

# COMPANY INFORMATION TECHNIQUES IN PRODUCTION ENGINEERING

Mariusz ŻÓLTOWSKI, Bogdan ŻÓLTOWSKI

**Summary:** This paper presents the elements of industrial developments in the field of computer support in production engineering management. Starting with drilling down data for the purposes of the knowledge acquisition, the programs from the ERP group were indicated as possible to apply. Basic information on expert systems and ERP IT systems applied more and more frequently was provided. The practical use of ProSeS system in production engineering was discussed.

**Keywords:** engineering of production, informative technics, industrial practice.

## 1. Introduction

The key problem in production management is the development of methods optimizing production planning and scheduling. Due to competition, on the one hand optimization criteria should satisfy the client, and on the other allow a company to gain positions on the market. The reason for assuming the most commonly adopted criterion of the optimization of production planning and scheduling is the deadline for the execution of commissioned tasks and the minimization of the total time of completion of tasks carried out during the production process. This approach provides many advantages - it shortens client waiting time for the execution of an order and lowers production costs (a decrease in the work in progress). Human desire for perfection is reflected in optimization. While selecting an optimization method and procedure in the field of production management one cannot focus only on whether the method reaches the optimum. It is important to take into account the efficiency of its search. Algorithms with high-accuracy are not suitable for practical use due to the need to use the superfast computers [1, 8, 9].

The basis for efficient procedures in industrial applications is constituted by measurement data, which are often available in excess. The road from acquired to established knowledge is long and strenuous (Figure 1), and yet so processed insight data constitute a basis for industrial innovation [2, 3, 4, 5, 6, 7].

Information redundancy and discovering knowledge aims to *identify the regularity* of data existing in a set that is contained in a database. *The regularity* is determined by a certain *pattern* and *extent* in which this pattern occurs.

The process of knowledge discovery in databases (KDD) has multiple stages, of which the best known is data mining (DM). In this process that you can see many iteration possibilities, the aim of which is multiple data selection, their initial processing, data drill down enabling an automatic search for dependencies of qualitative and quantitative nature, and finally the interpretation of received dependencies by result recipient.

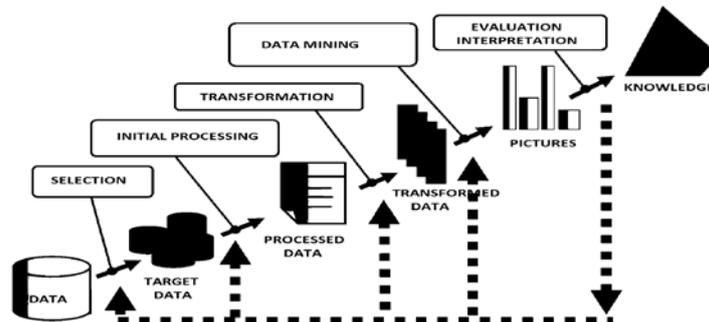


Fig. 1. Stages of dependence search in a data set

This paper is dedicated to the general characteristics of the issue of production management and the description of capabilities of a specific program - ProSeS. The aim of this article is a brief presentation of the issue of production management and advantages of most of the features of the program that help to solve the aforementioned problems. The proposed ProSeS program forming an entire IT system functions effectively in many Polish enterprises engaged in plastics processing and treatment of metals.

The program described herein is based on an expert system. In this system, knowledge and practical experience saved by a knowledge engineer as frames, slots for computer and used for the creation of consulting systems are important and crucial.

## 2. Systems for production management

In recent years, the concept of the integrated production management has found widespread applications. These are varieties of systems of MRP/ERP classes, which in practical applications are growing in popularity, and their application solves many problems in an enterprise. ProSeS program works based on production management system of ERP class (*Enterprise Resource Planning*).

