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APPLYING THE THEORY OF BUSINESS PROCESSES RE-ENGINEERING WITHIN THE CREATION OF THE UNIFORM INFORMATION SPACE OF THE ENTERPRISE

G.G. Kulikov[1], *gennadyg_98@yahoo.com*
T.K. Gindullina[1], *tamara_ugatu@mail.ru*
V.N. Kapustin[2], *Vladimir.Kapustin@iplc.ru*
M.S. Demchenko[1, 3], *demchenkoms@mail.ru*
R.R. Nabiev[3], *ravil.nabiev@iplc.ru*
[1] *Ufa State Aviation Technical University, Ufa, Russia*
[2] *IPL Consulting, Moscow, Russia*
[3] *IPL Consulting, Project office, Ufa, Russia*

Abstract. This article focuses on the issues of the practical application of the principles of business process reengineering during the implementation of the project on improvement of the automated system for operational control at the foundry of PJSC "UEC-UMPO" (Public Joint Stock Company "UEC-Ufa Engine Industrial Association") during the introduction of ERP Infor LN. The essence of the application of the principles of "development of various versions of the project", and "rationalization of horizontal links" is described in more detail. Application of the principle "development of various versions of the business processes" enables to implementation accounting of the division of one batch of castings into several parts during technological operations. Application of the principle "rationalization of horizontal links" creates the conditions for the formation of common information space for foundry management. This space is related to engineering design issues, process engineering issues, and issues of implementation and management of production processes. Even though reengineering involves "revolutionary" business process change, the use of its principles in the evolutionary path of development is also economically effective and at the same time reduces the risks of project failure. Thus, a simulation of the business process of management of finishing operations during the manufacture of castings performed in BPMN 2.0 showed a reduction in the duration of the processes by more than 15 %. **Aim.** Building a foundry management model in a single information space of the enterprise using the principles of reengineering business processes in the aspect of the management of finished operations. **Materials and methods.** The application of the principles of reengineering business processes to the management of finishing operations in the foundry, BPMN-modeling. **Results.** With the application of the principle of rationalization of horizontal connections, it becomes possible to transmit data from the ERP system to the CAD system and vice versa. A single information space of enterprise management is formed, which allows you to bring together all management functions. **Conclusion.** In this regard, it becomes possible to identify "narrow" places in the management of the foundry and take measures to eliminate them. To increase the level of information exchange between all divisions of the enterprise, which will create a closed production control circuit and will significantly increase the efficiency of using Infor LN.

Keywords: Uniform Information Space, business process, ERP system, IT technologies, management decisions, management automation, foundry industry, finishing operation

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ПРИМЕНЕНИЯ ПРИНЦИПОВ РЕИНЖИНИРИНГА БИЗНЕС-ПРОЦЕССОВ В РАМКАХ СОЗДАНИЯ ЕДИНОГО ИНФОРМАЦИОННОГО ПРОСТРАНСТВА ПРЕДПРИЯТИЯ

Г.Г. Куликов[1], *gennadyg_98@yahoo.com*
Т.К. Гиндуллина[1], *tamara_ugatu@mail.ru*
В.Н. Капустин[2], *Vladimir.Kapustin@iplc.ru*
М.С. Демченко[1, 3], *demchenkoms@mail.ru*
Р.Р. Набиев[3], *ravil.nabiev@iplc.ru*

[1] *Уфимский государственный авиационный технический университет, Уфа, Россия*
[2] *ООО «АЙПЛ Консалтинг», Москва, Россия*
[3] *ООО «АЙПЛ Консалтинг», Проектный офис, Уфа, Россия*

