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ONTOLOGICAL APPROACH TO THE KNOWLEDGE MANAGEMENT SYSTEM DEVELOPMENT IN PROVIDING INDUSTRIAL SAFETY

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Abstract. This article discusses issues related to the problem of information management in emergency situations (ES), on knowledge management system (KMS) as a way to solve it, and the ontology as a model of knowledge representation in the KMS. Therefore, this article examines the issues of effective knowledge management in the following setting: the use of an ontological approach to the construction of a knowledge management system for industrial safety in the prevention of disasters and mitigation at gas industry.

Key words: emergency situation; industrial safety; knowledge management; knowledge base; ontology.

In recent years, the number of emergency situations, their extent and consequences are becoming more dangerous for people, environment and economy of the Russian Federation.

For stable development of any country it is necessary to take measures to reduce the damage caused by disasters.

In areas that require immediate action and use of information held by geographically distant from each other workers, as well as statistics and experiences, knowledge management has become vitally important tool for increasing security in companies, that take care about hazardous production facilities.

Knowledge management has become a subject of research of many Russian and foreign scientists, such as E. Topchiev, M. Yarushina, M. Marinicheva, R. Kolosov, I. Simonov, L. Kostin, V. Egorov, Hirotaka Takeuchi, Thomas H. Davenport, Baruch Lev and others.

The first section is devoted to a description of emergencies at industrial facilities. The second section deals with knowledge management, corporate memory and the structure of CPS. The third section describes the processing of information in the knowledge management system. The ontology model of CPS to ensure industrial safety is presented in the fourth section.

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1. EMERGENCY SITUATIONS AT INDUSTRIAL FACILITIES AND PROBLEM STATEMENT

By sources an emergency situation is divided into natural, man-made and bio-social. They, in turn, are classified by natural hazards, man-made events and biological manifestations. These classifications are the basis for determining the total content and scope of the measures to counteract the various hazards and events, planning activities in this area, etc. On the basis of the above classification the statistics of emergencies are kept, which is used to assess the overall situation on the territory of the Russian Federation on natural and man-made threats, and identifies trends of its possible development. According to the ministry of emergency situations reports, in our country each year 300–350 of natural disasters and man-made disasters over 600.

Industrial safety of hazardous production facilities – a state of protection of vital interests of the individual and society from the disaster at hazardous production facilities and the effects of these disasters. Hazardous production facilities – the object on which are obtained, processed, stored, transported and disposed hazardous substances. Such a facilities are classified according to the accumulated potential danger, the mechanism of damage, type of risk, the nature of possible emergencies, etc. Emergency – a condition in which the resulting negative impacts from the implementation of a hazard at the site of the economy, a certain territory or waters violated normal living conditions and human activities, there is a threat to their life and health, damage to property of the population, the economy and the natural environment [1].

Guide companies in the industrial sector of the economy seek for the methods to prevent the occurrence of disaster s of various kinds. Often, however, they are faced with the problem of lack of information and data, a lack of structure and formalization of knowledge workers.

Knowledge management has become a new area of research and improved the decision-making in the management of the company. Leaders of companies seeking to automate the processes of data collection, storage and processing of information and knowledge.

2. KNOWLEDGE MANAGEMENT AND KMS

Each company has a physical and intellectual capital. Physical – is one of the determining factors of production: capital goods and manufactured products are involved in the production of goods and services. Intellectual capital – is based on ties structured knowledge and ability, with the potential development and value creation. It is a combination of knowledge, information, experience, qualifications and motivation, organizational capacity, and channels of communication technologies [2]. The basic component of intellectual capital is knowledge. Nowadays, knowledge – the result of practice-proven knowledge of reality, its true reflection in the thinking of man.

Knowledge Management (Knowledge Management) – is the systematic process of identification, use, and transfer of information, knowledge, people can create, improve and apply. This is the process by which an organization generates knowledge, accumulates and use it in order to obtain a competitive advantage.

The knowledge management system – it is system that improves the efficiency of the solution of problems in the company through the organization and optimization of the acquisition, preservation, dissemination and application of knowledge, as well as it support of information and communication technologies [3].

