CONSOLIDATION OF A KNOWLEDGE MANAGEMENT SYSTEM FOR INSTRUMENTATION AND PROCESS CONTROL FOR NATURAL GAS PROCESSING PLANTS

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ABSTRACT

This paper presents a successful implementation of a knowledge management system for instrumentation, process control and industrial automation activities for Natural Gas Processing Plants. The objective of this work is to support engineers, maintenance and operation technicians during plant overall life cycle.

Beginning from basic and detailed engineering design, and going through plant construction, commissioning, start-up, operation and maintenance, technicians are involved with many complex problems. To keep this knowledge in an easy-to-restore way for new generation of technicians inside the company is quite complex.

The development of knowledge models in computer systems is still a challenge in industrial plants. The feedback from technicians experience improves the company efficiency and generates a strong competence in a world competitive scenario.

The development of a knowledge management system that provides the integration of company knowledge in engineering field was first implemented in Petrobras in the year of 2002. Now, this system consolidates the effort of many years of investments and connects more than 1000 technicians inside the company improving engineering design quality, reducing maintenance efforts and keeping plant operation efficiency.

The knowledge system now was extended to Petrobras Natural Gas Processing Plant facilities and includes the best practices of engineering design and field maintenance and operation feedback.

The knowledge management system uses the infrastructure of the INTRANET to make possible the share of “know-how” among specialists all over the company.

KEYWORDS

Gas processing, knowledge management, Know how sharing, internet
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1 – INTRODUCTION

Knowledge management has been discussed in last few years focusing on how companies could keep its most valuable capital [DeSouza, 2001]. There is a great challenge between the idea that comes from real need and how this can be implemented considering the diversity of knowledge models.

Some knowledge expression forms that we can cite are trade secrets, the know-how of employees, patents, copyrights, internal procedures, etc. These are just a few examples of the intellectual assets that enterprises hold. As Davenport and Pruzac (1998) define: “Knowledge is a fluid mix of framed experiences, values, contextual information, and expert insight that provides a framework for evaluating new experiences and information. It originates and is applied in the minds of workers. In organization, it is often embedded not only in documents or repositories but also in organizational routines, processes, practices and norms.”

In the field of plant design, knowledge management is considered also part of the quality control of the project; moreover it introduces a new paradigm in enterprise internal practices. Trying to keep the experience of a company in a “former document” is not a trivial practice. Reports, calculation sheets and manuals are often considered reference documents for future consulting in projects and technical support services. The goal of knowledge management is to extract the main points, and make them available in a fast and easy manner for the technician.

Petrobras Basic Design Engineering Group, located at R&D Center, has designed natural gas processing plants. There are a total of 24 plants using many technologies. The growth of natural gas fields in Brazil is challenging specialists in plant design since engineers are required to be more efficient by the introduction of the company operation feedback into the new projects.

The loss of specialists interrupts the improvements originated from experience feedback and inhibits innovation. This prevents maturation of the technical staff and thus the growth of an institution.

This paper presents the development of a methodology and a standard environment to consolidate the knowledge of specialists related to instrumentation, process control and industrial automation activities, focusing on the design and technical consulting demands inside a petroleum refining company.

The paper describes the development of a system for gathering, organizing and disseminating a specific company’s knowledge related to industrial automation for natural gas processing plants. The objective is to preserve and formalize the knowledge of experts, so this information can be shared with others and reused in solving new and recurring problems. It’s a challenge because there are much tacit or implicit knowledge of experts, which are difficult to obtain and organize.

The paper is structured as follows. The industrial automation applied to natural gas processing plants is described in Section 2. The project and the approach to develop the knowledge management system are discussed in Section 3. The final knowledge management system is described in Section 4.

2 – NATURAL GAS PROCESSING PLANTS AND INDUSTRIAL AUTOMATION

Petrobras, the Brazilian petroleum company, has an installed industrial complex for natural gas processing units composed by 24 plants with 57 million Nm³/day of total processing capacity. Many types of technology can be observed in each of these plants according to table 1.

The objective of the process consists in the removal of impurities and fractionation of hydrocarbons generating industrial gas, LPG and naphtha.
There are different plants for each site, and each one of these Units has specific characteristics and thus specific design, maintenance and operation requirements related to its equipment and devices.

The specific problem addressed in this paper is related to instrumentation, process control and industrial automation specialty, focusing on the design and technical consulting demand. The engineers in these areas face some problems that can be listed as follows:

- Design the requirements for instrumentation for each specific plant;
- Create all strategies related to control, safety instrumented systems and automation for many equipment and subsystems;
- Insert into this stage, the company past design, operation and maintenance experience;
- Support and solve any problem according to these specialties in any operating Plant.

