Annals of Nuclear Energy 108 (2017) 386–393

Contents lists available at ScienceDirect

Annals of Nuclear Energy

journal homepage: www.elsevier.com/locate/anucene

A full life cycle nuclear knowledge management framework based on digital system

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ARTICLE INFO

Article history:
Received 5 January 2017
Received in revised form 27 April 2017
Accepted 30 April 2017

Keywords:
Knowledge management
Nuclear knowledge management
Digital system
Design basis
NPP full life cycle

ABSTRACT

The nuclear power plant is highly knowledge-intensive facility. With the rapid advent and development of modern information and communication technology, knowledge management in nuclear industry has been provided with new approaches and possibilities. This paper introduces a full cycle nuclear power plant knowledge management framework based on digital system and tries to find solutions to knowledge creation, sharing, transfer, application and further innovation in nuclear industry. This framework utilizes information and digital technology to build top-tier object driven work environment, automatic design and analysis integration platform, digital dynamic performance Verification & Validation (V&V) platform, collaborative manufacture procedure, digital construction platform, online monitoring and configuration management which benefit knowledge management in NPP full life cycle. The suggested framework will strengthen the design basis of the nuclear power plants (NPPs) and will ensure the safety of the NPP design throughout the whole lifetime of the plant.

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1. Introduction

Knowledge management (KM) is aimed at providing appropriate information for the appropriate personnel at the right time (Zhao et al., 2012). Just as Arthur Anderson Business Consulting claimed that knowledge management was not only a process of knowledge acquisition, integration, storage, sharing, transfer, application, innovation, etc., but also related to strategy and leadership, organizational culture, performance evaluation and information technology (Consulting, 1999).

Since Polanyi's discussion of the distinction between explicit and tacit knowledge (Polanyi, 1966), researchers developed a set of KM definitions, concepts, activities, stages, circulations, and procedures, all directed towards dealing with objects in order to describe the framework of knowledge management.

IBM claimed that knowledge management structure was composed of knowledge sharing and team collaboration including four models of innovation, skills, responsiveness and productivity (Mentzas et al., 2003). Microsoft discussed that three elements organization, process and technology should be overall considered a necessity to achieve knowledge management through organizational strategy (Chang, 2002). KPMG believed that knowledge management was planning and management methods composed of three basic services—awareness, strategic planning and execution, and knowledge management would rather be an ongoing process composed of a series of integrated projects than a discrete single project.

"Knowledge is power", particularly in the current era. The nature of engineering product development within modern organizations has altered dramatically over the past few decades as products have become more complex. Integrated product group members are not only multi-functional, but likely to work for different companies, have different nationalities and stem from different sites of one company, or even be scattered across the globe (Payne and Deasley, 2001). The significantly increased complexity of products makes the corresponding technology, processes and organization more complex, meanwhile the people more competent. At the same time, due to the large-scale division of labor,

Abbreviations: ASME, American society of mechanical engineers; BIM, building information modeling; DCS, Digital Control System; DKM, design knowledge management; DT, data technology; GB, China's national standard; HVAC, heating ventilation air conditioning; HAF, regulations on the nuclear safety in China; HAD, guidelines on the nuclear safety in China; IAEA, International Atomic Energy Agency; ICT, information and communication technology; IT, information technology; KM, knowledge management; NKM, nuclear knowledge management; NPP, nuclear power plant; O&M, operation & maintenance; R&D, Research & Development; SSC, system structure and component; V&V, Verification & Validation.

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http://dx.doi.org/10.1016/j.anucene.2017.04.047
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the preservation, transfer and inheritance of knowledge are also faced with big challenges. For this reason, knowledge management has been identified as one of the key enabling discipline for distributed engineering enterprises (nuclear power plant project is a good example) in the 21st century.

The nuclear power industry is highly knowledge-intensive. Therefore, it's very valuable and indispensable to focus on full cycle KM of specific nuclear power plant. Knowledge management will lead to a significant economic and technical benefit for stakeholders during the 60 $\sim$ 100 years' lifecycle of an NPP. A good knowledge management framework and practice can support the healthy safety awareness and safety culture, reduce the loss of knowledge due to staff turnover, reduce training time for new employees, improve collaboration and access to information, accelerate experience feedback between stakeholders, ensure project quality, and effectively address adaptation issues. Much work has been done by the International Atomic Energy Agency (IAEA) in addressing the knowledge management needs of different nuclear organizations, resulting in many publications(Carroll, 2006; Tecdoc, 2006). Meanwhile, a general concept of designing of a knowledge portal and also a typical content which helps NPP to maintain safety at a high level is introduced (A Kosilov and Pasztory, 2009). Reasons for establishing knowledge management system as a part of new nuclear power programs is provided (Kosilov et al., 2009). Although IAEA-TECDOC-1675 (Tecdoc) provides a general overview of the tools and techniques that might be adopted to gain business benefit in an R&D environment, a full cycle NPP KM framework is absent. This paper introduces a full cycle nuclear power plant knowledge management framework based on digital system and tries to find solutions to knowledge creation, sharing, transfer, application and further innovation in nuclear industry.

