Simulation of parts manufacturing in the enterprise mechanical-repair department

V A Ivanov¹, A A Feshchenko¹²

¹ Perm National Research Polytechnic University, 29 Komsomolsky prospect, Perm, 614990, Russian Federation
² e-mail: feshchenko_alexander@mail.ru

Abstract. A continuous production process has a number of peculiar properties that affect the organization of technological equipment maintenance and repair aimed at the most efficient using of the service time, that is, the required number of equipment maintenance and repair with the required quality. It is necessary to have its own service department in large manufacturing enterprises, which includes an autonomous mechanical repair unit, allowing one to manufacture, restore parts, components and assemblies for the main technological chain, without the third parties help to ensure the continuous functioning of the repair service. This approach provides a significant reduction of service cost, production and part (unit) repair time, a more accurate account of the production conditions characteristics. However, as a rule, the organization of the repair and mechanical shops is at a low technological level due to the secondary role of such units within the manufacturing enterprise. It is possible to revise the approach to the organization of internal material, information flows with the using of modern modeling process methods. This is the purpose of this work. A chronometric measurement of the manufacturing process, the part restoration before and after the test process change were carried out, a new process simulation was produced by ARIS EPC, which allows one to analyze the action algorithm of the process participants to achieve this purpose.

1. Introduction

According to M. Levin [1] the repair and equipment maintenance processes centralization in the centralized repair workshops of industrial enterprises and in specialized industrial repair and maintenance enterprises is widely used in the construction of technical repair and equipment maintenance systems in the world practice. This approach ensures prompt and reliable interaction on solution of equipment functionality restoring issues.

However, the repair functions centralization is not so obvious and unambiguous in the classical organizational structure of the enterprise repair service. Divisions (Shop repair services, repair and mechanic shops, design and technological Bureau, planning and production Bureau, department of the non-standard load-lifting equipment and transport systems, Bureau of planned and preventive repair and a spare parts warehouse) submit to department of the chief mechanic at one level [2] (Fig. 1).
In turn, the department of chief mechanics reports to the chief engineer of the enterprise or technical director.

Many enterprises with a continuous production type removed repair service units from their organizational structures during the formation of market relations [3]. They have become independent organizations providing services.

The main motive for development of independent repair service system is improvement of the provided maintenance and repair services quality [4].

The repair and maintenance introduction carried out by the company's own forces is a huge reserve. It is equipment maintenance in constant readiness for operation. It is ensuring high efficiency of equipment using by the company [3,5,6].

2. Methods and Software

The modeling of mechanical repair shop processes in the structure of industrial enterprise was carried out within the framework of this work using the modern methodology of business processes description ARIS [7] in EPC notation.

The simulation purpose is to optimize information and material flows in the implementation of the main shop activities, which is the restoration, manufacture of parts (orders). The order is the incoming document. The output product is the executed order. The main innovation is the maintenance of supporting documentation during the parts and documentation production cycle by customer shops in electronic form. It will reduce: the time for paperwork, the exchange of information in internal and external activities. Besides, it allows making room due to there is no to store paper documentation.

3. Results and Discussion.

The documentation was used only in paper form before the introduction of the change. The document "Order" for full filling required printing the form in paper form and manual filling of 18 fields. The average time of filling was ≈ 1.5 min by the customer shop forces before the order entering in the repair shop. The document "Routing sheet" [8] is formed, which is used together with the design documentation for the order execution in the process of document maintaining. In this process, results of each stage of production information is entered. Time spent on additional filling of the Order is ≈ 2
The total time spent on the transfer of a paper document from one employee inside the shop is \( \approx 3.5 \text{ min.} \) Thus, the total time of work with the document "Order" is \( \approx 7 \text{ min.} \)

Estimated total time with the document is reduced to 3 minutes (57\%) with the introduction of electronic document management in the mechanical repair shop. This eliminates: the personal transfer of the document between employees (excessive presence of employees in the production shop), the need to store documents in paper form (free room in the technical archive, there is no need to make a purchase for the shop additional archival and stationery), facilitates the search for the necessary document (because of a convenient search for an electronic document for various details), increases the document storage reliability, as a data backup can be stored on the company's own servers.

