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IT TOOLS IMPLEMENTED IN THE INFORMATION SYSTEM SUPPORTING MANAGEMENT IN THE RANGE OF KNOWLEDGE MANAGEMENT IN MECHANICAL ENGINEERING ENTERPRISES

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In the paper the authors showed and characterized IT tools implemented in the information system supporting management in the range of knowledge management in mechanical engineering enterprises. The authors gave a detailed description of the implementation of the following IT tools: knowledge objects management, risk management, case based reasoning.

Keywords: information tools, knowledge management, mechanical engineering enterprises

1. Introduction

Dynamic development of economy requires more and more effective solutions for knowledge management. This relates both to the concept of knowledge management supporting models and appropriate technological infrastructure which enables implementation of those solutions. Enterprises use information systems to support business processes based on quantitative collection and processing of information. However, effective knowledge management requires selective choices of knowledge sources, appropriate collection procedures of them, their transfer and use in the course of business procedures.

In case of the mechanical engineering industry that executes contracts for individual orders of their customers [3, 4, 5], it is necessary to support knowledge management in the complex system of internal processes [1, 2]. Access to contextual, quality knowledge for authorized users is one of the key factors which decide about the success of the contract portfolio in the mechanical engineering industry.

This article presents IT tools implemented in the Content Management System in the range of Knowledge Management designed on the basis of survey research. It also presents characteristics for each of the used IT tools and the scope of use for the support of particular knowledge processes. Establishment of a management support model for knowledge management and construction of an IT system on that basis were the main goals of the research and development project called "An IT system supporting knowledge management in enterprises of the mechanical engineering industry" run in the Faculty of Management and Administration of the Silesian University of Technology.

2. Characteristics of the it tools implemented in the knowledge management supporting system in a mechanical engineering enterprise

Contracts which require customized approach to meet the demands of a customer require an individual approach which uses resources of an enterprise in such a way as to provide the best possible support of the business processes. Effective collection of knowledge and its processing within the designed system required implementation of the following tools to support the knowledge processes:

- Case Based Reasoning (CBR),
- Knowledge Object Management System (KOMS),
- Risk Management Support Tool (RMST),
- Human Resources Support Tool (HRST),
- Rule-based Expert System (RES),
- Interactive Pair-matching System (IPS).

Detailed characteristics of those implemented tools can be found in the subsequent chapters.

2.1. The concept of Case Based Reasoning (CBR) in a management supporting system in the range of knowledge management

Case Based Reasoning uses specific knowledge of experience from past situations called "cases". The CBR method is used to solve new problems through adaptation of results obtained from solving previously met problems. A new problem is solved through finding a similar case in the records and through application of the solution related to that found case. An important feature of CBR is the ability to learn through collecting solutions of past problems and sharing them for solving new problems in future [6].

The proposed solution supports decision processes:

1. Choice of a supplier in the following cases: a necessity to change the supplier of a given material/service, a necessity to outsource some actions to appropriate suppliers in order to execute an order placed by a customer, at the stage of design and choices made by constructors of components and elements.
2. Estimation of the product price, based on an enquiry made by a customer.

In both cases a hybrid reasoning system was used, based on a case database and an expert system. An expert system supports the CBR at the stage of adaptation of found cases. A Rule-based Expert System (RES) is used to cooperate with small knowledge modules, which can be integrated in order to build a bigger database. Knowledge in the RES system is in the standard Horn clause format.

The mechanical engineering industry features a very vast group of suppliers from numerous branches, therefore a supplier assessment issue is so crucial for the final results of the execution of a taken order. Use of the suggested system allows for such a choice of a particular supplier of each component as to secure an appropriate level of supply made on time, to sustain a high level of quality of the ready product, as well as to keep the number of claims from the customers to the minimum. The system can support actions of constructors, engineers, purchase department staff and employees who prepare offers for customers.

As a result of a research conducted among mechanical engineering enterprises, two categories of actions taken during preparation of an offer for the customer based on their query can be distinguished. Those actions include an assessment, decision-making and actions related to the transfer of information. An offer is communicated to a customer who can reject it, accept it or undertake negotiations related to the price. In case of negotiations customer's requirements may be lowered in order to decrease the price.

A Case Based Reasoning system is a tool with an ability to gather, use and diffuse gained experience (including tacit knowledge) of employees responsible for preparation of an initial offer for a customer. Use of an expert system reinforces and broadens possibilities in reasoning and recommendations for the decisions being taken. In that way, joint use of CBR and ES allows to adjust previously found solutions to selected cases and solve current issues.

2.2. Knowledge Object Management System

A Knowledge Object Management System (KOMS) allows to handle knowledge represented by standardized elementary objects. Those objects can be linked through superiority – inferiority relations and connection relations into any structures fit for the purpose.

