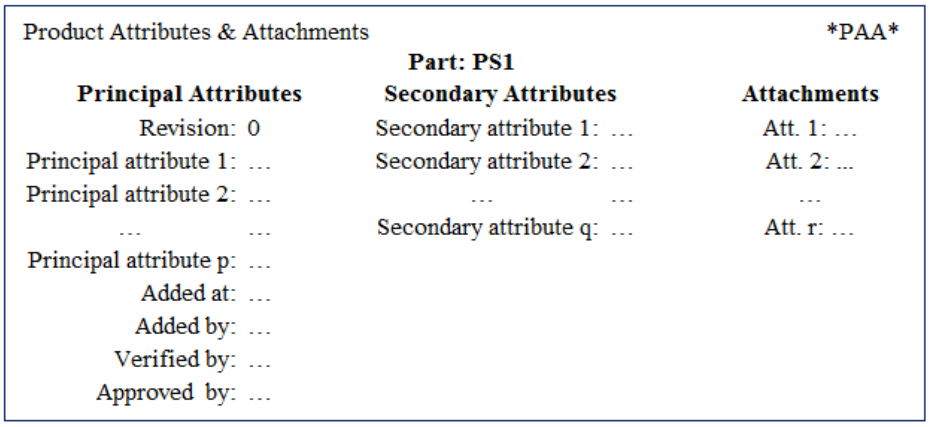

Fig. 3. Attributes and attachments associated to PS1 part

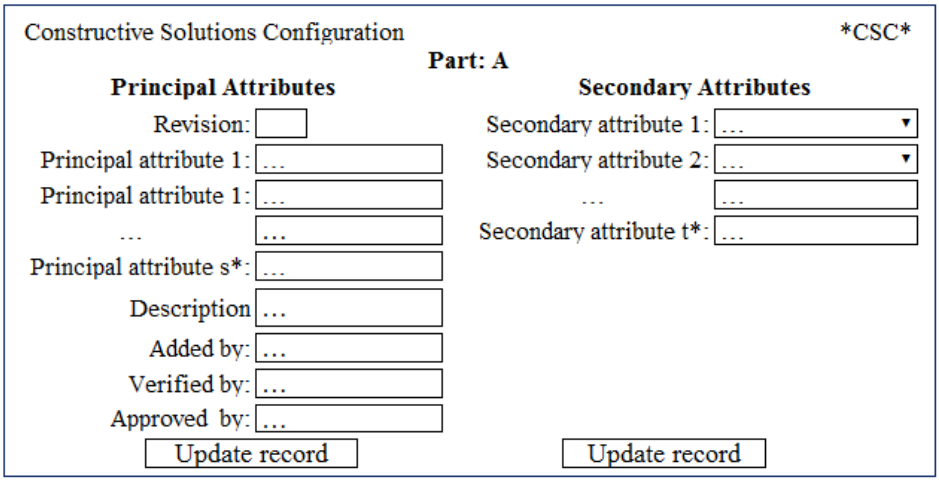

Fig. 4. Principal and secondary attributes of A part

So, the 3D model of the A part, and, implicitly, the other attachable documents are achieved very close to the final structure and content.

It is important to emphasize that, under PDEM.A01.S1 support, the time for the product design can be substantially reduced, due to the decreasing number and time of activities needed to achieve 3D model and the other documents, comparing with the case of product design without PDEM.A01 support. For instance, taking advantage of the drawing updating functions offered by the modern CAD systems, drafting is replaced by drawing verification activities.

It is to be noted that in the case of a B part input for which no any result/ potential solution is found in the database of PDEM.A01, the considered part will be designed without PDEM.A01 support.

PDEM.A01.S2 section

New constructive solutions can generate manufacturing matters.

The PDEM.A01.S2 section is designed for the analysis and validation of product parts from the technological/ manufacturability point of view, with regard to the existing manufacturing capabilities. This section has the operational title of "Technological Validation", *TV*.