All industrial plants have particularities intrinsically related to its process. For a natural gas processing plant, for example, there is a water removal section in order to avoid the presence of hydrates that may block lines and instrument taps. So plant design, operation and maintenance procedures must consider the peculiarity of this system. Instrument selection and installation detail specific requirements shall be applied from best practices and not only from general plant design guidelines.

High performance plants require good regulatory process control structures to ensure a reliable and flexible operation. These structures are also dependable on some process particularity. For example, a fractionator may be controlled from a temperature sensor located on a sensible tray at the tower, or at the reboiler gas outlet, since in some cases sensor positioning is not clearly predictable at design stage, but this measurement would be critical for product specification control. The design of sensor positioning and process control scheme from current plant operation knowledge is quite important.

The design of safety instrumented systems (SIS) is also a great concern since the identification of the risk associated to each safety function is related to process characteristics, control loops performance, plant operation plus maintenance feedback, and local environmental restrictions. Natural gas processing plants, presented in Figure 1, are provided with complex equipment as compressor and fired heaters. The knowledge to start-up and operate these equipment with automatic procedures makes the plant more safe and with good availability. Keep the expertise regarding these strategies is important to improve operation efficiency.

<table>
<thead>
<tr>
<th>PLANT</th>
<th>PROCESS</th>
<th>PROCESS CAPACITY</th>
<th>PRODUCTION</th>
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<tr>
<td></td>
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<td>LPG</td>
<td>C4*</td>
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<td>900</td>
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TOTAL: 57,310 9,307 12,527

Table 1: Installed capacity of natural gas processing plants
3 – THE KNOWLEDGE MANAGEMENT ENVIRONMENT DEVELOPMENT

The knowledge management environment designed by Petrobras specialists tries to capture and organize relevant knowledge required for a future best design and Unit operation.

Segregate particular information about plants is not trivial. There are many conventional ways to make information available for technical staff, like manuals, reports, calculation sheets, specification documents, etc. None of these resources considers an objective easy-to-restore facility to access main information inside a wide space of search.

This environment was designed as a platform to retain the experience, to promote knowledge sharing, to identify opportunities to consolidate criteria, and to create a specific forum of good practices for all company. Training and expertise integration are complementary focus of this tool.

One important feature related to design activity is the need to consolidate practices and criteria not described in international or company standards. Discussions and technical meeting conclusions must be translated to internal procedures, and this knowledge, when translated to conventional information media, is difficult to update and has great potential for loss of its contents over time.

In technical support activities, engineers face to situations where fast diagnostic and solution are required for a field problem. Execution time is reduced and uniformity in final products is searched by the development of knowledge integration facilities.

The main critical point observed during the development of a knowledge base is associated with its modeling. Translate the information that is available in a tacit form to an objective and structured form is not trivial. Even specialists with great experience have difficult in transfer its knowledge to rules or summarized texts.

The tentative to develop expert systems to solve these types of challenges is not recent. “A Knowledge-Based-System (KBS) is a computer system which embodies knowledge about a specific problem domain and can be used to apply this knowledge to solve problems from that domain.” [Smith, 1996]. A KBS may be designed to apply expertise procedures when solving real-life specific problems by the representation of its reasoning in the form of rules, but the limitation of this technology was expressed by Hughes (1991). “A KBS does not copy the structure of the human mind nor the mechanism for general intelligence, but it can emulate the thought and reasoning process of human expert for decision-making.”
In order to make a more general tool to handle all knowledge representation forms, Petrobras staff designed a new environment to treat every problem related to plant design and technical support services. The proposal of this new environment is to replace conventional documents and common procedures as:

- To look and to compare specific documents (calculation sheets, manuals, etc.) according to past designs;
- To reason about old experiences;
- To make site visit with the objective to obtain information regarding current installation details;
- To program technical consulting with experienced staff;
- To program technical discussions related to design criteria.

It was evident that, having a large amount of information without good organization to help users to find what they really need could make information completely useless. So, the new system was designed to be both easy to use and accessible to all employees on the company intranet delivering precise information with speed and efficiency.

The ultimate purpose of this knowledge management environment is to support human activity, i.e., engineers during basic design, detailed design, plant construction, operation and maintenance.