The most important feature of ERP systems enriching their functionality is the presence of financial modules allowing production planning and control not only on the basis of qualitative and quantitative indicators, but also value indicators. In addition, ERP systems are complementary of the MRP II system in terms of supporting additional functions (realized by separate applications), for example contacts with suppliers, distributors and customers. The core of the entire ERP system is a central database, which individual applications exchange data with and which the performance of the entire system is based on. The database collects and stores data from the different areas of enterprise business. The use of one database streamlines the flow of information between all areas of business activity of a company. The source of data for the base and its users are organizational units (i.e. applications operating in them) in different functional divisions of an enterprise. In ERP database, new data is entered only once in one spot. Their entry entails an automatic update of all related data. In practice, the construction of such a universal database, combining data from different applications, proves to be difficult in the case of a large company mainly due to a significant degree of defragmentation of information generated in an enterprise and different levels of its detailness. Therefore, in ERP systems a big emphasis is put on proper definition of the interfaces for information exchange between applications and the database [1].

Modern IT solutions evolve (Fig.2), going from the class of economic event record in the direction of controlling and accounting enabling strategic planning, company finance control, distribution and personnel management, production planning, reporting to management boards and external institutions.

**IC (Inventory control)**

IC – systems for stocks economy management, developed in the late 1950s. They were the first systems supporting management. The first systems were developed with a view to reduce storage costs.

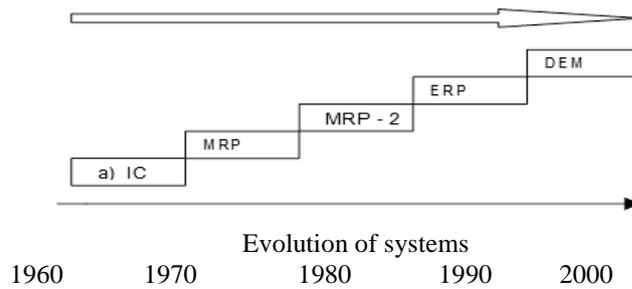


Fig. 2. Evolution of IT systems

**MRP (Material Requirements Planning)**

MRP method (Material Requirements Planning) has its origins in the late 1950s, when its first version was developed. Fundamental concepts of various techniques gathered under the name of MRP were already known. However, they could not be fully applied in previous years without data processing by modern computers with a large operating memory. MRP method calculates the exact amount of materials and the schedule of deliveries so as to meet the ever changing demand for various products, including more than one factory. In its later versions direct orders from end-users and dealers, sales and production forecasts, stocks status, accounting and invoice records are taken into account.

Systems of this type enable to obtain up-to-date lists of parts and subassemblies of products. They use data from the stock records (semi-finished products, finished products). Systems provide material demand for planned production order in terms of quantity and value. They generate scheduled purchase and production orders, and they allow to control production realization in terms of type, quantity and deadline and to optimally control the stock.

**MRP II**

MRP II (Manufacturing Resource Planning) – the most commonly used method today. This is a complex system for planning the production process, which facilitates the coordination of corporation operation, also in the case of a dispersed structure. MRP-2 model, compared to the previous one, was enhanced with elements related to the sales process and supporting the decision-making process at strategic levels of production management. As development progressed, MRP specification included further areas of company business, gradually becoming a complex tool. In MRP-2 model, it covers all the spheres of business management related to production preparation, its planning and control, as well as sale and distribution of manufactured goods. Apart from materials related directly to production, MRP-2 also takes into account supplementary materials, human

resources, money, time and fixed assets. Every few years analyses called “MRP-2 Standard System” are made.

**MRP-2 Standard System** describes the following functions:

- Sales and Operation Planning – SOP,
- Demand Management – DEM,
- Master Production Scheduling – MPS,
- Material Requirement Planning – MRP,
- Bill of Material Subsystem – BOM,
- Inventory Transaction Subsystem – INV,
- Scheduled Receipts Subsystem – SRS,
- Shop Floor Control – SFC,
- Capacity Requirement Planning – CRP,
- Input/Output Control; Purchasing – PUR,
- Distribution Resource Planning – DRP,
- Tooling Planning and Control – TPC,
- Financial Planning Interface – MCFPI,
- Simulation – SYM,
- Performance Measurement – PMT.

