VSB TECHNICAL UNIVERSITY OF OSTRAVA | FACULTY OF SAFETY ENGINEERING

Doctoral Thesis Assignment

Student:

Study Programme: P1032D020005 Fire Protection and Safety

Topic: Hydrogen dispersion in confined, partially confined and unconfined environment by a hybrid machine learning approach
Rozptyl vodíku v uzavřených, částečně uzavřených a otevřených prostředích s využitím hybridní metody strojového učení

The thesis language: English

Supervisoring centre: 025 Centre of Excellence for Safety Research

Rules for elaboration:

A short annotation of the proposed dissertation:
As hydrogen becomes increasingly integrated into energy, mobility, and industrial systems, assessing the consequences of accidental releases is crucial for ensuring safety. A key aspect of such assessments is understanding hydrogen dispersion under different temperature conditions — from ultra-low (associated with liquid hydrogen) to ambient — as this directly influences flash fire and vapour cloud explosion scenarios in unconfined, partially confined, and confined environments. While computational fluid dynamics (CFD) models can accurately simulate these phenomena, their computational demands remain too high for practical risk assessment and decision-making. Therefore, this dissertation proposes a hybrid framework that combines physics-informed machine learning techniques with numerical simulations and experimental data to enable fast and reliable predictions of hydrogen dispersion across various conditions.

Intended objective of the proposed dissertation:
The main objective of the dissertation is to develop and validate a hybrid simulation–machine learning framework capable of significantly accelerating the prediction of hydrogen dispersion at different initial temperatures. This will be achieved by:
- generating and integrating datasets from CFD simulations and controlled experimental releases of hydrogen under diverse conditions,
- training and applying physics-informed and residual-aware machine learning models to emulate dispersion dynamics with orders-of-magnitude computational speed-up,
- synthesizing these fast predictions into an operational decision-support tool that provides actionable safety recommendations.

Expected contribution to the scientific field and to practice:
The proposed research is expected to advance the state of knowledge in hydrogen safety by establishing a data-driven, physics-informed modelling approach for rapid dispersion assessment. Scientifically, it will contribute to the integration of hybrid modelling techniques combining first-principles physics and machine learning in the context of safety engineering. In practice, the resulting framework will enable near real-time consequence evaluation and risk-informed decision-making for hydrogen infrastructures, supporting the safe deployment of hydrogen technologies in energy and mobility sectors.

Supervisor: **dr hab. inż. Rafal Porowski**

Consultant:

Chairman of Studies Board: prof. Ing. David Řehák, Ph.D.

In IS EDISON assigned:

VSB TECHNICAL UNIVERSITY OF OSTRAVA | FACULTY OF SAFETY ENGINEERING

Doctoral Thesis Assignment

Student:

Study Programme: P1032D020005 Fire Protection and Safety

Topic: A multi-criteria approach for the sustainability of green hydrogen based on experimental data and machine learning
Vícekriteriální přístup k hodnocení udržitelnosti zeleného vodíku na základě experimentálních dat a strojového učení

The thesis language: English

Supervisoring centre: 025 Centre of Excellence for Safety Research

Rules for elaboration:

A short annotation of the proposed dissertation:
In the view of emission reduction of energy production, green hydrogen is considered as an efficient zero carbon solution. However, the extensive use of this gas poses significant challenges due to the current high cost, even if it may become less problematic as technological advances in electrolysis and declining renewable energy costs could make hydrogen commercially viable at competitive prices. Besides, successful implementation requires careful consideration of multiple factors, including safety and environmental aspects. These aspects will be analysed in the doctorate study, with specific reference to green hydrogen production and utilization. To this aim, key performance indicators will be established to enable the quantitative assessment of hydrogen sustainability and the comparison with other forms of traditional and renewable energy. Experimental investigations will provide the foundational data necessary for machine learning model development and implementation.

Intended objective of the proposed dissertation:
The sustainability assessment will be based on the definition of specific key performance indicators (KPI), which will quantitatively compare the production and the storage of green hydrogen with fossil-fuel-derived hydrogen. Also, the KPI will compare the use of green hydrogen for fuel cells, as a direct burner, as a blended fuel with methane and ammonia, and in the ideal case of pure oxygen-hydrogen combination. For the complex system, experiments for the safety and environmental indicators will be specifically designed. The experiments will be the basis for a data-driven machine learning approach.