Аннотация. В данной статье рассматриваются вопросы практического применения принципов реинжиниринга бизнес-процессов при реализации проекта по совершенствованию автоматизированной системы оперативного управления литейным производством ПАО «ОДК-УМПО» (Уфимское моторостроительное производственное объединение) при внедрении ERP Infor LN. Описана сущность применения принципов «разработка различных вариантов проекта», «рационализация горизонтальных связей». Применение принципа «разработка различных вариантов бизнес-процессов» позволяет реализовать учет разделения одной партии отливок на несколько частей при выполнении технологических операций. Применение принципа «рационализация горизонтальных связей» создает условия для формирования единого информационного пространства управления литейным производством. Это пространство связано с вопросами инженерного проектирования, технологического проектирования, реализации и управления производственными процессами. Несмотря на то, что реинжиниринг предполагает «революционное» изменение бизнес-процессов, использование его принципов на эволюционном пути развития так же экономически эффективно и в то же время снижает риски провала проекта. Так, моделирование бизнес-процесса управления финишными операциями при изготовлении отливок, выполненное в BPMN 2.0, показало сокращение продолжительности процессов более чем на 15 %. **Цель исследования:** построение модели управления литейным производством в едином информационном пространстве предприятия с использованием принципов реинжиниринга бизнес-процессов в аспекте управления готовыми операциями. **Материалы и методы.** Применение принципов реинжиниринга бизнес-процессов к управлению отделочными работами литейного производства, BPMN-моделирование. **Результаты.** С применением принципа рационализации горизонтальных связей становится возможной передача данных из ERP-системы в CAD-систему и наоборот. Формируется единое информационное пространство управления предприятием, позволяющее объединить все функции управления. **Заключение.** В связи с этим появляется возможность выявить «узкие» места в управлении литейным производством и принять меры по их устранению. Повысить уровень обмена информацией между всеми подразделениями предприятия, что создаст замкнутую схему управления производством и значительно повысит эффективность использования Infor LN.

Ключевые слова: единое информационное пространство, бизнес-процесс, ERP-система, ИТ-технологии, управленческие решения, автоматизация управления, литейное производство, финишные операции

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Introduction

The scientific interests of the authors of the submitted article concern the problems of automation of the business processes of the machine-building enterprise, building models of the management system of production business processes, adaptation of existing ERP systems to the conditions of real industries, as well as business process reengineering.

Problems of improving the efficiency of activities, and the growth of competitiveness are acutely facing industrial enterprises in the modern digital world. A good plan for the development of information technology in the company involves the creation of a single information space, a single integrated information system, which would allow bringing together all production management functions, all activities of the enterprise and management levels, thereby setting an in-extensive control circuit by all resources of the enterprise. The Uniform Information Space is a set of distributed heterogeneous data repositories, where are standard rules of processing, storage, updating, retrieval, and information transfer through which paperless communication between all stages of the life cycle is conducted work. The Uniform Information Space allows storage on a centralized basis of project data in a single system of control of engineering data, to provide collective interaction between enterprise subdividing and as much as possible to use the processing power to reduce material costs and time.

IPL Consulting specializes in improving business processes and the introduction of corporate information systems for industrial enterprises. Decisions are based on the best sectoral practices and the application of reference models of management of world industry leaders. IPL Consulting is an Infor partner with the status of Infor Gold Channel Partner provides a full range of services in the field of implementing, maintaining, and technical support for INFOR products for industrial companies [1]. The choice of this vendor is due to the best functionality and technological informality of Infor solutions for industrial enterprises of secondary and large businesses [2]. It should be noted that the Infor LN ERP system is chosen as corporate by JSC “United Engine Corporation” (JSC “UEC”). JSC “UEC” is an integrated structure producing engines for military and civil aviation, space programs, gas turbine installations, etc. Currently, JSC “UEC” consists of the twenty-six largest engineering enterprises in Russia is among largest engineering enterprises in Russia, one of which is the Public Joint Stock Company “UEC-Ufa Engine Industrial Association” (PJSC “UEC-UMPO”). There is a pilot operation of an operational management system for the execution of production orders In PJSC “UEC-UMPO”. The barcoding system is implemented in the PTC (production and technological center) and integrated with ERP Infor LN. In-shop management and dispatching based on ERP Infor LN are conducted by PJSC “UEC-UMPO” Information Technology division and IPL Consulting teams. The implementation will allow the largest Russian manufacturer of gas turbine engines to create a single information space for production management and production planning, to achieve an increase in labor productivity and cut any errors in planning and accounting for production operations There is a foundry management automation project via ERP Infor LN launched on PJSC “UEC-UMPO” [2].

