Evaluation of the results of the implementation of a product data management system in the technology department of a high-tech enterprise

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Abstract. The technology department at any manufacturing enterprise is engaged in ensuring the release of new high-quality products on time with high economic efficiency. Depending on how successfully the technical department functions, the quality of technical documentation and, as a result, the quality of products depends. In this regard, it is necessary to constantly improve the efficiency of this department through the introduction of new management solutions, including those based on the use of modern software. This article discusses the process of introducing a product data management system into the technology department of a high-tech enterprise. A modified reengineering algorithm for the technical department is presented, functional modeling of business processes in the IDEF0 rotation is considered, and functional models are built. A small economic evaluation of the results of the implementation of the PDM system in the technology department is also carried out, and the results are presented. It is shown that the greatest effect of using a product data management system lies in two areas: reducing time to market and improving product quality. Thus, the introduction of the proposed system can significantly improve the quality of the production process not only in the department in question but throughout the enterprise.

1 Introduction

Currently, all manufacturing enterprises are striving for digitalization and the transition to computer technologies for supporting the life cycle (LC) of products [1,2]. Most enterprises in their activities already use modern software tools that can create design drawings and three-dimensional models to facilitate working with products - CAD (Computer-Aided Design (CAD)). However, these business leaders often fail to realize how important and cost-effective it will be to manage all product data holistically. The solution to this problem can be a separate software (SW) - a product data management system that helps administrators, designers, engineers, technologists, and other specialists manage both data and product development processes.

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A product data management system (PDM) is an organizational and technical system that manages all information about a product. Product information primarily includes engineering data such as CAD models and drawings, digital mock-ups, and bills of materials. The main idea of PDM technology is to increase the efficiency of information management by increasing the availability of product data necessary for the information processes of the product life cycle [3]. According to an expert assessment, the use of PDM systems leads to significant savings and additional profit achieved by reducing:

- Timing of launching new products on the market (up to 75%).
- Costs for the design of complex products (up to 30%).
- The share of defects and the volume of changes in the design (up to 70%).
- Costs for the preparation of operational and technical documentation (up to 30-40%) [4].

Despite the complexity of the process, some enterprises already have experience in implementing a PDM system and highlight the following advantages:

- Quick search for the required information on the product/technology [5,6];
- Creation of an electronic archive of documentation in a common database [7-9];
- Use of unified catalogs of technological resources and reuse of information [10,11];
- Organized cooperation between the departments involved in the creation of a set of product documentation;
- Complete digital description of the product and organized access to up-to-date information about the product [12].

A common mistake many enterprises make is to try to implement a PDM system throughout the entire enterprise at once. This implementation option can lead to unnecessary costs due to the inevitable occurrence of unforeseen problems in the course of work. Under these conditions, it is advisable to implement software locally, assuming in the future the use of the experience gained, integration and integration. In this regard, this paper, it is proposed to consider the introduction of a PDM system in the technology department, since its quality, development cost and the proportion of defects directly depend on the production technology of the product.

The purpose of this work is to demonstrate the positive effect of the introduction of a PDM system in a specific department of one of the high-tech enterprises in the Russian Federation.

This article is based on the concept of business process reengineering proposed by M. Hammer and D. Champi in the book “Corporate Reengineering: A Manifesto of a Business Revolution” [13]. Business process reengineering involves the construction of two functional models (FM): “AS IS” and “HOW SHOULD BE”. By comparing the two models, it is possible to determine whether existing processes are effective and whether they need to be changed.

2 Stages of re-engineering business processes

Business process reengineering is a business management strategy originally developed in the early 1990s and aimed at analyzing and designing workflows and business processes in an organization [14].

According to one of the first supporters of the theory of reengineering, Thomas Davenport, a business process is a set of logically related tasks performed to achieve a certain business result. Business process reengineering is affected by innovation as industry players replace old business process management practices with new technologies such as automation that can radically transform the management process [15].

Business process reengineering reduces the cost and time spent building a product by eliminating inefficient operations and the people who perform them. Business process reengineering improves quality by reducing work fragmentation and establishing clear
process ownership. Employees are held accountable for the outcome of their work and can measure their performance based on quick feedback.