Expected contribution to the scientific field and to practice:
The research question is manyfold and includes the development of advanced numerical tools, the design of experimental tests, and the definition of advanced, however practical methodology for the energy-decision-makers.

Supervisor: **Dr. Ernesto Salzano**

Consultant:

Chairman of Studies Board: prof. Ing. David Řehák, Ph.D.

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VSB TECHNICAL UNIVERSITY OF OSTRAVA | FACULTY OF SAFETY ENGINEERING

Doctoral Thesis Assignment

Study Programme: P1032D020005 Fire Protection and Safety

Topic: Virtual Twin model for modernise OHS training
Model virtuálního dvojčete pro modernizaci školení v oblasti BOZP

The thesis language: English

Supervisoring centre: 040 Department of Occupational and Process Safety

Rules for elaboration:

Proposed Doctoral Thesis – Brief Annotation
The thesis explores the application of Digital (Virtual) Twin technology in OHS as a tool for preventive risk identification and the enhancement of employee competencies. Leveraging advancements in virtual reality and simulation, the research creates realistic models of work processes to analyze operational states and hazardous scenarios without endangering personnel or disrupting production. Following a systematic literature review, the work involves designing and implementing a digital twin for a selected section of a medium-sized company in Ostrava. The core focus is simulating risk scenarios to support preventive measures and modernize OHS training frameworks.

Proposed Objectives of the Doctoral Thesis
The primary objective is to develop a high-fidelity virtual twin of an operational area within a company in Ostrava. This model will serve as a dynamic environment for simulating hazardous situations tailored to the organization's specific needs. Based on these simulations, the thesis will propose targeted preventive measures.
Furthermore, the research aims to verify the practical efficacy of these measures in fostering employee competencies. Through a comparative analysis, the study will evaluate the advantages of this digital twin approach against traditional risk assessment and training methodologies, establishing its value as a modern tool for industrial safety.

Expected Contribution to Science and Practice
Scientific Contribution: The academic merit lies in developing a methodological framework for the design, verification, and implementation of digital twins within the OHS domain. By bridging safety engineering and advanced simulation, the research contributes to the systematization of digital twin applications in industry. Additionally, the work offers insights into human factor research by analyzing worker behavior and risk perception within virtual hazardous scenarios, expanding the theoretical boundaries of preventive safety management.

Practical Contribution: The thesis validates virtual workplace models as essential tools for proactive OHS management. It enables the simulation of planned changes—such as new layouts or technological updates—without costly or risky real-world interventions. The implementation supports robust OHS audits and accelerates the onboarding of new employees. Ultimately, these tools lead to higher risk awareness and a sophisticated approach to competency development. The resulting model will be verified within Stant Manufacturing s.r.o. Ostrava.

Supervisor: **doc. Dr. Ing. Michal Lesňák**

VSB TECHNICAL UNIVERSITY OF OSTRAVA | FACULTY OF SAFETY ENGINEERING

Doctoral Thesis Assignment

Study Programme: P1032D020005 Fire Protection and Safety

Topic: Develop an Integrated Occupational Risk Assessment: A Case Study in the Textile and Footwear Industry in Vietnam
Vypracování integrovaného posouzení rizik na pracovišti: Případová studie v textilním a obuvnickém průmyslu ve Vietnamu

The thesis language: English

Supervisoring centre: 040 Department of Occupational and Process Safety

Rules for elaboration:

Brief annotation
This doctoral thesis examines occupational risk assessment within Vietnam's textile and footwear industries—sectors characterized by high labor intensity and significant exposure to diverse physical, chemical, and psychosocial hazards. The primary objective of the research is to integrate the Hazard Identification (HAZID) method into existing occupational health and safety management systems. The study proposes a structured, proactive, and participatory framework that utilizes industry-specific guidewords and multidisciplinary workshops to systematically identify risks across production processes. The resulting outcomes include a practical risk assessment framework and detailed risk profiles for typical manufacturing environments, offering actionable recommendations to improve working conditions. Ultimately, this research contributes to both applied practice and scientific discourse regarding occupational safety in the context of developing economies.