Features of foundry production

One of the main procurement bases of the machine-building complex is casting production. Foundry production is concentrated on machine-building enterprises, and the performance of foundry workshops determines the performance of the machine-building enterprise. Foundry productions are characterized by a complex management structure defined by the multivariance of the same processes. Such a feature of the foundry is directly affecting all management levels [3].

An essential element of the foundry system is technology, i.e., a step-by-step defined process of turning raw materials into the finished product. The production process in the foundry shops consists of a large number of interrelated operations, but significantly different from each other of operations, the execution of which is divided both in time and geographically (preparation of molding and rod mixtures, production of forms and rods, preparation of metal to smelting, producing liquid metal, pouring and knocking forms, cleaning and hardware castings, control of castings and correction of defects). The large nomenclature and volumes of the production of castings and a broad range of outflows produced by mass predetermine significant fluctuations in the complexity of molding and rod work. In almost all cast shops, several brands of alloys are used. For foundry shops, it is impossible to create reason forms, rods, and liquid metal. Some operations in the manufacture of castings are performed in parallel (for example, the manufacture of forms and rods), while others - are only sequentially (for example, fil-

ling and knocking out forms, cleaning, and stubbing castings), which makes it difficult to synchronize the operation of the main production sites of the workshops. As a result, casting goals are distinguished by a variety of forms of production sites, various in their organizational and technological type.

The casting production processes are significantly different from each other by a set of operations depending on the alloy brand, the interlacing method, the type of casting, and the specifics of the equipment, as well as the required technical parameters of alloys and castings. In the simplified form of the circuit of the casting process, or the process of manufacturing the casting is a mirror of materials, fresh and return, forming a mixture set, and spilling the alloy obtained (with certain properties) in the form [4]. The Table 1 presents the technological stages of two types of casting, demonstrating their diversity.

Table 1

Technological process stages

Stages of the process	
Sand casting	Chill casting
1. Chills preparation 2. Flask preparation 3. Cores manufacturing 4. Cores drying 5. Preparation of cores 6. Quality control of cores 7. Molding form manufacturing assembly 8. Charge preparation 9. Alloy preparation 10. Crucible preparation 11. Alloy processing 12. Filling the form with alloy 13. Quality control of the casting process 14. Removing molding 15. Cores removing 16. Initial quality control 17. Trimming 18. Casting cleaning 19. Correction of defects 20. Marking 21. Heat treatment 22. X-ray quality control 23. Final quality control 24. Cast verification	1. Cores manufacturing 2. Cores stripping 3. Quality control of cores 4. Charge preparation 5. Alloy preparation 6. Preparation of the coquille for operation, assembly, pouring 7. Filling 8. Cores removing 9. Trimming 10. Heat treatment 11. Marking 12. X-ray quality control 13. Final quality control 14. Cast verification

The successful functioning of the CTK AT requires large-scale changes in terms of the development of modern technologies and the expansion of production, including the creation of the Uniform Information Space (UIS) [3]. The UIS will allow to store of project data in a single system of engineering data management, to provide collective interaction between departments and maximize the use of the processing power to reduce material costs and time. The UIS creation will solve the problem of registration data exchange between the production system and system and the process design system. Within the UIS creation were applied the principles of business process reengineering [5].

In this work, we consider the practice of reengineering principles using the example of the business process of operational management of the finishing operations execution in a foundry.

The description of the existing process of management by finishing operations in the foundry

Finishing operations are performed in two sections: the finishing operations section and the control section Fig. 1. It is a process of final processing and testing of castings. The finishing operations management is performed to ensure the effective functioning of the foundry.