#### **ERP**

The next step in the development of MRP method is ERP (Enterprise Resource Planning), by many simply called MRP III (Money Resource Planning). ERP is considered to be the specification of the 1990s. ERP is a system embracing all the production and distribution processes which integrates various areas of enterprise activity, streamlines the flow of information critical for its functioning and allows a rapid response to changes in demand. ERP method covers the following areas:

- **customer service** – customer database, order processing, specific order service (products on request), electronic transfer of documents (EDI),
- **production** – warehouse service, production cost estimation, purchases of raw materials and materials, production scheduling, managing product changes (such as making improvements), forecasting production capacity, determining the critical level of resources/stocks, production process control (e.g. tracing the product in manufacturing plants), etc.,
- **finance** – bookkeeping, controlling the flow of accounting documents, preparing financial reports in accordance with the expectations of different recipient groups (e.g. the division into the head office and branches).

All currently offered fully integrated management systems partly realize the concepts of MRP/ERP. Used properly, modern fully integrated IT system for management is not only a hardware and software environment, but primarily fixed and condensed vast knowledge on management and business venture environment.

#### **DEM**

DEM (Dynamic Enterprise Modeller) – this is an innovative solution introduced in 1996 by Baan. This relatively young solution provides a set of integrated tools for dynamic modelling of company structure enabling direct transition from a company model to a finished application and menu for individual users. This System is simply an extension to ERP system, with an automatic implementation of changes taking place in the company. The management can thus track these changes and adjust accordingly.

A comparison of systems occurring in Poland is difficult due to limited information. According to the presented information an attempt to compare the systems can be made

(Figure 3) with respect to the class in which they work. This is a very important criterion which determines system modernity. Based on the materials contained herein, this stems from the evolution of information technology.

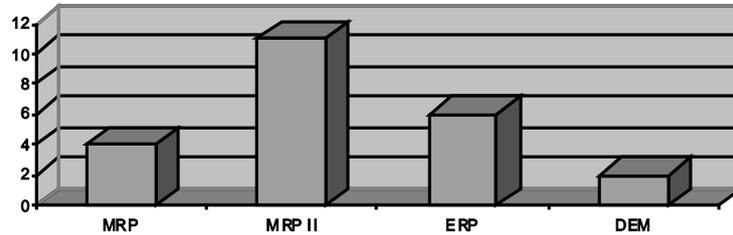


Fig. 3. The chart of offered and applied IT systems by companies in Poland

### 3. Expert system structure in production management

Basic areas of using expert systems in production systems involve functions they may perform, that is: consultant, modelling tool, expert in various specialized fields.

Expert systems use rules of “IF THEN” type. A database contains specific facts in the subject matter, which are used by an element of the knowledge base. Before applying the rule, the elements of its conditional part must be presented in the database. The application of the rule gives rise to new facts that update the database. The requesting machine controls the reasoning process by adjusting facts from the database to conditions of rules, and then examining the conclusions of rules as bases for the next rule. This is the so-called “forward chaining”. “Backward chaining” can also be experienced; it is based on the designation of premises from assumed conclusions - from targets to elementary facts.

Considering the structure of an expert system in greater detail, the following key features can be distinguished:

- knowledge base – i.e. a set of rules,
- database – i.e. data on an object,
- inference procedures – inference machine,
- explanation procedures – explain inference strategies,
- dialog control procedures – input/output procedures enable to formulate tasks by a user and forward a solution by the program,
- procedures for extending and modifying knowledge – the acquisition of knowledge.

The construction of an expert system is facilitated by specially constructed skeletal expert systems (*expert system shell*) [2]. Such systems have an empty knowledge base and an empty database and complete other items [1].