Objectives of the Thesis
"The primary objective of this doctoral thesis is to develop an integrated occupational risk assessment approach by combining traditional methodologies with the HAZID (Hazard Identification) method, specifically tailored for the textile and footwear industry in Vietnam. In line with this goal, the research aims to design a systematic and proactive risk assessment procedure adapted to real-world production conditions. Furthermore, the study seeks to establish comprehensive occupational risk profiles to support the prioritization of control measures at the enterprise level and to propose practical solutions for enhancing working conditions and preventing occupational accidents and diseases. Ultimately, the thesis intends to contribute new scientific knowledge to the field of OSH by adapting and extending the HAZID method for labor-intensive industries."

Expected contribution to science and practice
The proposed research contributes to the development of safety engineering through the systematic application of qualitative methods and structured risk analysis using the HAZID (Hazard Identification) method. The work will methodologically develop the process of hazard identification through the precise definition of the scope of the assessment, the creation of field-specific "guidewords," the analysis of causes and consequences, and the evaluation of risks using a probability-consequence matrix. The theoretical contribution lies in the integration of current scientific knowledge and international standards into a unified, systematic, and replicable analytical framework for occupational risk assessment. The expected result will be a methodologically anchored and transferable model for the systematic identification and assessment of occupational risks, which will strengthen the theoretical basis of risk management and create a scientifically sound foundation for its application in industrial practice.

Supervisor: **doc. Dr. Ing. Michal Lesňák**

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VSB TECHNICAL UNIVERSITY OF OSTRAVA | FACULTY OF SAFETY ENGINEERING

Doctoral Thesis Assignment

Study Programme: P1032D020005 Fire Protection and Safety

Topic: Environmental Safety and Oceanic Hydro-Biogeochemical Responses to Marine Renewable Energy
Environmentální bezpečnost a Oceanic Hydro-Biogeochemical Responses to Marine Renewable Energy

The thesis language: English

Supervisoring centre: 040 Department of Occupational and Process Safety

Rules for elaboration:

Abstract
This dissertation examines the mechanistic link between hydrographic changes caused by offshore renewable energy infrastructure (OWF, FPV) and subsequent biogeochemical shifts that directly affect the stability and safety of marine ecosystems. In the context of the Net Zero 2050 targets, the focus is shifting from mere coexistence to active management of environmental risks and ecological enhancement through the "artificial reef" effect. The key question remains whether the presence of critical energy infrastructure leads to enhanced resilience of biological production or merely to risk aggregation of existing biomass. Previous studies (e.g., Deltares/WOZEP) have often simulated the effects of technologies as a whole, without a deeper understanding of the safety implications of individual variables. This work uses top-down and bottom-up approaches to decompose the effects on ecosystem integrity. The goal is to remove the information barrier for safe and environmentally friendly design of structures that minimize negative environmental impacts.

Objectives of the work
· Environmental risk analysis: Decomposition of aggregated data into discrete physical factors threatening the stability of ecosystem processes.
· Quantification of links: Determination of correlations between specific physical influences and biogeochemical response in the context of environmental safety.
· Determination of resistance limits: Identification of tipping points (threshold values) where physical changes begin to generate new production instead of mere aggregation, which is essential for predicting long-term ecological stability.

Expected benefits
Scientific contribution:
· Contribution to the "Attraction vs. Production" hypothesis – verification of whether structures actually increase biological safety and biomass capacity.
· Identification of key physical drivers for early warning detection of changes in local plankton levels.
Practical contribution:
· Safe design and optimization: Background information for engineers to modify structures with a view to minimizing ecological accidents and risks.
· Model validation: Provision of ground-truth data to refine risk scenarios of coupled models (e.g., Deltares).
· Crisis monitoring: Definition of key hydrographic indicators for effective monitoring of the environmental status around energy complexes.

Supervisor: **doc. Dr. Ing. Michal Lesňák**

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