2. KM in nuclear power plant life cycle

2.1. Characteristics of NPP life cycle KM

From the viewpoint of the safety a good knowledge management approach can reduce the frequency of near-miss events, to support the healthy safety culture and safe operation. For a specific nuclear project, it covers siting, basic design and detailed design, manufacture, construction, commissioning, operation and maintenance and decommissioning. This full cycle nuclear project requires agreement with regulatory requirements, analysis of site characteristics, information of reference design and its adaptation to the designated country's specific regulations and site data, as well as other supporting knowledge.

From the very beginning of the nuclear project lifecycle, it is essential to recognize the roles of all participating organizations that will generate, or handle data & information that affects the design of a nuclear power plant (NPP), and their involvement in the capture, utilization, transfer, and storage of knowledge. In view of the NPP project particularity, the following characteristics have to be considered when managing nuclear knowledge.

- Complexity of nuclear technology

Nuclear knowledge is highly complex on both the micro and macroscale. The thermohydraulic, material, neutron physics, mechanic, chemical as well as the sociological, economic, political, safety and security aspects must all be considered as a whole.

- Long term

Generally, the full cycle of NPP lasts for 60–100 years. A KM system for a typical nuclear project therefore has to be robust to the best of its capability and pay attention for the information and communication technology (ICT) changes.

- Historical context

The average age of the nuclear reactors globally is about 30 years, which means it is great challenge how to properly record, preserve and transfer information for these old NPPs. The design and also the configuration changes during the life of the plant were collected if they have been followed the international and national requirements. Accordingly, the knowledge management have to take care about each change related to the NPP configuration, documentation and the related information complete and accurate.

- Safety

Safety is the prerequisite for nuclear infrastructure development. Nuclear industry makes lots of effort to emphasize safety by experiment, analysis, V&V, management documents, design basis, safety culture etc. For this purpose, knowledge management needs to make sure that all activities related to the safety design is consistent, not only for each interested party but also between them.

- Quality

Quality management in nuclear is – vitally important because it contributes to both NPP safety and performance. From the aspect of information, quality management is about information inspection and comparison, but for the complicated NPP design, 'know how' enhances quality management to a higher level. The latest version of the ISO 9001 requires the management of organizational knowledge properly and also pays attention for all the organizational context.

- Information overload

Measures have to be adopted to capture the changes in knowledge arising from all the phases and have to reflect the changing state of the plant at all times. With the addition of operating experience, periodic safety reviews, and implemented design changes, the amount of information increases continuously and considerably over the plant lifecycle which will be a challenge for KM.

- Multi-stakeholders

Nuclear knowledge evolves over time along with the life cycle of the nuclear project, involving different stakeholders. Government, regulator, suppliers, Research & Development (R&D) organizations, academic educational institutions, training organizations, vendors, utility and technical support organizations are expected to be closely connected in the complex flows of knowledge among different stakeholders. Due to the characteristics mentioned above, innovative nuclear knowledge management (NKM) approach should be proposed to tackle down the specific challenges of nuclear power.

2.2. NKM framework principles

An overview model will help to fully understand the nature of knowledge management and its importance to an organization. The Fraunhofer Reference Model for knowledge management presented in Fig. 1 has been recognized as one of the holistic KM frameworks for standardization in Europe. The model is a three-layer schema that depicts the relationships between value-adding business processes, four knowledge management core pro-

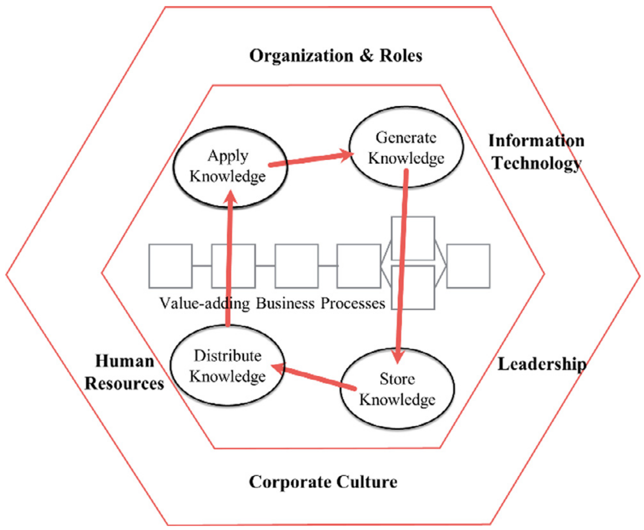

Fig. 1. Fraunhofer reference model for knowledge management.

cesses, and six design fields of knowledge management (Weber et al., 2002).

