Research Trip Summary Report

Task 2. Foreign mobility of WUST doctoral students

I. Data of the doctoral student

1.Full name: **Sindu Daniarta**

2.Year of studies: **2nd year**

3. Educational discipline: **Environmental engineering, mining, and energy**

II. Foreign research trip (research visit)

1. Research institute in which the foreign research was implemented: **Department of Thermohydraulics and Department of Environmental Physics, the Centre for Energy Research, Budapest, Hungary**

2. Name and surname of the host person (mentor): **Professor Attila R. Imre., D.Sc. and Bálint Hartmann, PhD**

3. Dates of the research trip: **1 April – 30 June 2022**

4. Title and date of a seminar delivered during the research trip: **Part of the results entitled "A comparative study of direct expanders utilizing different mixtures of natural gas" was presented at the 8th International Youth Conference on Energy (IYCE 2022, iyce-conf.org), in Eger (Hungary), 6-8 July 2022. and between WUST and BME, 19 July 2022.**

5. Description of work carried out during the research trip:

Although the current state appears that a mature development for the first generation of the organic Rankine cycle (ORC), there is still room for advancement for further research. During this research visit, the PhD student studied the performance improvement of the ORC. The main objective is to develop an advanced ORC architecture with improved efficiency in which the design utilizes selected organic working fluids, combined cycle, two-phase expansion, and other related problems. The research objectives were achieved through a wide range of analyses that are described as follows:

1. Analyzing the first generation of ORC (basic design) utilizing organic working fluids.
2. Analyzing and developing innovative design and selection of pro-ecological impact of working fluids in order to increase the efficiency performance of the ORC system, and
3. Developing a mathematical description of thermodynamics and flow process in computer-based modelling simulation (in this case, using MATLAB software).

6. Description of the main results obtained:

Part of the results has been published in the Energy journal (D1 journal) with an impact factor of 7.147 (or MniSW: 200 points) entitled "Thermodynamic efficiency of subcritical and transcritical cycles utilizing selected ACZ working fluids" (DOI: https://doi.org/10.1016/j.energy.2022.124432). The obtained result shows that the superheated ORC system with a special configuration may have higher efficiency than basic ORC at maximal efficiency. Moreover, at a certain condition (depending on the characteristic of organic working fluids), the superheated ORC may have lower efficiency than basic ORC, partially evaporated ORC and trilateral flash cycle. Further modelling simulation was conducted to design the transcritical power cycle in this case. The obtained results proved the existence of three novel markers (ACZ-S, ACZ-S and the "ideal identity" band) that may help in designing a good thermal power plant utilizing organic working fluid.

Part of the results has been published at the 8th International Youth Conference on Energy 2022 (in Eger, Hungary, 6-8 July 2022) entitled "A comparative study of direct expanders utilizing different mixtures of natural gas". In order to utilize waste heat sources, a direct expansion system can be used for power generation. In the system, the organic working fluid is directly expanded to drive the generator. In this case, the liquefied natural gas (LNG) regasification system was chosen as an example. The obtained results show that a direct expansion system may have an efficiency of around 5-7%.

Advancing the power plant by integrating the ORC with a direct expansion for waste heat recovery (in this case, the geothermal power plant as an example), the efficiency of the system could be improved by around 15%. Part of the results will be presented as a pitch in the summer school "Design your own renewable district heating and cooling system" (in Delft, the Netherland 11-15 July 2022) organized by Geothermal-DHC (https://www.geothermal-dhc.eu/).

7. Future collaborations (if applicable):

The mentors and the PhD students intend to develop further work for the internationalization of scientific research that is in perfect harmony with the goal of the NAWA STER program. In this case, together with the Department of Environmental Physics, Centre for Energy Research (Hungary), we plan to expand the investigation in the form of a project on developing a geothermal power system and in the form of further collaborative scientific publications.

8. Title and date of a seminar presenting the results of the trip delivered at Wroclaw University of Science and Technology after returning from the research trip: **subcritical and transcritical power cycle utilizing selected organic working fluids and the possible integration with a direct expansion system, 19 July 2022.**

III. Doctoral student's signature

Eger (Hungary), 8 July 2022
(Date)

.....
(doctoral student's signature)

IV. Confirmation and information from the host

1. Confirmation of compliance of the information contained in the report: **I CONFIRM / ~~DO NOT CONFIRM~~**. (*In justified cases, the confirmation of the host may be sent by e-mail to the Dean's Office of the Doctoral School email: interdocschool@pwr.edu.pl)*

2. Additional information and comments

Mr. Daniarta obtained very good results during his stay; more publications are expected from these results. His results are useful for geothermal project of the Centre for Energy research; this might be a good point for future cooperation

Budapest, 8 July 2022

Mentor 1

Professor Attila R. Imre., D.Sc

Department of Thermohydraaulics
Centre for Energy Research
Hungary

Mentor 2

Bálint Hartmann, PhD

Department of Environmental Physics
Centre for Energy Research
Hungary