University of Maribor

FRAMEWORK PROGRAMME OF EARLY STAGE RESEARCHER TRAINING[1]

1. BASIC DATA

Mentor's name and surname	**Filip Kokalj**	Mentor's register number at ARIS (SICRIS):	**21377**
Mentor's e-mail:	filip.kokalj@um.si	Mentor's tel. no.:	+386 2 220 77 28
Research programme (RP) leader's name and surname:	Matjaž Hriberšek	RP leader's register number at ARIS (SICRIS):	11167
Title of research programme:	Research in Power, Process, and Environmental Engineering	RP's Register number at ARIS (SICRIS):	P2-0196
Research organisation (RO) of University of Maribor, where training shall be conducted:	Faculty of Mechanical Engineering	RO Register number at ARIS (SICRIS):	0795
Research field according to ARIS classification:	Procesno strojništvo 2.13.00	Research field according to EURAXESS classification	Process engineering

2. DEFINITION OF RESEARCH PROBLEM AND GOALS OF DOCTORAL RESEARCH[2]

Starting point of research task of the early stage researcher and its position in the research programme, where the mentor is included, work hypothesis, research goals and foreseen result with emphasis on an original contribution to science:

Starting point of the research task The use of alternative fuels, especially those of biological origin and fuels derived from waste, is increasing, mainly due to commitments to reduce emissions of climate-relevant carbon dioxide. However, the combustion of alternative fuels can involve completely different mechanical and temporal scales of combustion, which may require additional measures to ensure stable and safe combustion, as well as specific actions to reduce emissions of substances into the air. The starting point of the young researcher's work is numerical modeling and simulation of combustion processes for alternative fuels of renewable

[1] *Term early stage researcher (ESR) is written in male form and used as neutral for women and men.*

[2] *Research and study programme of training have to harmonise with contents of the research programme, where the mentor is a member.*

origin, with an emphasis on analyzing stable combustion and the conditions for the formation of harmful substances. The results of this research will contribute to understanding the complex and relatively unexplored mechanisms of the formation of certain harmful substances during the combustion of alternative fuels, which are based on the transfer phenomena of matter and energy and chemical kinetics. The content of the young researcher's work thus represents an advancement of fundamental research on transport phenomena in solids and fluids, which form the scientific and theoretical foundation of the engineering research program "Research in Energy, Process and Environmental Engineering (P2-0196)," namely momentum transfer, heat transfer, and mass transfer, with the dominant turbulent nature of a multi-component reactive flow.

The research problem and goals

Significant progress has been made in the development of commercial computational fluid dynamics (CFD) packages. However, the currently implemented numerical models are not suitable for all simulations of alternative fuel combustion. As a result, commercial CFD software cannot yet simulate the entire process of gasification and combustion of solid alternative fuels in a real combustion chamber using a single numerical model. When simulating solid fuel combustion, it is first necessary to obtain appropriate boundary conditions using an additional external model and then incorporate these conditions into the CFD numerical model, since commercial CFD packages can simulate only the gas phase of combustion. In this context, external combustion models are crucial; these are typically based on equilibrium combustion conditions, which we aim to replace with chemical kinetics as part of the young researcher's work. To achieve this, it will be necessary to select and evaluate a suitable chemical reaction mechanism, using the combustion of an isolated fuel particle as the basis. The complete model will be validated using experimentally obtained values of characteristic fuel combustion parameters in a real combustion chamber.

Foreseen results

The primary goal of the young researcher's work is to develop a combustion model for an isolated fuel particle (wood biomass, RDF, biodiesel, synthetic fuels). For solid fuel combustion, the validated model will be integrated into the existing bed combustion model developed within the research program P2-0196 to assess the impact of chemical kinetics on the final results, including the temperature profile in the combustion plant and the concentration fields of complete and incomplete combustion products. The model will also be used to simulate fuel combustion in a fluidized bed and in dust combustion. The current model of solid fuel combustion on a grate assumes that the fuel layer is divided into a finite number of homogeneous reactors, where combustion at chemical equilibrium prevails. Therefore, as part of the research, it is important to determine the significance of time-dependent chemical reactions for analyzing the formation of gasification products (CO_2, CO, H_2, CH_4, etc.) and NOx, which serve as boundary conditions for the coupled combustion simulation model in the gas phase using the commercial CFD software package. It is expected that accounting for chemical kinetics will be beneficial in determining the conditions for the formation of incomplete combustion products, although it will not significantly affect the final results. An original scientific contribution is anticipated in developing a complex model for the combustion of an isolated fuel particle and its implementation in a gas-phase combustion model that considers chemical kinetics. The practical utility of such numerical models is demonstrated in optimizing the operating conditions of existing devices for alternative fuel combustion and in the design and planning of new devices, which significantly reduces the need for experimental research and has a favorable impact on development costs.

Position of the early stage researcher

The candidate will join the established Research Group for Energy, Process, and Environmental Engineering (https://cris.cobiss.net/ecris/si/sl/group/2079). The research group addresses problems related to fluid flow, heat, and mass transfer, applying this knowledge to solve engineering challenges. The areas covered include process engineering, combustion, environmental protection, turbomachinery, internal combustion

engines, heat engines, refrigeration and drying technology, and thermodynamics. The research group consists of 18 members, including three young researchers.