In order to formalize a knowledge management model for the NPP life cycle, the characteristics of NPP project discussed above should be taken into consideration. The following principles are proposed with the consideration of the characteristics of NKM.

- Regulations and standards & codes

Regulations, standards & codes are part of the NKM and also they define the safety criteria for the whole NPP life cycle. NKM should ensure that all the activities, including storage, sharing, transfer, application, innovation meet the safety requirements and criteria.

- Life cycle integration

NKM framework should combine all the stakeholders related to the NPP life cycle together and define a general knowledge transfer principle between stakeholders which benefit knowledge acquire and update.

- People, process, technology integration

Knowledge management focuses on improving people' competencies, work processes and the supporting technology interaction to perform work activities and make decisions effectively while achieving the organization's business functions and goals safely and economically. Knowledge is embedded in all three areas and must be sufficiently built up and maintained in a systemic and synergistic manner.

- Tacit knowledge capture

Tacit knowledge is in people's minds, and typically cannot be easily captured or transferred in any form. It is difficult to reveal, but it is still possible to record and transfer part of it. Loss of tacit knowledge due to attrition and workforce ageing is a particular area of concern. Conversion of individuals and groups' knowledge into accessible knowledge is an essential element of the NKM.

- Data mining

Nuclear project full cycle generates big data. These data are not static but vary with time. It is a trend to mine knowledge with the help of big data analysis and data mining technologies which would benefit quantity analysis of economy, safety and reliability of NPP.

- Process management integration (management system)

Project management, quality management and human resource management connect people's activities and knowledge. An integrated process management which combined project, quality and human resource should be established to address the specific requirements for NPP.

3. Full cycle NKM framework based on digital systems

Fig. 2 depicts a NKM framework which we develop to meet the above principles. This framework is a full life cycle knowledge management model for nuclear power plants based on digital technology. A high performance parallel computing information technology (IT) infrastructure is developed to serve as the infrastructure to manage and trace nuclear knowledge over different phases of the NPP lifecycle. The model fully considers the use of data center which contains meta data, documents, drawings, codes & standards to break down knowledge barriers of the whole industry chain and realizes flexible storage and accessibility of knowledge. From R&D to operation & maintenance (O&M), we provide digital solutions for all stakeholders including digital R&D, digital design, digital V&V, digital manufacture, digital construction and digital O&M. Knowledge generation, transfer and application are realized through integrated automatic design and analysis integration platform, 3D visible design, digital dynamic performance V&V, collaborative manufacture, building information modeling (BIM) technology, online monitoring and configuration management. Among the stakeholders, knowledge handover and feedback in apple pie order with the help of data center. For example, 3D models and engineering parameter will be delivered to the data center and transfer to the V&V stage after NPP design is accomplished. Meanwhile, in this framework, knowledge generation, transfer and application are managed in an integrated way which embedded in the knowledge flow, including schedule/project management, quality management and human resources management. The entire knowledge management system is accessed through a unified interface.

3.1. Digital R&D optimization support platform

The digital R&D optimization support platform builds top-tier object-driven work environment for the development and optimization of nuclear power plant models, as shown in Fig. 3. It has the following features:

1) Decompose model objects and then assign to specific design activities based on safety, main parameters and other top-tier object of nuclear power plant model, carry out synergic design.
2) Embed design criteria in the system, combining experts' experience to analyze the impact of a design activity on top-tier objectives and on other system design. Analyze cost-benefit effect, evaluate each part of the design process and provide support for overall plan decision.
3) Improvements and iterative optimization of models' design based on feedback from operation of nuclear power plants.

In the long-term development, the system can be gradually connected to equipment, systems, economics and other specialty to achieve the overall R&D and optimization support of nuclear power plant model.