The *technological validation* algorithm summarizes regulations in order to decide if the characteristics of the analyzed product are technologically compliant with the limitations of a given technological endowment.

Working with PDEM.A01.S2 section/ Technological Validation support, and based on the product data determined in PDEM.A01.S1 section, the required data are defined and, under "Verify" *action*, the analysis result can be "Technological construction is: valid", as presented in Fig. 5 for A part, or "Technological construction is: not valid" - case in which one or more attributes of the considered part must be properly changed.

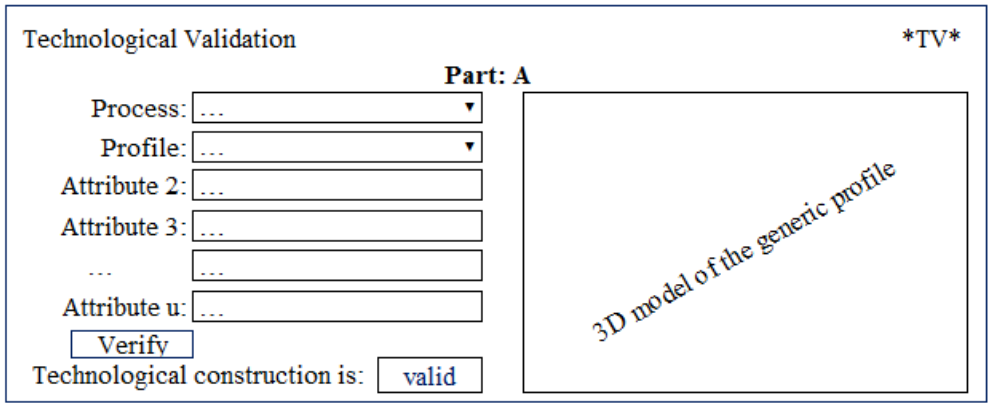

Fig. 5. Technological validation of the A part

PDEM.A01.S3 section

PDEM.A01.S3 section is for analysis, recording and archiving of product data associated to provision and design.

The PDEM.A01.S3 section has the operational title of "Product Attributes & Attachments", *PAA*.

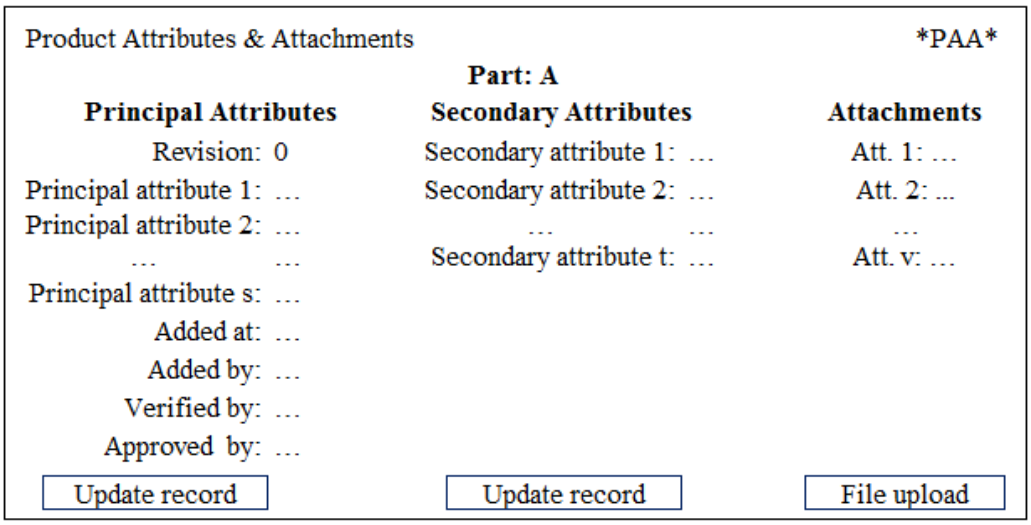

Fig. 6. Attributes & Attachments of the A part

Working under PDEM.A01.S3 section/ Product Attributes & Attachments support, and based on the product data determined and technologically validated in PDEM.A01.S1and PDEM.A01.S2 sections, the attributes and the attachments of the A part - 3D model, native drawing, etc. - are finalized and *saved*, as presented in Fig. 6.

