THE MODEL OF DECISION SUPPORT SYSTEM FOR A MANUFACTURING COMPANY

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Abstract: *Decision making processes in manufacturing companies are becoming extremely complex and require more and more knowledge, both of technological quality of products, concerning a production process, as well as the industrial engineering and control. The increase in the scale of production and the level of technological development have caused that industrial companies have become systems that require the application of modern effective methods of the decision making. This paper presents a study of the issues related to decision-making and knowledge acquisition in enterprises. The model of intelligent decision support system for the production company has been developed. The paper presents the main idea of system and data models in the form of ER diagram, that will finally be implemented in RDBMS environment. In addition, an attempt to assess such systems.*

Keywords: *decision support systems, knowledge base, knowledge representation, knowledge acquisition.*

ACM Classification Keywords: *I. Computing Methodologies, I.2.1 Applications and Expert Systems, J. Computer Applications,*

Introduction

Manufacturing companies operating in the market today collect more data on manufacturing processes, supply, customers and their preferences, the defects of products and control processes as well as customers' feedback. They accumulate large amounts of data, where you can find the information you need to make right decisions, at the design stage of products, in the manufacturing process and product control, as well as in the final stage - selling [Piróg-Mazur, 2010].

Currently the decision support systems, that continually collect data and analyze different areas of production processes, are beginning to play an important role. Managers and experts have begun to use these systems to obtain and evaluate collected information and to make use of gathered data in planning and decision making processes.

In order to effectively support decision-making processes, contemporary information systems are increasingly using artificial intelligence (AI) technologies [Dhar V., Stein R., 1997]. Owing to them, we are able to solve complex problems that require reasoning under conditions changing in a dynamic way, burdened with a high degree of uncertainty and sometimes with incomplete data [Sroka, Wolny, 2009].

Intelligent Decision Support System is the system that uses AI methods and techniques. An intelligent decision support system should behave like a human consultant; supporting decision makers by gathering and analyzing evidence, identifying and diagnosing problems, proposing possible courses of action and evaluating the proposed actions. The aim of the artificial intelligence techniques embedded in an intelligent decision support system is to enable these tasks to be performed by a computer, whilst emulating human capabilities as closely as possible [Turban E., J.E.Aronson, 2004].

The main goal of the research presented in this paper is to design of the intelligent decision support system for production company. The main purpose of development of an intelligent decision support system is to reflect experts' knowledge and experience, which are indispensable for solving problems by the system. Integration of intelligent methods allows to create better and more precise methods which can be applied in this field. In intelligent decision support system the process of knowledge acquisition plays the most important role.

The process of knowledge acquisition

The concept of knowledge is not clearly defined in literature. Knowledge do not only encompass very extensive and dispersed resources of different types of information, but also, and above all, it is a complex structure of links between pieces of information and it involves information that is difficult to formalize. Experience, qualifications, human intuition, and models of different processes (including discreet, dynamic and stochastic processes) are all knowledge. Holsapple C.W. and Whinston A.B. [Holsapple C.W., Whinston A.B.,1996] define six types of knowledge that knowledge management applications can contain. These include descriptive, procedural, reasoning, linguistic, presentation, and assimilative knowledge.

Knowledge is immaterial wealth of the organization in terms of human action, if implemented, could be the basis of competitive advantage of organizations. It is connected with possessed resources such as data, information, procedures, and with experience and education. Knowledge strongly associates with factors such as culture, ethics, intuition, working conditions, management style. The last factor has a decisive influence on the efficiency of knowledge management system, and thus the competitiveness of the organization [Kisielnicki, 2004]. The knowledge refers to the various aspects of reality, it is diverse. Its classification encounters many difficulties. Marking types of knowledge is made up from many points of view. The division is into formalized knowledge contained in information bases and personalized knowledge which is in the workers' minds. [Sroka, Wolny, 2009].

Since knowledge can be structured in the decision support system, it can also be used to unify and extend the usage possibility of specialist knowledge base. The knowledge and expertise can be passed on others through teaching, and also conveyed by a single person throughout the organization. The consequence of this phenomenon is the treatment of knowledge in the organization as an important resource that can be administered outside of the human mind. Thus, it avoids making the effort to collect and maintain knowledge and gain a greater uniformity in decision making.

