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Applicability of Business Rules to Production Management in Foundries

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Abstract

The size and complexity of decision problems in production systems and their impact on the economic results of companies make it necessary to develop new methods of solving these problems. One of the latest methods of decision support is business rules management. This approach can be used for the quantitative and qualitative decision, among them to production management. Our study has shown that the concept of business rules BR can play at most a supporting role in manufacturing management, but alone cannot form a complete solution for production management in foundries.

Keywords: Application of information technology to the foundry industry; Operation management, Business rules

1. Introduction

Enterprises nowadays have complex information systems that supports decision making processes at all management levels. Some information is stored in the companies' computer systems, some is written e.g. in the form of processes' description documents, and some of it is stored in the heads of the experienced staff. That is why enterprises search for a convenient and effective way to describe the rules that can support the decision making process. Today's recommended solution is the use of business rules. Such approach has been successfully applied in customer relationship management, marketing, the mortgage industry, insurance services, e-government, telecommunications, engineering, transportation and manufacturing [2]. Possessing a well-designed business rule management system can bring a competitive advantage not only for huge, globally operating enterprises, but also for small and medium manufactures.

In this paper we focus on the business rules approach for production management in foundries. Section 2 describes the conception of business rules. Section 3 outlines the core areas of production management. In Section 4 the details of potential BR applications in foundries are shown. The conclusions are drawn in Section 5.

2. Business rules management

The Business Rules (BR) concept is defined as a formal way of managing and automating an organization's business rules so that the business behaves and evolves as its leaders intend [10]. Business Rules Management (BRM) is one of the latest approach to computer support of business activities: BRM concept is implemented in business practice as Business Rules Management Systems (BRMS). BRMS is a computer system used to define, distribute, execute, monitor and maintain the decision logic. The major objective of BRMS is to allow describing business processes to be implemented independently of the software system. The rules referring to the chosen decision problem establish a rule set. From the user's point of view, the rule set is a closed structure upon which the conclusion process can be conducted. The knowledge base of BRMS allows for storing many mutually independent rule sets. The knowledge base usually allows also for storing the knowledge in other structures like decision tables and decision grids that can be converted into rules form.

A single rule consists of a premise and a conclusion, and uses the following pattern:

IF <premise> THEN <conclusion>

Rule-based decision systems can be used for both quantitative and qualitative decisions: they have proved their usefulness in [10]:

– CRM systems,
– customer assessment systems,
– sales systems,
– systems supporting supply chain management,
– cost control and budgeting,
– production management,
– energy management.

3. Production management

Classification of production management areas is not clear - different sources give different schemes, although we can distinguish some common elements. J.B. Dilworth, in the classic work "Operations management" [4], groups together activities of production management in the seven functions of management: planning, organizing, controlling, directing, motivating, coordinating, training and developing personnel.

Consistent standard of objects and decisions promotes the International Society of Automation [5]. The ISA 95 standards provide a formal model for exchange data between business systems and manufacturing systems. The model also includes a definition of Manufacturing Operations Management (MOM), i.e. the activities on the shop floor required to manufacture products. ISA-95 standard was developed in order to reduce the costs, risks and errors associated with the implementation of computerized systems for management and control. The general scheme of decision-making activities in the ISA-95 model is shown in Fig. 1.

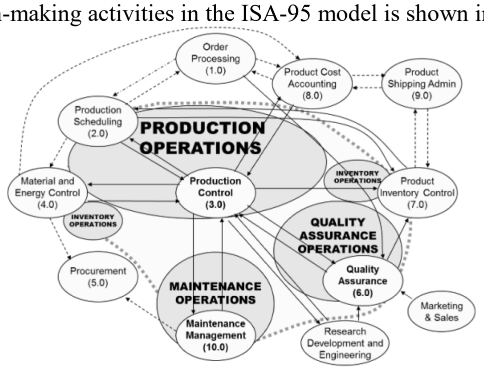

Fig. 1. Production management activities according to ISA 95 standard. Source: [5]