The development strategy of knowledge management in the company aims to maximize the automation of processes and the development of a culture of knowledge. Knowledge of individual employees, their experience, skills and contacts develop into the collective experience, and it, in turn, to the knowledge of the company.

Fig. 1 represents the structure of knowledge management system.

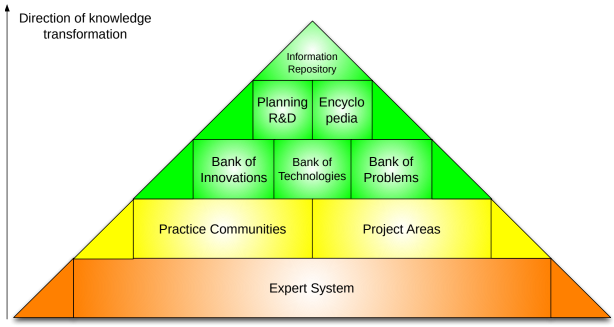

Fig. 1. KMS structure

The knowledge management system helps to structure already existing expertise and best practices, and creating a favorable environment for knowledge creation and the generation of new ideas (community of practice, brainstorming, etc.).

One of the new solutions for knowledge management is the concept of a corporate memory that is similar to the human memory allows you to use previous experience and avoid repeating mistakes. Corporate memory captures information from various enterprise sources and makes this information available to professionals to solve production problems. Corporate memory does not allow to disappear knowledge of retired professionals (retirement, dismissal, etc.). It stores large amounts of data, information and knowledge in various forms, such as databases and knowledge base documents.

There are two levels of corporate memory:

• The level of explicit knowledge - is expressed in the form of words and numbers and can be transmitted in a formalized form on media (documents, manuals, books, diskettes, memos, etc.).

• The level of latent knowledge - is a personal knowledge is inseparably connected with the individual experience. It can be transmitted through direct contact – "face to face" through knowledge extraction procedure.

Knowledge Management provides an integrated approach to the use of new management, marketing and information technology to stimulate innovative activity and creativity of the people. [4].

The experience of each employee involved in the process of disaster prevention and mitigation at hazardous production facilities, is particularly valuable because, first of all, we are talking about human lifes (according to the Ministry of Emergency Situations of the Russian Federation for 2012 affected more than 95,000 people). Thus, the development of a knowledge management system for Emergency Situations at hazardous production facilities is an urgent task.

3. THE STRUCTURE OF INFORMATION PROCESSING IN KMS

The subject area is an enterprise that is working in the gas industry. To construct the KMS were taken into account the flow of information processed by the employees of the company as at normal functioning on the hazardous production facilities, and in the cases of emergencies and elimination of its consequences.

The key components of a knowledge management system to ensure the safety of hazardous production facilities and elimination of ES are: an expert system, a bank of problems and solutions, encyclopedia and information repository.

The structure of the information processing in the knowledge management system is shown in Fig. 2.

As can be seen from Fig. 1, the base of the pyramid is an expert system (ES) – one of the major sub-systems of knowledge management system, which is designed to produce experts' recommendations or solutions for the leadership of the company. The subsystem improves the efficiency of solving problems by maximizing the knowledge and experience of experts, through the maintenance of a single directory of experts and optimizes the allocation requests between them. ES supplement subsystem "Bank of problems and solutions" (BPiR). BPiR represent a subsystem, minimizing operational risks in the primary and secondary processes of the company by optimizing the scheduling and use of best practices of the organization by identifying, processing, storage and dissemination of information on existing and unsolved problems in the company.

Information repository (IR) – a subsystem of knowledge management system that provides a single point of access to all available company documents, intelligent full-text search of data and information, organization of documents and process of update information in the repository.

Encyclopedia – KMS subsystem, which increases the effectiveness of knowledge management in the company through the formalization of a uniform terminology and conceptual framework.

The large volume of data and information circulating in the industrial organization requires the development of processes for the collection, preservation, structuring, formalization and dissemination of knowledge.

Gas companies characterized by the following structure types of documentation of origin: external, internal and bilateral.