A primary KOMS object integrates a homogeneous formal structure with an ability to register various types of information (numerical, textual, graphical and other, also more complex elements). The structure of those elementary objects of knowledge allows to assign various attributes to them: descriptive and interpretative, classifying and evaluative, verbal and numerical (such as e.g. an ordinal number, an update date, an information source, an importance score, a reliability score, etc.) in order to characterize factual information.

In a knowledge system of general application, such as KOMS, textual description is the basic representation. A natural language description is particularly useful for classification of qualitative information with poor structuring that reflect sequential thought models. However, descriptive language has limited application in representation of quantitative information and information about multidimensional (e.g. spatial) objects, as well as in representation of complex, non-sequential dependencies (e.g. networked relations).

A KOMS system has a possibility to supplement a textual description with any MS Windows object. It can be a graphics or sound object, a video clip, an MS Word text file, an MS Excel spreadsheet, etc. Particularly, it is possible to attach objects which exist within the rule-based RES expert system and the Interactive Pair-matching System (IPS).

An elementary knowledge object of the KOMS is recorded as one entry in a database which has the following structure:

1. Object type – chosen from user pre-defined types.
2. Label (title).
3. Basic textual description (content).
4. Any MS Office object – OLE object.
5. Numerical, textual attributes, dates.
6. Other information fields – pre-defined by the user.

Moreover, an entry includes additional fields related to the system management. It is also possible to add further fields if needed.

Entries with elementary knowledge objects can be linked to each other in superiority-inferiority relations or connection relations into a hierarchical or networked structure (a directed graph) [7]. Each entry can be linked to any number of superior, inferior and peer entries. It is also possible to establish relations which form a loop. It is possible to register free entries which have no relation to any other entries.

2.3. Risk management support tool in a knowledge management supporting system in a mechanical engineering enterprise

Execution of orders for contracts in the analysed mechanical engineering enterprises proves legitimacy of utilization of the Project Management Institute methodology. Implementation of the functions of the tool called the Knowledge Object Management System (KOMS) allows to use it as a tool to support risk management in a mechanical engineering enterprise. For that purpose, it is necessary to make some additional assumptions to the concept of KOMS:

– an ability to define object types with a strictly set structure in a minimal scope (i.e. a list of object parameters which cannot be then removed without an ability to change types of those parameters) with an ability to add more parameters,
– an ability to define object types with a limited number of parameters (strictly set) without an ability to add more parameters,
– arrangement of an explicit relationship between some objects (pertains to objects of the "risk factor assessment" type: each of those objects should be explicitly assigned to one and one "risk factor" type of object only), which means that once assigned assessment cannot be used for any other object,
– arrangement of an object type with one superiority relationship (risk factor – contract), i.e. an object type which can be in a superiority relationship with only one other object,
– an ability to clone objects without preserving their superiority-inferiority relationship to other objects,
– an ability to clone objects which meet established criteria or are chosen by an user.

A "risk factor" object as a structure in the database should at least comprise the following parameters (types of parameters given in parentheses):

– a name of risk factor (text),
– an assignment of a factor to a contract ("None" or an ID of a contract) (assignment of a particular contract is made during establishment of a relation between a risk factor and a contract),
– a risk factor verification attribute (to be chosen from a list: "before verification", "after verification", "after conclusion of the contract"),
– owner of the risk entry (text),
– a risk scope (to be chosen from a list: "Design", "Supply", "Production", "Distribution", "Contract portfolio") as a parameter to classify the risk factors in the system,

- description of a risk factor (text),
- relationships with the list of risk assessment objects (including the probability and results in both quantitative and descriptive formats),
- result-limiting actions (as a text list).

The KOMS tool will allow to realize the following functions in relation to risk management support in a mechanical engineering enterprise:

- collection of knowledge on risk factors assigned to particular contracts,
- qualitative analysis of risk factors assigned to particular contracts,
- analysis of information on the state of assessment of risk factors at the early identification stage, at the stage of verification after preventive measures were proposed and at the stage of contract execution,
- collection of experiences from risk assessment as a result of comparative analysis of the state of risk factors during execution of a contract and after it was finalized,
- searching the database of risk factors according to a complex lookup key (with several conditions set, e.g. a particular value of the risk level, a particular contract or risk scope).

2.4. A tool to support human resource management processes in knowledge management system in mechanical engineering enterprise

Suggested solutions within a management support system in the range of knowledge management, which support resource management processes are primarily aimed at improvement of effectiveness and execution of contracts for particular orders of customers of the mechanical engineering industry. Support of management of human resources within the system comprises 4 main functionalities:

- employee database,
- external expert database,
- employee competence matrix,
- allocation of human resources to contracts.