The term “expert” is intuitively understood as a man with well established knowledge and experience in a given field and the authority. Assessment made by an expert on the one hand depends on his or her knowledge and experience, and the other on a subjective sensation related to the results of his or her professional experience, current trends in the approach to the issues requiring a solution, etc. These problems affect the direction of research, and applied methods of testing and result analysis. The process of selecting experts, based on such subjective feelings, and evaluations generated by them require careful realization and thorough verification.

The main reason for resorting to expert systems is the awareness that knowledge on the considered problem is neither complete nor entirely certain. With regard to diagnostic expert systems, this takes place when diagnostic inference may not be sufficiently reliable as a result of logical inference carried out on the basis of object construction analysis, principles of its functioning and the results of conducted observations and measurements.

Such situations take place especially during the preparation of guidelines by a designer (e.g. instructions, projects of diagnostic equipment) for service diagnosing (the location of damage).

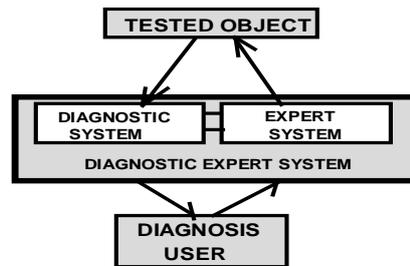


Fig. 4. A general scheme of using an expert system in diagnostics

In diagnostic system structure considered so far it was assumed that a set of tested traits of an object is known, reference values enabling an elaboration of results of checks established, and a diagnostic relation for logical inference on the condition of the tested object unambiguous. However, if these conditions are not fully fulfilled, the need to appoint an expert (expert team) appears. His or her actions will help to establish a reliable diagnostic relationship between the condition of an object and its symptoms. For this purpose, certain means for the implementation of expert actions composing an expert system (ES) are necessary. In conjunction with a diagnostic system enabling object testing a diagnostic expert system (DES) arises, whose links with the environment are shown in Figure 5.

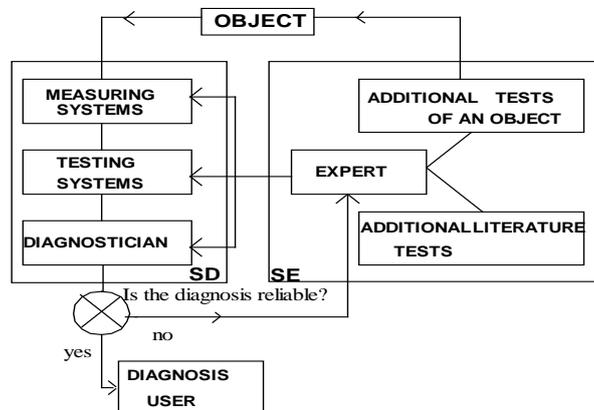


Fig. 5. IT connections in a diagnostic expert system

Diagnostic expert system operation can be described as follows: if the diagnosis established by the diagnostic system does not meet user requirements (e.g. is false), a user asks for the assistance of an expert, who, using the additional information, recommends changes in the diagnostic process (the examination of other properties of an object, other reference values, other diagnostic relationship), which gives a more reliable diagnosis. From the point of view of the circulation of information, loopback closed with an expert system occurs in a diagnostic system.

The primary task of a diagnostic expert system is an indication to a user of diagnoses possible failures of an object based on the observed symptoms and causes of their occurrence, or possibly ways of their removal. In order to achieve this task, the system enables to create diagnostic knowledge, using various sources of information. These are:

1 – literature tests; they allow to determine what we do not know. It should be noted that the source of information in this respect can be, in addition to scientific papers, manuals, protocols of complaints and test results of both an object for which the diagnostic system was elaborated and other objects belonging to the same class; 2 – the analysis of object construction and functioning; 3 – experimental tests, supplementing or verifying already acquired knowledge on the object and its diagnosing. These tests can be simulated or modelled, conducted in laboratory or exploitation conditions.