The developed model of the restoration and production process of parts (orders) consists of 4 main stages (Fig. 2):

1. Order processing.
2. Order execution.
3. Order OTC (output technical control).
4. Delivery of the order.

\[ \text{Order received} \]

1. Order processing

\[ \text{The order is processed, transferred for execution} \]

2. Order execution

\[ \text{The order is executed, transferred to OTC} \]

3. Order OTC

\[ \text{OTC is finished, order transferred on delivery} \]

4. Delivery of the order

\[ \text{Order delivered} \]

**Figure 2.** Parts (orders) restoration, production process model.
At the first stage there is a received electronic order registration check from the shop customer by the operator (Fig. 3). The order is marked "Refusal" in case of incorrect ordering and the order is returned to the customer. Further verification of the correctness of the design documentation attached to the order...
in the case of correct ordering. The order is marked "Failure" in case of incorrect attached design documentation and the order is returned to the customer. The possibility of execution of the order by the branchwork manager is further evaluated in the case of correct design documentation attached to the order. The order is marked "Refusal" in the absence of the possibility of execution of the order and then the order is returned to the customer (the option of execution of the order by a third-party contractor through the department of chief mechanic). The application for materials supplied and Routing sheet (all documents are issued in electronic form) are transferred to the stage of execution of the order and together with the design documentation and in paper form if the execution of the order is possible.

The stage of the order execution begins with the receipt of paper copies of the Routing sheet, design documentation and materials supplied by the contractor (mechanic) (Fig. 4). The machinist executes the order in accordance with all the requirements described in the received documentation only upon receipt of all incoming documents and materials. The branchwork manager performs the initial check of the order execution when all the technological operations are performed. The defective order is registered, the defective order is returned to the warehouse, the cycle of the execution stage is repeated in case of detection of critical remarks. The order is given to the stage of final technical control in case of critical remarks absence.

**Figure 4.** Model of the process of restoration, production of parts (orders), the stage of the order execution.

At the stage of the output technical control, the OTC-engineer receives the executed order and Routing sheet, design documentation (DD) and order, according to which it has been executed (Fig. 5).
The engineer checks the executed order for compliance with the design documentation and the Routing sheet. If the order does not correspond to the design documentation and the Routing sheet, then the defect is registered, and the executed order is returned to the warehouse, the cycle of the execution stage is repeated. If the order corresponds to the design documentation, Routing sheet, then results of the output technical control are marked in the order and the executed order is transferred at the stage of delivery with a package of documents.

Figure 5. Model of the process of restoration, production of parts (orders), the stage of order output technical control.

At the stage of order delivery the operator receives the executed order and design documentation, then he notifies the customer about the readiness of the order and the operator provides executed order with the accompanying documents to customer when he arrived (Fig. 6). The customer checks the executed order for compliance with the accompanying documents. If the order does not comply with the documentation, the customer describes the comments in the order and the executed order is returned to the execution stage. If the order corresponds to the documentation, the customer accepts the executed order and the order is marked "Accepted". If the order corresponds to the documentation and the customer has comments, then the order can not be returned to the stage of execution and the customer must place a new order in this case.
Figure 6. Model of the process of restoration, production of parts (orders), the stage of delivery of the order.
4. Conclusions
The areas of responsibility of specialists become unambiguous because of the detailed study of the model: the peculiarity of EPC notation allows to distinguish the beginning and the end of each action by events. Based on the model, it is convenient to describe user algorithms for software development [7], generation a package of job descriptions, operating instructions and other regulatory documents necessary for the introduction of the production process modified logic [9, 10].

5. Acknowledgments
The results of this work were tested in the mechanical equipment centralized repair workshop in The Group of Enterprises "Perm pulp and paper company". The existing process of manufacturing, execution of parts was analyzed and a proposal was made for automation with the change of the current regulations of the process and the standard of the enterprise by means of the above models.

References
[1] Levin M A 2005 Equipment service management of the enterprises of industries with network technology of continuous production (ext. abstr. of PhD thesis). Moscow.
[2] Fedorov A V 2004 Improvement of technological equipment maintenance and repair quality management on the process approach basis (PhD Thesis), Tula.
[3] Tomazova O V 2012 Maintenance and repair system formation according to the actual condition of oil equipment Economic and law issues 6 55-59
[4] Equipment maintenance and repair (2019). Retrieved from: http://intecinfo.ru/uslugi/txnicheskoe-obsluzhivanie-i-remont-toir.html (accessed 3 February 2019)
[5] Kozhekin G Ya and Sinitsa L M 1998 Organization of production (Minsk: Ekoperspektiva Publ.)
[6] Kurochkin A S 2001 Organization of production (Kiev: InterRegional Academy of Personnel Management Publ.)
[7] Repin V V and Eliferov V G 2012 Process approach to management. Business process modeling (Moscow: Standards and Quality Publ.)
[8] State Standart 3.1118-82 Forms and rules of route maps registration. Moscow, Standartinform Publ. 2012 109
[9] Gracheva K A, Zakharova M K, Odintsova L A and Skvortsov Yu V 2003 Organization and planning of machine-building production (production management) (Moscow: Vysshaya shkola Publ.)
[10] Fathutdinov R A 2011 Organization of production (Moscow: INFRA-M Publ.)