The functionality of the "employee database" will include the following:

- entering a new employee,
- removing an employee,
- modifying information about an employee,
- searching for contracts/contract tasks executed by an assigned employee,
- searching for employees who have a required level of competence within the scope of a given task/process,
- searching for employees with particular experience in contract execution.

The functionality of the “external expert database” will include the following:

- entering a new expert,
- modifying information about an expert,
- searching for contracts/contract tasks executed by an assigned expert,
- searching for experts who have a required level of competence within the scope of a given task/process,
- searching for experts with particular experience in contract execution.

The employee competence matrix as a functionality in the designed system is a tool which allows to assign a certain level of competence (or a skill) to each employee of a mechanical engineering enterprise for a given business process (a task, an operation or type of skill). The designed system allows for a context-sensitive search of competence levels (and their modification) for the employees selected according to a custom lookup key. “Employee competence matrix” is a functionality related to the “allocation of human resources to contracts” functionality. Ability to edit the level of employee competence is limited to the group of employees who have a particular access level.

The functionality of the “allocation of human resources to contracts” will include the following:

- choice of a project team for execution of a contract,
- access control for contract execution tasks pertaining the the scope of human resources,
- introduction of changes in assignments of contract tasks,
- assessment of employees in executed contracts,
- a platform for co-operation between employees involved in execution of a given contract.

2.5. Rule-based expert system (RES)

A rule-based expert system (RES) was designed to co-operate with knowledge modules which can be integrated in order to expand the knowledge database. Knowledge in the RES system is kept in standard Horn clauses. Those are rules (expert implications) with one conclusion and with their conditional parts being conjunction statements. The conclusion is always a non-negative statement. Conditions and conclusions in those rules are logical sentences (not predicates), therefore they have no variables. That approach simplifies the architecture of an expert system and facilitates stability of its functioning. The conclusion process does not suffer from combinatorial explosions and looping, provided its rules are not internally contradictory.

Statements in the conditional parts of rules can be both simple (without negation) and negated, forming an extended knowledge database [8]. In that way, knowledge can be represented by multiple levels of nested rules (statements in a simple form) and exceptions (negated statements). It allows for complex (non-monotonic) logical dependencies in a much simplified way.

2.6. Interactive Pair-Matching System

Interactive Pair-matching System (IPS) supports sequencing of objects on the basis of qualitative assessment. Comparison of two objects does not require to hold information about all other objects in the system memory. The standard method of paired comparisons has a disadvantage as it is time-consuming and requires matching all pairs for comparisons. Therefore, an original method of interactive pair comparisons was used in the IPS system. As compared to the standard method, this approach significantly decreases the required assessment time.

The original pair-matching method is based on a relation between the comparative score with database sorting. In that way, not all but only some pairs are matched for comparison. The choice of pairs and sequence of comparisons are a result of the work of a sorting algorithm and depend on the results of previously made comparisons.

Many sorting methods exist. In case of typical IT applications, effectiveness of an algorithm depends mainly on the number of operations such as data moving and control [9], whereas in case of an expert method of pair-matching the basic criterion of optimality is the number of matches. A method to minimize the number of comparisons was described by L. Ford and S. Johnson [10] and is called merge sorting. When compared to the standard method of pair-matching, a significant decrease in the number of comparisons is obtained, especially in case of databases with many objects (entries).

The number of matches can be decreased even furthermore in the following cases:

- a set of objects is initially ordered. Such situation occurs, for example, when the order of objects in a set is determined by a number of subsequent experts.
- Pairs or groups of objects in a set have the same assessment due to an assumed ordering criterion.

The system of interactive pair-matching uses a modified version of the Ford-Johnson method which facilitate a decrease of the average comparison operations without a risk of higher probability of negative results.

Execution of the pair-matching procedure makes the sorting algorithms choose subsequent pairs of objects. An expert may choose a factual answer or a control command for each of those pairs:

- Object A is more important than B.
- Object B is more important than A.

- Objects A and B are equally important.
- Undo – that command cancels the last assessment of an object pair. It is possible to undo an unlimited number of comparisons.
- End – stops the pair-matching session. Starting the session again allows to continue where it ended.

After all pairs chosen by the algorithm are assessed, an ordered set of objects is saved.

3. The scope of functionality of the it tools in the management supporting system in the range of knowledge management in mechanical engineering enterprises

Establishment of necessary functionality of the IT system supporting management in the range of knowledge management was based on the analysis of processes which are included in the knowledge management in a mechanical engineering enterprise. The structure of the system comprises the following modules:

- design,
- supply,
- production,
- distribution,
- supporting processes,
- system configuration.

