METHODOLOGY OF ERP SYSTEM IMPROVING

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Abstract
Today, it is hard to imagine a production company which is not using information technology. IT (Information Technology) infrastructure and software have become indispensable tools used by the majority of companies. Moreover, many companies could not run their business if it was not for efficient IT infrastructure and involvement of highly qualified IT specialists. The interpretation of the ERP (Enterprise Resource Planning) vary depending on whether it is used by a company, an IT market analyst or software distributor. The ERP systems are defined as a cohesive integration of processes in functional areas of the company, which improve work flow and order management, standardizes business practices, improve materials accounting and facilitates supply chain management [1].

The paper describes methodology of continuous improvement of the ERP system functionality on the basis of a user satisfaction survey, data analysis and the Deming Cycle. The proposed methodology is a result of many practical functionality innovations implemented in ERP systems, executed in order to improve business, logistic, production and decision processing. Some of the implemented innovations have been described using the example of manufacturing companies. The necessity of constant adaptation and improvement of the ERP system functionality caused by changing market conditions and the necessity of adapting enterprises executing engineer-to-order production to these changes is the principal reason for applying the presented methodology. The research is based on the survey and case study analysis of a manufacturing company (Delta company). The illustrative examples are also given.

Keywords
enterprise resource planning, PDCA Deming cycle, data analyze, case study, survey research.

Introduction

The need to implement the ERP class information management system occurs most frequently in the case of a dramatic increase in the number of orders, when the company management arrives to a conclusion that without IT support for decision making the company ends up in chaos, and IT solutions applied previously are insufficient. Such a moment is the least favorable for implementing the ERP system, since human resources are overburdened and the involvement in the project requires taking many employees (most frequently the best ones) away from their regular activities and their full engagement in the implementation. Since for the majority of companies rapid development starts unexpectedly, it is hard to blame them for the fact that they do not have plans to implement the ERP. With rapid income growth, companies accumulate funds for implementing ERP projects. In many instances, the implementation entails a number of problems and threats, including inappropriate preparation to the project and poor attitude employees and the board may have to the implementation [2–4].

Comparing the ERP system to a tool is appropriate only when analyzed together with the ability of using it. Similarly to an engineer whose tool is his knowledge, for a company the ERP system is a tool linked to knowledge employees have, procedures, data, software, hardware and IT infrastructure. Implementing of the ERP system should be considered from the point of view of project management, and possible success is determined by the budget, as well as implementation scope and schedule. It is neces-
necessary to define short-, mid- and long-term objectives to be achieved through the implementation of the ERP system and impact of the implementation on the company. Research on ERP systems distinguishes organizational preparedness of the company to the system as an important success factor [5]. Benefits derived from implementing the system are divided into the following groups [6]:

- operational benefits related to reduction of cost, duration of cycles, improved productivity, quality and more efficient customer service,
- management benefits in terms of improved efficiency in managing resources, better planning and decision making, and enhanced productivity,
- strategic benefits related to supported company development and cooperation, development of innovation, diversification of products, registration of management cost and building interfaces with external partners,
- IT infrastructure benefits in the form of more flexible business processes, reduced cost and wider opportunities for developing IT infrastructure, and
- organizational benefits related to facilitating organizational changes, more efficient employee training, building the structure of competences and cohesive company development vision.

But the ERP systems have to be changed together with the companies that fit to the customer and market conditions. The main goal of the paper is concept of the methodology of continuously ERP system improvement based on the Deming PDCA (Plan-Do-Check-Act) Cycle [7].

In the next chapter the results of the survey research in the Delta company are analyzed. In the next two chapters the examples of improving of ERP systems in area of production preparation and registration are presented. The last chapter discusses the methodology of ERP system improvement based on Deming PDCA Cycle.

How improve the ERP systems

Because the surroundings of the company are changing, they have to adapt to the market’s requirements through adapting business, logistic and production processing. The most important processes in an enterprise require the support of the ERP systems so the system must evolve as well.

The suggested method of improving the ERP system (Fig. 1) is based on a classic attitude of constant improvement by W. Deming – PDCA.

