Specialists Workshop on Advanced Human-Machine Systems Studies for Complex Energy Systems

Date : March 26 -27, 2024

Place: Research Institute of Advanced Energy Science, Kyoto University, Uji-shi, Kyoto-fu, Japan (Fifth Floor of the Main Building, Uji Campus, Room N571E) with Hybrid mode

Organized by: NPO Symbio Community Forum, Uji, Kyoto, Japan

with the support of the Joint Usage/Research Center for Zero Emission Research, Institute of Advanced Energy, Kyoto University

The purpose of this workshop is to exchange information among experts in advanced human-machine systems research, with the selected themes of risk analysis and fault diagnosis of complex energy systems, and research related to technical standards for nuclear power plant HMS together with talent cultivation for science education. This special workshop is organized as a pre FMWS2024 workshop, with the visiting members of three Chinese universities (Shenzhen University, South China University of Technology, and Heilongjian Institute of Technology) who will participate in the International Workshop (FMWS2024) on Functional Models and Socio-Technical Systems to be held in Okayama Prefectural University in Soja City, Okayama Prefecture on March 29, 2024.

General coordinators for the conference:

General Chair: Prof. Hidekazu Yoshikawa (Symbio Community Forum)

Secretary: Mr. Kenji Yoshikawa (Symbio Community Forum)

Conference room manager: Ms. Mari Takatsuka (Institute of Advanced Energy, Kyoto University)

ZOOM Host: Mr. Junya Nitta (Symbio Community Forum)

Program

March 26, 2024

Opening address by Prof. H. Yoshikawa 2:00 pm

Session I How to organize the Review Guideline of Human Factors Engineering Program for NPP"

Chaired by Prof. H. Yoshikawa (Symbio Community Forum)

I-1　Introductory review of the NUREG-0711 Rev. 3 and the relevant Guideline being under discussion in the Japan Electric Association

Hidekazu Yoshikawa (Symbio Community Forum: Kyoto University)　1. 0 hours

I-2　IEC-60960 revision: Human factors issues in SPDS design in nuclear power plants

Wang Xiaoye (NPIC)　via internet　0.5 hours

I-3　Discussion　0.5 ours　Chaired　by　Prof. H.Yoshikawa

Pause

Session II　An Active Learning Practice on Talent Cultivation on nuclear and energy sciences　4:00-5:00

Chaired by Prof. H. Yoshikawa (Symbio Community Forum)

Prof. Yoshikawa will first make a small guidance on an active learning method being developed by Prof. Takeshi Yao (Prof. Emeritus Kyoto University). Then all participants (first Chinese students, second Chinese teachers, and last Japanese participants) will be asked to make a short speech in English for self-introduction including their research activities on the basis of Prof. Yoshikawa guided speech subject.

Group photo

Welcome party　17:30 ~　Kihada Hall Obaku plaza Uji campus

March 27,2024
Start from　9:30 am

Session III　Researches for new methodologies for risk monitoring and performance evaluation for complex energy systems

Part 1: Chinese presentation　1.5 hours　Chaired by Prof. T. Matsuoka
III-1　Report of research project on the key technologies for intelligent risk-informed decision support system for nuclear safety and emergency response management with

highlighting Upgrade of GO-FLOW for Success Path Planning and Exact Quantification Support

Jun Yang (South China University of Technology)　　1.0　hours

III-2　Research progress on operational safety and risk monitoring & prediction of nuclear power plants

Sijuan Chen (Shenzhen University) via internet 0.5 hours

Pause

Part 2: Japanese Presentation：“Research on diagnosis and reliability/availability analysis for complex energy system- A case study for Heliotron J device at IAE”
Start from 11:00 am　Chaired by Prof. Yang Jun

III-3　Introduction of Heliotron J facility and the scope of the case study
Hidekazu Yoshikawa (Kyoto University)　(20 Min)

III-4　Degradation diagnosis of Heliotron components by higher harmonics diagnosis method
Junya Nitta(Arcadia Co.) and　Prof. H. Yoshikawa (Symbio Community Forum) (30 Min.)