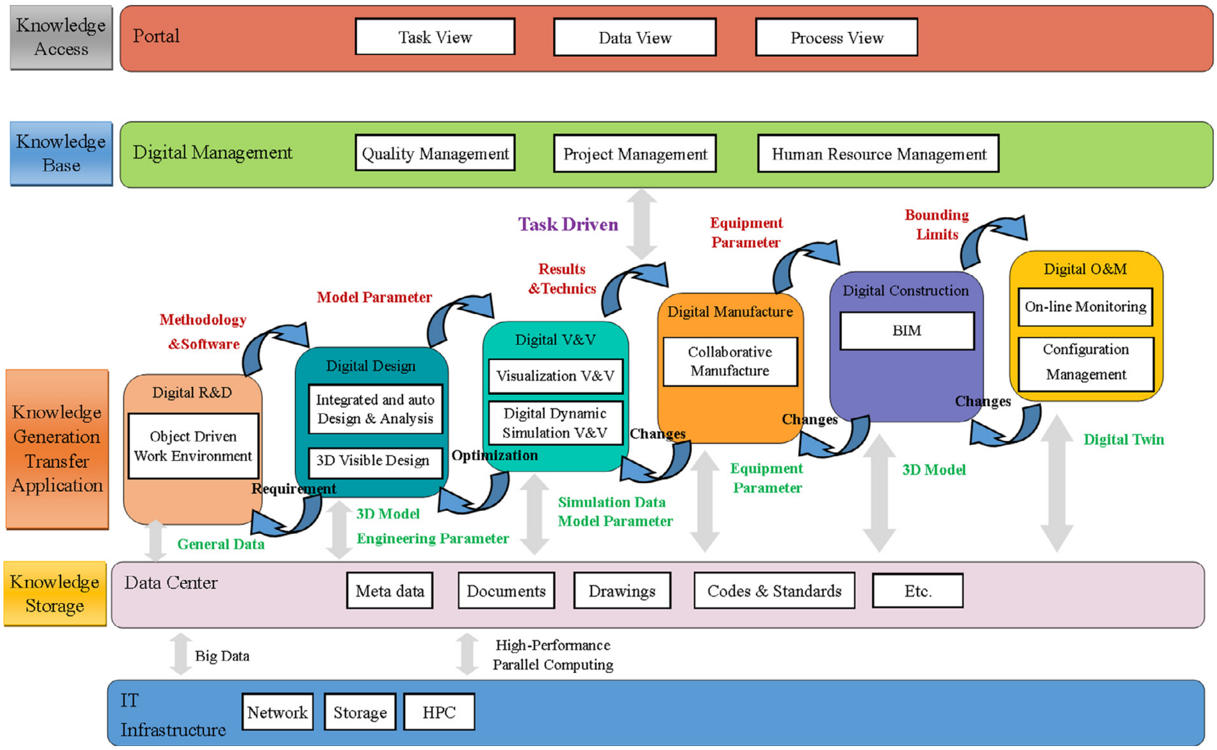

Fig. 2. Full cycle NKM framework.

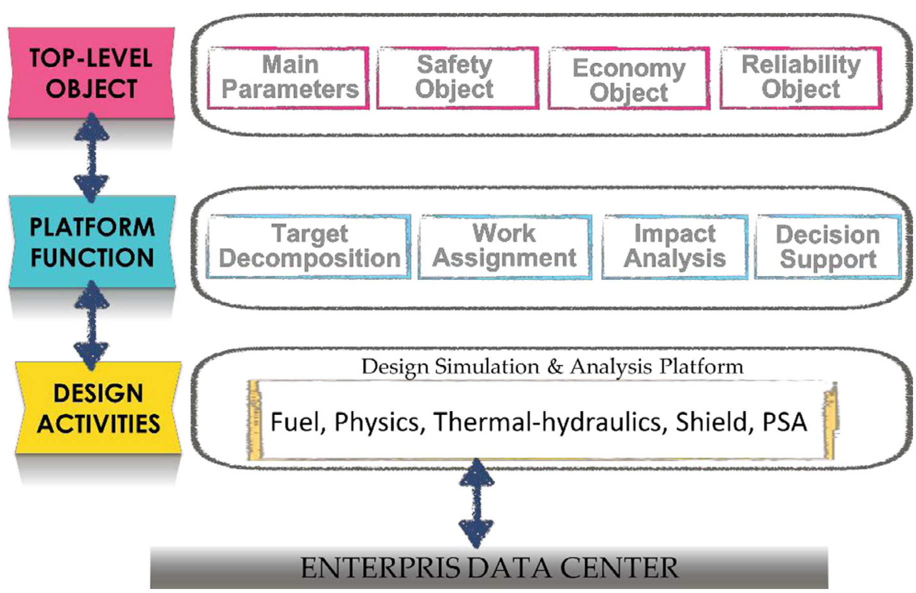

Fig. 3. Digital R&D object decomposition logic.