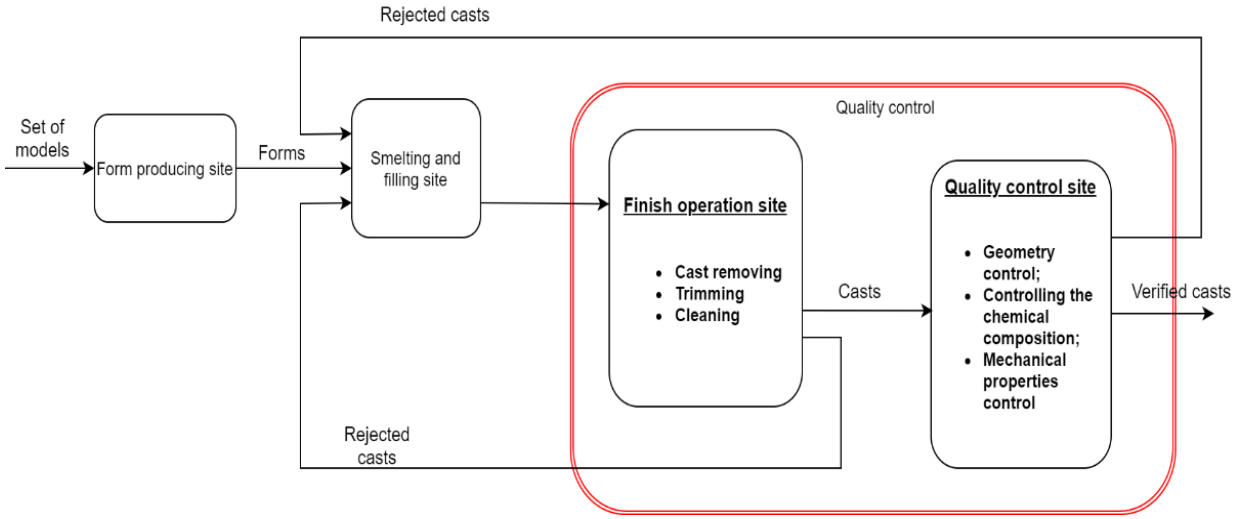

Fig. 1. Titanium Casting Workshop Production Chain Scheme

A block of castings arrives at the finishing operations site, which then undergoes the procedures of knocking out, separating the glacial-nutrient system, and stripping. Next, the castings arrive at the control site, where they undergo warping control, X-ray, and luminescent control. If correctable defects are detected at any control site, the casting is returned to the machining area, where the necessary operations to correct the defect take place. Suitable castings arrive at the site of finished products. At each stage, casting is followed by the production order. If the correctable rejection is detected the control section generates an act of fault detection, which is transmitted to the general foreman of the machining. The foreman issues replaceable jobs to certain groups depending on the type of defect. If the casting declared unfit generated the act of rejection, then this act with the defective product is transmitted in the pantry of defective products. Rejection acts are transferred from the pantry of ready casts to the bureau of quality control (BQC). The BQC generates a report on rejection and indicates there the reasons for rejection. Further, the report of rejection was transferred to the production and dispatch management bureau (PDB). Finish operations are managed by workers of PJSC "UEC-UMPO": general foreman, workload coordinator, head of the workshop, and foreman of dispatch bureau [6].

The existing process identified the following shortcomings:

– the management staff receives the results of plant operations with a delay of one day;

– information system does not allow a full-featured accounting of the separation of parts batches (a part of a batch is issued, and a part goes for correction);

– there is no full-function accounting of rejection;

– IS for recording the production progress and technology and construction engineering IS are not integrated.

These shortcomings significantly reduce the effectiveness of the management of the aluminum alloys foundry complex (AAFC). The existing system is not able to support the effective functioning of the foundry in terms of modern technologies development and expansion of production nomenclature of the positions [7]. This problem shows that the management of foundry production, including finishing operations, needs in improving. It is proposed to apply the principles of business process reengineering to solve the problem.

Applying the principles of business process reengineering

According to the definition by M. hammer and J. Champy [8, p. 10–11] business process reengineering (BPR) is defined as the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical contemporary modern measures of performance, such as cost, quality, service, and speed.

To improve the management of the finishing operations, offer to use the following principles:

• Horizontal compression business processes.