References:
JAEGER, Marc, HRIBERŠEK, Matjaž, SAMEC, Niko, GUO, Yang, WANG, Xuebin, KOKALJ, Filip. The numerical analysis of flame stability in case of premixed hydrogen-air combustion. Applied thermal engineering. Aug. 2025, vol. 273, [article no.] 126535, 13 str. ISSN 1873-5606. Digitalna knjižnica Univerze v Mariboru – DKUM, DOI: 10.1016/j.applthermaleng.2025.126535. [COBISS.SI-ID 236398595]
JAEGER, Marc, HRIBERŠEK, Matjaž, KOKALJ, Filip, ZADRAVEC, Matej, SAMEC, Niko. Numerical modelling and simulation of hydrogen and air mixing to prevent ignition delay and flashback. Thermal science. [Online ed.]. 2024, 19 str., ilustr. ISSN 2334-7163. DOI: 10.2298/TSCI230529250J. [COBISS.SI-ID 219268611]
KOKALJ, Filip, ZADRAVEC, Tomas, JOVOVIĆ, Aleksandar M., SAMEC, Niko. Small wood pellet boiler 3-D CFD study for improved flue gas emissions employing flue gas recirculation and air staging. Thermal science. 2023, vol. 27, iss. 1, str. 89-101. ISSN 0354-9836. Digitalna knjižnica Univerze v Mariboru – DKUM, DOI: 10.2298/TSCI2301089K. [COBISS.SI-ID 144637187]
ZADRAVEC, Tomas, RAJH, Boštjan, KOKALJ, Filip, SAMEC, Niko. The impact of secondary air boundary conditions on CFD results in small-scale wood pellet combustion. Fuel. [Print ed.]. 15 September 2022, vol. 324 (124451), 19 str. ISSN 0016-2361. DOI: 10.1016/j.fuel.2022.124451. [COBISS.SI-ID 108600835]
ZADRAVEC, Tomas, RAJH, Boštjan, KOKALJ, Filip, SAMEC, Niko. Influence of air staging strategies on flue gas sensible heat losses and gaseous emissions of a wood pellet boiler: An experimental study. Renewable energy. [Print ed.]. Nov. 2021, vol. 178, str. 532-548, ilustr. ISSN 0960-1481. DOI: 10.1016/j.renene.2021.05.150. [COBISS.SI-ID 73900291]
ZADRAVEC, Tomas, YIN, Chungen, KOKALJ, Filip, SAMEC, Niko, RAJH, Boštjan. The impacts of different profiles of the grate inlet conditions on freeboard CFD in a waste wood-fired grate boiler. Applied energy. 15 June 2020, vol. 268 (115055), str. 1-11. ISSN 0306-2619. DOI: 10.1016/j.apenergy.2020.115055. [COBISS.SI-ID 14440451]
ZADRAVEC, Tomas, RAJH, Boštjan, KOKALJ, Filip, SAMEC, Niko. CFD modelling of air staged combustion in a wood pellet boiler using the coupled modelling approach. Thermal science and engineering progress. [Online ed.]. 1 Dec. 2020, vol. 20, [art. no.] 100715, str. 1-13. ISSN 2451-9049. DOI: 10.1016/j.tsep.2020.100715. [COBISS.SI-ID 33172483]

3. STUDY PROGRAMME

Foreseen study programme, to which early stage researcher shall be enrolled in academic year 2026/2027:

The doctoral school study programme, 3. cycle, DOCTORAL SCHOOL OF THE FACULTY OF MECHANICAL ENGINEERING

Year 2026/2027: 1.year; Individual research work 1 and 2, Elective subjects
Year 2027/2028: 2.year; Individual research work 3 and 4, Elective subjects
Year 2028/2029: 3. year; Individual research work 5 and 6;
Doctoral dissertation writing; Defense of doctoral dissertation.

4. DESCRIPTION OF WORK AND TASKS

Implementing projects of scientific research.
Taking part in the design of research programmes.

Cooperating with research sponsors.
Drawing up research and other reports.
Monitoring and coordinating research work according to the grant agreement.
Ensuring safety and health at work.
Organising and instructing employees and students on using personal safety equipment and other safety measures.
Performing other tasks at the behest of the superiors.
Participating in ad-hoc and permanent committees of university or faculty bodies.
Acting on behalf of colleagues and superiors during their absence (upon authorisation).
Participating in annual and other inventories.
Performing other related tasks delegated by superiors.

5. REQUESTED LEVEL OF EDUCATION

VII/2. tariff group

6. REQUESTED FIELD OF EDUCATION

Technical, Natural sciences

7. KLASIUS SRV

Seventh level: Second cycle of higher and similar education/Second cycle of higher and similar education

8. KLASIUS P

01 – Educational sciences and teacher education
05 – Natural Sciences, Mathematics and Statistics
07 – Technology, production technologies and construction

9. REQUESTED KNOWLEDGE

Computer skills: MS Windows, Word, Excel, Internet, e-mail, e-commerce

10. REQUESTED SPECIAL REQUIREMENTS

/

11. REQUESTED LANGUAGES

Active knowledge of one world language

12. REQUESTED WORK EXPERIENCE

/

13. FORESEEN POSTDOCTORAL TRAINING

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Mentor's signature:

Filip Kokalj

Digitally signed by Filip Kokalj
DN: C=SI, S=Slovenija, OU=individuals, G=Filip + SN=Kokalj + CN=Filip Kokalj + SERIALNUMBER=2464245612048
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Research programme leader's signature:

Digitally signed by Matjaž Hriberšek
DN: c=SI, st=Slovenija, ou=individuals, givenName=Matjaž, sn=Hriberšek, serialNumber=2469558612032, cn=Matjaž Hriberšek
Date: 2026.01.30 11:52:55 +01'00'

Name and surname of Dean or authorised person[3]:
Red. prof. dr. Matej Vesenjak

Signature of dean or authorised person:

Digitally signed by Matej Vesenjak
Date: 2026.02.01 12:26:36+01'00'

Place and date:

Maribor 30. 01. 2026

Stamp:

[3] The training program is signed by the dean of the member where the ESR's employment and training will take place.