NKM contributions

1) The digital R&D system converts the design target into explicit parameters, which will be helpful for us to obtain optimized proposal at the conceptual design. Safety, economy, and reliability are reflected in the R&D stage by quantities, visualizations and traceability.
2) In the NPP R&D stage, balance and optimization could be achieved between specialties according to the embedded criteria in the system.

3.2. Digital design and analysis integration platform

The design and analysis integration platform established mainly through software and tool integration, process control, template customization, parameterization and parameter management, to formalize multi- disciplinary integrated design and analysis environment. The design and analysis integration platform has the following functions.

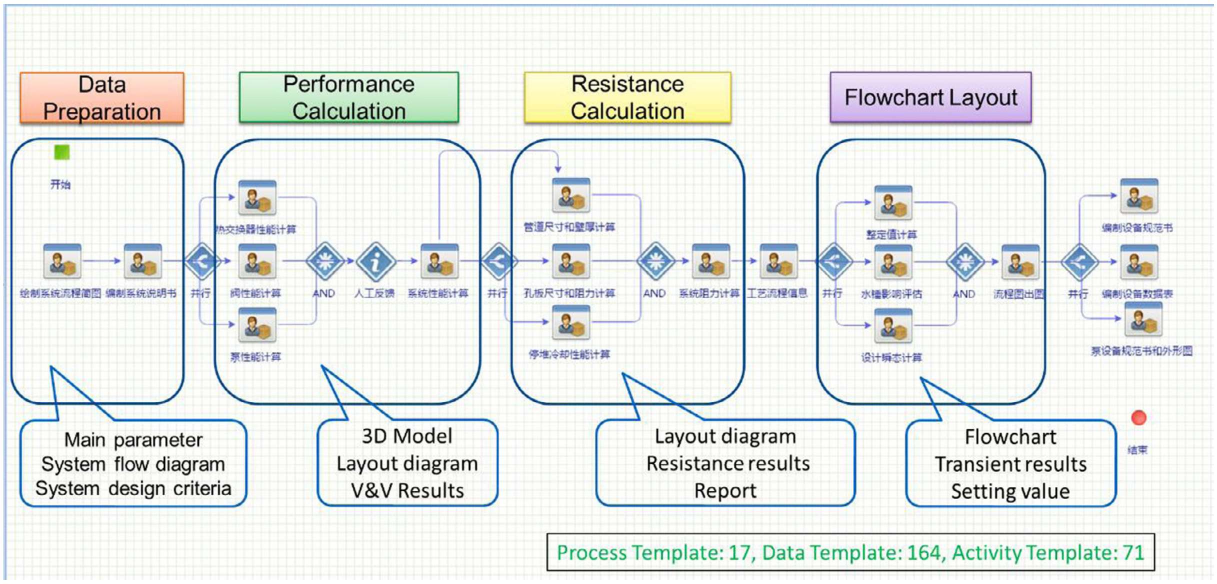

Fig. 4. Automatic design process.

1) **Task process management:** the task management and process management are integrated as a whole, both management and design process are explicit. The design process is constrained through visualization process and digital, standardized guidance.
2) **Design process management:** the steps, software, gadgets, design analysis model, regulatory and safety requirements, experiences, knowledge, upstream and downstream data and quality assurance are integrated in the design process. Once the designer build a process module, it will automatically complete the data transfer and achieve accurate knowledge transfer. The design process is traceable, clearly defined, as shown in Fig. 4.
3) **Integrated design and analysis environment:** visualization collaborative design technology based on the 3D model and database supported integrated design technology are integrated and professional designers can follow the automation and standardization of work processes, use the same design tool around the same model, work locally or remotely and share all kinds of enterprise technology resources.

The platform can guide the designer step by step, prepare the input dataset and generate the analysis model, prompt the necessary regulations, safety requirements and knowledge. The calculation results will be automatically released to the collation staff and the final results will be released for other downstream activities. The client interface of the platform can be what is shown in Fig. 5.

The results of the design process are captured in the defined design basis for all system structure and component (SSC), in guides, requirements and in bounding limits (margins) for operation, which, generally, encompass i) operating procedures (normal and emergency), ii) maintenance procedures, and iii) equipment specifications to be used for tests, maintenance, spare parts and replacement procedures and requirements.

