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A NEW PERSPECTIVE FOR THE APPLICATION OF THE ACTIVITY BASED COSTING METHOD IN MANUFACTURING COMPANIES USING MES CLASS SYSTEMS

NOWA PERSPEKTYWA ZASTOSOWANIA METODY ACTIVITY BASED COSTING W FIRMACH PRODUKCYJNYCH WYKORZYSTUJĄCYCH SYSTEMY KLASY MES

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Abstract: The purpose of this paper is to present a new perspective for the practical use of the Activity Based Costing method for cost accounting in manufacturing companies using modern MES systems. In this example, the data from a company in the metal industry has been studied. The article shows how the use of software for automatic registration of data from machines can significantly eliminate the disadvantages of the Activity Based Costing method and contribute to relevant optimization in the field of product costing. The calculations were made based on the example of one manufacturing machine carrying out three different production orders. It was shown that operating at the interface between IT and financial

analysis can bring the desired benefits in the field of data analysis automation and the elimination of human error thanks to the use of hardware and software platforms integrating the latest IT and industrial automation solutions.

Keywords: Activity Based Costing, MES, data collection optimization.

Streszczenie: Celem niniejszego artykułu jest omówienie nowej perspektywy praktycznego wykorzystania metody *Activity Based Costing* do rozliczania kosztów w firmach produkcyjnych wykorzystujących nowoczesne systemy klasy MES. W omawianym przykładzie wykorzystano dane pochodzące z firmy z branży metalowej. Zaprezentowano, jak wykorzystanie oprogramowania służącego do automatycznej rejestracji danych z maszyn może w dużym stopniu wyeliminować wady metody *Activity Based Costing* oraz przyczynić się do znacznej optymalizacji w zakresie kalkulacji kosztów produktu. Obliczenia wykonano na przykładzie jednej maszyny produkcyjnej realizującej trzy różne zlecenia produkcyjne. Wykazano, że działanie na styku IT i analiz finansowych może przynieść pożądane korzyści w zakresie automatyzacji analizy danych oraz eliminacji błędów ludzkich dzięki wykorzystaniu platform sprzętowo-programowych integrujących najnowsze rozwiązania z zakresu IT i automatyki przemysłowej.

Słowa kluczowe: *Activity Based Costing*, MES, optymalizacja gromadzenia danych.

1. Introduction

The paper presents an example of the use of the Activity Based Costing (ABC) method for cost calculation carried out by the controlling department at a company in the metal industry. The data applied in the example was obtained from the MES (Manufacturing Execution System) class system functioning in the company and enabling fully automatic data collection and initial processing. The article also deals with the innovative technical layer of the system for automatic data acquisition from manufacturing machines, which is part of the MES software. As indicated in this paper, automatic data acquisition is a key element that enables the application of the ABC method in industrial practice and obtaining reliable results without errors related to the stage of manual data collection and reporting by human personnel. The greatest drawbacks of the ABC method, as indicated by the authors, are its complexity and the time-consuming collection of the data necessary to prepare settlements. By using information from the MES system, the second problem can be completely eliminated. These limitations and an example of the data application in practice are discussed in Sections 3 and 5.

2. Controlling – historical outline, tasks of the cost controller in a company

The concept of controlling is often associated with exercising control, and even though there is a lot of truth in this statement the actual scope of activities related to it is much wider. The history of controlling is inextricably linked with the United States of America, where, as a result of the dynamic development of the economy in the 19th century, the managers began to register the lack of information. Financial planning and the control of the budgets of developing companies were becoming increasingly difficult. At the end of the century, in 1892, the General Electric Company (GE) implemented principles that can still be applied to today's controlling. The person employed as a controller at GE was responsible mainly for the budget and accounting. As crisis is always an opportunity for growth, similarly in this case the greatest development of controlling occurred during the great economic crisis. At that time, an organization called the Controllers Institute of America was created. Today it is operating under the name of Financial Executives Institute of America, which developed a catalogue of the controller's tasks as a person in the organization responsible not only for control, but also for planning and reporting.

In Europe, Germany is considered the cradle of controlling. However it cannot be denied that the foundations were created by managers of American corporations with branches in Europe, which dates back to the 1950s. Yet the managers encountered a number of difficulties while trying to adjust the principles of controlling developed in the USA to the European reality. Hence in the first phase of operation the focus was mainly on the theoretical aspects of controlling. Controlling arrived in Poland much later, and is still used mostly in large companies. In recent years there has been an increase in interest in this subject (Materac, 2020, p. 54).