In Section 4 we use ISA-95 activities as the areas of potential BR applications [5]:

1. Manufacturing operations management defines functions typically associated with the shop floor operations: product definition management, production resource management, detailed production scheduling, production dispatching, production execution management, production tracking, production data collection, and production performance analysis.
2. Maintenance operations management: the activities that ensure the availability of personnel, equipment and tools for manufacturing operations.
3. Quality operations management: the collection of activities related to measuring and reporting on quality. The quality operations management includes both quality operations and the management of those operations in order to ensure the quality of intermediate and final products.
4. Inventory operations management: the collection of activities that manage the inventory of products and materials, perform periodic and/or on demand inventory cycle counts, manage the transfer of material, measure and report on inventory and material transfer capabilities, and coordinate and control the personnel and equipment used in material transfer.

4. Business rules for production management

The review of the literature concerning business rules, has shown that there is no reports on the practical applications of BR in production management of the foundry industry. Therefore we will analyze and try to make use of some solutions developed for related industries, in particular the metal industry.

4.1. Manufacturing operations management

Business rules can be useful only in two fields of operations management: production scheduling and production analysis. The remaining activities are administrative or control, in which the use of BR is unjustified. It is true that production dispatching is based on simple rules, but they do not have the nature of business rules.

Production scheduling is carried out on a daily or weekly basis to find the assignment and sequencing of tasks (clients' orders) to production resources (e.g. machines, labour). In real production environment there are a lot of organizational and technological constraints which must be satisfied by schedule. Thus, sophisticated optimization algorithms have to be used to solve the scheduling problems, while BRM systems do not allow for incorporating the optimization models. Rules can express empirical associations between decision-making conditions and problem solving actions, for example [1]:

IF a lot is available and could be scheduled but it is known that an essential machine must undergo maintenance in a short time THEN delay this lot and try to schedule another.

Attempts to use BR (or more broadly - expert systems) in the scheduling have been taking place since the eighties of the

10.1515/afe-2016-0008

twentieth century [6] and show that BR can play at most a supporting role, but alone cannot form a complete solution.

Another field of BR applications to production scheduling is clients' orders prioritizing based on clients' classification. Due dates are usually related to the priorities of clients as due-dates for less prioritized orders can be sometimes postponed for a few days without significant consequences.

The successful implementation of BRM for foundry clients' classification was presented in [11]. The system consists of 64 rules which cover three properties: economic attributes (sales value per year, profit margin), trading attributes (complaints period, payment time-limit), production attributes (specified tolerances, special packing, external treatment, the level of technical cooperation). The client classification has a great importance in business cooperation as it can be the basis for orders' prioritisation or discount policy, according to the client class. This classification problem appeared to be not very complicated and declarative knowledge proved to be sufficient to solve it.

Production analysis consists in investigation of useful information from the collected data about the current status of production performance. Performance indicators evaluate the success of production activities in physical or financial units of measure. Although we haven't found any example of BRMS for production performance analysis, the development of such a system would not be difficult. After calculating the indicators, a set of rules would be fired, to draw the conclusion on how to classify the production process. For example, if some indicator *Ind1* took one value from four ranges, a set of rules would look like:

IF Ind1<Level1 THEN Process1=”poor”
IF Ind1>=Level1 AND Ind1<Level2 THEN Process1=”average”
IF Ind1>=Level2 AND Ind1<Level3 THEN Process1=”good”
IF Ind1>=Level3 THEN Process1=”very good”

After performing such an analysis for all indicators, the overall performance index would be determined by the main set of rules which summarize conclusions from bottom-level rules.

4.2. Maintenance operations management

Maintenance operations include all activities to keep productive facilities and equipment in acceptable operating conditions. There ae two types of maintenance: preventive and remedial (breakdown) [4]. Since maintenance activities are among the most critical in production management, the systematic and comprehensive approach to maintenance is needed.