Obtained diagnostic knowledge is used in co-operation with an expert so as to:

- create a set of possible failures of an object and a set of their symptoms on the basis,
- obtain a determination of dependence between a symptom and a failure from experts through interview (i.e. in the form of a questionnaire). The obtained connections can be saved with the help of the so called *base charts of knowledge representation*,
- verify these results by experimental tests, conducting various diagnostic experiments.

The final result of these activities is the creation of inference rules in the form of an implication: “**If {x} then y**”; where x stands for “conditions” and y for “conclusions”. These rules are different from the diagnostic relations in that:

- they entail uncertainty characterized by degrees of certainty since both the facts and inference rules based on them of are not entirely certain;
- inference rules may be simple, in the form of implications: **If x then E<sub>i</sub>**, or complex, in the form: **If x then E<sub>i</sub> or E<sub>j</sub>** ( $i \neq j$ ).

The creation of inference rules, that is implications combining symptoms (“conditions”) and diagnosis (“conclusions”) requires a collection of many pieces of information on an object, determination of the way they can be obtained, and, in particular, a selection of interesting symptoms, which may narrow down the indeterminateness of an object. Related problems can be combined in the following, related modules:

1. diagnostic information collection module (knowledge acquisition),
2. module of controlling the dialogue with a user,
3. inference rule creation module,
4. diagnostic knowledge base module.

The first one involves a set of measuring apparatus and transducers to generate data. The second one concerns the selection of signs, symptoms and conditions of an object (possible damage), which should be studied and determined. The third module includes a

methodology for developing the relationship more accurately and certainly connecting the observed symptoms with object condition.

The results obtained in the course of literature tests (including the design data on the object), experimental tests (including data on the exploitation), and inference results and their verification are collected in knowledge base module and used in subsequent operations performed by the system.

#### **4. Expert systems in production management**

Expert systems are applied in different areas of manufacturing activities of man. They are used primarily when the actual situations in an enterprise are difficult to define and formalise through the construction of a purely mathematical models.

Expert systems are also adequate resources for planning and controlling the production cycle, gaining increasing recognition and popularity. They constitute problem-oriented computer programs supporting the decision making process.

In many cases, the object of extensive and intensive tests conducted in this area of research is the integration of common techniques of computer support with expert systems. Systems of computer planning and production control support are most frequently applied at present. They use the achievements of three scientific disciplines: artificial intelligence, operation tests and control. Hybrid models linking models of closed networks of lines with expert systems [4] and systems that are a combination of Petri networks and an expert system [3] are a good example.

##### **4.1. Planning**

Subprogram PLANNING enables to schedule tasks effectively. With current information, it is possible to eradicate the "bottleneck" even before their appearance. The change of plans during the execution of orders automatically takes into account nominal data of the tool. Each order is shown as a coloured bar; red colour indicates that the order in question cannot be completed in the expected time. Bars can be moved freely in a calendar, finding optimal time for a machine to complete the task on time. An additional benefit is an instant review of free capacity.

##### **4.2. Picture of the hall**

The main program window shows all the machines in the hall as large icons and current machinery condition as small icons (pause, changeovers, boot, automatic operation, end of task, failure, service). Practically every client in the planners' room has a monitor or TV with a large screen diagonal, which by default shows the PICTURE OF THE HALL. This enables constant control of the basic conditions of machinery and quick response in the event of irregularities. Creating a program, the client decides what information should appear on the home screen.

##### **4.3. PC terminal**

There is a possibility of order update directly on machines with the help of service terminals, touch screens and mobile panels. This enables efficient and effective order changes, entering the causes of deficiencies, downtime, as well as registering and

unregistering staff. The best solution would be to equip the machines with a separate terminal; however, customers rarely choose this option due to significant costs. An optimal solution is one computer in a hall in an optimum point, used by operators. Figure 6 shows the program window running on a PC. Operators with password or access card have access to the computer located in the center of the hall.