In the literature on this subject one can find many different definitions of controlling. And there is no doubt that this is a very broad term. Most of the authors agree that one of the main tasks of controlling is to provide information to make the right business decisions. This view is shared, among others, by Horváth, who defines controlling as a management subsystem whose main role is to coordinate planning, but most of all to provide information for the entire system (2011). The definition formulated in this way places controlling in one of the key positions in the organization, looking through the prism of decision-making in general. Mockler approached the formulation of the definition in a more practical way. In his opinion, controlling can be considered as a process of constantly comparing plans with their actual implementation. Such an approach may contribute to the implementation of quick corrective actions, and this in turn results in the maximum use of the resources in the organization (Nesterak, 2013, pp. 23-27).

As mentioned above, it is very difficult to indicate a single definition that would include all aspects and activities in the organization for which controlling departments

are responsible. Below are some of the most important tasks that are most often the focus of controllers:

- Forecasting,
- Strategic planning,
- Budgeting,
- Management Reporting,
- Risk management,
- Cost Accounting (Heimel, Lohnert, Michel, Ropers, Tretter, and Waniczek, 2012, p. 18).

In this paper the issue of costing is discussed. There are many methods to measure, identify and assign costs to the appropriate cost centres. Based on the publication by the Chartered Institute of Management Accountants (CIMA, 2018), the most important of them are:

- Absorption Costing,
- Marginal Costing,
- Activity Based Costing (ABC),
- Target Costing,
- Kaizen Costing.

3. Activity Based Costing

In the previous section, various methods for calculating costs were mentioned. This part focuses on one specific solution that is gaining popularity and also constantly evolving, i.e. the Activity Based Costing method which has its origins in the 1980s. ABC was developed in response to the dynamic economic development and the ever-growing customer requirements. The aforementioned changes also required some actions on the part of the suppliers of goods and services. With the gradual shift from mass production to personalized products, the ways of calculating costs also had to fundamentally change. Indirect costs accounted for an increasing share of the total cost pool, which resulted in the need to depart from traditional cost calculation methods (Kaplan and Anderson, 2007). In their assumptions, they do not offer the required precision of assigning costs to cost objects. For organizations with high overheads and a wide product range, the use of single cost breakdowns (division keys) could lead to incorrect calculations (Cooper and Kaplan, 1988).

Two concepts are inextricably linked to the ABC methodology:

- *cost pool* – **an activity** that ‘consumes’ the company resources. In addition, it is associated with overhead costs related to this specific activity. Each cost pool requires a dedicated *cost driver* (CIMA, 2018);
- *cost driver* – **a unit** of action that consumes resources. A specific unit can only be “assigned” to one activity, but the number of activities depends on the management. For instance:

Two activities were identified in a company: production planning, for which the unit of activity may be the number of production orders, and the second activity, namely order acceptance, for which the unit could be the number of accepted orders. Each action has its individual unit. It is precisely the aspect of the number of different units used for accounting that clearly distinguishes ABC from standard calculation methods. It can be said that *Cost drivers* serve as the basis for allocating costs to individual activities (Kim and Ballard, 2001).

Why is it worth implementing ABC into a company? What financial and organizational benefits can the managers expect from the implementation of this solution? Referring to the article *Activity Based Costing in Morocco* by Bescos and Charaf (2014), here are some of the main advantages of implementing ABC:

- improved pricing process,
- more accurate cost data,
- improved communication between departments,
- better allocation of overhead costs,
- product improvements.

As one can see, the implementation of ABC, in addition to strictly financial benefits, can also contribute to the improvement of the product itself and its quality. Importantly, from the point of view of the profitability of the entity, by deciding to act according to ABC rules, managers can greatly improve the pricing process. Price calculations are more accurate, which may be reflected in new product offers in the future, since the greater the cost awareness, the more profitable products a company can produce.