Performance indicators

In order to evaluate the performance of product design with PDEM.A01 support, comparing to cases of product design without PDEM.A01 support, the following *performance indicators* are considered:

- Percentage increase of configured customized products/ parts (ICCP);
- Reduction of design time for constructive solutions configuration (RTCC);
- Reduction of design time to verify technological solutions (RTVT);
- Reduction of overall product design time (RODT).

4. Case study

Design object

In order to evaluate the performance characteristics of PDM.A01 on products design, a study case has been developed, by analyzing the design process of two *oversized electrical control shelters* in real industrial conditions from a Romanian customized packaging equipment developer.

The *Oversized Electrical Control Shelter*, let OECS be this, is a customized structure/ product that hosts command, control, power distribution and communication equipment. The principal specifications of two OECS, OECS 1 and OECS 2, are as presented in Table 1.

Table 1

OECS characteristics

Characteristic	OECS 1	OECS 2
Length	10,000 mm	10,000 mm
Width	3,100 mm	4,000 mm
Height	3,700 mm	3,790 mm
Roof slope	3%, single side	3%, single side
Bottom frame load due to equipment	13,091 kg, static	9,816 kg, static
Roof load due to equipment	1,300 kg, static	300 kg, static
Floor	raised, min. 300 mm	raised, min. 300 mm

The OECS 1 product has been designed without PDEM.A01 support, and the OECS 2 new product - with PDEM.A01 support.

Design of OECS 2 parts with PDEM.A01 support

Product data from previous projects which are registered to PDEM.A01 are visualized through its interface.

During the design of OECS 2 new product, certain parts have been configured with PDEM.A01 support.

As an exemplification, let Lower Side Beam-1QV0 be a new part from the structure of OECS 2 accepted by PDEM.A01 to be configured.

The OECS 2 Lower Side Beam-1QVO new part is defined by certain "Selection criteria", as presented in Fig. 7.

By "Configure" action, two "Results"/ potential solutions, for the OECS 2 Lower Side Beam-1QV0 new part, are identified and displayed, LOWER SIDE BEAM LEFT-1Q60 and BOTTOM FRAME RAIL-1Q70, as presented in Fig. 7.

The principal attributes, secondary attributes and attachments associated to the most appropriate solution, LOWER SIDE BEAM LEFT-1Q60 part, are displayed.

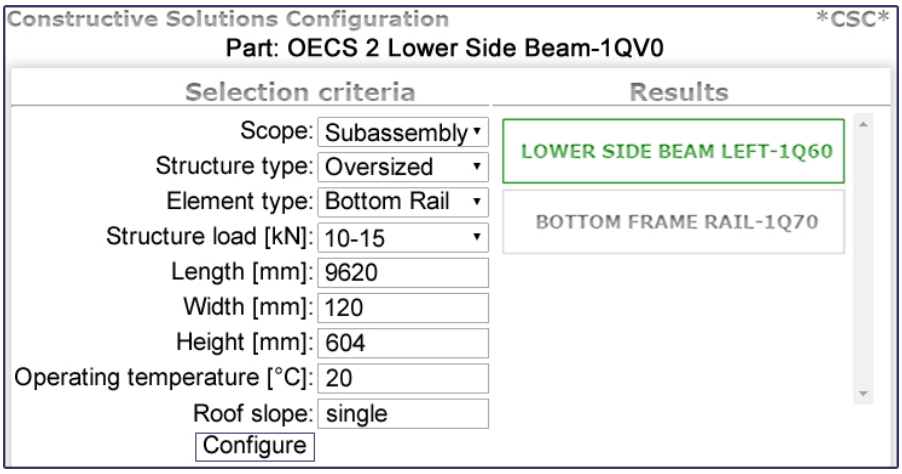

Fig. 7. Selection criteria and results for the OECS 2 Lower Side Beam-1QVO new part

According to the entrance selection criteria and the attributes of the LOWER SIDE BEAM LEFT-1Q60 part, the principal and secondary attributes of the OECS 2 Lower Side Beam-1QVO new part are further completed (Fig. 9).

