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Proposal

Knowledge-based Information Resource Management System for Materials of Sodium-cooled Fast Reactor

by
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Background

In the development of advanced fast reactors, materials and coolant/material interactions pose a critical barrier for higher temperature and longer core life designs. For advanced burner reactors (sodium cooled) such as EBR-II and FFTF, experience has shown that the qualified structural materials and fuel cladding severely limits the economic performance. In other liquid metal cooled reactor concepts, advanced materials and better understanding and control of coolant and materials interactions are necessary for realizing the potentials.

Liquid sodium has been selected as the primary coolant candidate for Gen. IV nuclear energy systems. Global Nuclear Partnership (GNEP) Advanced Burned Reactor (ABR) has identified materials improvement as a major thrust to improve Fast Reactor (FR) economics, Researches from universities, national laboratories and related industrial participants have been continuously generating invaluable data and knowledge about materials and their interactions with coolants in the past few decades. Under the consideration of cost and time constraints, the paradigm of designing and implementing a successful Gen IV Nuclear Energy Systems can be shifted and updated via the integration of information and internet technologies. Such efforts can be better visualized by implementing collective (centralized or distributed) data storages to serve the community with organized material data sets. Material property data provided by MatWeb.com and the ongoing development of web-based GEN IV material handbook are few examples.

From system design perspective, sodium-cooled fast reactor (SFR) proposed in the GEN IV system have been significantly developed. According to the GEN IV ten-year program plan, current R&D work will be pointed to demonstration of the design and safety characteristics, and design optimization. Major activities defined in the current SFR R&D Plan scopes can be summarized to (1) ensuring the needs and goals of the program are followed by GEN IV International Forum (GIF) countries, (2) document and share the R&D progress and accomplishments and (3) integrate relevant activities from GIF SFR R&D with Global

Nuclear Partnership (GNEP) Program. All of those activities follow the path of data generation, analysis, knowledge discovery and finally decision making and implementation.

We are proposing to create a modularized web-based information system with models to systematically catalog and analyze existing data and guide the new development and testing to acquire new data. Technically speaking, information retrieval and knowledge discovery tools will be implemented for researchers with both information lookup options from material database and technology/development gap analysis from intelligent agent and reporting components. The goal of the system is not only to provide another database, but also to create a sharable and expandable platform-free, location-free online system for research institutes and industrial partners.

Research Approach

We will design, develop and implement a knowledge-based resource management system that provides tools for organizing data, searching information and reporting integrated knowledge of sodium-cooled nuclear reactor systems. Such knowledge discovery and data mining (KDD) process generally includes data integration, preparation and transformation, data mining and evaluation, and data visualization. Parallel to the development of those front-end analysis tools, web-based data updating and portal administration interfaces will also be designed and developed. Data collection will start during the early stage of the project due to its time consuming nature. A series of analysis models and tools will be developed from existing literatures and from instructed graduate student thesis. We presume the proposed system will served as a prototype for designing liquid metal systems and therefore more modules can be integrated and combined into the system under pre-defined open-source architecture. The research has been further divided into seven subtasks described below:

- Subtask 1: Data collection and cleanup. To effectively identify research gaps, past researches on liquid metals need to be initially collected and documented.

- Subtask 2: Requirement analysis. There are three major components need to defined prior to designing system architecture. Stakeholder identification will be carried out to understand requirement and roles involved. Data-structure analysis layouts the data properties and variation directly related to database design and internal data retrieval efficiency. Analysis tool definition outlines the scope and development stages related to prototype, intermediate and final products.

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- Subtask 3: Application architecture design. Based on the requirement defined, multi-tier application architecture will be defined. The system will contain two data sources. The configuration settings are stored in an XML (eXtensible Markup Language) formatted file while the content for the application is stored in a Microsoft (MS) SQL Server database. The data access is provided through a MS .NET assembly that provides access to the data source using the stored procedures. In addition, the portal framework is built through the use of a number of components that handle both the security and portal configuration. The presentation layer will be organized by several Web Forms and user controls that handle the display and management of the portal data for end users.

- Subtask 4: System development. System development will be divided into three parts: database development, portal functionality development and portal presentation development. The MS SQL Server database will be selected as major database package while other form of database can be considered based on the actual circumstance. Portal development and information presentation will be performed using the MS .NET technology, including ASP.NET, VB.NET and XML.

- Subtask 5: Web-based resource management system Implementation. Web portal implementation required two considerations, hardware configuration and package installation. A Windows-based resource management system will be designated as a web server while database servers can locate onsite with the web server or at various locations depending on the accessibility of data sources. Data entry task will be performed separately during or after the completion of Subtask 6.

- Subtask 6: System testing, debugging and refinement. After the system has been implemented, a sequence of testing in terms of functionality and server efficiency will be performed. The task will open to the designated members from the projects and possible industry partners. More refinement will be made based on the feedback.

- Subtask 7: Graduate student instruction and result publication. Information retrieval involving significant efforts on data collection, search algorithm development and refinement, and theoretical models development which are suitable for MS level research and thesis topics. More advanced expert system design including innovative KDD and sophisticated search strategy development can be done by Ph. D. student with longer research timeframe. All research findings from this project will be published in related association publication.

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Significance and Participation

There are a number of publications and compilations of the materials properties and test results. Currently there are efforts in AFCI/GNEP and Gen IV to develop handbooks and databases. Our database differs from the other efforts in its comprehensive scope of data inclusion, and specific emphasis of materials-coolant interactions with built-in models and analytical tools for the interpretation and extraction of design use data. The PI of this task has developed and maintains several nationwide resource management systems for US DOE on thermal chemical production of hydrogen (under Solar Hydrogen Generation Research -SHGR) and indoor environmental quality evaluation (under National Center for Energy Management and Building Technology -NCEMBT) and is highly skilled and well experienced in this field. One undergraduate and two graduate students will participate.

Deliverables

1. Construct a knowledge-based resource management system with
   - Collected research references and data/information from existing available data for liquid metal systems in the designed database system,
   - Developed analysis modules for advancing engineering improvement for designing advanced nuclear reactors,
   - Developed theoretical tools for analyzing the existing data,
   - Implemented web-based portal management tool,
   - Implemented web-based data/information upload/updating interface,
   - Implemented web-based information reporting interface.

2. Generate MS-level thesis and related publications.

3. Compile progress reports
   - Monthly highlights reports will be provide on the third day of each month summarizing the progress made in the reporting period. An updated MS Project chart indicating % completion of each subtask will be submitted with the monthly highlights report.
   - Quarterly progress reports will be submitted on the first day of each new quarter providing a comprehensive summary of the work performed and the progress achieved in the reporting period.
   - A comprehensive written Final Report that describes the original purpose, approach, results and conclusions of the work done under this project will be submitted.

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Timeline

The effort will be completed in 12 months. The detailed timeframe based on month breakdown is listed below based on the subtasks.

Subtask ID	Task Description	M 1	M 2	M 3	M 4	M 5	M 6	M 7	M 8	M 9	M 10	M 11	M 12
1	Data collection and cleanup												
2	Requirement analysis												
3	Application architecture design												
4	System development												
5	Web-based resource management system Implementation												
6	System testing, debugging and refinement												
7	Graduate student instruction and result publication												