NKM contributions

1) Design and analysis integration platform achieves curing and transfer of design experience, process and knowledge.
2) Automated design analysis and localized intelligence. Quality management for both design process and results is traceable.
3) Expertise unified management: the basic database, American society of mechanical engineers (ASME) database, purchased parts library, heating ventilation air conditioning (HVAC) equipment data sheets, water supply and drainage equipment database are built which facilities engineers to refer and make use of the right knowledge fast and convenient.
4) Provide online access to knowledge, online knowledge push, knowledge entry, super vocabulary library and knowledge fragmentation.
5) Manage and maintain ASME, HAF, HAD, GB and other standards, provide easy access of formulas, parameters and specifications to improve engineers' work efficiency.
6) Develop an expert system for analysis and evaluation of nuclear power equipment and other specialties

3.3. Digital V&V

In order to ensure the safety and quality of nuclear power plant design, to ensure the safety of nuclear power plant models, digital prototypes are developed to validate and verify R&D and design results. Digital V&V system optimizes feedback to design results and reasonably reduces tests and unnecessary rework. Meanwhile also improve the competence of the designer staff through the learning process.

One of the primary objectives of the digital V&V system is to help build digital dynamic simulation NPP, which integrated thermo-hydraulics, 3D neutron dynamics, instrumentation and control algorithm, serious accident and virtual Digital Control System (DCS) to evaluate and validate I&C algorithm, human factor engineering, operation transients and accidents, set-point and standard operating procedures.

Another objective of the digital V&V system is to help to build up 3D digital NPP model, which integrates NPP full cycle data including site analysis, design, construction and commissioning and helps to fulfil configuration management requirements. Each process is analyzed, verified and validated by analysis tools. The 3D digital NPP model is combined with the NPP dynamic simulation kernel to extract NPP simulation operation status and to realize the virtualized personnel training through the human-computer interaction. In addition, the virtual model is emerged into the digital factory environment to analyze and evaluate the

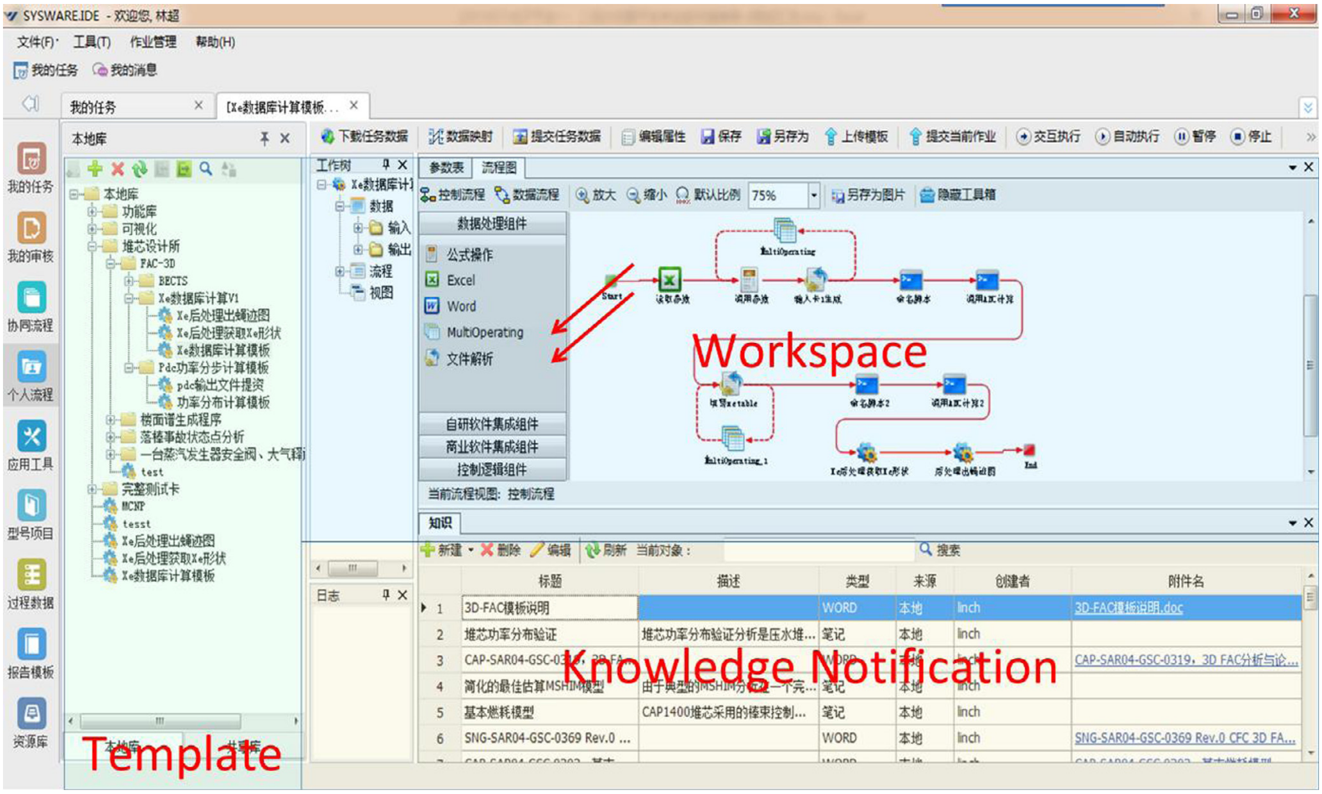

Fig. 5. Design and analysis integration platform client interface.

ergonomics, and the manufacturability, accessibility, detachability and maintainability could be intuitively analyzed.