It should be noted that the PDM system is implemented except for the technological department, whose activity is based on the task of developing technological processes, according to which the product is subsequently created. Technological process (TP) is a set of labor processes and operations that are in mutual organizational dependence, ensuring the creation of final elements of products. This can be a complex activity involving a range of tools and equipment with many levels of automation using computers, robots, and the cloud.

Based on the concept of business process reengineering, there are classic stages of reengineering, but they need to be modernized for this work. During the modernization, the following reengineering processes were identified:

1) Modeling of existing business processes in the development of TP.
2) Analysis of existing business processes in the development of TP.
3) Modeling of business processes in the development of TP after the implementation of the PDM system.
4) Transition to new business processes.

The main task in modeling business processes, at the first stage of reengineering, is to describe the processes existing in it to build an “AS IS” model. To do this, it is necessary to collect all available information about the process of developing a technological process, which, as a rule, is fully owned only by process engineers directly involved in the implementation of the process [16].

3 Functional modeling

The situation at industrial enterprises, where various types of documents are stored and searched, is the same. Electronic files of drawings are scattered in different places: some on the computers of performers, some in a centralized repository, and most of the drawings are stored in paper form in the archive. Electronic documents, as a rule, are not sufficiently protected from unauthorized access, and sometimes they are not protected at all. Finding the right file or paper document takes some time - from 10 to 60 minutes a day for each employee, and sometimes more.

For a visual representation of the situation described above, we use the IDEF0 functional modeling methodology. Building an IDEF0 model begins with a representation of the entire system in the form of a context diagram. This diagram displays the purpose of the system and the necessary input and output data, control and regulatory information, as well as mechanisms. Figure 1 is a context diagram of process development.
After construction, the context diagram is detailed using the first-level decomposition diagram. This diagram shows the functions of the system that must be implemented within the main function. Figure 2 shows a decomposition of the “AS IS” context diagram of workflow development.

In our case, the “Develop a process flow” block can be detailed, below is the decomposition diagram of the second level in Figure 3.

After building the FM “AS IS”, it is necessary to conduct an analysis that will give an idea of the state of the processes in the development of the TP. Based on the results of the analysis, a complete scheme of workflow in the organization is drawn up. The identified inconsistencies should be recorded in a separate document, which will subsequently be used in the development of the FM of the predicted processes [16].

Correction of deficiencies found in the “AS IS” model is done by creating the “HOW IT SHOULD BE” model. This model is necessary for the analysis of alternative ways of executing processes in the future.

Figure 4 shows the context diagram of the FM “HOW IT SHOULD BE”.

By this model, the workflow is carried out in an integrated information environment (IIS), which is created using the PDM system. When implementing all processes, only reliable information obtained from a common database is used. Information from the common database is available to employees of the organization's subdivisions by access rights. The database also stores information about suppliers and customers of the organization. They may be granted access to certain sections of the database through Internet technologies [17].

Figure 5 shows the decomposition of the IDEF0 context diagram of the FM “how it should be”.

By this FM, the data necessary for the development of the technological process are stored in a common database. The common database classifies the types of technological processes according to certain criteria, and it also contains a catalog of previously created technical processes. Tasks such as the calculation of the cost of the technological process and the calculation of production capacities are carried out in specialized software that is integrated with the PDM system, which speeds up the process of transferring documentation through electronic document management. The data that is the result of the stages of development of the technical process automatically supplements the overall database, which contributes to its constant increase and improvement.
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**Fig. 2.** First level decomposition diagram “AS IS”.

**Fig. 3.** Decomposition diagram “AS IS” of the functional block “Develop workflow”.

**Fig. 4.** Context Diagram “HOW IT SHOULD BE”.
Fig. 5. Decomposition diagram of the first-level “HOW IT SHOULD BE”.

Figure 6 shows the decomposition diagram of the second level “HOW IT SHOULD BE”. The functional diagram of the second level contains functional blocks that display the main subfunctions of the functional block “Develop process technology” of the decomposition scheme of the first-level.

Fig. 6. Decomposition diagram “HOW IT SHOULD BE” of the functional block “Develop process technology”.

4 Economical evaluation of PDM-system implementation

As mentioned earlier, each employee spends an average of 10 to 60 minutes a day searching for the documents he needs during working hours. In connection with these data, we calculate the economic losses of the enterprise when searching for documentation.