The variety of information flows in industrial organization requires a detailed study of the process of gathering data, information and knowledge.

As shown in Fig. 3 it is provided during the completion of the data warehouse not only the company's experts, but also specialists (readers) of various official levels. The process developed is intended to preserve the maximum amount of knowledge to account for every detail that could be a further reason for emergency situations at hazardous production facilities.

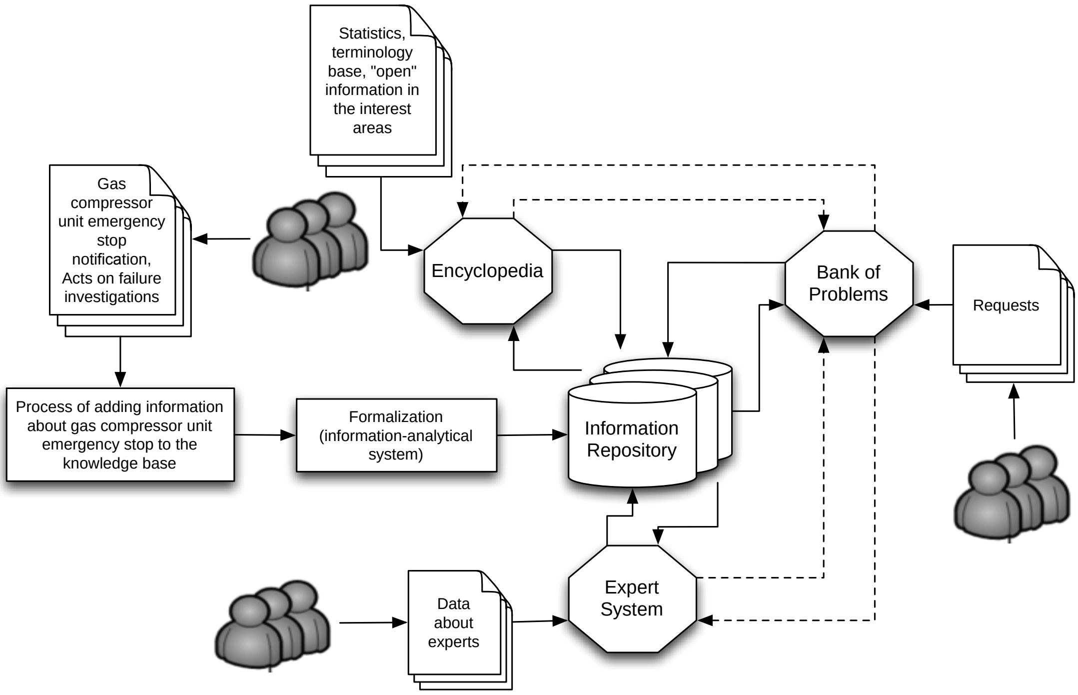

Fig. 2. The structure of information processing in KMS

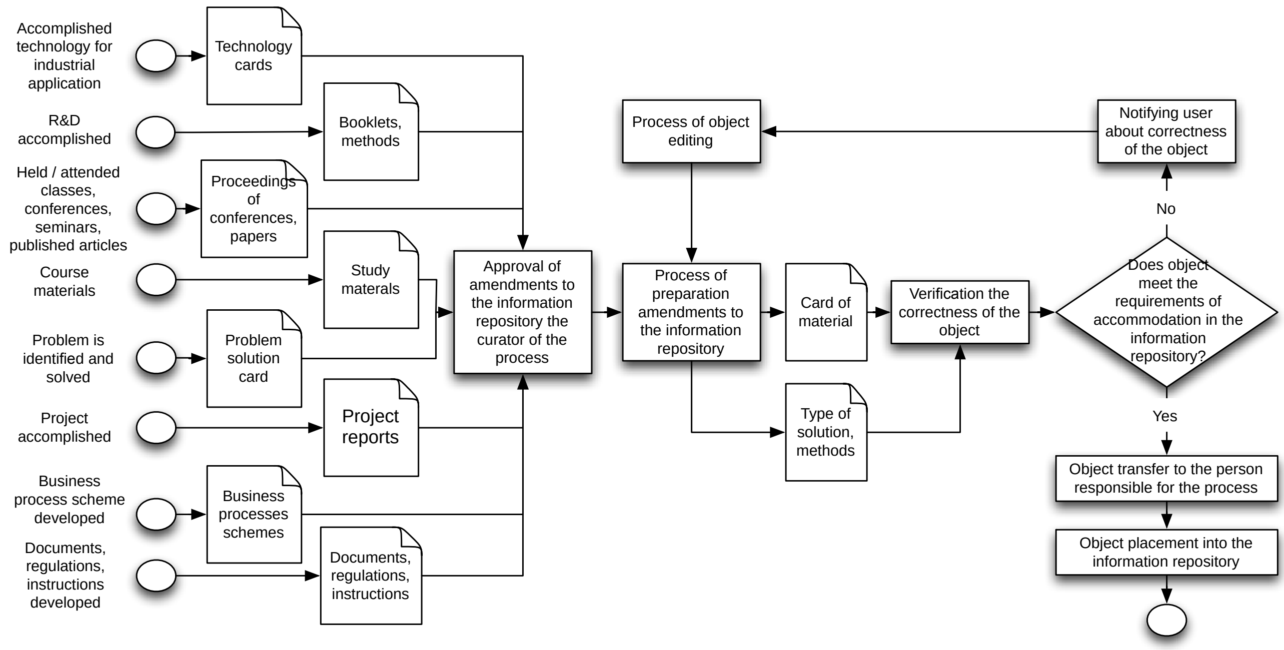

Fig. 3. Basic scheme of completion of the data warehouse

As a model for knowledge representation in the information repository of KMS was selected ontology. In contrast to the production model of semantic networks and frames, are achieved through the use of ontology consistency, uniformity and scientific character, allowing you to reach all of the subject area and recover the missing logical connections in their entirety.

4. ONTOLOGY AS A MODEL REPRESENTATION OF KMS

Ontology – is the exact specification of a certain subject area. Formal and declarative representation which includes the vocabulary (or names) of pointers to the terms of the domain and logical expressions that describe what these terms mean, how they relate to each other, and how they may or may not be related to each other. Thus, ontologies provide a vocabulary for representing and sharing knowledge about a certain subject area, and a lot of relations established between the terms in the dictionary [5].

Currently, the use of ontologies is the most active in the field of knowledge management systems, as well as in the field of intelligent multi-agent systems.

Figure 4 is a conceptual model of the ontology of knowledge representation in KMS for the enterprise with hazardous production facilities. The circuitry of the ontology includes a description of some concepts used by employees of the organization while working with industrial facilities in the normal mode, in case of emergencies and elimination of its consequences.