Knowledge acquisition is the process that allows understanding and obtaining the answer, by an expert, on how to solve problems in a specific domain, combined with the recording of acquired knowledge in the formal representation or model of decision-making [Knosala, 2002].

The growing role of knowledge-based systems will be based on the spread of knowledge in the organization. From a technical point of view the needs of employee, who uses the knowledge base, can be characterized as follows [Sroka, Wolny, 2009]:

- there must be an access to various information resources,
- there must be a variety of tools available for processing and presenting information or knowledge,
- the exchange and distribution of information among co-workers must be provided.

Data acquisition and knowledge for decision support systems shall be carried out both by traditional and formal methods [Pondel, 2003]. Data concerning materials and the means of production is obtained from the standards, **catalogs, literature, records and databases that already exist in the enterprise.**

The traditional method of knowledge acquisition is to observe the technologist and interview with him. In this method, the key role plays a knowledge engineer, who observes an expert. The expert works on solving the problem. Then, the engineer analyzes the knowledge on the basis of instructions and real examples solved or given by the expert, and he/she gathers knowledge by analogy. Further, the knowledge engineer selects and organizes the knowledge handed by experts so it could be stored and used effectively on a computer [Zieliński, 2000].

Technological knowledge is a collection of information on the technological process carried out in specific realities of the company. Technological knowledge is a dynamic set, which means that it changes over time as the parameters undergo changes. It is assumed that technological knowledge can be processed in an appropriate manner in every stage of building an advisory system. There are the following stages of this process:

- acquisition of technological knowledge,
- models' development representing technological knowledge,
- storage of knowledge in the technological knowledge base system.

Participation of an expert in the construction of the advisory system is vital because it is necessary to benefit from his experience both in terms of tasks solved in the past and ways to solve certain tasks and how to select appropriate methods of solving problems.

For the evaluation of knowledge sources an engineer takes:

- information necessary to carry out the work (materials derived from literature sources, both compact and continuous),
- information about all processes conducted at the manufacturing system (material collected in the glassworks, consultation with the Head of the Department OI Manufacturing Poland, consultations with specialists in various phases of the process – expert's knowledge),
- methods to assess the quality of finished products (high standard or acceptable standard),
- permissible options for development (purchase of new machinery, upgrading of existing ones, new technologies, new materials, etc.),
- criteria for evaluating options for developing the system.

An important component in the processes of data processing is the operation of extracting data or knowledge discovery, which can be defined as computer-aided search process and analysis of vast amounts of data. Extracting data is used to describe the historical trends, as well as determining future trends. Implementing this process requires knowledge and understanding of applications and the knowledge about the quality of sources where data is gained from. The first step to solve the problem of decision-making is to define access to the necessary data. When solving complex decision problems data from different sources should be used. Figure 1 shows the process of gathering data to provide a basis for decision making.

Data warehouse is a dedicated, read-only database that supports decision-making process. The concept of "separate database" means that a data warehouse cannot work on operational data. You need to prepare a separate database designed for this purpose. The concept of "read only" means that the stored data is historical.

Model of decision support system

The process of model development has been based on technological documentation of an industrial enterprise, with which a cooperation agreement was signed (Glass Works, Owens-Illinois Manufacturing Poland). The results of work can be practically tested and applied in the same industrial plant, limiting the scope of research to support the process of quality control of finished products. The advisory system is designed to classify defects in products and select appropriate method (most preferred way) to eliminate them. This system responsibility is to assist the line manager and the people working on the production line. Its functioning will be based on a dialogue between the system itself and the user in a natural language. It will collect information not only from the user, but also from external sources such as databases, spreadsheets, statistics, etc.