Let us assume that the average number of employees directly involved in the development of TP is 100 people. They all do their work using personal computers. Let's take 20 minutes a day as an average search time for the necessary documentation. The average salary of a process engineer in Russia and China is about 1.5 thousand dollars per month [18,19]. The calculation is shown in Table 1.
Table 1. Losses of the enterprise per 1 and 100 employees.

<table>
<thead>
<tr>
<th>Period</th>
<th>Losses per 1 employee</th>
<th>Losses per 100 employees</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minutes</td>
<td>Days</td>
</tr>
<tr>
<td>Losses for 1 day</td>
<td>20</td>
<td>0.05</td>
</tr>
<tr>
<td>Losses for 1 month</td>
<td>420</td>
<td>0.88</td>
</tr>
<tr>
<td>Losses for 6 months</td>
<td>2520</td>
<td>5.25</td>
</tr>
<tr>
<td>Losses for 1 year</td>
<td>5040</td>
<td>10.5</td>
</tr>
</tbody>
</table>

It turns out that every year each employee loses an average of 10.5 working days to search for documents, which for the enterprise is $ 525 in the cost of his wages. For 100 employees, this value will already be 1050 working days and, accordingly, 52.5 thousand dollars of the cost of their wages.

5 Results of the product data management system implementation

In general, functional models clearly show how the process of developing a technological process has changed after the introduction of a PDM system.

Based on the previously constructed FM “AS IS”, conclusions were drawn about the functioning of processes in the TD:

- At almost all stages of process development, TD’s personnel spend time searching for the necessary information from documents, catalogs, standards, etc., presented in paper form.
- Calculation results during normalization and when calculating the need for equipment are issued in paper form, which slows down the process of subsequent formation of TP;
- Communication with other divisions of the enterprise is debugged through paper workflow.
- When agreeing and approving the technological process, the technologist provides a set of TDoc to each representative from among the responsible persons. In this case, there is a delay in the approval of a set of technological documentation.

The results of the paper document of the turnover in the TD are the delay in the creation of the TP and the failure to fulfill the plan.

Analyzing the functional model “HOW IT SHOULD BE” it is noticeable that the PDM system allowed to effectively manage the introduction of changes because all changes in the documentation are automatically uploaded to the IIS and the personnel involved in the development of the TP receives the notification of changes in the documentation.

The most important advantage of implementing a PDM system is the ability to optimize the development of the technological chain, equipment selection, etc. to process a specific part.

The interaction of various departments of the TD is important. The use of the PDM system made it possible to organize their parallel work to create their parts of the TP for certain products. These measures significantly save time and can significantly reduce the time for issuing a set of technical documentation and the entire product as a whole.
Approval of a set of technical documentation with the help of new technologies introduced automates this process and sends the documentation requiring approval to all coordinating departments simultaneously or in the sequence approved by the enterprise.

Even with the above superficial calculation, the economic benefit is obvious. When implementing a PDM system, only the costs associated with finding the necessary documents will be reduced by 52.5 thousand dollars per year. It should be noted that economic efficiency will grow as the number of documents in the electronic archive and the number of employees connected to electronic document management increase.

6 Conclusion

In this paper, the process of business process reengineering in the TD was considered during the implementation of the PDM system. As part of the reengineering, functional models “as is” and “how it should be” were built using the IDEF0 functional modeling methodology.

The transition to a fully automated product data management system will effectively solve the problems of improving the quality of technical documentation, which in turn will improve the quality of products.

In addition to the above, the effective PDM system proposed for implementation allows for saving time resources of highly qualified technologists and provides an opportunity to use information from more relevant and reliable sources.

The greatest impact of using a PDM system lies in two areas: reducing the time to market and improving the quality of the product. Thus, the implementation of the proposed PDM system can significantly improve the quality of business processes, not only in the TD but also throughout the enterprise.

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References

3. P.A. Kurylev, Creating a single information space (SIS) based on the PDM system, VII All-Russian scientific and practical conference of young scientists Young Russia (2015)
5. V. Yakovlev, A. Efimov, O. Bessmertny, CAD and graphics 4, 24–27 (2015)
12. V.A. Khanov, B.N. Maryin, D.N. Frolov, Manag., computer sci. and inf. 2(14), 22-26 (2013)
16. A.V. Gubarev, Information support of the quality management system (2013)