The attachments - 3D model, native drawing, etc. - of the LOWER SIDE BEAM LEFT-1Q60 part are downloaded, the 3D model is changed with respect to the OECS 2 Lower Side Beam-1QVO new part attributes, and the result is *saved* as 3D model of the OECS 2 Lower Side Beam-1QVO new part, noting that the other associated documents are implicitly changing.

The OECS 2 Lower Side Beam-1QVO new part is analyzed (Fig. 8) from technological point of view, with regard to existing manufacturing capabilities.

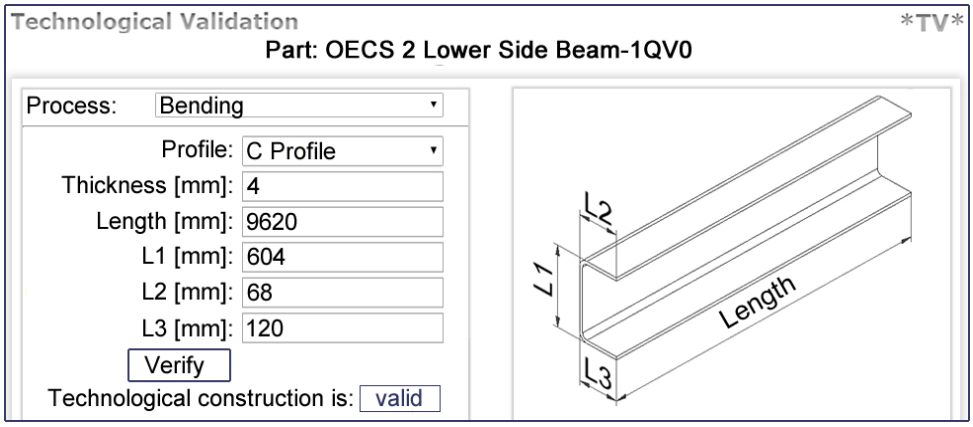

Fig. 8. Technological validation of the OECS 2 Lower Side Beam-1QVO new part

The attributes (Fig. 9) and the other associated product documents - 3D model, native drawing, etc. - of the OECS 2 Lower Side Beam-1QVO new part are finalized and *saved*.

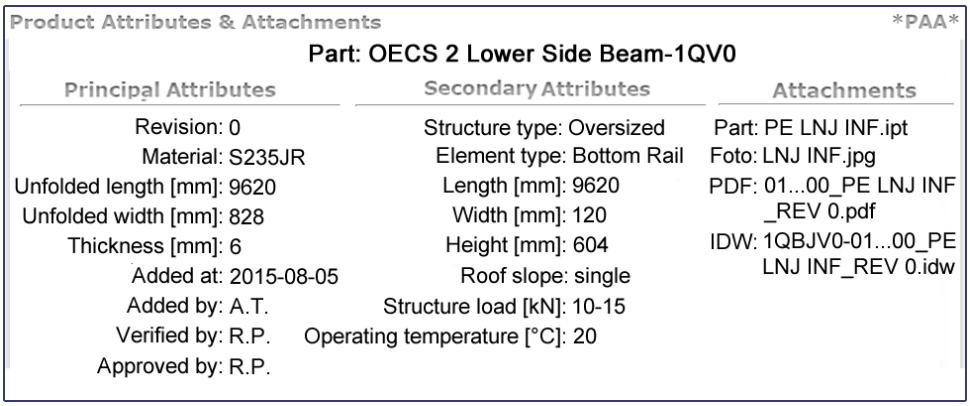

Fig. 9. Attributes & Attachments of the OECS 2 Lower Side Beam-1QVO new part

The configuration process to achieve the OECS 2 Lower Side Beam-1QVO new part is completed.