Obviously, apart from the above-mentioned advantages, there are also obstacles that in many cases may turn out to be too big to apply ABC in business practice. First of all, attention should be paid to the complexity of ABC implementation. This consists of many steps that managers/controllers have to take in order to start settling costs according to the discussed method. One should, among others, determine what activities occur in the company and whether it is worth monitoring them. It will also be necessary to assign *cost drivers* – which in practice may turn out to be burdened with a large dose of subjectivity. Moreover, it is necessary to inform employees about the changes taking place in the organization because they may be mainly burdened with the obligation to, for example, collect the data necessary for subsequent settlements. It is this factor (data collection) that in many cases may turn out to be key when deciding about the implementation of ABC. The authors agree as to the problems related not so much to the implementation of ABC, but the subsequent ongoing provision of data for calculations. Velmurugan and Manivannan Senthil (2010) argues that ABC works and is applicable in pilot projects, but it is extremely difficult and expensive to apply this method throughout the organization due to the complexity and time-consuming nature of data collection. Exactly the same problem is identified by Metin Reyhanoglu in the article „Activity-Based Costing System, Advantages and Disadvantages” (2004, p. 10). The author draws attention to the fact that in the initial

phase of an organization operation based on ABC, the process of collecting data is time-consuming, and finding sources of reliable information is also not easy. On the other hand, Cardoso and Pete (2011) do not attach importance to the fact that it is difficult to identify and manage activities later on, but also focus on the possible reluctance of employees to change, or the lack of understanding of the method by the management, which may result in uncertainty among the staff. If the process of data management is not optimized enough, it may turn out that operational activities are neglected in favour of providing information for activity-based costing. Moreover, possible changes in assumptions regarding e.g. *cost pools* or *cost drivers* may also turn out to be highly time-consuming as they will require a re-evaluation of the process and discussions with colleagues. In the case of changes, the possibility of comparing data will be lost for a certain period, because in the past these activities were ‘settled’ according to other assumptions, in other units. All the above-mentioned disadvantages of ABC should be taken into account when deciding to implement this method.

4. Platform for automated data collection and processing in the production company in the metal industry

The EDOCS MES (EDOCS Systems, 2020) platform for automated data collection and processing consists of embedded devices installed on the factory floor and equipped with custom-made software for data collection in real-time, and communication with the MES layer as well as business logic components and graphical user interfaces dedicated for system end users, i.e. machine operators and production management personnel.

The hardware platform used on the factory floor consists in Programmable Automation Controllers (PACs) and touchable panels. PACs are equipped with an operating system and meet the demands of modern manufacturing systems. One PAC device is installed for each machine, and performs diverse tasks simultaneously, i.e. acquiring, processing and collecting data (e.g. machine work time); communication with the data server layer; Graphical User Interface (GUI) and communication with peripheral devices, e.g. barcode and RFID readers or electronic calipers. The ethernet network is used for communication between PACs and a data server layer as well as communication between the data server and touchable panels. In addition, mobile data collectors (wireless communication) are used for collecting data for modules used to trace product genealogy on manual work places. The platform hardware structure is presented in Figure 1.

In the system’s software layer (factory floor level) three modules are distinguished, namely Efficiency, Quality Control and SSE (start-stop-end). The Unified Modelling Language (UML) diagram of the software components is shown in Figure 2.

The Efficiency module is responsible for the monitoring of machines, i.e. acquiring signals from machine control systems and converting them into production

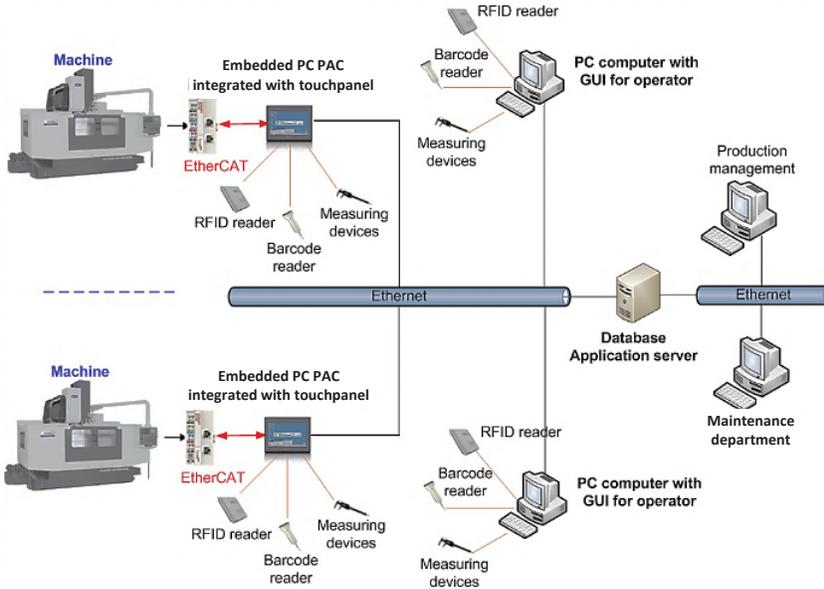


Fig. 1. Platform for automated data collection and processing – hardware structure

Source: (EDOCS Systems, 2020).