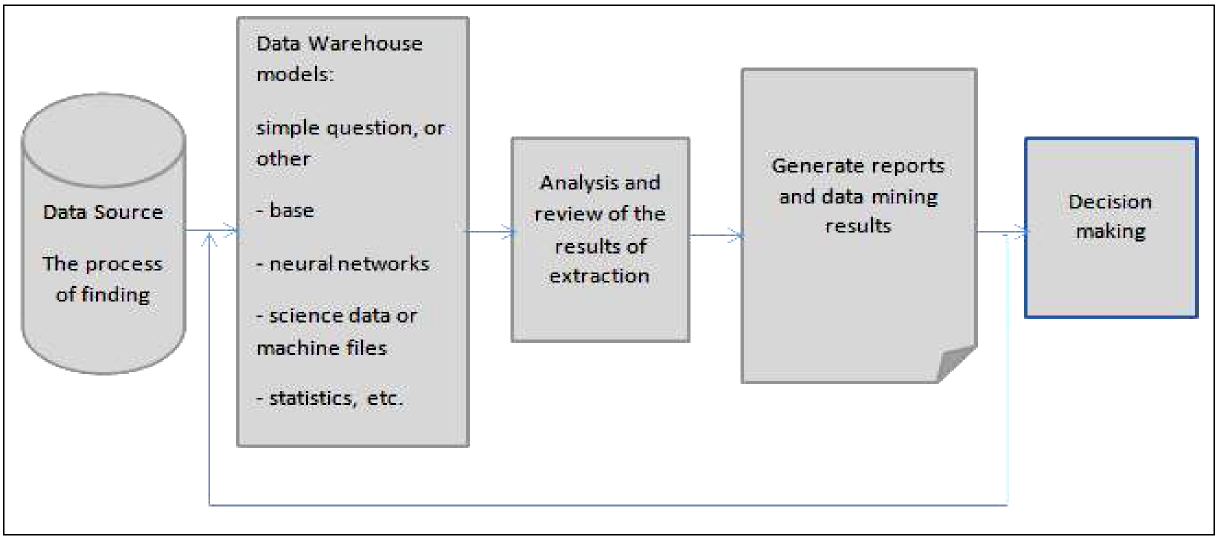

Fig. 1. The process of data acquisition. Source: [Fayyad, 1995]

As a result of dialogue, based on data entered from the keyboard by the user, and the data taken from the measurement points the advisory system will execute a process consisting of:

- defect diagnosis and qualification into relevant group,
- identification of the cause of defect formation (whether it is a mechanical defect, form defect, etc.),
- identification of ways or methods to eliminate the resulting defect,
- selection (from the previously established ways or methods) an optimal solution.

Currently, the management staff in decision making processes, concerning the elimination of defects, does not use any IT systems. Actions that can be described as the most important, most expensive and generating the longest effects are not supported by computer. These decisions are usually made intuitively or with the use of "trial and error" method based on previous practice.

Verification in practice is the only way to confirm the correctness of assumptions of the model. As the evaluation criteria elements user friendliness, data security, their integration and system vulnerability to modification were adopted.

The data structure in the system

Data models can be developed at different levels of detail using the technique of modeling relationships among entities (ERM - Entity Relationship Model), which graphical equivalent is the entity relationships diagram (ERD). The project is usually expressed in graphical form and supplemented by a verbal description in which the information contained in the graphic design is characterized in detail. In the diagram, entities are usually denoted as rectangles, and the relationships between them are marked with lines connecting rectangles and the symbols placed next to these lines, describing the type of relationship.

The figure 2 shows an excerpt of ERD that has been made for the manufacturing enterprise needs.