The OECS 2 Lower Side Beam-1QVO part has become component of the PDEM.A01 database.

PDEM.A01 performance evaluation

During the case study, some relevant design process data have been recorded (Table 2).

Table 2

Design process data

OECS 1: designed without PDEM.A01 support, OECS 2: designed with PDEM.A01 support	OECS 1	OECS 2
	Values	
Degree of product customization/ Degree of product complexity/ Experience of the product designer	same/ same/ same	
Percentage of standard parts	10 %	
Percentage of customized parts	90 %	
Percentage of customized parts designed by configuration with PDEM.A01 support	-	30 %
Design time for constructive solutions configuration/ Design time to verify technological solutions/ Overall product design time	31 h/ 20 h/ 300 h	18 h/ 8 h/ 240 h

The performance indicators associated to OECS 2 product design with PDEM.A01 support are determined based on effective specific design data (see Table 2), and presented in Fig. 10.

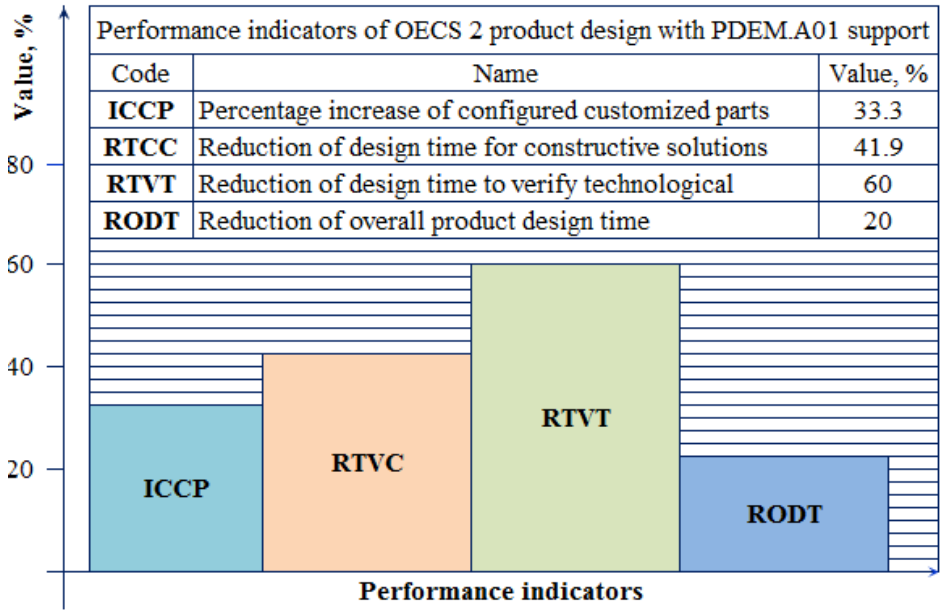

Fig. 10. Performance indicators of OECS 2 design with PDEM.A01 support

The values of the performance indicators associated to OECS 2 design with PDEM.A01 support demonstrate that PDEM.A01 is a powerful tool in the considered design process. It is to emphasize the important usefulness of PDEM.A01 in the complex design process of the new OECS 2 customized product, as well for other such of equipment, in industrial conditions.

Progressively, PDEM.A01 has become a global environment and the principal method of normalizing constructive solutions for the OECS package design. Also, the *technological validation* tool allows the sharing of the manufacturing matters to all designers.

5. Conclusions

The web based PDEM.A01 application, as *Product Data Engineering and Management Applicatio*n, has been developed and applied for certain customized products.

The usefulness of PDEM.A01, as an important support in the complex configuration process of elements from the structure of the new products, is demonstrated by the performance indicators values.

PDEM.A01 has become a global environment and a principal method of normalizing constructive solutions for the specific products under design, as well a tool allowing the sharing of the manufacturing matters to all designers.

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