LITHUANIAN ENERGY INSTITUTE

ADMISSION TO PHD STUDIES FOR THE YEAR 2024

DOCTORAL RESEARCH TOPIC:

Investigation of heat production using reactions of aluminum and aluminum-based alloys with water

RESEARCH FIELD:

Energetics and Power Engineering (T 006)

BRIEF DESCRIPTION OF RESEARCH TOPIC:

Waste management and energy production are recognized as essential areas for ensuring global sustainability in the present times. Aluminium (Al) is a highly important strategic material in Europe with numerous applications. Unfortunately, this leads to the significant generation of aluminium waste. Even though a significant portion of aluminium waste is recycled, there still remains an issue with unused Al residues that pollutes environment. Additionally, a considerable amount of non-recyclable waste with aluminium content is generated in industries related to aluminium production. Innovative ways to utilize these Al residues are being sought. Therefore, aluminium and its alloys, considered low-value waste, could be utilized for energy generation.

Aluminium and its alloys actively react when immersed in alkaline water. Since this reaction is exothermic, it releases not only hydrogen but also heat. When 1 kg of Al reacts with water, approximately 0.11 kg of H_2 is generated (producing about 2.2 kWh of electrical energy), resulting in about 1.9 kg of aluminium hydroxide by-product and releasing around 15–16 MJ (≈ 4.3 kWh) of heat. However, if only hydrogen is collected without utilizing the heat, the potential efficiency of such a system remains untapped. There is a lack of research and experimental work analysing the heat generated by these reactions and their transfers. Therefore, successfully harnessing both hydrogen and heat according to demand (which can be converted into electrical energy when needed) could enhance the attractiveness of such decentralized systems and contribute to the development of sustainable heat production technologies.

The main objective of this work is to explore and evaluate the potential of heat production using reactions of aluminium and aluminium-based waste with water. The tasks to achieve this goal are as follows: 1) Conduct a literature review and summarize knowledge on this topic; 2) Develop a small-scale reactor with heat dissipation and the ability to monitor selected parameters to investigate the thermodynamic properties of Al and water reactions, taking into account the chemical composition of waste, water temperature, and other parameters; 3) Analyse the chemical and structural properties of initial and final materials; 4) Study the kinetics and conditions of heat generation (analysis of thermodynamic processes); 5) Evaluate the practicality of utilizing Al-water reactions for heat production in various fields and scales.

Upon successfully completing this interdisciplinary work, the doctoral candidate will have deepened their understanding of heat exchange processes and comprehensively grasped the heat production potential in metal-water reactions. The anticipated results will not only contribute to existing knowledge in this field but also provide practical insights that may aid future scientific research in the field of sustainable energy production.

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