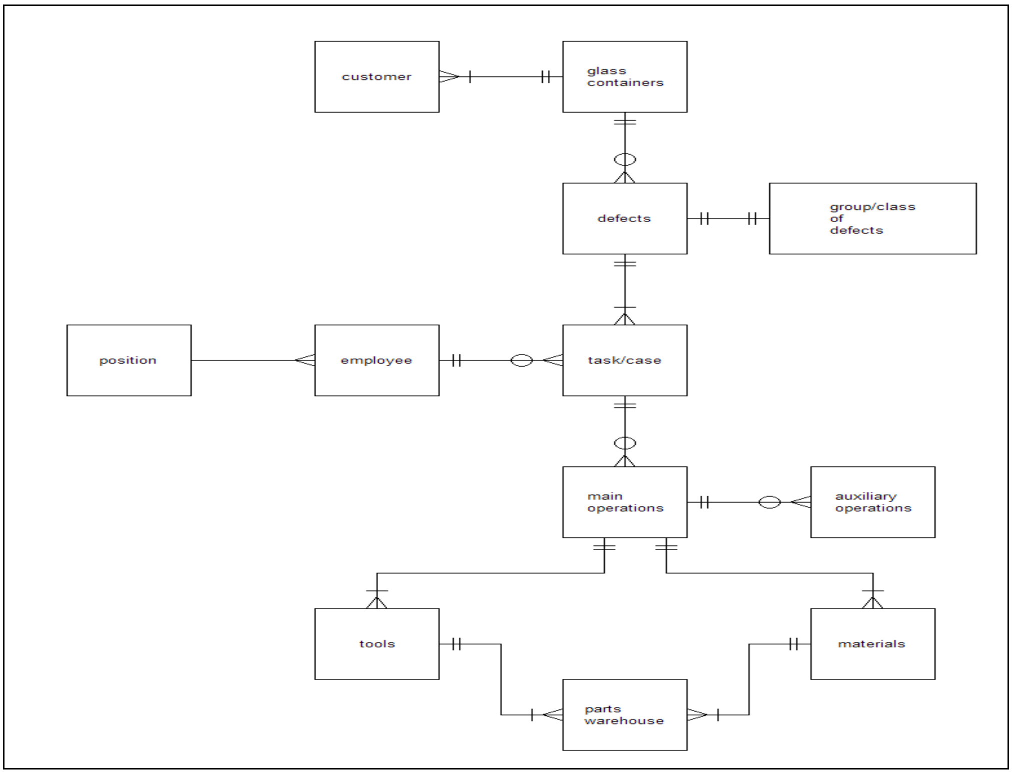

Fig. 2. Entity Relationship Diagram. Source: own work

One of the first stages of database design is to develop a conceptual data model, which is crucial to usefulness and quality of the proposed database. It is created independently of solutions specific to any logical model and database management systems. Conceptual model will enable to conceive the technological process described above in a formalized way. The main goal of the conceptual modeling of database is to create a design that reflects the fragment of reality, that is being analyzed, free from details, which could place it among models of a particular class (object, relational or other) and platform-independent programming. The end result of the conceptual design process is to identify a set of facts in the analyzed company (objects), properties of these elements (attributes) and inter-dependencies between these elements (relationships).

This process involves both the designer and the future user of the system. The head of the production line and the production line operator, in the future, will be the users of that system in a manufacturing company [Piróg-Mazur, 2012].

In the relational database model, shown in figure 3, for the proposed decision support system the following tables have been included:

- glass containers / product packages - contains information about the manufactured product (product data sheet, specification of the final product),
- materials - contains information about the materials used (semi-finished product) for repair,
- tools - contains information about the tools used and their storage for repairs
- task / issue - a list of tasks / things to do in order to eliminate the resulting defects,
- the main operations - provides a list of consecutively performed operations (process steps) to repair,
- auxiliary operations - provides a list of additional activities to do destined for specific products (additional operations),

- defects - contains detailed information regarding all possible defects, where they occur, the causes of creation, whether there is a risk of consumer injury etc.
- defects group / class - provides a classification of defects,
- employees - a list of people involved in the technological process,
- position - includes the allocation of particular competence, duties to perform.