![Diagram](image.png)

Fig. 1. The framework of ERP system improving.
While taking the first step it is important to collect the data concerning business processing occurring in the given functional area and evaluation of the possibility of their automation using the ERP (evaluation of the occurrence frequency, work consumption, change implementation benefits). Taking the first step also requires designing all of the changes (new functions of the software, changes in the software, new report forms, process of implementing the changes, persons responsible, schedule of implementing the changes). In the first year, it is necessary to define quantity and quality criteria of the changes being implemented. They will be verified in the third step. The second step is the implementation of changes planned. Before starting the implementation process, it is necessary to inform users and management about the goals of changes implemented. Such changes apply to the IT integrated system of an ERP class, so it is significant to predict the influence of the innovations being implemented on the business processing in other functional areas. Because one cannot predict all effects at the planning phase, it is important to reduce the disturbances and undesirable effects [8].

The third step requires evaluating the chosen effectiveness of change implementation evaluation criteria in particular functional areas. At this stage of implementing innovation it is important to involve the management of the company.

The last step requires identifying consecutive business processes in a given functional area to be improved. At this stage, it is also necessary to inform participants of the implementation and the management about effects of changes.

In the next chapters the innovation examples supported by the ERP system indicate that on the basis of the survey of end users and data analysis it is possible to improve the course of business processing in an enterprise executing commissioned production will be presented.

The Survey of ERP system end users

An evaluation of the ERP system from the perspective of key users and end users was a subject of many research. The survey should be executed regularly (e.g. annually), in order to estimate if the development of the system is compatible with the requirements and the development of the company. On the one hand, the companies apply their business processing and products to the market requirements, which suggests that every ERP system should evolve accordingly with the needs of the company. On the other hand, the ERP systems are constantly developed and enriched by new opportunities so the companies should implement useable functions [9]. Many companies decide to implement the ERP and TQM (Total Quality Management) systems in a complementary manner to obtain new quality of processing [10].

An analysis of user satisfaction was executed in Delta at the beginning of 2007 (4 years after ERP system implementation). Questionnaires were anonymous. Along with the evaluation of operations (technical preparation of production, material management, etc.) administration (finances, accounting, staff, wages, fixed assets etc.) were taken into consideration. Among 191 registered users of the ERP system, only 130 of Delta’s employees work actively in the system.

The survey considered 39 employees actively working in the ERP system. 26 of the responders have answered the question concerning general evaluation. Results of the general evaluation are presented in Fig. 2. The scale of the evaluation was the following: 0 – very poor, 1 – poor, 2 – satisfactory, 3 – good, 4 – very good, 5 – excellent.

![Fig. 2. General ERP system evaluation by end users in Delta.](image)

Important evaluations average equaled 3.5 – above good. Graph analysis indicate that there were very little radical evaluations. This means that the ERP system is stable and it fulfills its most important functions [11].

The employees considered lack of training and independent work of the system the main problems disturbing the company’s activity (Fig. 3). This indicates that after implementing the ERP systems Delta practically stopped training the staff in the sphere of the system’s functionality. Shortage of business processing instructions supported by the ERP indicates the lack of constant training as well. Slow work and frequent breakdowns drew attention to IT infrastructure of the company [14].

The average daily amount of hours worked in the ERP system is 4.13. However, there are significant discrepancies between the times of ERP system usage by the management staff and operative employ-
Figure 4 presents the analysis of hours worked daily using the ERP system.

Mainly the managing staff declare that they use the ERP only for a short period (one hour daily). They use the system to generate lists and analyses. The designers, supply workers and production planners are using the system most often. The next analysis confirms this, it shows which functional areas are most often used by the ERP (Fig. 5).

The ERP has been implemented in Delta in the areas from $F_2$–$F_7$ (ERP does not support marketing or tool management and repairs).

Figure 4 indicates that Delta most often uses the ERP $F_3$ area – Technical production preparation. This is related to the complexity of Delta’s products and the involvement of designers and technologists in developing new products. Functional areas which use the ERP in descending order are: $F_3$ – Production and product assembly (mainly operation registration, $F_7$ – Material management and warehousing, $F_4$ – Planning and production control, $F_2$ – Sale and distribution and $F_6$ – Purchasing and cooperation logistics.

The statistics of ERP usage intensity in particular functional areas of a company executing engineer-to-order production is the basis for analyzing the work consumption of business processing ERP service and introducing innovative changes which improve the work productivity and the effectiveness of business processing. The analysis of ERP module usage intensity indicate that eventual improvements of ERP processing service may be introduced in the areas of technical product preparation, operation registration, storage and material management and production planning.