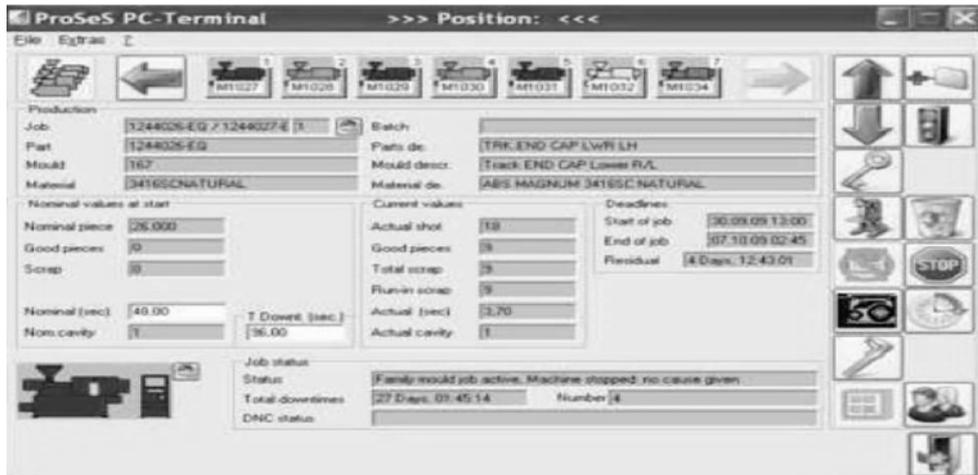


Fig. 6. A program window on a PC terminal

It is possible to enter occurrences such as:

- change of production batches,
- unlocking the control system,
- data transfer,
- printing labels,
- the assignment of production means,
- client-specific special functions.

Figure 9 presents various solutions of terminals that cooperate with ProSeS system. Quite often a client already has other types of terminals with an operating system which can be customized to support ProSeS system installed on the machine.

#### 4.4. Process parameter management

The program enables to control adjustable data, production parameters and limits of tolerance. It allows forwarding information on a process to the system of quality parameter management (CAQ) and automatically triggering an alarm when toleration limits are crossed. Figure 7 shows a window of a process parameter management system.



Fig. 7. A process parameter management system window

#### 4.5. Evaluation of exploitation data registration

The program allows compiling and comparing any number of process data for analysis. The data is presented in the form of a table or complex charts, mainly used to create reports from a specific period of production. Figure 8 shows such a program window.

#### 4.6. Management (DNC)

The Program allows managing adjustable data, parameters, and machinery software. The ability to upload programs to machines facilitates the operation in a large degree, eliminating actions that would have to be conducted at the desktop of machine control panel, i.e. entering parameters from the order card. With the help of computer, it is possible to automatically upload production parameters for a given tool. Starting the production on a given machine, after equipping it with a tool, the program automatically uploads production parameters into the machine.

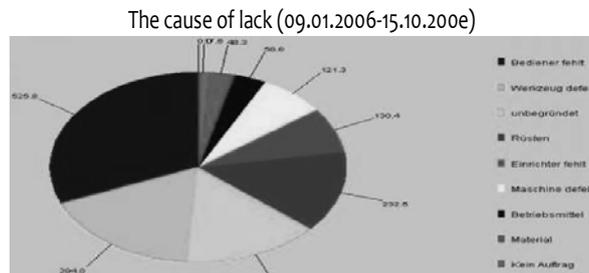


Fig. 8. A program window

#### 4.7. Maintenance

The program monitors production means, periods between repairs and machine maintenance, moulds and peripheral devices. Thanks to the database with the number of worked hours and performed cycles, the program informs about the need to review or repair a machine before crossing limit values. The status of a given tool is also visible at the stage of production planning if an order may not exceed the number of cycles allowed prior to the

closest review and the operator will be informed about it. Figure 9 shows the program window.

