Doctoral Thesis Reviewer's Report

VŠB-Technical University of Ostrava
Faculty of Material Science and technology

Study program | Process engineering.
Applicant | Ing. Artem Chesalkin.
Candidate's workplace, institution | Centre of Energy Utilization of Non-traditional Energy Sources ENET and Institute of Environmental Technology IET VŠB-TU Ostrava.
Supervisor | Prof. Ing. Kamil Wichterle, DrSc.
Specialist supervisor | Prof. Ing. Stanislav Mišák, Ph.D.
Reviewer | Prof. Ing. Pavel Kolat, DrSc.
Workplace of reviewer: | VŠB-Technical University Ostrava, Faculty of Mechanical Engineering, Department of Power Engineering.

Reviewer's report:

The reviewer's report was written at the request of prof. Ing. Jana Dobrovská, CSc dean of faculty of Material Science and Technology received on the 16th September 2019. Formally the work is very well designed, written in a clear, easy-to-understand language. It comprises 71 pages, tables and 43 figures that are adequate and informative. References used in the work are interpretative.

1. The Doctoral Work

The doctoral thesis being discussed describes issues of safe, efficient and cost-effective way of hydrogen storing, which is part of hydrogen technologies - perspective clean fuel for the future. The work is supported by the research and experimental activities. It reflects long-term research conducted at the Faculty of Material Science and Technology over the last years. Ing. Artem Chesalkin also utilized experiences and knowledge gained during his work placement at the ENET and IET VŠB-TU Ostrava.

The results from doctoral thesis enable practical application in energy and chemistry sector. New energy transition is coming to the scene. It is driven by climate change concerns, and the primary goal of this transition is to decarbonize the world economy. Hydrogen technologies are surging around the globe, with decreasing investment costs, increasing efficiency and predictability, and generally with high public support.
Very important is the research occupied by the theoretical concepts associated with research of low-temperature metal hydrides and their practical application and integration with fuel cells, which also constitutes the theoretical foundation of doctoral thesis. An experimental investigation is based to modify the well-known metal hydride and find the optimal working temperatures and pressures parameters of the alloy for reversible hydrogen sorption via fuel cells. The identification of phases was done by using XRD high resolution transmission electron microscopy and electron energy loss spectroscopy EELS analysis. Thermodynamics was studied by SETARAM PCT devices.

**Realization of the chosen topic is highly significant and relevant since the importance of the change of energy transition.**

2. **Meeting of objectives**

The doctoral thesis summarised research activity of Ing. Artem Chesalkin in the field of process engineering. The solution of this problems was initiated by the Czech energy sector and State Energy Policy of the Czech Republic in 2014.

**The goal of doctoral thesis such as:**

- To modify LaNi5 metal hydride and find working parameters like temperatures and pressures of the alloy for reversible hydrogen sorption in fuel cells,
- to optimize the time-temperature parameters of the alloy synthesis and final hydrogen storage density,
- detailed physicochemical analysis of the prepared alloys and corresponding hydrides
- the influence the thermodynamic properties and value gravimetric capacity of the hydride,
- the preparation of materials with various structure states and thermodynamic properties at low temperatures which is **novel research way**, metal hydride testing in real operation conditions during reversible hydrogen sorption during low and high temperature fuel cells,
- thermography analysis of the whole hydride-fuel system,
- heat transfer simulation of the fuel cell using more efficient components of the hydrogen system,

**was fulfilled.**

3. **Methodology of investigation**

Methodology is based on an analysis of the present energy situation in fossil fuels limitation and serious environmental pollution and ways to use hydrogen as an alternative ecological fuels. The methodology of investigation clearly describes how each specific objective will be achieved, with enough detail to enable an independent and informed assessment of the proposal. The doctoral thesis also includes:

- Restatement of research problems: hypothesis or research questions; formulating the research problem, justifying its practical and theoretical relevance.
- Description of study areas, the procedures for their selection; mainly for “energy transition,” to switch from fossil-fuel technologies to low-carbon ones.
- Data collection: description of the tools and methods used to collect information, and identification of variables, providing the research tools to approach the empirical case.
• Data analysis: description of data processing and analysing procedures; focused on examination of the transition of the energy system.

The methodology is consistent with the objectives of the doctoral thesis. The problem under investigation is formulated in an appropriate and clear form.

4. Evaluation of the research results

Ing. Artem Chesalkin developed a research approach of the system of alternative way of hydrogen storage in compact solid form in low-temperature metal hydrides. This approach is very precise, and allow practical application and integration with fuel cells. The interaction of these constitutive elements ensures the functioning, reproduction, and gradual evolution of the system. This is main benefit of the evaluation of research results.

The subject of doctoral thesis is in the correspondence with the research topics and energy policy of European Union.

5. Comments.

• What are potential applications of your current research results, in particular in the field of future hydrogen technologies and in low carbon energy systems. How do you envisage the further development of your methods?

• Explain aims of further research for investigation the possibilities of more effective use of LiH or different reducing agent for the alloy thermochemical synthesis.

• Present more clearly rational technological conditions of the processes of thermal deformation.

6. Conclusion.

The habilitation thesis is in compliance with energy research program of the European Union. It has very high scientific quality and the obtained findings significantly contribute to the development of new energy technologies. Doctoral thesis meets the requirements standard in the field of material engineering. It fulfils the criteria laid down by the decree of the Czech Ministry of Education.

I recommend this work for defence subsequently leading the defendant to be awarded the academic title of “Ph.D.”, once all the necessary formal requirements have been fulfilled.

Ostrava 7th October 2019

[Signature]

Prof. Ing. Pavel Kolat, DrSc
Department of Power Engineering
VSB-Technical University Ostrava