The next three questions in the survey were open and dealt with the lack of data required for making operational decisions, improvement propositions and the most often used specifications.

The most important issues related to using of the ERP system in Delta are the following:

- production designers are not enclosed in ERP after execution of the commission. This leads to wrongly listed material requirements,
- the lack of cooperation registration in ERP (the analysis of data exported from ERP indicates this as well),
- difficulties in calculating the product. Product calculations are executed outside the ERP in Excel sheets. Data concerning product calculation are often invalid. Difficulties in monitoring the costs of executing a commission. This is resulted in the manner of creating construction documentation. Sometimes the construction specification of the product is created outside the system, usually it is being typed into the system while execution, and only then the costs of production can be calculated. If the production budget is exceeded, a labor consuming verification of the project is needed,
- difficulties in material turnover, list of missing material outside the system,
- no system documentation or employee training – the analysis of factors disturbing working with the ERP indicates this as well,
- no data updating and supplementing the data (pictures of materials and sketches of products).

One must notice a significantly low amount of answers to open questions. Most of the responders did not answer the open questions at all, which may indicate lack of commitment in improving business processing based on the development of the ERP sys-
The survey carried out is a basis for analyzing the course of business processing supported by the ERP and the positions of their improvement. The improvements should be based on technical and organizational changes in the ERP system which will decrease the time and lower the work consumption of actions executed using the ERP systems [12].

**Business processing improvement propositions in area of technical production preparation**

Delta implements production of complicated devices for thermal treatment of metals. Most of constructions are prototypes and designing them involves many engineers and it is labor consuming (Fig. 6). The number of registered working hours of all the designers in 2005 and 2006 was over 14 000 (production period of a new device equals from 6 to 12 months).

![Fig. 6. Increase in registered working hours of Delta’s designers in consecutive year.](image)

The products are being designed in accordance with the client’s requirements. The constructors are obliged to monitor the costs of production during the process. While designing the product, an engineer creates a material specification in the ERP system, in that way monitoring the increasing costs of production is possible. At an early stage of designing, the engineer is obliged to create a list of so called hard-to-find materials [7].

Creating the BOM (bill of material) is a very work consuming task performed by the designer in the ERP system.

The analysis of data included in Table 1 indicates that the constructors create 20 000 new product and element indexes and over 10 000 new material indexes annually (Fig. 7).

![Fig. 7. The increase of indexes in Delta.](image)

Errors occurring in the phase of the product’s construction may have very serious consequences if not detected in the phase of construction verification and then transmitted to the areas of production or to the client. In order to eliminate the errors and to reduce the number of complaints, the ERP system registers all cards of changes in construction documentation (Fig. 8).

The following causes of changes in construction documentation have been specified:
- engineer error,
- purchasing error,
- technical requirements,
- changes of customer,
- documentation supplement,
- change of material.

<table>
<thead>
<tr>
<th>Superior index</th>
<th>Resource index</th>
<th>Name of the index</th>
<th>Quantity</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>P2076903</td>
<td>Z00073</td>
<td>Thick sheet metal 4</td>
<td>0.082026</td>
<td>m²</td>
</tr>
<tr>
<td>P2076903</td>
<td>Z00073</td>
<td>Thick sheet metal 4</td>
<td>0.013068</td>
<td>m²</td>
</tr>
<tr>
<td>P2076903</td>
<td>Z00083</td>
<td>Thick sheet metal 12</td>
<td>0.0192</td>
<td>m²</td>
</tr>
<tr>
<td>P2076903</td>
<td>Z00073</td>
<td>Thick sheet metal 4</td>
<td>0.00196</td>
<td>m²</td>
</tr>
<tr>
<td>P2076903</td>
<td>Z00057</td>
<td>High precision pipe 42.4 × 4.05</td>
<td>737</td>
<td>mm</td>
</tr>
<tr>
<td>P2076903</td>
<td>Z00042</td>
<td>Thick sheet metal 8</td>
<td>0.001225</td>
<td>m²</td>
</tr>
<tr>
<td>P2076903</td>
<td>Z00161</td>
<td>Hexagon screw M8x40 A2</td>
<td>1</td>
<td>pcs</td>
</tr>
<tr>
<td>P2076903</td>
<td>Z00024</td>
<td>Hexagon nut M8 A2</td>
<td>1</td>
<td>pcs</td>
</tr>
</tbody>
</table>
One must notice that the amount of change cards related to the designer errors is increasing constantly year after year which indicates serious disturbances and translates into an additional cost in the production process. A significant part of the errors occurs during creating specifications of product constructions while ascribing material norms for the structure of products and elements in the CAD figure.