Or [8] presented a decision support system (DSS) for maintenance planning in a large foundry supplying castings for automotive industry. Planning involves balancing preventive maintenance (PM), breakdown maintenance (BM), and backuping costs with costs of lost production. The proposed system has the following characteristics:

– efficient knowledge base,
– capability for generating of daily (weekly) PM task schedules,
– capability for calculating and keeping track of various performance indicators,
– availability of material requirements planning,
– realistic determination of PM task priorities,
– a control mechanism for deviations between plans and actions.

Although this DSS didn't use business rules, the author suggested to employ a set of rules reflecting the managers' behavior in various policy decision situations. This mechanism should be supported by analysis of performance indicators; the analysis, in turn, could be done with BRMS module.

4.3. Quality operations management

Quality control is based on statistical methods, but many problems may be written using rules notation. One of them is the diagnosis of defects of semi-finished and finished products. As an example may serve CastExpert - an expert system for the diagnosis of defects in castings, developed at the Foundry Research Institute by a team of S. Kluska-Nawarecka [7]. The core of the system is a set of IF ... THEN rules, that with over 90% efficiency is able to detect the type of defect and the reasons for its origination.

Another example is an expert system for diagnosis of equipment failure in the production of oils and lubricants. The system proposed by Y. Qian et al. [9] contains hundreds of rules to cover, among others, measured in real-time physical parameters of equipment and materials, offering the operator appropriate response to the diagnosed errors and failures.

4.4. Inventory operations management

The analytical methods, simulation, or mathematical programming are employed in typical inventory problem. However, there are situations in which these methods cannot be used because of the unusual nature and dimension of the problem. R. Venkatraman and S. Venkatraman [12] described such a problem for manufacturing the constructions of large diameter steel pipes, in which human judgment must be taken into account. Pipes are purchased from suppliers who provide them in lengths of 10-20 meters. Tubes are cut to appropriate lengths and then assembled; the respective lengths may also be obtained by welding shorter pipes, but less than 3 meters and with a maximum of two welds (for reasons of strength). Pipes are stored in stacks up to 10 pieces in one, while only the top layer of the pipes can be used to the production. The task of logistics and planning services is to control laying the pipes in stacks and cutting/welding operations to keep waste (pieces less than 3 meters) during week periods at minimal level. Eight complex rules, using the calculation of attribute values and supporting functions, were developed for this purpose. The authors reported the high usefulness of such a system in a particular company.

J. Cheng and C. Chou [3] proposed a decision support system that uses control charts to monitor the volume of stocks and demand for products in order to determine the cycles and volume of supply. They developed four complex rules taking into account the size of the inventory and another four taking into account the quantity of orders for products. The rules are based on the proposals of the Western Electric Handbook cards in conjunction with ARMA (Auto-Regressive Moving Average), monitoring time series data. In spite of system simplicity the authors reported its high efficiency confirmed by simulation experiments.

5. Conclusions

Business rules proved to successfully support a wide range of management decisions, from sales and marketing activities, through accounting, up to human resources management.

In both literature and business practice, we can find examples of problems where business rules would function as a stand-alone tool or as part of a hybrid system. The aim of this paper was to indicate possible applications of rule-based approach in production management, especially in foundries. BRMS are a relatively new tool, hence in the literature there are only few reports of their applications in the production management. Moreover, this is an area in which decisions are primarily of quantitative nature, for which business rules are not the best solution. In this situation, we believe that BR can play at most a supporting role in manufacturing management, but alone cannot form a complete solution. Knowledge base utilizing business rules approach combined with modern architectures of computer integrated systems allow for decision making at various production areas i.e. manufacturing, maintenance, quality control, and inventory management.

The main advantages of BRM approach, compared with traditional manual system, are:

1. similar, objective view of firm activities across all firm departments,
2. easy simulation of the system performance,
3. flexible solution which means that it can follow even rapid changes in of factors coming from inside the enterprise and/or its environment,
4. easy to maintain system; as it is no problem to delete, add or update the rules.

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