NKM contributions

1) Digital V&V system verifies and validates NPP life cycle data to ensure the safe and quality NPP design.
2) Digital V&V system helps better understand the interrelations among the parameters in the NPP design which are conducive to clarify the direction of optimization and reduce the potential risks.
3) V&V results are not only beneficial for design feedback, but also guide downstream activities such as commissioning, operation, maintenance, decommissioning and remediation.

3.4. Intelligent equipment design and manufacture collaboration platform

Intelligent equipment design and manufacture collaboration platform is based on holographic 3D equipment design and automatically load standards, safety and manufacturing requirements to achieve virtual manufacturing.

In the process of transferring data from design to manufacturing, based on the 3D labeling technology and ASME digital product definition method, the model design conforming to model definition can be realized, and the design data can be maintained and used as the fundamental data source in the whole product chain. As a result, equipment holographic model and related information are applied by subcontractors, procurement and upstream and downstream units online. Equipment life cycle reference equipment information management library, equipment suppliers' online management and equipment life cycle data control are established.

NKM contributions

1) Sharing design and manufacturing data, enabling real-time interaction between manufacturers and design institutes for design, manufacturing, and test scheduling.
2) Full lifecycle data management based on the 3D model.

3.5. Digital construction

Digital construction enables the engineering and technical personnel correctly understand and respond to various construction information through the application of the 3D NPP model which is handed over from designer and integrates the relevant data and information from front end to back end. In this way design team and all parties including construction company (integral engineering service) are able to work on the same model. Furthermore, actual construction can be 4D simulated (3D model plus the project time) to determine a reasonable construction program according to the construction plan. Ultimately, 5D simulation (4D plus cost) can support the cost control.

NKM contributions

1) Digital construction plays an important role in NPP full cycle knowledge sharing and transfer, construction efficiency improvement, cost saving and construction duration control.
2) Preserve and update NPP databases, transfer practical NPP engineering parameter to utility.

3.6. Digital O&M

In the full cycle NKM framework, the NPP O&M will receive the upstream data and knowledge. Knowledge update, design improvement and new principles and phenomena discovery which ensure NPP safety, economy and reliability are supported by NPP configuration management, O&M service support, on-line monitoring and intelligent diagnosis and visualization maintenance.

1) NPP configuration management and O&M service support platform

The platform can be based on the digital NPP data received from the upstream, to achieve unified management, correlation management and real-time updating of all items, documents, data and models of the nuclear power plant. In addition to configuration management, the platform also has other features, such as:

- Storing the static and dynamic data generated during the NPP operation and maintenance. After data uniqueness and accuracy check, it can support the power plant operation data analysis and decision making, and provide experience feedback to the design, manufacture and construction.
- A unified data query portal, which combines the 3D NPP model and plant items data generated in design, procurement, construction, commissioning, operation and decommissioning phases, facilitates operating state and specific equipment inquiries.
- Status display, trend forecast, statistical analysis, alarm, equipment parameters cross- comparison, system management and other functions are achieved by the data analysis and processing.

2) NPP on-line monitoring and intelligent diagnosis systems

The on-line monitoring system realizes the monitoring, diagnosis and risk assessment of the equipment and system. It provides equipment performance diagnosis, accident decision support and optimization O&M to ensure NPP long-term safe operation. New phenomena and knowledge could be discovered by data mining of monitoring results which could deepen the understanding of nuclear power plant.

3) Visual virtual maintenance platform

The 3D digital NPP inherited from designer and virtual reality technology are integrated to provide services for the plant operation and maintenance, including the planning of complex visual maintenance process, coordination of personnel and tool, safety and accessibility analysis of personnel comfort, simulation and guidance of inspection operation, virtual training etc.

NKM contributions

1) Ensuring the completeness, accuracy and accessibility of NPP life cycle data.
2) Staff training support.
3) Discover new knowledge through data mining to guide the safe, reliable and economical O&M of nuclear power plants.

3.7. Digital management

It is possible to realize schedule management, quality management and human resource management through this framework. Furthermore, the associate information can be tracked automatically and feedback can be accumulated. Especially for design, the whole process (including design input, interface and output) and quality information can be digitalized by IT technology. Following this, statistical analysis of quality can be established by collected information of design process quality information and product information.