A multidisciplinary team was formed to develop this project, and many engineers of the company were contacted and involved. The environment development was organized in three main stages:

- Knowledge extraction
- Environment design: Knowledge modeling and representation
- Environment implementation

During knowledge extraction, technical requirements were identified and information was extracted from many different ways: technical discussion forums, technical meetings, site visit, specific studies, technician interviews, etc. Operators and engineers of many refineries were contacted in order to extract their field experience in these areas.

Nevertheless, “the great challenge in knowledge base construction is associated to its modeling and representation. Synthesis and objective information shall substitute detailed explanation and basic concepts, since the main objective is to concentrate the company “know-how”, and not general information. The focus on the problem and how to characterize the solution become key factors for the success of the knowledge modeling and representation. The search for a functional information structure shall be constructed by making an index according to the “natural way” as a technician searches for the information in his mind.” [Saito, Campos & Silva, 2002]. So, close integration between environment developers and final user was done and became important for the practicality of the knowledge base.

Web site search structures are a worldwide easy-to-use information-sharing tool. In this environment, there is not a requirement for a rigid pre-defined information structure. The process for information search is made according to each users association “feeling”. Considering the diversity of human behavior, we can propose that technicians search information dynamically and close to a pseudo random procedure. The facility to structure a dynamic information-handling environment using hyperlinks in web design tools provides a potential environment that is easy to configure and make constant improvements and maintenance.

So, the model of the environment was structured based on actual internal practices during each stage of engineering works. This model tried to simulate each step of the workflow of a technician during the design of an industrial plant to make clear the association between technicians’ work and the knowledge environment.
4 – THE KNOWLEDGE MANAGEMENT SYSTEM

Figure 2 shows the knowledge management system’s front page, consisting in numerous links such as search, department’s activities, company’s main technologies, first user registration and headlines. The plant was detailed and classified according to its subsystems also showed in figure 2.

All plant subsystems include knowledge about all relevant features associated to equipment and devices related to the natural gas process technology that can affect the design of proper instrumentation, process control and industrial automation.

Examples of the functionalities are showed in figures 3 to 5. User selects the specific system or equipment that he is interested inside the plant. Relevant information, as instrumentation criteria, requirements for installation considering plant operation feedback, process control strategy, safety instrumented system concern, real time automation description, etc, are presented by the use of all resources available (free text, pictures, P&I diagrams, installation details, equipment drawings, etc) for a consistent information handling.
The knowledge environment also guides technicians with all documentation, which shall be generated for the specific process plant design, including the scope of each document and the procedure for its execution. These documents include “Control Loop Description”, “Safety Instrumented System Description”, “Equipment automation (compressor, fired heater, air cooled exchangers) specification”, “Process analyzers technical specification”, etc.

The environment can potentially concentrate design criteria and store technical practices to help engineers in real time. Information considered useful for decision-making during design stage is available for on line consulting during a technical support service.

Links to Intranet and Internet sites were implemented to enable access to technical standards and manufacturers web site. Search inside these sites was made to direct access on specific informations.

The implementation of the knowledge environment was done by using a web design tool. Interface construction was continuously discussed and improved since new requests generated new functionalities. Some functionalities that were incorporated are search mechanisms, interface improvements for graphics handling, search for specialists, calculation programs download and links to “virtual technical communities” of the company. Therefore, new solutions were found to present a user-friendly interface that enabled technicians to obtain the required information without the need to be faced with complicated mechanisms.
Web consulting services were contacted to improve multimedia functionalities and implementation of information security services and staffs access control.

Tests were conducted with the environment installed at Petrobras R&D (CENPES) Intranet server enabling remote access from refineries staff.

5 - CONCLUSION

This paper presented a system for knowledge management related to instrumentation, process control and automation activities focused on Natural Gas Processing Plants. This environment was constructed as a continuation of the development of the knowledge system for refineries large and important plants like Distillation, Fluid Catalytic Cracking (FCC), Delayed Coking and Hydrorefining Units. The community of specialists inside the company has considered this project the most relevant internal development during workshops and technical meetings.

The benefits of the environment are enormous. Some of these are listed below [Saito, Campos & Silva, 2003]:

- Consolidation of company experience;
- Establishment of tool for better and faster decision making;
- Integration of technical communities creating synergies and patterns of communication;
- Training;
- Consolidation of Intranet and Internet investments.

“This knowledge management system also helps to create collaboration among people from different departments in the company. The system provides a basis to create a virtual organization, and helps the employees to respond quickly and effectively to their tasks. The possibility to share in a simple manner restricted data, information, and so on, with other users over a company network shows the full power of web and multimedia applications.” [Saito, Campos & Silva, 2002]

REFERENCES