The implementation of this principle is achieved in the transition from the formation of a production

order (hereafter PO) for the batch to the formation of PO on the casting that will allow taking into account the division of the batch in case of detection of a correctable defect in the part of the batch.

• Decentralization of responsibilities (vertical compression business processes).

The implementation of the principle of vertical compression will allow the decision makers in BQC to select and transmit independently information to CAD systems for future planning.

• The logic of the implementation of business processes.

With the implementation of the tasks of the accounting division of the batch, accompanied by the opening of the new PO, there is the possibility to analyze the progress schedule in parallel with performing operations for the defect's correction. In the existing system, the implementation of the schedule analysis is performed after closing the PO to the batch.

• The development of various versions of business processes.

The proposed information system is provided for the execution of business processes in different scenarios: the batch may separate, and part of the blanks can be found fit, some may return to the correction of the defect, and some may be considered defective.

• Diversification of business processes.

The process focuses on the production of mass products must be conducted equally for all inputs leading to agreed outputs: the separation of the batch should be considered.

• Rationalization of horizontal connections.

Work is performed in the place where it is most appropriate. This principle is shown in the improved process of transferring information from the ERP system to the CAD system at the point where it is more appropriate to do so.

Using the above principles of business process reengineering will change the process of finishing operations management. BQC staff will be able to generate the report in electronic form. The separation of the batch will be considered: the technological Bureau can create a new PO for the act of fault detection, which will transfer to PDB for accounting operations on defect correction. We will consider using the principle of development of various versions of business processes and the principle of rationalization of horizontal connections in more detail.

The principle of development of various versions of business processes allows implementing batch separating owing to the detection of defects during the passage of the control operations. This fact causes the need for the development of various versions of business processes [9, p. 74–77].

The proposed information system allows considering the separation of the batch.

There are three scenarios for the implementation of the business process:

1) defects are not detected; the whole batch is found to fit;

2) adjustable defect is detected, castings with adjustable defect return to the correction;

3) unrecoverable defect is detected; casting is recognized as defective.

For the possibility of accounting for the progress of the production of castings operations, it is necessary to provide all three scenarios. The proposed system solves the problem of considering the separation of the batch by creating a new PO for each casting in which an adjustable defect is found. The technological bureau opens a new PO, further PO is transferred to PDB for accounting operations on defect correction

The process of batch separation is illustrated by a dynamic model of control of finishing operations management Fig. 2. If a defect is verified the possibility of elimination of the defect is checked. If we remove a defect, then a new PO is created and operations on defect elimination are executed.

Applying the principle of rationalization of horizontal connections allows transferring data from the ERP system to CAD systems and back [10]. Such communication consists of the automated transfer of standard information in the form of:

1) material master records;

2) specifications for materials;

3) process charts to materials that contain a list of operations and their duration.

4) changes in the existing product technologies.

Statistics of rejection must come directly to the scheduled system of foundry production that will allow the identification of "bottlenecks" of the process and take measures for their elimination. In the offered system the BQC employees can create the report on rejection in the automated mode [11].