It can realize the legalization of electronic documents by reliable electronic signature and visual signature technology, meet the legal and regulatory requirement of electronic document filing, realize the paperless design, and lay the foundation for digital handover.

NKM contributions

Schedule, quality, human resources management system is established corresponding to NPP full cycle process and data

3.8. Data Center

A data center is a data management system for the modeling, organization, storage, presentation and application of information-related elements of the activities (e.g., item, data, archive, activity, knowledge). It provides data service for various activities and schedule/project management as well as providing data interface for manufacturing, purchasing, construction, operation and maintenance to realize the NPP full-cycle knowledge management. Moreover, the data in the center is dynamic, data changing will also be recorded by date center, which will be helpful for stakeholders to get the right data for their specific task. As time goes by, it is possible to implement data mining in the data center to satisfy various demands, like preparation for a long-term operation (license renewal) through safety evaluations.

NKM contributions

1) Data storage and presentation, data association and change management, design data input and output services, data-based design quality management, data-based schedule management and design knowledge management (DKM).

4. Conclusion

Through deep analysis of nuclear power industry and the understanding of knowledge management, 6 principles for NKM are proposed to effectively implement KM for nuclear. Moreover, by fully integrating the digital technology, a systematic full life cycle NKM framework based on digitalized system is put forward, which is able to deal with the challenges of multi-disciplinary, long term and multi stakeholders of nuclear industry. The framework is in consistence with (O'Leary, 1999) who believes the principle functions of a knowledge management system are to facilitate

- conversion of data and text into knowledge;
- conversion of individual and group's knowledge into accessible knowledge;
- connection of people and knowledge to other people and other knowledge;
- communication of information between users,
- communication of information between different groups, and
- creation of new knowledge that would be useful to the organization.

The NKM framework contains a big data center where new knowledge beneficial to the organization could be discovered through data analysis and mining. Knowledge could be shared and transferred among the various stakeholders through the 3D NPP model which acted as a carrier of knowledge. Digital processes which integrates schedule, quality and human resources management become a bridge between people and knowledge. The wide use of simulation and visualization technology links people, technology, processes and knowledge more closely.

The practice of full cycle NKM framework will facilitate tacit knowledge transfer into explicit knowledge, mitigating singleton reliance, improving innovation, developing collaboration relationships and partnerships, maintaining and developing staff competence and compliance with nuclear legislative requirements, comprehensive enhance the safety, economy and reliability of NPP. Last but not least, this framework not only meets the needs of knowledge management in the IT era, but also prepares for the upcoming data technology (DT) era. However, new technology and IT systems are always needed and practiced to enrich this framework.

References

Carroll, B., 2006. Comparative Analysis of Methods and Tools for Nuclear Knowledge Preservation.

Chang, Z., 2002. Research on the construction of knowledge management model based on the viewpoint of business competitive advantages (Master dissertation). National Sun Yat-sen University. www.kuo.bm.nsysu.edu.tw.

Consulting, A. A. B, 1999. Zukai Knowledge Management. TOKYO Keizai, Inc., Tokyo.

Kosilov, A., Pasztory, Z., 2009. The development of KM portals for nuclear power plants. Int. J. Nucl. Knowl. Manage. 3 (4), 348–354.

Kosilov, A., Yanev, Y., Mazour, T., 2009. Knowledge management for a new nuclear power infrastructure. Int. J. Nucl. Knowl. Manage. 3 (4), 431–440.

Mentzas, G., Apostolou, D., Abecker, A., Young, R., 2003. Knowledge Asset Management. Beyond the Process-centred and Product-centred Approaches.

O'Leary, D.E., 1999. Reengineering and knowledge management. In: Paper presented at the International Conference on Knowledge Engineering and Knowledge Management.

Payne, K., Deasley, P., 2001. Cultural issues in aerospace engineering design teams. In: Paper presented at the Proc. International Conference on Engineering Design, ICED01, Design Management—Process and Information Issues.

Polanyi, M., 1966. The Tacit Dimension.

Tecdoc, I. 1510, 2006. KM for Nuclear Industry Operating Organizations. IAEA, Vienna.

Weber, F., Wunram, M., Kemp, J., Pudlatz, M., Bredehorst, B., 2002. Towards common approaches and standards for knowledge management in Europe. In; Paper presented at the Proceedings of UNICOM Seminar towards Common Approaches & Standards in KM.

Zhao, J., Pablos, P.O.D., Qi, Z., 2012. Enterprise knowledge management model based on China's practice and case study. Comput. Hum. Behav. 28 (2), 324–330.