III-5　Reliability/Availability evaluation of Heliotron J by GO-FLOW
Takeshi Matsuoka (Utsunomiya University)　(30 Min)

Lunch　12:30~　Lunch　at Uji Campus Canteen
(Take food and pay individually by cash to Canteen staff)

Facility visit to Heliotron J at IAE　　13:30 -14:30
Guided tour by Mr. Wang Chenyuu (PhD Student, Kyoto University)　with　Mr. Kiyoshi Tohshi（Heliotron J Facility, IAE、Kyoto U.）

Group photo
Adjourn　　15:00

Abstracts of Presentations

I-1 Introductory review of the NUREG-0711 Rev. 3 and the relevant Guideline being under discussion in the Japan Electric Association

Hidekazu Yoshikawa（Symbio Community Forum, President）

Abstract:
The U.S. human factors engineering program (NUREG-0711) aims to rationally improve the safety of nuclear power generation by programming not only the design and manufacture of the main control room of a nuclear power plant, but also the entire plant, including the other software aspects such as operating procedures, education and training, etc., by applying the human engineering principles. Since the latter half of the 2010s, the IAEA has issued a safety guide based on the US human factors engineering program (NUREG-0711) as SSG-51, and the US NRC has issued human factors engineering guide based on SSG-51 that systematically organizes regulatory requirements, and the IEC is also considering a similar human factors engineering guide. This presentation provides an overview of the latest NUREG-0711 Rev. 3, followed by an introduction to similar initiatives currently under preparation by the Japan Electric Association as human factors engineering standard in Japanese nuclear industry.

I-2　IEC-60960 revision: Human factors issues in SPDS design in nuclear power plants

Xiaoye Wang (Nuclear Power Institute of China, Assistant Engineer)

Abstract：
After the accident of the nuclear power plant in Three Mile Island in 1980s, the concept of Safety Parameter Display System (SPDS) was proposed internationally. SPDS, as one of the important human-machine interfaces, is used to enhance the ability of control room personnel to overall monitor the safety status of nuclear power plants, especially under abnormal conditions and accident conditions, in order to improve the safety of reactor operation. The International Electrotechnical Commission (IEC) released the standard IEC 60960, which outlined the functional requirements, display specifications, and performance criteria for SPDS in 1988. However, with the development of computer technology and human factors engineering, this standard needs to be updated

to adapt the design of SPDS to the current development system of control room design and human factors engineering.
The purpose of this presentation is to provide an overview of the ongoing revision of IEC 60960, highlights the directions of the changes and the current status of the revision process, and finally discusses the development direction of SPDS and human factors issues in SPDS design.

II　An Active Learning Practice on Talent Cultivation on nuclear and energy sciences

Hidekazu Yoshikawa（Symbio Community Forum, President）

Abstract:
Prof. Yoshikawa will first make a small guidance on an active learning method being developed by Prof. Takeshi Yao (Prof. Emeritus Kyoto University). Then all participants (first Chinese students, second Chinese teacherss, and last Japanese participant) will be asked to make a short speech in English for self-introduction including their research activities on the basis of Prof. Yoshikawa guided speech subject.

III-1 Report of research project on the key technologies for intelligent risk-informed decision support system for nuclear safety and emergency response management with highlighting upgrade of GO-FLOW for success path planning and exact quantification support.

Jun YANG　（South China University of Technology, Associate professor）

Abstract

In the presentation, the research progress and accomplishments of an international collaborative project on the key technologies for intelligent risk-informed decision support system for nuclear safety and emergency response management are presented. The objectives of the project focus on: i) risk layering for safety supervisory and management; ii) an enhanced modeling and analysis platform to be developed for dynamic reliability and risk analysis; iii) success path planning for emergency response management in the early stage of accident mitigation and recovery. A decision support system augmented with a hybrid compute engine and a goal-oriented success path planner is designed and developed for nuclear safety and emergency response

management. The latest innovations of GO-FLOW method for success path planning and exact quantification support with both Minimal Path Sets (MPSs) and Minimal Cut Sets (MCSs) will also be in detail discussed.