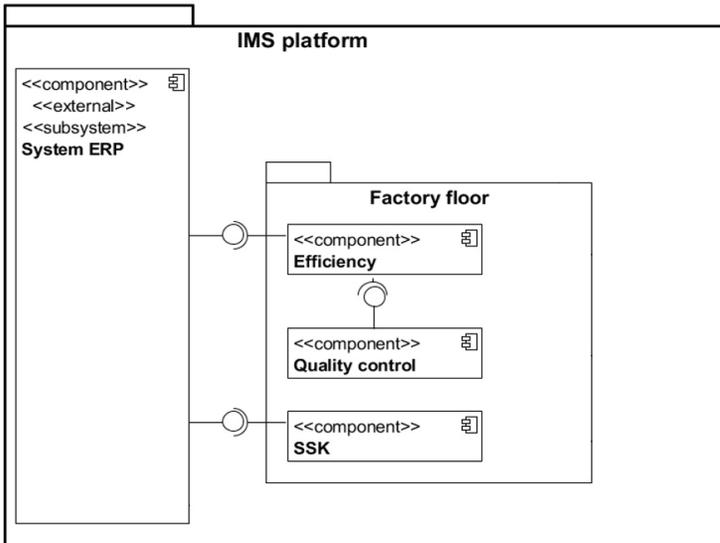


Fig. 2. Platform for automated data collection and processing – software structure

Source: (EDOCS Systems, 2020).

start and stop events as well as storing data in a database. On the basis of a set of start and stop events, the operation period presented in Table 1 is calculated on the server side. The module uses PACs and provides GUI used by machine operators for inputting orders identifiers presented in Table 1, as well as reasons for stoppages and operators' login and logout time. An on-line view of machine working states and historical reports are provided for production management personnel in the web application (Figure 3 and 4).

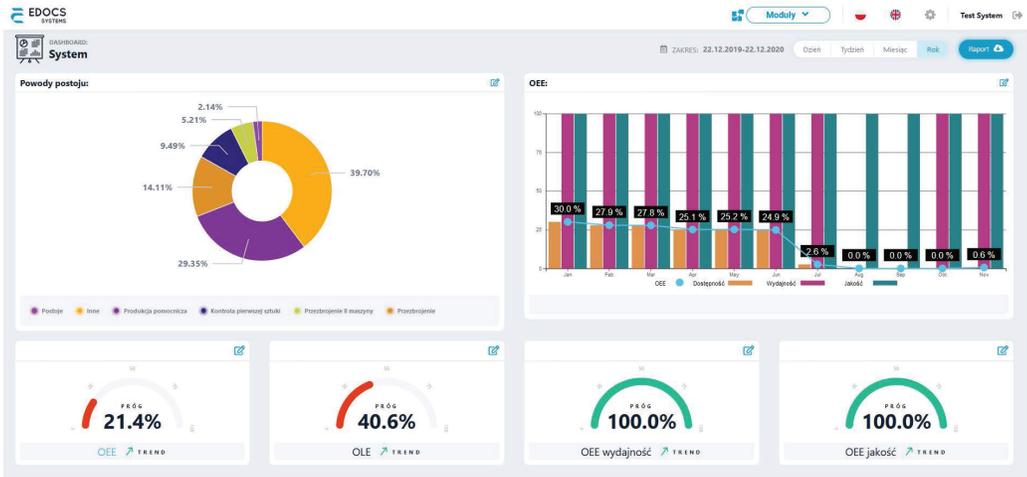


Fig. 3. Example of historical reports

Source: (EDOCS Systems, 2020).