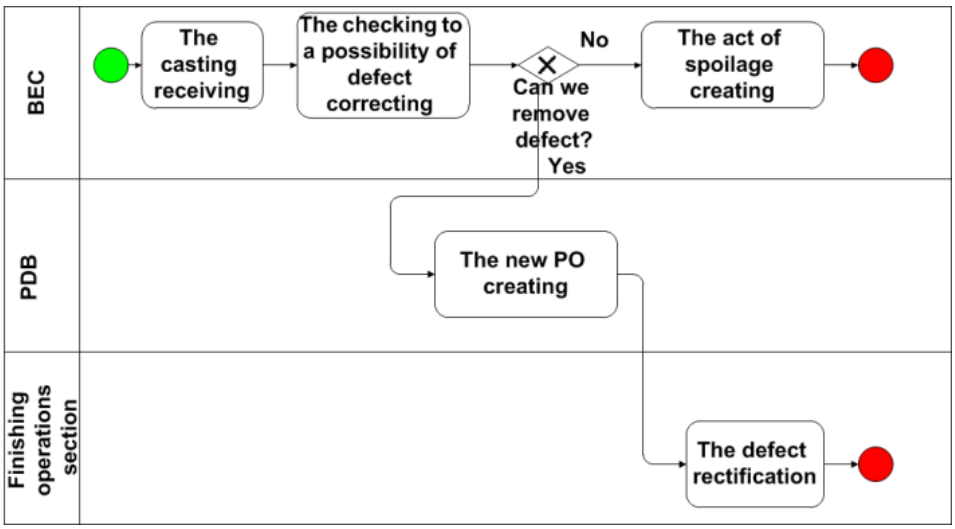

Fig. 2. Dynamic model of the proposed batch separation

Results

To measure the results of improvement of business processes of finishing operations management in foundries were simulated the proposed and the existing processes were. The simulation was based on the BPMN model Fig. 3.

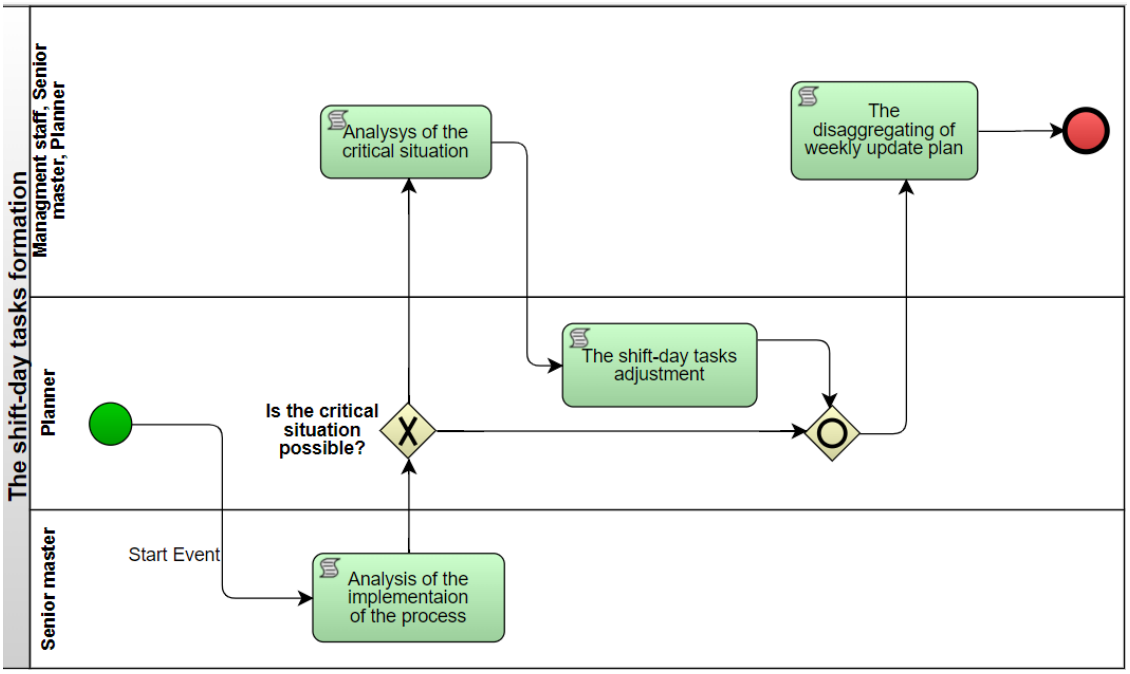

Fig. 3. The fragment of a BPMN model. The shift-day tasks formation

During the simulation, 1500 pieces were used that allow setting the ability of the offered system to cope with the planned load. The duration of the operations process and the probability of the activated output branches of an exclusive gateway are defined based on expert data [12]. The simulation showed that the process duration will be decreased: the average spent for passing by one nomenclature position of all operations of the process will decrease for 3 minutes and 3,8 seconds. The total time for the 1500 positions will make: in the existing process – six hundred hours, in offered – five hundred hours. The difference for 1500 the nomenclature positions will be one hundred hours.

The comparison of results showed that the offered model will allow performing operations on finishing operations management faster than the existing [13].