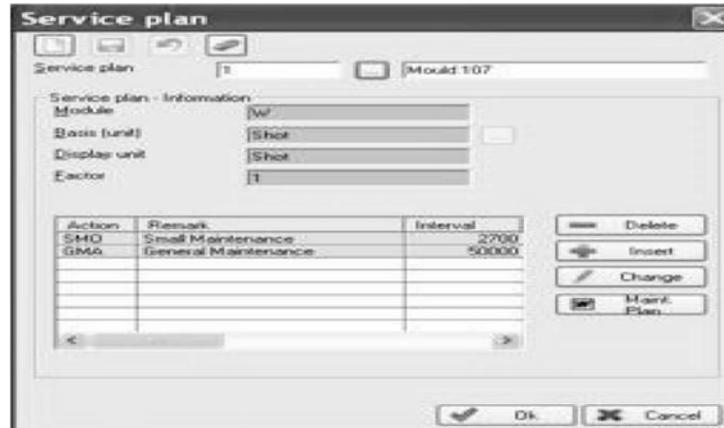


Fig. 9. Maintenance program window

## 5. Conclusion

Programs for production management such as ProSeS support company business in a variety of ways. First of all, their implementation improves making key decisions in a company. This takes place due to the fact that the system collects the most important business information in one spot. Owing to such a monitoring of business processes in a company, it is easier to adjust company strategies. Constant control over the process of execution of orders, both cost- and time wise, is very important. One can decide decisions that result in company better adjustment to the requirements of the market more quickly. This is very important because nowadays the speed of response to market changes is crucial in the fight for a good position in the branch.

The system collects data from various company departments, so that instant reaction to current market demand is possible. In addition, the software enables to coordinate activities related to an optimal use of resources, both human and material, and to keep a minimum stock level. The implementation also contributes to the fact that it is possible to plan on many levels. After a successful implementation of the system, the circulation of documents in a company is also streamlined.

All important documents can be sent at express pace of both internally and between company's external partners. In addition, an automation of logistic processes is a considerable benefit.

## References

1. Szczepkowski Ł.: The rationalization of the economy service - the repair machine engines. The works of the qualifying study, under the hearts B. Żółtowski. UTP 2010, Bydgoszcz.
2. Ławrynowicz A.: The management production in the cell of the net of deliveries with the use of the system ekspert and the genetic algorithm. The School publishing houses ATR, 2006, Bydgoszcz.

3. Ławrynowicz A.: COMPLAN - ekspert system of the selection of technics of the computer aid of the management the production. The Publishing Wroclaw Engineering college, 2004, Wroclaw.
4. Brzeziński M.: Organization and steering the production. Projecting productive systems and the processes of steering the production. Placet, 2002, Warsaw.
5. Sroka H.: Expert Systems. The computer aid of the decision in management and finances. Fuel- efficient academy in Katowicach, 1994, Katowice.
6. <http://www.dopak.pl/proses.htm>.
7. <http://www.proses.eu/POL/polska.htm>.
8. Żółtowski B.: The basis of the diagnostics of machine. Bydgoszcz, ATR, 1996.
9. Żółtowski M.: The computer aided of the management the system of exploitation. The integrated by computer management, T. II, Publishing Annexe Polish Company Management Production, Opole, 2011.

*This study was executed in the project of No. WND -POIG.01.03.01-00-212/09.*

Prof. dr hab. inż. Bogdan ŻÓŁTOWSKI  
Dr inż. Mariusz ŻÓŁTOWSKI  
University of Technology and Life Sciences  
85-796 Bydgoszcz, Kaliskiego 7  
tel./fax.: (0-52) 340 82 83  
e-mail: bogzol@utp.edu.pl  
          mariusz.zoltowski@utp.edu.pl  
Bydgoska Szkoła Wyższa