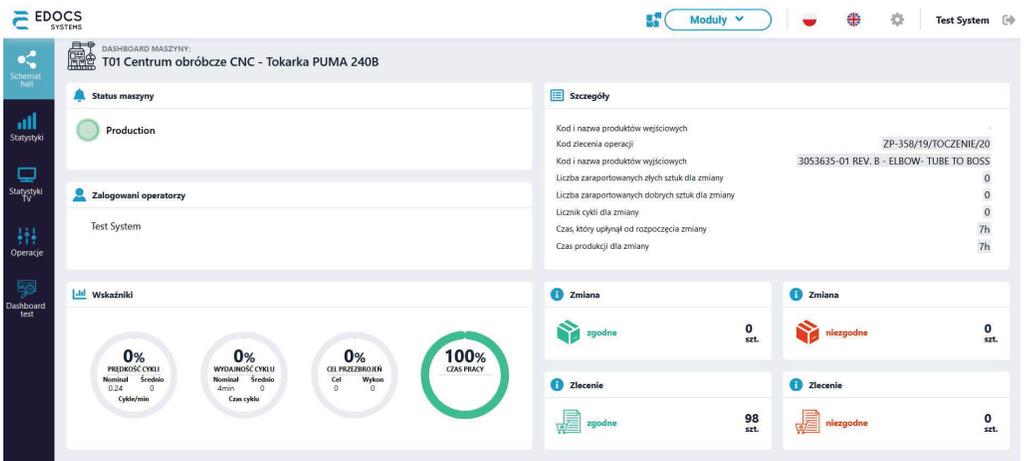


Fig. 4. Example of on-line reports

Source: (EDOCS Systems, 2020).

The SSK module is used for tracing the genealogy of the products. The module registers the flow of materials, intermediate and final products on the factory floor level using PACs and mobile wireless data collectors.

The Quality Control module supports quality procedures and provides integration with measuring devices. Quantitative and qualitative quality parameters can be entered into the system by machine operators or quality control personnel.

The platform provides automatically collected data which are used by different departments, including controlling; the ABC analysis described in Section 4 uses data collected by the system.

5. Automation of the settlement process by Activity Based Costing methods using data from the MES class system

In Section 3, the barriers encountered in implementing the ABC method in production companies were discussed. Attention was drawn to the necessity to obtain and collect the data necessary for the preparation of settlements and their subsequent analysis. The optimal solution for the organization is the complete automation of the above-

Table 1. Sample data import from the MES system

No.	Data-Start	Data-Stop	Operation's duration [min]	Production order ID
1	01.07.2020	01.07.2020	422	ZP-1
2	01.07.2020	01.07.2020	258	ZP-1
3	01.07.2020	01.07.2020	156	ZP-1
4	02.07.2020	02.07.2020	785	ZP-1
5	02.07.2020	02.07.2020	365	ZP-1
6	04.07.2020	04.07.2020	25	ZP-1
7	04.07.2020	04.07.2020	48	ZP-1
8	04.07.2020	04.07.2020	41	ZP-1
9	10.07.2020	10.07.2020	365	ZP-2
10	10.07.2020	10.07.2020	69	ZP-2
11	10.07.2020	10.07.2020	240	ZP-2
12	12.07.2020	12.07.2020	346	ZP-2
13	12.07.2020	12.07.2020	246	ZP-3
14	16.07.2020	16.07.2020	465	ZP-3
15	16.07.2020	16.07.2020	452	ZP-3
16	16.07.2020	16.07.2020	364	ZP-3
17	20.07.2020	20.07.2020	523	ZP-3
18	20.07.2020	20.07.2020	412	ZP-3
19	21.07.2020	21.07.2020	397	ZP-3
20	22.07.2020	22.07.2020	381	ZP-3

Source: own study based on data from the EDOCS system by EDOCS Systems sp. z o.o.

mentioned process. Through the prism of production stations, such possibilities are offered by MES class systems equipped with the functionality of automatic data collection from production machines. This section presents a proposal of cost accounting for production machines with the use of data collected in a fully automatic manner. The data comes from a company from the metal industry and was recorded using the MES class system called EDOCS MES, which is a product of the EDOCS Systems company (EDOCS Systems, 2020), whose structure in the technical layer is discussed in Section 4.

Table 1 shows the data import from the MES system concerning the operation of one machine during one month.

It is worth mentioning that the range of data that can be obtained is much wider. For the purposes of the paper, this was limited to presenting the key information from the point of view of settlements by means of the ABC method. The key data are included in column 4 (containing the machine working time related to the execution of a specific order) and in column 5 (containing the production order ID).