To study the detailed scheme of the processes and the relationships between them with a clear description of the indicators and their characteristics consider in more detail the ontology knowledge representation for oil and gas companies on the example of the gas transportation. Due to the fluctuations of gas consumption and a number of other secondary causes of this process is variable. Therefore, to ensure uninterrupted supply of gas to the consumers need to regulate and control gas transmission modes, with the help of gas compressor unit (GCU), designed for compression of natural gas at compressor stations (CS) gas pipelines and underground storage, and compressor section. Standard deviation of the parameters of these objects can cause disaster and endanger people's lives and the functioning of the pipeline, so their consideration is the actual problem of industrial safety.

Under the formal model of the ontology, in our case we mean :

$$O = < C, R, A, L, F, G, H, K, M, Y>,$$

where: C represent finite set of concepts (entity classes) domain; R propose finite set of relationships between concepts (classes); A render a set of axioms, propositions, built from these concepts and relationships between them; $L = L_C \cup L_R$ present dictionary ontology that contains a set of lexical units (characters) to the concepts of the L_C and the character set for relationships (links) L_R; F and G present links that connect sets of lexical units $\{L_j\} \subset L$ with a set of concepts and relationships on which they are respectively referred to in this ontology; H captures the nature of taxonomic relationships (links), in which the notion of ontology related non-reflexive, acyclic, transitive relations $H \subset C \times C$; K perform finite set of parameters characterizing the fuzzy concepts and relations between them, M occur finite areas of reasoning for fuzzy parameters; Y present finite set of membership functions characterizing the fuzzy sets.