In order to reduce the time of creating construction specification and to reduce the amount of errors and automation of the process of creating construction specification has been proposed. The process includes generating it directly from the CAD figure. This solution will allow not only the reduction of the time of performing routine processing but will also cause the material norms to be transmitted to the ERP systems after previous calculations in the CAD system, and they will not be typed in manually, which is the cause of errors. Implementing this solution requires creating an interface between the CAD system and the ERP system, which on the basis of geometrical data of the product’s construction or element’s construction will allow generating construction specifications from CAD to ERP (Fig. 9).

During designing of a new product in the CAD system, the designer chooses from two ways of introducing new elements or materials to the editing space:

1. From the library of materials and elements – objects containing data for the ERP.
2. New objects without data for the ERP.

In the second case, after sketching a new object, the designer should bring the interface to the ERP system, then find or create a new index and ascribe it to a new CAD object. After completing the creation of a new product or element in the ERP, a constructor should start the testing procedure, which will show all the objects, which do not have an ascribed data for the ERP. In order to create the construction specifications, one must ascribe an index from the ERP and a measure unit. The allegory of calculating material norms from the CAD system on the basis of the information about units of measurement and construction data of the object, will define the length, surface area, capacity, weight or the amount of items. Such data are used in creating the product’s construction specification. An exemplary specification is presented in Table 1.

The CAD-ERP interface calculates material norms without considering technological surpluses. So after introducing the data into the CAD system and accepting the product’s structure by the main constructor, the specification should be verified by a technologist.

In Delta the technologist makes changes related to material surpluses and the cutting process at the stage of production commission. At this stage it is decided whether the element should be manufactured in Delta or in a cooperative.

On the basis of the analysis of times of execution by constructors of Delta after introducing the changes, the reduction of time of operation execution by 15–30% has been estimated.

Improving business processing in production and product assembly area

In the case of piece production, the execution of a given product is often based on manufacturing prototype elements. Planned times of execution may differ by several hundred percent from the real time.
Figure 10 presents the time (h) of all operations registered in Delta in the years of 2003–2006.

![Graph](image1)

Fig. 10. Time of all registered operations in Delta.

Figure 11 presents an analysis of operation time registration according to assembly teams (teams from 1 to 9, in 2006 team 8 has been terminated). It is clear that the number of actually worked hours is irregular for each team, which indicates differences in efficiency and work organization system.

![Graph](image2)

Fig. 11. Time of operation execution by assembly teams.

A precise time of work measurement makes sense in the case of repeatable production. Only then the costs related with time measurement are apportioned for many identical products manufactured later.

In order to create a schedule of project realization during piece production it is acceptable to use the lump sum evaluation methods (which usually allow a ±10–20 % error), mark method or conversion rate method. These are, however, rated methods which are based mainly on experience, and support production planning only approximately. Not being able to estimate the error scale is the primary drawback of these methods.

An automatic measurement of execution time enables registering the times of executed operations and verifying the production plans created on the basis of rate methods (monitoring the level of production commission realization). Moreover, a calculation of production costs in relation to actual labor costs is possible [13].

The fault of the suggested method is that registering beginning and completion of an operation is time consuming (the employee must leave his work place and register execution of the operation). Automatic time measurement system model has been created on the basis of UML language. In order to create a program enabling automatic time measurement of operations performed during production, the following assumptions have been considered:

- operations for execution are previously defined in the section of production planning,
- times of executing the operations are specified roughly, on the basis of estimation methods,
- the beginning and completion of every operation is registered as well as the number of produced elements,
- a given employee can execute only one operation at the same time,
- many users can execute the same operation simultaneously,
- opening a new operation automatically ends the execution of a current operation,
- the user chooses one of the operations defined for the production order. The order of executing operations does not have to be followed,
- the operations are saved in the form of a bar code on the production order,
- ending the production order prevents registering operations ascribed to it.

Figure 12 presents a diagram of beginning. Fig. 13 presents the completion of automatic time measurement of operation execution.

![Diagram](image3)

Fig. 12. Automation of time measurement of executing operations in ERP system – beginning the registration.