Conclusion

As part of the interaction of the Department of Automated Management Systems of the Ufa State Aviation Technical University, PJSC "UEC-UMPO" and IPL Consulting there is underway work of forming a structural model of the casting process, developed models of intra-workshop planning (manufacturing execution system level), accounting for the production and support of decision-making in operational management on the methodology of structural modeling and process modeling [14]. Also, the model of the component composition of the alloy charge was developed, in which all reference books are presented as existing ERP Infor LN and newly created. The conducted research demonstrates that the introduction and adaptation of Infor LN in the enterprises of the class of PJSC "UEC-UMPO" is an urgent task.

The need to apply the principles of reengineering business processes to create a single information space of an enterprise is obvious. This makes it possible to adapt the existing system to other conditions. Increase the level of information exchange between all enterprise divisions, which will create a closed loop management loop and will significantly increase the efficiency of using Infor LN. The access of managers and specialists of the enterprise to the necessary reliable information in real-time will increase the quality of management decisions [15].

The applying principle of horizontal relations rationalization will create conditions for the formation of the Uniform Information Space. ERP-system allows quality statistics but using only the ERP system to solve the problem of rejection reduction is impossible. Planning of foundry production in PJSC "UEC-UMPO" is conducted with the CAD system. This system does not allow to realize the finishing operations management. The creation of the UIS (Uniform Information Space) will allow the integration of the data of CAD and ERP systems and to quickly make management decisions in case of changes in production.

The systems integration will allow avoiding errors due to re-enter data and reducing production preparation time.

The double-side data exchange between ERP and CAD systems can be conducted both in real-time and batch mode at regular intervals manually.

Thus, the execution of horizontal communications the principle will allow to reveal of "narrow" places of process and to make management decisions on their elimination.

The described technique is verified by conducting a simulation of the proposed and existing processes with the performing execution of dynamic analysis. The results apply to the PJSC "UEC-UMPO".

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Information about the authors

Gennady G. Kulikov, Dr. Sci. (Eng.), Prof. of the Department of Automated Control Systems, Ufa State Aviation Technical University, Ufa, Russia; gennadyg_98@yahoo.com.

Tamara K. Gindullina, Cand. Sci. (Eng.), Ass. Prof. of the Department of Automated Control Systems, Ufa State Aviation Technical University, Ufa, Russia; tamara_ugatu@mail.ru.

Vladimir N. Kapustin, Executive Director, IPL Consulting, Moscow, Russia; Vladimir.Kapustin@iplc.ru.

Marina S. Demchenko, Senior Lecturer of the Department of Automated Control Systems, Ufa State Aviation Technical University, Ufa, Russia; Analytics department consultant, IPL Consulting, Project office, Ufa, Russia; demchenkoms@mail.ru.

Ravil R. Nabiev, Senior Consultant, IPL Consulting, Project office, Ufa, Russia; ravil.nabiev@iplc.ru.

Информация об авторах

Куликов Геннадий Григорьевич, д-р техн. наук, проф. кафедры автоматизированных систем управления, Уфимский государственный авиационный технический университет, Уфа, Россия; gennadyg_98@yahoo.com.

Гиндуллина Тамара Камильевна, канд. техн. наук, доц. кафедры автоматизированных систем управления, Уфимский государственный авиационный технический университет, Уфа, Россия; tamara_ugatu@mail.ru.

Капустин Владимир Николаевич, исполнительный директор, ООО «АЙПЛ Консалтинг», Москва, Россия; Vladimir.Kapustin@iplc.ru.

Демченко Марина Сергеевна, старший преподаватель кафедры автоматизированных систем управления, Уфимский государственный авиационный технический университет, Уфа, Россия; консультант отдела аналитики, ООО «АЙПЛ Консалтинг», Проектный офис, Уфа, Россия; demchenkoms@mail.ru.

Набиев Равиль Раисович, ведущий консультант, ООО «АЙПЛ Консалтинг», Проектный офис, Уфа, Россия; ravil.nabiev@iplc.ru.

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