Denoted by $MF_K(x)$ appear a degree of membership to the fuzzy set K. $MF_K(x)$ is a generalization of the concept of the characteristic functions of a conventional set. Then the fuzzy set K is a set of ordered pairs of the form $K = \{MF_K(x)/x\}$, $MF_K(x) \subset [0, 1]$. The value of $MF_K(x) = 0$ means that the membership of a set, 1 means full membership. The strengths of the application of the mathematical approach based on fuzzy sets and fuzzy logic are: a description of the conditions and method of solution in a language close to the natural, versatility and efficiency.

Using a logical language for the formal description of ontology (OWL – Web Ontology Language), will present an ontology knowledge for oil and gas companies on the example of the account and investigate the cause of the stops GPA and CS in ontology editor Protégé version 4.2 . Fig. 5 shows a fragment of circuit created by the plugin OWLviz, reflecting communication classes in the ontology and taxonomy relationships represented subjects. As shown classes were chosen «components», and «parameters». This fragment illustrates the relationship between these classes and the membership relation to the investigation of the domain.

A more detailed picture of the relationships of classes, properties and individuals (concepts) gives the graph shown in Figure 6. This figure allows us to estimate not only the taxonomy of relations, but also types of relationships between the different levels of classes and individuals. As an example, was chosen above schema fragment pertaining to accounting and investigate the cause of the stops GPU and CS in the process of transporting the gas in the gas industry [6–8].

The use of ontologies as a model of knowledge representation, allows the user to organize an effective search for information with regard to its context for various contingencies. Generation of individual knowledge from various sources, such as documents, databases, knowledge and experience of the staff allows the subsequent use of this information by different users: employees of the organization or the program (software agents) for further processing it [9, 10].

Since the investigated domain specific classes, such as characteristics of hazardous facilities may be represented by fuzzy sets and linguistic variables, planned use of ontology elements of fuzzy logic for the implementation of intelligent search user information in a language close to natural language used in queries and documents [11, 12].

Presented ontological approach will allow the organization to provide detailed knowledge in the knowledge management system and to reflect all of the logical relationships in their entirety.