The user starts to register the operation by entering his number (the number may be written in a form of a bar code on the workers identification
Then the user scans a number, written in the form of a bar code, from the production order. Because the order may include many technological operations, the user chooses the operation which he is going to execute. If the worker has started registering other operations and did not end them, then the system should complete that action by itself and only then can the worker open a new one, according to point 4. Then the worker types in the number of elements intended for production and confirms starting the registration. A maximum number of elements always stems from the production order. After confirming the data input, the system registers the time beginning the operation. Ending or pausing the operation is a lot easier. All of the data concerning the operation along with the calculated time are shown to confirm after typing in the number of the worker. If the worker wants only to pause the operation, he ends the operation inscribing “0” as the number of products and elements manufactured. After the pause the worker starts the interrupted operations using standard starting procedure.

![Fig. 13. Automation of time measurement of executing operations in ERP system – completion of registration.](image)

On the basis of presented and described diagrams of activity one may conclude that the proposed method of operation registration will be less effective if the technology of the product will be more detailed and the times of technological operations will be shorter. Therefore, the production worker is directly involved in the operation registration process. The second very important factor which influences the efficiency is the distance and the amount of terminals designed to register the operations in the production hall.

Thus the technology should be described exact to operations executed by an employee, e.g.:
- Locksmithing,
- Turning,
- Cutting,
- Assembly,
- Packing, etc.

Assuming that the registration time (depending on the distance between the place of work and the terminal) ranges from 1 to 3 minutes, then the times of executing the operations should not be less than 20 minutes. In cases of shorter times it is advisable to increase production lots.

Moreover, the system must consider registering same operations by several employees (e.g. when the production lot is being processed by more than one worker). However, then each employee should register the beginning and completion of executed operations individually.

Terminals required for operation registration may be placed close to the material and element storages because then the worker while receiving the material may register beginning an operation, and while returning it register completing the operation. However the number and place of the terminals depends mostly on the type and form of production organization and should be designed accordingly to the requirements of each production hall.

An important element related to operation’s time measurement is previous deliberation of technologies of manufacturing the product in the ERP system. It is especially important in the case of piece production, when the products are mainly prototypes. Designing of technology is based mainly on experience of a technologist, who has to estimate execution times of the operations (they are the basis of production plan and calculation). The actual operation time measurement should be compared with the planned time estimated by the technologist.

After designing the constructive and technological stricter of the product in the ERP system it is possible to plan the production and generate production commissions. The commissions are issued directly to production workers. The worker receives materials and elements in accordance with the order and registers the beginning of operation. If the analysis of production float requires time of receiving the material or preparing the work place then these kind of operations have to be in the technology defined in the ERP system. After finishing the execution of the operation the worker should register the completion. In the case of pausing the execution the worker should register the end with the number of elements being “0”, or at least lower than planned. After a break the worker restarts the paused operation. After registering completion of the operation, the system saves the difference between the time of beginning and time of completion as the actual time of execution.
Summary

The implementation of the ERP system in a manufacturing enterprise is expensive and time-consuming and often results achieved are poor. In order to reduce the rate of failure in ERP implementation, a number of studies have attempted to identify critical success factors for the implementation of ERP. An ERP project should be completed within one to three years but what should happen with the system after implementation. Most enterprises do not want to change anything if ERP works properly and keeps the most important functions. But ERP software integrated with an enterprise has to evolve together with the enterprise. Vendors develop ERP systems generally by adding new functions and modules. The business processes inner the company are changed. If the ERP development is limited only for new software updates without business processes improving then the whole enterprise development can be disturbed. The ERP system should support decision making and documentation flow in the enterprise.

The proposed methodology of ERP systems improving could be implemented in every manufacturing enterprise that uses ERP systems several years. The methodology is based on analyzing users’ opinions expressed in surveys and business processes supported by the ERP system.

Using the proposed methodology of ERP system improving, the enterprise gets the following benefits:
1. The ERP system can evolve together with the company.
2. New functions of the ERP systems are implemented and support the enterprise activities.
3. The functions of ERP are closely integrated with the functions of software.
4. The results of the ERP system use can be evaluated.
5. The ERP system can better and better support business processes of the enterprises.

The further research in the presented area, the bad scenarios of ERP systems use will be analyzed. On the base of proposed evaluation methodology of ERP system use the safety transfer procedure between different ERP systems will be prepared.

References