5.1. Settlement of machine costs using real data

With reference to Section 3, for the purposes of the ABC method it is necessary to define two key parameters, i.e. *cost pool* and *cost driver*. In the discussed case, the following assumptions were adopted: *cost pool* is a production process (order) carried out on a given machine, *cost driver* is the machine working time related to the execution of a specific order. As shown in Table 1, during one month (July), the machine worked for three production orders, and a summary of the working times for each of them is presented in Table 2.

Table 2. Summary of machine working times for individual orders

ID of the production order	Working time [min.]	Working time [hrs.]
ZP-1	2 100	35
ZP-2	1 020	17
ZP-3	3 240	54
sum	6 360	106

Source: own study based on Table 1.

The accounting department assigned various costs by type to the activity in question, i.e. production on the machine. The summary is presented in Table 3.

The next step in the application of the ABC approach is the calculation of the ratio for the settlement of costs for individual orders [*Cost Driver Rate*]. The method of calculations is presented below.

$$\text{cost driver rate} = \frac{\sum \text{costs of implementing activities on the machine in a given month}}{\sum \text{machine working time for all orders}}$$

For the case under consideration, the value of the indicator is:

$$\text{cost driver rate} = \frac{9699}{106} = 91.5.$$

Table 3. Costs by their nature booked for the operation, i.e. production on a specific machine in the month of July and their values

Type of cost	Value [PLN]
Machine amortization	3 000
Operator remuneration	5 000
Spare parts wear	199
External services performed on the machine	1 000
Electric energy usage	500
sum	9 699

Source: own study based on information from a company from the metal industry.

On the basis of the analysis, it was found that the cost of one hour of the machine under consideration amounted to PLN 91.5. For the purposes of the study, the aspect of unused production capacity and the division of costs into constant and variable were omitted. The main focus was to present the systemic possibilities and how to use them in economic practice.

A summary of the settlements of production costs on the machine is presented in Table 4.

Table 4. Summary of cost settlement of production orders

ID of the production order	Working time [min]	Working time [hrs.]	Cost driver rate	Cost of the operation charging an order
ZP-1	2 100	35	91.5	3 202.5
ZP-2	1 020	17	91.5	1 555.5
ZP-3	3 240	54	91.5	4 941
			sum	9 699

Source: own study.

Table 4 presents the effect of the settlement of the operating costs on three production orders. The application of the methodology, assuming the lack of automation of the process of collecting data from machines, would be practically impossible in practice. If a company has a dozen or several dozen production

machines where several dozen different orders are produced, the manual process of collecting data could turn out to be too tedious and time-consuming within a month. It would also be burdened with the possibility of a mistake on the part of the data-typing person. The use of IT tools described in this publication completely automates the process and, moreover, excludes the possibility of incorrect data entry.

6. Conclusion

In today's rapidly changing environment it is crucial to quickly make the right business decisions. Making the right decision is conditioned by several factors. One of the key factors is, of course, having reliable data that will support the decision-making process. Controlling can be a tool that greatly facilitates the above-mentioned process, based on data that can come from various sources, most of which are ERP, CRM, APS or MES systems. The present how to combine the potential of a modern MES system with Activity Based Costing, which is an element of controlling. The result is the complete automation of data collection from machines, which can then be used to calculate and calculate the cost of manufacturing a product. Having data is just the beginning. The final result depends on whether the organization is able to process them properly so that they become a source of knowledge about the company and its productivity. The combination of controlling with the source of reliable data, which is the MES system, provides the managers with an easy analysis and no human error. The presented approach is the basis for the development of typical MES class software with elements of automatic data processing for the needs of analyses carried out by controlling departments. Such activities are consistent with the idea of the broadly understood automation of the processes occurring in production systems, including the automation of the business processes carried out with the use of the appropriate computer software (Przemysł 4.0). It seems to be clear that an advanced data analysis to make reasoned and generalized conclusions about production processes is a demanding task for human analysts (Wang, 2007; Choudhary et al., 2009). Therefore, the authors of this paper are currently working on applying Computational Intelligence techniques to automatically discover knowledge, e. g. finding association rules from the data collected by IT systems to provide controlling personnel with a reliable knowledge of the production processes.

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