The presented structure of the system focuses on supporting the decision-making processes executed as parts of contracts. It is necessitated by a need to provide vast support of knowledge processes in preparation, execution and control of contracts in order to enable their effective conclusion. Table 1 presents a set of tools to support knowledge management processes and their assignment to the main processes which manage the contract portfolio in a mechanical engineering enterprise.

4. Conclusions

1. The concept of a system supporting management in the range of knowledge management in mechanical engineering enterprises was designed on the basis of survey research. The model which served as the base for designing the IT system includes, as its key aspect, the current deficit of knowledge in the field of IT tools which support knowledge management in the key processes that manage the contract portfolio.

2. The designed system supporting management in the range of knowledge management in mechanical engineering enterprises included implementation of the following IT tools:
   - Case Based Reasoning (CBR),
   - Knowledge Object Management System (KOMS),
   - Risk Management Support Tool (RMST),
   - Human Resources Support Tool (HRST),
   - Rule-based Expert System (RES),
   - Interactive Pair-matching System (IPS).
3. The IT system which facilitates the suggested information tools will be a solution to support knowledge management aimed at increasing the effectiveness of management in the range of planning and supervision of the contract portfolio in a mechanical engineering enterprise.

Table 1. Assignment of tools supporting knowledge processes in management of the contract portfolio in a mechanical engineering enterprise in the Management Support System in the range of Knowledge Management

Customer portfolio management processes	**Knowledge process**			
	Knowledge collection	**Knowledge gathering**	**Knowledge transfer**	**Knowledge use**
Design	KOMS (record of good and bad practices) ES (collection and codification of knowledge in the form of expert system rules) CBR (codification of experiences in the form of cases)	KOMS (gathering of experience in the hyper-text form) CBR (gathering of knowledge in the form of verified cases)	KOMS (update and sharing of knowledge) RM (update and sharing of risk-related knowledge) CBR (possibility to share knowledge through access to the case database)	KOMS (use of electronic procedures for monitoring of business processes) ES (initial analysis of technical and organisational conditions of contract execution) ES (initial legal analysis of a contract) CBR (simplification of the contract price estimation process)
Supply	KOMS (record of good and bad practices, codification of procedures) ES (collection and codification of procedures) CBR (codification of experience in a form of cases)	RM (gathering of risk-related knowledge) KOMS (gathering of experience in the hyper-text form) CBR (gathering of knowledge in the form of verified cases)	RM (update and sharing of risk-related knowledge to system users) KOMS (update and sharing of knowledge to system users) CBR (possibility to share knowledge through access to the case database)	SE (initial selection and assessment of suppliers) KOMS (use of electronic procedures for monitoring of business processes) IPS (support of expert evaluation in the field of supply) CBR (support for constructors, employees of the purchase department, ensuring high quality of supply terms)
Production	KOMS (record of good and bad practices, codification of procedures) ES (collection and codification of procedures used as expert system rules)	RM (gathering of risk-related knowledge within the field of production) KOMS (gathering of experience and description of good practices in the hyper-text form)	RM (update and sharing of risk-related knowledge to system users) KOMS (update and sharing of knowledge to system users)	KOMS (use of experience, good and bad practices) ES, KOMS (use of electronic procedures for monitoring of business processes) ES (initial analysis of resource availability) IPS (support for expert evaluation)

Table 1. Continued

Customer portfolio management processes	Knowledge process			
	Knowledge collection	**Knowledge gathering**	**Knowledge transfer**	**Knowledge use**
Distribution	KOMS (record of good and bad practices, codification of procedures) ES (collection and codification of procedures used as expert system rules)	RM (gathering of risk-related knowledge within the field of distribution) KOMS (gathering of experience in the hypertext form) KOMS (gathering of good practices in the field of services)	RM (update and sharing of risk-related knowledge to system users) KOMS (update and sharing of knowledge to system users) KOMS (sharing of good practices in the field of services)	KOMS (analysis of customer claims) ES, KOMS (use of electronic procedures for monitoring of business processes) ES (support of analysis of possible decisions in the field of distribution) IPS (support of expert evaluation) KOMS (use of good and bad practices for the purposes of the service department)
Additional processes	KOMS (record of good and bad practices used in additional processes, codification of procedures) ES (collection and codification of expert knowledge used as expert system rules)	HRM (gathering knowledge about employees and external experts) RM (gathering of risk-related knowledge within the field of additional processes)	RM (update and sharing of risk-related knowledge to system users)	KOMS, HRM (location of knowledge resources, searching information about experts and their assessments) RM (risk minotioring within the field of additional processes) HRM (choice of project staff for execution of contracts) HRM (choice of project manager for execution of contracts)

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