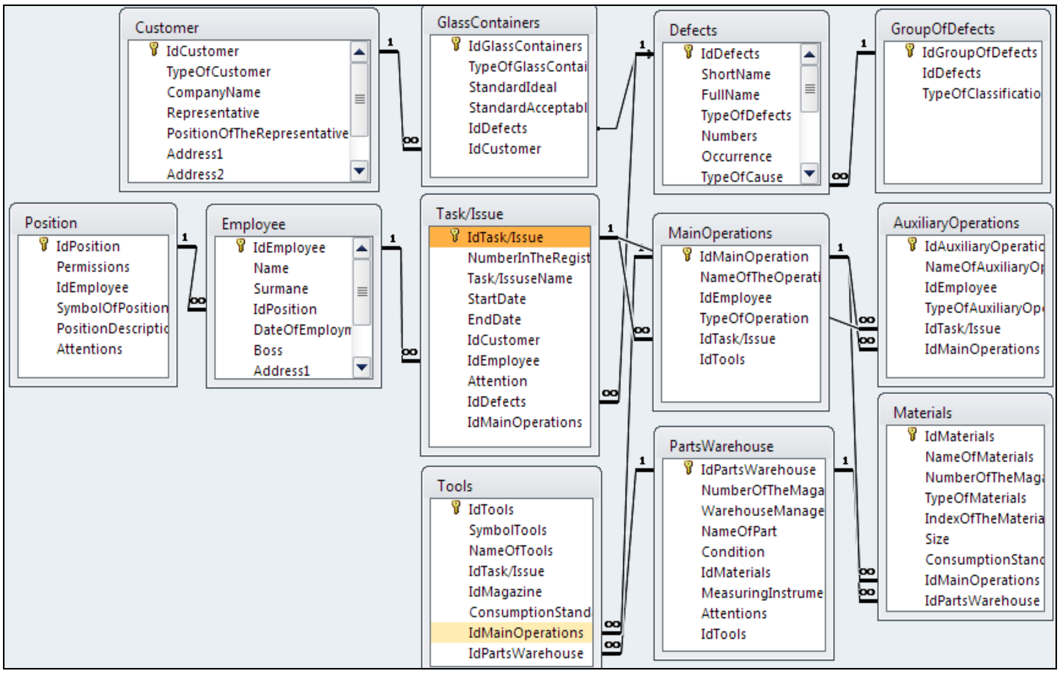

Fig. 3. Relational database model. Source: own work

Methods of evaluating decision support systems

Evaluation of IT systems, in particular decision support systems, is one of the most difficult aspects of their design methodology and implementation. These issues concern both the implementation and the evaluation itself. The system can be assessed according to [Sroka, Wolny, 2009]:

- the results of decisions,
- changes in decision-making processes,
- changes in revealing decision situation by the decision maker,
- alteration in procedures,
- analysis of costs and effects,
- measure of service,
- decision-makers estimation of the system value.

Not all of the above methods are suitable for the particular situation. In situations, where designer's intent was to obtain measurable effects, use the analysis of costs and effects, estimation of the decision results or service measurement. To avoid the situation in the form of negative results of DSS usage, to the evaluation of a situation, more than one way of evaluating should be used. The agreement on the choice of assessment approaches between designers and users must be obtained already in the preliminary design phase. One of the better ways to assess whether the system actually makes decisions, is the current result of the decision. This measure is not always possible to explain. In a situation where the production or rate of return on investments are higher, the improvement may be caused by other factors. Another way is to assess the changes that the system brings to the way of making decisions. If you cannot prove that the introduction of a new system will improve the decision, you need to refer to the assessment accepted by the user, based on comparison of subjective feelings of the user, concerning the advantages of new decision-making process, from the previous one. As acceptable solution, one that meets expectations and satisfaction of specific teams is considered.

Regardless of the difficulties in many examined DSS can be clearly seen [Sroka, Wolny, 2009]:

- facilitation of problem identification,
- faster acquisition of information through graphic images,
- acceleration of recognition and realization to which part of bank's methods qualify the problem,
- improvement in the assessment of the actual cost,
- use of routine sources of information that are only available to the analysts,
- stimulation of new approaches to strategy development,
- pressure on thinking about the results,
- conviction of decision maker about the fact that investing in the improvement of intellectual work is an effective undertaking.

We can distinguish four possibilities for improving the efficiency of decision making [Sroka, Wolny, 2009]:

- reducing time of decision making,
- decreasing the number of people involved in making decisions,
- better preparation of printed documentation in the decision-making process,
- reducing delays in decision making.

Conclusion

The application of decision support systems can provide multiple educational outcomes. These systems offer the opportunity to pass knowledge and experience of older workers on younger staff. In this situation, experienced workers may be directed to more important tasks. The very process of creating a system may have educational value due to the deepening and structuring knowledge. What is more, less experienced workers can supplement their knowledge by the use of such systems as a practical help in carrying out their tasks. It is also important to reduce spending on education by improving employees productivity by enabling them to efficiently handle tasks without the need for long training and gaining experience [Sroka, Wolny, 2009].

Key areas for expert systems applications in decision support issues depend on the knowledge provided by an expert. They make conclusions on the basis of knowledge provided by system creators, which is stored in data base, and use learning methods or automatically by the absorption of the examples provided, or by providing additional information. Most often, they support decision making in the field of:

- developing optimal financial plans,
- planning of production Portfolio,
- analysis of market data,
- selection of an appropriate set of suppliers,
- workforce planning with variable working time,
- evaluation of investment projects,
- development of product design, etc.

The system guides the user through the problem, asking a structured set of questions and draws conclusions based on received responses. Problem-solving skills are based on a set of programmed rules, modeled on the reasoning processes of specific field experts. Advisory systems can serve its knowledge if there are no specialists and often reach the knowledge faster than the experts do.

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