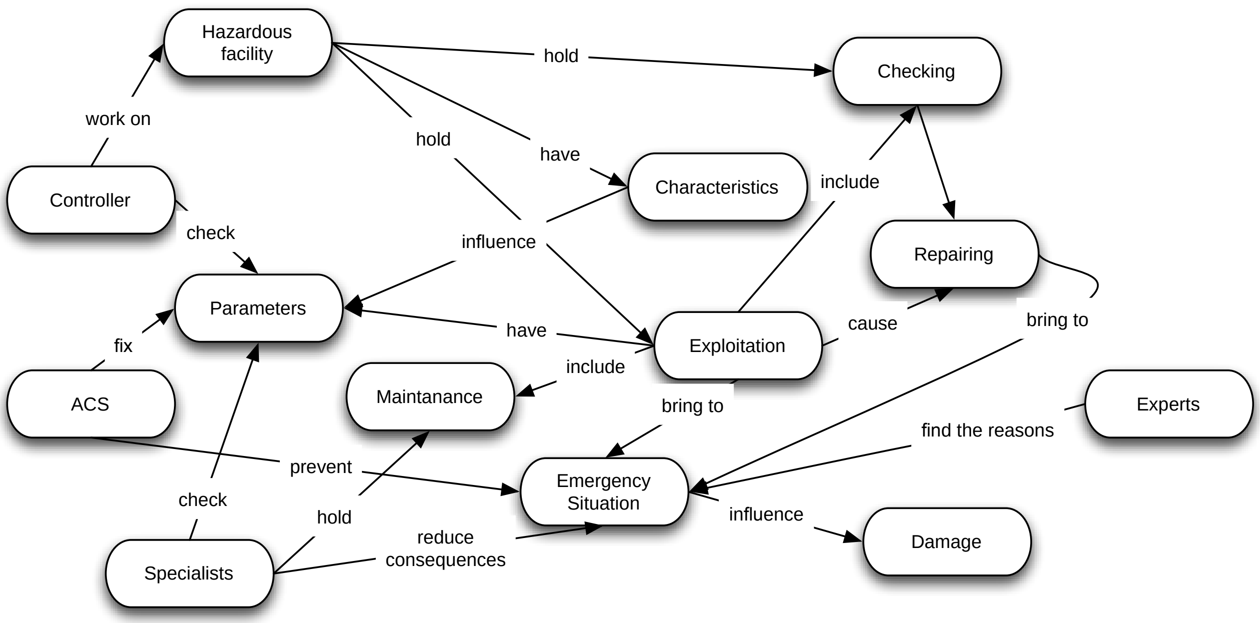

Fig. 4. Conceptual model of the ontology of knowledge representation in KMS

Fig. 5. Scheme fragment OWLviz, reflecting classes relationship in ontology

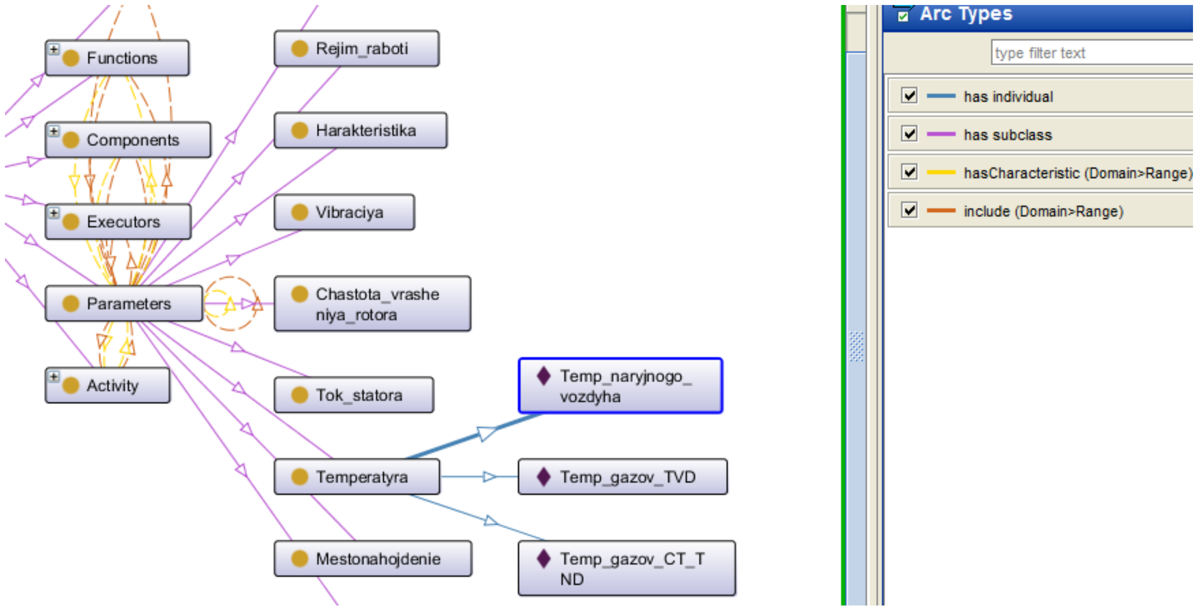

Fig. 6. Count reflecting communications classes and individuals in the ontology (process of investigation the cause of the emergency stops at gas hazardous facilities)

Further study is proposed to develop a fuzzy ontology knowledge representation in KMS in the gas industry (for example, gas transportation) and its follow-up program implementation.

5. SYSTEM WORK SCHEME

The process of knowledge management represents work with lots of individual software modules for different processes: data collection; formalization and further input into the system, as required, on the basis of the intended structure of the data store, search for information on users' queries and the formation of many possible solutions particular situation. Specificity domain suggests the possibility to geographically remote users work with the modules of the system.

Figure 7 shows the diagram of the system, executed in accordance with Standard 19.701-90. This scheme reflects the work by KMS in enlarged form.