III-2 Research progress on operational safety and risk monitoring & prediction of nuclear power plants

Sijuan Chen (Shenzhen University, Lecturer）

Abstract

The risk monitor (RM) for nuclear power plants (NPPs) based on the Living Probabilistic Safety Analysis (Living PSA) technology can evaluate the instantaneous risk of the NPP and implement the configuration risk management based on the actual state of the system/component. During the long-term operation of NPPs, there is a possibility of component availability but performance degradation. However, the impact of component degradation on the risk of NPPs has not been considered in the current RM. The development of Prognostics and Health Management (PHM) technology provides an opportunity to predict the future state, remaining useful life (RUL) and time-varying probability of failure (POF) specific to the unique component. The combination of PHM and RM can compensate for the shortcomings of traditional RM. In this presentation, the latest progress of real-time online risk monitoring (RORM) technology of NPPs in China will be introduced, and on the basis of the previous research on RORM, the ongoing research progress of risk prediction technology combining PHM and RM will also be displayed. In the latest study, the risk prediction method framework combining PHM and RM was built, the risk prediction system was developed, and the feasibility of the scheme was proved through the case. The time-varying POF prediction was performed using the component health state and RUL predicted through PHM technology, and the quantitative indicators for the impact of component performance degradation and preventive maintenance plans on the risk of NPPs were further provided.

III-3 Introduction of Heliotron J facility and the scope of the case study

Hidekazu Yoshikawa (Kyoto University)

Abstract:

The Symbio Community Forum is conducting a joint research project titled ``Experimental research on advanced failure diagnosis and reliability evaluation methods for complex energy systems'' with the support of Zero Emission Research Base of the Institute of Advanced Energy, Kyoto University. In FY2023, we are proceeding with experimental application and verification of failure diagnosis and reliability evaluation methods for the Heliotron J plasma experimental facility at the Institute of Advanced Energy. In this presentation, the principles of fusion power generation and the configuration of tokamak-type fusion power generation system will be explained first, and then introduce the specific character of Heliotron-type plasma device, and system configuration of the Heliotron J experimental facility.

III-4　Degradation diagnosis of Heliotron components by higher harmonics diagnosis method

Junya Nitta　(Arcadia Systems Inc., Director)

Abstract

In recent years, "predictive maintenance" has been attracting attention in the world of equipment maintenance. It is expected to accelerate further in the flow from conventional TBM to CBM. Even if you don't take the SDGs and the big step, it is a natural flow to use things that can still be used to the fullest of their life, and then to perform appropriate maintenance and parts replacement before they fail.
One of the most suitable diagnostic technologies for predictive maintenance is harmonic diagnostic technology. Non-contact, live-wire diagnosis is safe and simple, so it can be applied in a wide range of fields.
In this study, harmonic diagnostic technology was used to diagnose the auxiliary equipment (various pumps of the vacuum system and the cooling system) of Heliotron J. Here are some of the diagnostic cases.

III-5 Availability Analysis of Heliotron J water-cooling system by the GO-FLOW methodology

Takeshi Matsuoka (Utsunomiya University, Lecturer)

Abstract

Heliotron J is a fusion research device, specifically a helical-axis heliotron designed to study plasma confinement It is located at the Institute of Advanced Energy, Kyoto University. Experiments with the Heliotron J are conducted continuously for six months and the remaining time is spent on system maintenance. The availability of the water-cooling systems of the Heliotron J is critical for the successful operation of the system. Reliability/availability analysis of the cooling systems have been performed by the GO-FLOW methodology for possible maintenance schedules and methods.The equipment is divided into several groups. Important active components such as pumps, valves, motors are checked and repaired annually. Less important passive components, such as filters, piping are checked once every two years or three years. The study examines the effects of different maintenance practices. Component failure rates were assigned based on the Heliotron J operating records. Also, the data shown in nuclear industry are referred.

The water-cooling system was modeled into GO-FLOW chart giving failure data and analysis conditions. Analyses are performed for the possible combinations of different maintenance schedules and maintenance effects. Results of the analysis will be used to determine strategies for maintenance schedules and methods.