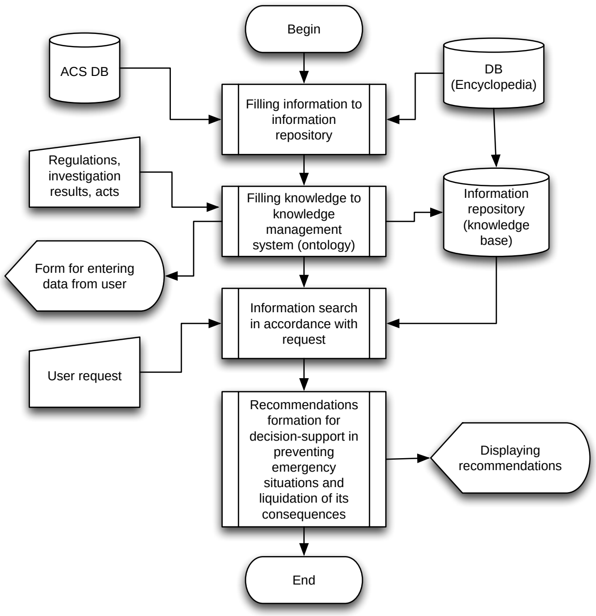

Fig.7 System work scheme

User interaction with the KMS is the interaction of several interconnected modules. As shown in Figure 7 the scheme of the system is provided including information of sensors, which is fixed to the ACS database. This procedure is done automatically. In the investigated domain such a data include the key parameters for gas industry hazardous facility (gas compressor unit).

Following parameters of the GCU are automatically recorded:

- modes of operation (start-up, to the ring, in the backbone);
- temperature (of air, oil, centrifugal pump, etc.);
- rotor speed;
- vibration (engine, supercharger);
- pressure (oil lubricating the engine, supercharger);
- stator;
- centrifugal pump rotor speed;
- gas density under normal conditions;
- operating time from the beginning of the operation and the last outage.

Adding to the information repository data representing encyclopedia knowledge also interact in automatic mode because of their strong initial formalization.

The procedure for bringing the knowledge to KMS is associated with employees information are clamped in the acts and the results of the investigation, formed on the facts of unplanned shutdowns on hazardous facilities and regulations of the organization. The described procedure requires formalization related to the model of knowledge representation in the KMS. Made to complement the information and data construct in information repository ontological model of KMS .

Further work is carried out on a system of requests user, resulting in an intelligent search performed on the ontology with the formation of a user and output to the screen the set of recommendations to support decision making in prevention and liquidation of emergency situations.

6. KMS EMBODIMENT IN PREVENTING EMERGENCY SITUATIONS AT HAZARDOUS FACILITIES

KMS software implementation to support decision-making in the prevention of emergency situations and liquidation of their consequences in the organizations of gas industry is associated with the implementation of the set of technical requirements for the system being developed. To consider the possibility of remote access for users at geographically distant objects, which involves the use of the network, the ability to work with information flowing automatically from the objects (sensors) in near to the regime of the real-time as well as privacy of a separate information, ensuring the required level of security. The totality of these requirements, as well as the volume of information involves the use of big amount of resources and capacity of data centers, but it brings serious costs, and, ultimately, does not give the same flexibility that is needed for solving presented problem. Providing the ability to store large amounts of information, data, creation of virtual machines, without significant cost, allow modern technology represented in cloud computing.

CONCLUSION

Following terms were presented in this article:

• analysis of the problem of information management in emergencies at industrial enterprises of the gas sector;

• knowledge management system model for industrial safety;

• development of the process of information management and knowledge to the process of collecting in the data store;

• ontology model to represent knowledge on the example of the accounting and investigation the cause of stopping the gas processing unit and compressor plant in the transport of gas, with a view to preventing and managing disasters in the gas industry.

Currently, there is considerable interest in the KMS by industrial companies. The use of ontologies as a model for knowledge representation makes it possible to more effectively organize the processes of production, processing and retrieval of information by employees at work, thus enabling a higher level of industrial safety .

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